1.1

Number of Courses Offered by the Institution across all Programmes = 273

Science and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Engineering
(First Semester)

Maths –I: CE-BS-101T **Total Credits: 02**
Teaching Scheme: Lectures: 2Hours/ Week
Examination Scheme: T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

UNIT -I : Linear Algebra-I

Matrices, Vectors,Vector Space, Rank of a Matrix, Linear Independence, Inverse of a Matrix, Linear Systems of Equations: Existence, Uniqueness,
Solutions of Linear Systems: Gauss Elimination, Cramer's Rule, Gauss-Jordan Elimination.

UNIT -II : Linear Algebra-II

Linear Algebra: Eigenvalues, Eigen vectors of Matrix, Symmetric, Skew-Symmetric, and Orthogonal Matrices, Cayley Hamilton Theorem, Sylvester Theorem, Diagonalisation.

UNIT -III: Integral Calculus

Beta, Gamma functions, Double integration : Cartesian and polar co-ordinates, Change of order of integration, Change of variables between Cartesian and polar co-ordinates, Area as a double integral, Triple integration, Volume as a triple integral.

UNIT -IV: Vector Calculus

Vectors in 2-Space and 3-Space, Inner Product (Dot Product), Vector Product (Cross Product) Vector and Scalar Functions and Fields, Derivatives Curves. Arc Length. Curvature, Gradient of a Scalar Field, Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field.
Integral Calculus. Integral Theorems, Line Integrals, Path Independence of Line Integrals, Green's Theorem in the Plane, Surfaces for Surface Integrals

Reference Books:

1. Higher Engineering Mathematics by H. K. Das, Er. Rajnish Verma
2. A text book of Engineering Mathematics by N. P. Bali, Manish Goyal
3. A text book of Engineering Mathematics (Vol- I & II) by Dr. D. T. Deshmukh
4. Higher Engineering Mathematics by B. S. Grewal

Physics CE-BS-102 T **Total Credits: 02**
Teaching Scheme: Lectures: 2Hours/ Week
Examination Scheme: T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Quantum Mechanics: Planck's Hypothesis, Properties of Photons, Compton Effect, Wave – particle duality, De-Broglie Hypothesis, Matter Waves, Davisson-Germer Experiment; Bohr's Quantization condition.
Wave Packet & Wave Equations. Heisenberg's uncertainty principle, Wave function and its probability interpretation, Schrödinger's Time dependent & time independent equations, (No derivations). Solution of Schrödinger's equation for one dimensional infinite potential well.

Unit 2: Basic Semiconductor: Qualitative idea on the formation of electron energy bands in solids, Band-theory based classification of solids into insulators, semiconductors and conductors, Intrinsic semiconductors: Germanium and silicon, Doping and Extrinsic semiconductors.
PN- junction diode; Unbiased, Forward biased & Reverse biased mode, Zener diode: Forward and reverse bias characteristics, Avalanche breakdown, Applications: Half wave rectifier & Full wave rectifier, Transistors: PNP and NPN. Configuration: - CB, CE, Bipolar Transistor action, V-I characteristics of i) Photodiode, ii) LED.

Unit 3: Lasers: Three quantum processes: Absorption, Spontaneous emission and Stimulated emission. Metastable state, Conditions for light amplification, Pumping schemes: Three level pumping scheme, Four level pumping scheme. Optical resonator, Laser beam characteristics, Ruby laser and He-Ne laser. Numericals.

Unit 4: Optical fibres: Structure, Propagation of light through a cladded fibre, Acceptance angle, acceptance cone, Fractional refractive index change, Numerical aperture, Modes of propagation; Types of Optical fibres: Single mode step index fibre, Multimode step index fibre, Graded Index fibre, V-number. Transmission Losses, Applications: Sensor, Numericals.

Books recommended:
Text Books:
Fundamentals of Physics: David Halliday, Robert Resnick and Jerle Walker, John-Wiley India(8e, extended)
A text book of Engineering Physics: M. N. Avadhanulu and Kshirsagar S. Chand & Co.
Electronic Engineering Materials and Devices: John Allision, (TMH edition, 10th reprint)
Concepts of Modern Physics: Baiser (Tata McGraw Hill).
Laser: M. N. Avadhanulu, S. Chand & Co.

Reference Books:
University Physics:Young and Freedman(Pearson Education)
Solid State Physics: C. Kittel
Solid State Physics: R.L. Singhal
Quantum Mechanics: Schiff
LASERS: Theory and Applications: Thyagarajan K and Ghatak A.K.

Chemistry-I : CE-BS-103 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week
Examination Scheme: Theory T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit I Co-ordination Chemistry and Chemical bonding: Introduction to co-ordination chemistry, explanation of terms like complex, ligands, co-ordination number, co-ordination sphere. Classification of ligands, chelates & its classification. Werner's coordination theory & its application to Co (III) and Pt (IV) ammine complexes.
Valence Bond Theory and its application to 6-coordinated complexes, Crystal Field theory and Crystal field splitting in Octahedral and tetrahedral complexes, MO theory, Structure, bonding and energy levels of bonding and shapes of many atom molecules like H2, N2, and CO.

(12)

Unit II Water: Sources, types of impurities and their effects, hardness of water & its estimation, Numerical on EDTA method, treatment of water for domestic & industrial purposes, sedimentation, coagulation, filtration, types of filters, Sterilization- chlorination, break point chlorination, Ozonization. Removal of hardness of water: Lime- soda process, Numerical on lime-soda process, Zeolite process, its advantages and disadvantages, comparison with L-S Process, Numerical based on zeolite process, Ion- exchange process, demineralization process. Boiler troubles: -Carry over- priming & foaming-causes & prevention, sludge & scales, causes of scale formation and prevention methods, Corrosion & caustic embrittlement causes & prevention.

(12)

Unit III Cement: Raw materials, constitutional compounds& its properties, Process parameters, Manufacture of Portland cement by wet and dry process, setting and hardening of cement, Cement additives & admixtures.
Refractories: Definition, requisites of good refractory material, properties of refractory, raw materials, manufacture of refractory products, application in industries. **(10)**

Unit IV Chromatography: Introduction, Classification, General and fundamental concepts of TLC, Column, HPLC, GC, Ion Exchange and their applications. **(06)**

Books Recommended:

1. A Text Book of Engineering Chemistry, by S.S.Dara, S.Chand & Co., New Delhi.
2. A Text Book of Engineering Chemistry, by Jain & Jain, Dhanpat Rai Publishing Co.,
New Delhi.
3. Industrial Chemistry by B.K.Sharma Goel Pub. House, Meerut.
4. Advanced Inorganic Chemistry, Vol.II, by Satya Prakash, G.D.Tuli, S.K.Basu & R.D.Madan.
5. Text of Engineering Chemistry by Dr. Sunita Rattan, S. K. Kataria and Sons, New Delhi.
6. Analytical Chromatography by Dr. G. R. Chatwal, Himalaya Publication House.
7. Instrumental Methods Of Chemical Analysis By G. R. Chatwal, S. K. Anand, Himalaya Publication House.

Fundamentals of Reaction Mechanism: CE-BS-104 T **Total Credits: 02**
Teaching Scheme: Lectures: 02 Hours/Week
Examination Scheme: Theory T (U): 35 Marks T (I): 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Reactivity of organic molecules: factors influencing acidity, basicity and nucleophilicity of molecules with few examples. Introduction to Stereochemistry: Stereo-descriptors – R, S, E, Z. Enantiomers and Diastereomers. (**6L**)

Unit 2: Strategies for synthesis of organic compounds: Reactive intermediates, Mechanism of Addition, substitution, elimination, condensation, role of solvents. Technical preparation of bio-ethanol using molasses, enzymatic catalysis, commercial significance (**8L**)

Unit 3: **Mechanism and recent advancement (Green chemistry and catalysis etc.):** Basic principles of green chemistry, industrial significance, green catalysts. Technical preparation supported green route, Preparation of adipic acid, Acetanalide with mechanism, photo-halogenation of benzene etc (**6L**)

Unit 4: Nitration: Vant Hoffs factor for suitability of agents, Catalytic effect of sulfuric acid in industrial nitration, Mechanism of aromatic nitration process using Inductive and Mesomeric effect, examples, Equipments for nitration and safety aspects. Technical preparation of nitroglycerine (**6L**)

Books Recommended:

1. Engineering Chemistry – By Baskar, Wiley

2. Engineering Chemistry –I By D. GrourKrishana, Vikas Publishing
3. Green Chemistry: Theory and Practice by Paul T. Anastas, J.C. Warner; Oxford University Press
4. Unit Processes in Organic Synthesis- by P. H. Groggins
5. Reaction and Reagents- By O.P. Agarawal
6. Monograph on green chemistry, Green chemistry Task Force Committee, DST

Engineering and Solid Mechanics: CE-GES-105 T **Total Credits: 03**
Teaching Scheme: Lectures: 03Hours/Week
Examination Scheme: Theory T (U): 70 Marks T (I): 30 Marks
Duration of University Exam. : 03 Hours

Unit I: **Force:** Definition, Characteristics of a force, System of forces, Resolution and composition of forces. **Resultant force:** Definition, Analytical and graphical methods for resultant force in two dimensions, Moments and Couples, Varignon's theorem of moments. **Equilibrium of rigid bodies**: Principles of equilibrium, types of equilibrium, conditions of equilibrium, free body diagrams, Analytical and graphical methods for equilibrium of rigid bodies in two dimensions.

(7 Lectures)

Unit II: **Support reactions**: Types of supports and loading in beams, determination of support reactions in cantilever, simply supported and overhang beams. **Trusses and Frames**: Types of frames, Analysis of simple plane trusses in equilibrium by the method of joints and method of sections. **Friction**: Frictional forces, types, limiting friction, coefficient of friction, angle of friction, laws of friction, Equilibrium of bodies lying on rough horizontal and inclined planes, wedge friction. (8 Lectures)

Unit III: **Centroid and Moment of Inertia:** Centroid of plane standard geometric figures and composite figures, Moment of inertia (second moment of area) of plane standard geometric figures and composite figures, parallel and perpendicular axis theorems, Radius of gyration. **Simple lifting machines**: Types of machines, efficiency of a machine, ideal machine, friction in machines, law of machine, Maximum M.A. and Maximum efficiency of a machine, reversible and non reversible machines, Differential wheel & axle, single and double purchase winch crabs. (8 Lectures)

Unit IV: **Simple stresses and strains** : Types of stresses and strains, modulus of elasticity, modulus of rigidity, bulk modulus, relation between elastic constants, stress-strain diagram for mild steel, lateral strain, Poisson's ratio, volumetric strain, triaxial loading in rectangular sections, stresses in bars of varying and composite sections, Temperature stresses and strains. (7 Lectures)

Unit V: **Stresses in beams**: Theory of simple bending, simple bending equation, bending stress, moment of resistance, assumptions in theory of simple bending, section modulus. **Shear force and bending moment**: Basic concepts, Shear force and bending moment diagrams for cantilever, simply supported and overhang beams for different loading conditions. **Slope and defection of beams**: Basic concepts, slope and deflection of cantilever and simply supported beams under standard loading conditions, Macaulay's method, simple problems. (8 Lectures)

Unit VI: **Torsion**: Theory of pure torsion, torsional moment of resistance, torsion equation, assumptions in the theory of pure torsion, polar modulus, power transmitted by solid and hollow circular shafts. **Columns and struts**: Axially loaded compression members, Euler's and Rankine's formula for buckling of columns, end conditions of column, buckling load, effective length of columns, slenderness ratio. (7 Lectures)

Suggested Text Books:

1. R. S. Khurmi, A Textbook of Engineering Mechanics, S. Chand & Co., New Delhi.
2. S. N. Saluja, A Textbook of Engineering Applied Mechanics, Satya Prakashan.
3. R. S. Khurmi and N. Khurmi, Strength of Materials, S. Chand & Co., New Delhi.
4. B. C. Punmia, Mechanics of Materials, Laxmi Publications (P) Ltd.

Suggested Reference Books:

1. F. L. Singer, Engineering Mechanics, Harper & Row Publishers.
2. S. Timoshenko and D. H. Young, Engineering Mechanics, McGraw Hill Publications.
3. Andrew Pytel and F. L. Singer, Strength of Materials, Harper & Row Publishers.

HASS I Communication Skills CE-HSMC-HS-106 T Total Credits: Audit
Teaching Scheme: Lectures: 2Hour/ Week
Examination Scheme: Theory T (I) : 50 Marks

Unit I: Communication Skills: Introduction to Communication, Types of Communication, Barriers to communication and overcoming them **(03)**

Unit II Listening and Reading Skills: Importance of Listening, Types of listening, Listening barriers and overcoming them, Importance of reading, Sources of Reading, Skimming, Scanning and Gist Reading, Comprehending Passage, Use of Figurative Language
(03)

Unit III: Speaking Skills: Effective Speaking Skills, Components of Public Speaking, Effective Presentation Strategies, Vocabulary Acquisition **(03)**

Unit IV: Group Discussion and Interview Techniques: Importance of Group Discussion, Techniques of Group Discussion, Types of Interviews, Interview Process, Interview Techniques
(03)

Books Recommended:

1. Technical Communication by Meenakshi Raman and Sangeeta Sharma, OUP
2. Public Speaking and Influencing Men in Business by Dale Carnegie
3. Professional Communication Skills by Bhatia and Sheikh
4. Communication Skills by Dr. P. Prasad
5. Communication Skills by Sanjeev Kumar and Pushpalata, OUP

Physics Laboratory CE -BS-107 P Total Credits: 01

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**P (U) : 25 Marks P (I) : 25 Marks**

Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

1. To study the characteristics of a PN-junction diode in forward and reverse bias & determine its cut in voltage, static & dynamic resistance.
2. To study the characteristics of a Zener diode in forward and reverse bias & determine its

breakdown voltage.

3. To determine the Energy gap Eg of semiconductor using PN junction diode in reverse bias mode.
4. To study the V-I characteristics of a Light Emitting Diode
5. To study the V-I characteristics of a Photo Diode
6. To study PN junction diode as Half wave and Full wave rectifier and calculate ripple factor and efficiency in each case
7. To study the input and output characteristics of a transistor in Common base mode & calculate input resistance and current gain α.
8. To study the input and output characteristics of a transistor in Common emitter mode & calculate input resistance and current gain β.
9. Study of Optical Fibre kit.
10. Demonstrations of Lasers.

Chemistry-I Laboratory: CE -BS-108 P **Total Credits: 01**
Teaching Scheme: Practical: 2 Hours / Week
Examination Scheme: Practical P (U): 25 Marks, P (I): 25 Marks
Duration of University Exam: 03 Hours

LIST OF EXPERIMENTS

1. Estimation of Total Hardness by Complexometric Method in a given Sample of water.
2. Estimation of Calcium and Magnesium hardness in a given sample of water.
3. Estimation of Nickel by Complexometric Method in a given Sample of water.
4. Estimation of total alkalinity in the given water sample.
5. Estimation of percentage of Copper in the given solution of copper sulphate by Iodometry Method.
6. Estimation of Strength of Potassium Dichromate using Sodium Thiosulphate by Iodometry Method .
7. Determination of strength of Ferrous Ammonium Sulphate using Potassium Dichromate and SDS as an internal indicator.
8. Estimation of strength of NaOH using oxalic acid.
9. Estimation of strength of HCl using Borax.
10. To determine the number of components in a mixture using TLC.

Fundamentals of Reaction Mechanism Laboratory CE -BS-109 P **Total Credits: 01**
Teaching Scheme **Examination Scheme**
Lectures: 2 Hours/ Week **P (U) : 25 Marks P (I) : 25 Marks**
Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

1. Identification of unknown organic compounds using preliminary investigations such as Phase, Color, odour, solubility in various solvents.

2. Identification of unknown organic compounds on the basis of aromatic and aliphatic as well as saturated and unsaturated nature.

3. To detect the elements (N, S and Cl) present in given unknown organic compounds using sodium extract.

4. Identification of unknown organic compound using Functional group detection and confirmatory tests (Phenols and Napthols)

5. Identification of unknown organic compound using Functional group detection and confirmatory tests (Carbohydrates; aldehydes and ketones)

6. Identification of unknown organic compound using Functional group detection and confirmatory tests (mono carboxylic acids)

7. Identification of unknown organic compound using Functional group detection and confirmatory tests (di- carboxylic acids)

8. Identification of unknown organic compound using Functional group detection and confirmatory tests (Amides)

9. Identification of unknown organic compound using Functional group detection and confirmatory tests (Nitro)

10**.** Detection of Melting points of few organic compounds using melting point apparatus.

List of Books

1. A Laboratory hand bbok of Organic Qualitative analysis and separations By V. S. Kulkarni and S.P. Pathak
2. Vogels textbook of Practical Organic Chemistry

Engineering and Solid Mechanics Laboratory: CE-GES-110P Total Credits: 1.5
Teaching Scheme: Practical: 3Hours/ Week
Examination Scheme: Practical P (U): 25 Marks, P (I): 25 Marks
Duration of University Exam.: 03 Hours

List of Practicals:

Suitable number of experiments from the below list will be performed.

1. Study of forces in the members of Jib crane.
2. Reactions of a beam.
3. Law of Moments.
4. Verification of Polygon law of forces.
5. Inclined friction plane.
6. Forces in single roof truss element.
7. Graphical method of analysis of forces.
8. Differential wheel & axle.
9. Single purchase winch crab.
10. Double purchase winch crab.
11. Study of Universal testing machine.
12. Deflection in beams.

Communication Skills CE-HSMC-HS-111 P Total Credits: 01
Teaching Scheme Practical : 2Hours/ Week
Examination Scheme: P (U): 25marks, P (I): 25 Marks
Duration of University Examination. : 03 Hours

1. Barriers to Communication
2. Non-Verbal Communication
3. Listening Skills
4. Reading Skills
5. Use of Figurative Language
6. Speaking Skills
7. Presentation Skills

8. Development of Word Power
9. Group Discussion
10. Interview Techniques

Science and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Engineering
(Second Semester)

Maths –II: CE-BS-201 T **Total Credits: 03**
Teaching Scheme: Lectures: 3Hours/ Week
Examination Scheme: T (U) : 70 Marks T (I) : 30 Marks
Duration of University Exam. : 03 Hours

Unit I : Ordinary differential Equation and Higher Order Differential Equation : Differential Equations: First order first degree differential equations: Linear, reducible to linear and exact differential equations. Higher order differential equations with constant coefficient, method of variation of parameters. Cauchy's and Legendre's homogeneous differential equations, simultaneous differential equations.

Unit II : Partial Differential Equations: First order Lagrange's Linear Partial Differential Equation, Solution of higher order linear homogeneous Partial Differential Equations and linear non-homogeneous Partial Differential Equations.

Unit III : Application of Partial Differential Equations : Method of separation of variables for Partial Differential Equations, Applications of Partial Differential Equations: (i) One dimensional wave equation, (ii) One dimensional heat conduction equation in Cartesian co-ordinates and polar co-ordinates and (iii) Two dimensional steady state heat conduction equation

Unit IV : Function of Complex Variables : Basic Concepts of Complex numbers, De-Moivre's Theorem, Calculus of Functions of Complex variables : Analytic functions, Cauchy –Riemann conditions in Cartesian co-ordinates and polar co-ordinates, methods for finding conjugate functions,

Unit V: Statistics and Probability : Fitting of straight line y=a+bx, parabola and Exponential curves by method of least squares, Lines of regression and Correlation, Rank correlation.
Random variables: Discrete and Continuous random variables, Probability distribution: Binomial, Poisson, Normal Distribution.

Unit VI : Fourier Series : Fourier series, expansion of function, Even and odd function, Half range fourier series, Change of interval, Harmonic analysis.

References
1. Higher Engineering Mathematics by H. K. Das, Er. Rajnish Verma
2. A text book of Engineering Mathematics by N. P. Bali, Manish Goyal
3. Applied Engineering Mathematics (Vol- I & II) by J. N. Wartikar
4. Higher Engineering Mathematics by B. S. Grewal
5. Text book of Engineering Mathematics by Bali, Iyenger (Laxmi Prakashan)

Properties of Matter CE-BS 202 T **Total Credits: 02**
Teaching Scheme Lectures: 2 Hours/ Week Theory
Examination Scheme T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: VISCOSITY: Streamline flow, Turbulent motion, critical velocity, Viscosity, Coefficient of viscosity, Poiseulle's equation, Stokes's method, Ostwald viscometer, Numericals

Unit 2: SURFACE TENSION: Surface tension, Excess pressure inside a liquid drop and soap bubble, Angle of contact, Searl's Torsion Balance method, Quincke's method, Interfacial surface Tension, Numericals.

Unit 3: Crystal structure and X-rays : Meaning of lattice and basis, Unit cell: primitive and non primitive unit cell; Cubic crystal structure: Body and Face centered cubic structures, SC, BCC and FCC unit cells. Unit cell characteristics: Effective number of atoms per unit cell, atomic radius, nearest neighbour distance, coordination number, atomic packing fraction, void space, density; Crystal planes and Miller indices, Inter-planar distance between adjacent planes, Tetrahedral and octahedral voids, Numericals.
Production of X-Rays: Coolidge tube, Origin of X-rays, Properties of X-rays, Applications of X-Rays, Bragg's law and Bragg's X-ray spectrometer. Numericals.

Unit 4: Interference in thin film: Plane Parallel thin film, wedge shaped thin film, Newtons rings, Applications: Determination of wavelengrh and Refractive index of liquid, test of surface finish. Antireflection coating, Numericals

TEXT BOOKS

1. Brijlal and Subramaniam N., Properties of Matter , Revised Edition, S.Chand and Company,2005.
2. Murugesan R., Properties of Matter and Acoustics, Revised Edition, S.Chand and Company, 2005.
3.Thiruvadigal, J. D, Ponnusamy,S..Sudha.D and Krishnamohan M, "Physics for Technologists", Vibrant Publication, Chennai, 2013.
4. Dattu Joshi. R. "Engineering Physics",Tata McGraw- Hill,New Delhi.
5. Mathur D. S, Elements of Properties of Matter, 3rd Edition, S. Chand and Company.
6. Satyaprakash and Akash Saluja, Oscillations and Waves, Pragati Prakashan, 2002

REFERENCES

1. Landau L. D., Pitaevskii L P, Kosevich A M and Lifshitz E M, "Theory of Elasticity", Revised Edition, Butterworth-Heinemann, 2014
2. Landau L. D., Pitaevskii L P, Kosevich A M and Lifshitz E M, "Fluid Mechanics", Revised Edition, Butterworth-Heinemann, 2014.
3. "Laboratory Experiments in College Physics", C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.

Chemistry-II: CE-BS-203 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week
Examination Scheme: Theory T (U) : 35Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: A] Gaseous state: Gas laws, kinetic theory of gas, collision and gas pressure, derivation of gas laws from kinetic theory, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature. Maxwell's distribution of speeds. Kinetic energy distribution, calculations of average, root mean square and most probable velocities. Principle of equipartition of energy and its application.

B] Collision of gas molecules, Real gases: Collision diameter, collision number and mean free path; frequency of binary collisions; Deviation of gases from ideal behaviour; compressibility factor; Andrew's plots; van der Waals equation and its characteristic features. Existence of critical state. Critical constants in terms of van der Waals constants. Law of corresponding state, compressibility factor, and Joule-Thomson effect, Numericals. **[8L]**

Unit 2: Quantum mechanics: De Broglie equation, experimental verification, Compton effect, Heisenberg's uncertainty principle, Introduction of quantum mechanics, Postulates of quantum mechanics, Derivation of Schrodinger wave equation from postulates of quantum mechanics. wave function, normalized and orthogonal wave function, operators, properties of operators, eigen function and eigen values, (problems on operators, eigen values), numericals.

B] Application of Schrodinger wave equation to simple systems: Particle in a one dimensional box: derivation of energy and normalization and orthogonality of wave function. Graphical representation of Ψ and its square Ψ2. Schrodinger wave equation for 3-dimensional box(without derivation, in terms of r, ⍰ and Φ), degeneracy, Numericals. **[8L]**

Unit 3: A] Rate expressions, order and molecularity of reaction, Integrated rate expression with examples, Factors influencing the reaction rates, Arrhenius equation, Energy of Activation, Half life, Methods for determining the order of chemical reaction, Numericals.
B] Steady state approximation, kinetics of consecutive (chain) reactions, parallel reactions, opposing reactions with examples, Mechanism of chain reactions with examples, general catalytic mechanisms, acid-base catalysis, catalysis by enzymes, Michaelis-Menten Equation, Photochemical reactions of hydrogen and bromine, hydrogen and chlorine and decomposition of HI. **[8L]**

Unit 4: A**] Chemical equilibrium:** Chemical equilibria of homogeneous systems, derivation of expression of equilibrium constants, Relation between Kp, Kc and Kx, Le Chatelier's principle of dynamic equilibrium. Effect of change of concentration, pressure, temperature and catalyst on equilibrium constant, Numericals.
B] Thermodynamics of Equilibrium: Introduction, partial molar properties, Chemical Potential, Gibbs-Duhem equation; fugacity of gases Van't Hoff Reaction isotherm – isochore & isobar, Numericals **[6L]**

Reference Books-

1. F. Daniel,Mathematical preparation for physical Chemistry, Mc. Graw Hill publication.
2. Maron and Pruton, Principles of Physical Chemistry, 4th Ed. Oxford and IBH publication.
3. I.N. Levine, Quantum Chemistry, 5th edition (2000), Pearson Educ., Inc. New Delhi
4. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8 th Ed., Oxford University Press (2006).
5. Ball, D. W., Physical Chemistry, Thomson Press, India (2007).
6. Castellan, G. W., Physical Chemistr,y 4 th Ed. Narosa (2004).
7. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
8. Laidler, K. J. Chemical Kinetics Pearson Education: New Delhi (2004).
9. A A Pearson, R G Frost, Kinetics and Mechanism.
10. House, J. E., Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
11. Lowe, J. P. & Peterson, K., Quantum Chemistry Academic Press (2005).

Text Books-

1. C.N. R. Rao, University General Chemistry. Mc. Millan Publication.
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).

Organic Process Technology : CE-BS-204 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week,
Examination Scheme: Theory T (U): 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Introduction to unit processes, e.g. Nitration, Sulfonation, sigificance of kinetics and thermodynamics, feasibility aspects of chemical process, basic concept of flowsheet, nitration and sulfonation of benzene (**6L**)

Unit 2: (Mechanisms and recent advances (green chemistry, catalysis, etc.) Basic principles of green chemistry, industrial significance. Homogeneous and hetrogeneous catalysis with examples. Alkylation of benzene, transesterification of fatty acid to bio-diesel **(7L)**

Unit 3: Mechanisms and recent advances (green chemistry, catalysis, etc.) of following processes: Hydrogenation and alkylations, e.g. hydrogenation of nitrobenzene, petroleum hydrogenation, alkylation reactions of anilines, etc. and their flow diagrams, Oxidation, e.g. oxidation of xylene etc. (**8L**)

Unit 4: Recent developments in polymerisation (reaction mechanism and catalysis) Technical preparation of biodegradable plastics such as polylactic acid, rayon using waste biomass, zeolite resins and their applications in green detergents. (**5L**)

Books Recommended:

1. Chemical and Catalytic Reaction Engineering by Carberry, J.J. Dover books on chemistry
2. Engineering Chemistry by B.L.Tembe, Kamaluddin and M.S. Krishnan(NPTEL web book)
3. Green Chemistry: Theory and Practice by Paul T. Anastas, J.C. Warner; Oxford University Press
4. Unit Processes in Organic Synthesis- by P. H. Groggins, Wiley Publication
5. Monograph on green chemistry, Green chemistry Task Force Committee, DST
6. Zeolites: Molecular sieves Textbook by D.W.Breck

Thermodynamics-I : CE-GES-205 T **Total Credits: 03**
Teaching Scheme: Lectures: 3 Hours/ Week
Examination Scheme: Theory T (U): 70 Marks T (I) : 30 Marks
Duration of University Exam. : 03 Hours

Unit 1: Introduction- Scope of thermodynamics, Dimensions and Units, Temperature, Pressure, Work, Energy, Heat. Energy conservation & first law of thermodynamics; State functions; Equilibrium; Phase Rule; Reversible process; Constant P,V, T processes; Mass and energy balances for open systems; Ideal gas law, Vander Waals.

(8L)

Unit 2: Heat effects-latent heat, sensible heat, standard heats of formation, reaction and combustion. Statements of the second law; Heat engines, Carnot’s theorem,; Thermodynamic Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the second law; Entropy balance for open systems; Calculation of ideal work, Lost work.

(8L)

Unit 3: Thermodynamic property of fluids, Maxwell relations, 2-phase systems, graphs and tables of thermodynamic properties. Properties of Steam, Use of steam tables, measurement of dryness fraction, entropy of steam, temperature entropy and mollier charts.

(8L)

Unit 4: Application of thermodynamics to flow processes-pumps, compressors and turbines. (8L)

Unit 5: Thermodynamic analysis of steam power plants; Rankine cycle; Internal combustion engine, Otto engine; Diesel engine; Jet engine. (8L)

Unit 6: The Carnot refrigerator; Vapour-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes. (8L)

Suggested Text Books

1. J. M. Smith, H.C. Van Ness and M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 7th edition, McGraw-Hill International Edition, 2005.
2. P. K. Nag, Engineering Thermodynamics, Tata McGraw-Hill Publications.
3. P. L. Ballani, Thermal Engineering, Khanna Publications.
4. M. J. Moran, H. N. Shapiro, D. D. Boettner and M. B. Bailey, Principles of Engineering Thermodynamics, 8th Edition, Willey.
5. Yunus A. Cengel, Michael A. Boles, Thermodynamics and Engineering approach, Tata McGraw-Hill Publications.

Electrical & Electronics Engineering: CE-GES-206 T Total Credits: 03
Teaching Scheme: Lectures: 3Hours/ Week
Examination Scheme: Theory T (U): 70 Marks T (I): 30 Marks
Duration of University Exam. : 03 Hours

Unit 1: **DC Circuits:** Resistor, Inductor ,Capacitor, Diode, Concept of Voltage and Current sources, resistance in series and parallel, Kirchhoff's Laws, Superposition Theorem, Thevenin's theorem, Norton's theorem, Star-Delta transformation, Analysis of simple circuit with DC excitation, Node and Mesh analysis. (8L)

Unit 2: **AC Fundamentals**: Concept of AC current and voltages, difference between AC and DC, Periodic functions, Average & RMS values, Form factor and Peak factor, Steady state behaviour with sinusoidal excitation, Phosor representation, Phase and Phase difference concept. (8L)

Unit 3: **Steady State Analysis of AC circuits:** Consisting of R, L, C, RL, RC and RLC in series and parallel circuits, resonance.
Introduction to three phase AC circuits, star and delta connections, measurement of power in three phase ac circuits. (6L)

Unit 4: **Transformer modelling and analysis:** Introduction, General theory of Transformer, Basic Principles, Construction phasor diagram for transformer under no load, Transformer on load, Balance of MMF on two sides, Phasor diagrams, Equivalent Circuit, Loses in transformer, Normal and All day Efficiency, Regulation, Open- circuits and short-circuits tests. (8L)

Unit 5: Energy in Magnetic field and Principles of electromechanical Energy conversion: Working of Thermal, Hydro and Nuclear power plants. (4L)

Unit 6: Basic Electronics: BJT and its characteristics, CE and small signal model, MOSFET, SCR, Operational amplifier, Introduction to digital circuits. (8L)

Suggested Text Books

1. B.L. Thereja, A Text Book of Electrical Technology, Vol. 1, 2 and 4, S. Chand & Co., New Delhi.

2. D. P. Kothari and I. J. Nagrath, Basic Electrical Engineering, 3rd edition, Tata McGraw Hill, 2010.
3. D. C. Kulshrestha, Basic Electrical Engineering, Tata McGraw Hill, 2009.

Suggested Reference Books

1. L. S. Bobrow, Fundamentals of Electrical Engineering, Oxford University Press, 2011.
2. E. Huges, Electrical and Electronics Technology, 10th edition, PEARSON, 2010.

3. Vincent Del Toro, Electrical Engineering Fundamentals, 2nd edition, Prentice Hall India 1989.

Properties of Matter Laboratory CE-BS 207 P Total Credits: 01
Teaching Scheme Practical: 2 Hours/ Week
Examination Scheme P (U) : 25 Marks P (I) : 25 Marks
Duration of University Exam. : 03 Hours

1. Elementary analytical techniques: Method of linear least squares fit to the experimental data, error estimation, calculations involving idea of significant figures.

2. To determine the coefficient of viscosity of liquid using Stoke's method.

3. Study of Ostwald's viscometer.

4. To determine the coefficient of viscosity of liquid using Poiseulle's method.

5. To determine the surface tension of liquid using Searl's Torsion Balance method

6. To determine the surface tension of liquid using Jaeger's method.

7. To determine the surface tension of liquid using Quincke's method.

8. To determine the Interfacial surface tension between the two immiscible liquids.

9. To determine the radius of curvature of a plano convex lens using Newton's rings method.

10. Interference in thin films: Study of wedge shaped thin film.

Chemistry-II Laboratory: CE-BS-208 P Total Credits: 01
Teaching Scheme : Practical: 2 Hours / Week
Examination Scheme: Practical P (U) : 25 Marks, P (I) : 25 Marks
Duration of University Exam: 03 Hours

LIST OF EXPERIMENTS

1. Calibration of glass wares (Burette, pipette, volumetric flask etc.)

2. To determine the surface tension & Parachor value of liquid using Stalagnometer.
3. To Study the surface tension of liquids & to determine the concentration of given unknown solution using Stalagnometer.
4. To Study the viscosity of liquids & to determine the concentration of given unknown solution using Oswald's Viscometer.
5. To study the kinetics of the reaction between Potassium Persulphate and Potassium Iodide and to determine its energy of activation.
6. To study kinetics of saponification of ethyl acetate.
7. To study the relative strength of acids using method of kinetics.
8. To study the adsorption of acetic acid on charcoal and verify the Langmuir and Freundlich adsorption isotherm
9. To determine heat of ionization of weak acid by thermometric method.
10. To determine the heat of crystallization of $CuSO_4.5H_2O$ by thermometric method.
11. To determine the optical rotation of glucose / fructose /cane sugar by polarimeter.
12. To study the kinetics of inversion of cane sugar by polarimeter.
13. To study the kinetics of iodination of acetone.
14. To determine the molecular weight of a volatile substance by Victor-Mayer's apparatus.

Reference Books-

1. Experiments in general chemistry by C.N.R. Rao and Agrawal East West Press.
2. Experiments in Physical Chemistry by R.C. Das and Behere Tata Mc Graw Hill.
3. Experimental physical Chemistry by F. Daniel and others (International Student Edition)
4. B. Vishwanathan, P.S. Raghavan; Practical Physical Chemistry, Viva Books, 2010.

Organic Process Technology Laboratory CE -BS-209 P **Total Credits: 1.5**

Teaching Scheme	**Examination Scheme**
Lectures: 3 Hours/ Week	**P (U) : 25 Marks P (I) : 25 Marks**
Duration of University Exam. : 03 Hours	

LIST OF EXPERIMENTS

1. To prepare urea formaldehyde resin using bulk technique of polymerisation

2. To prepare phenol formaldehyde resin using solution technique of polymerisation.

3. To prepare Acetanilide from aniline using green route

4. To prepare p-bromo acetanilide from acetanilide.

5. To prepare 2-methoxy napthalene using unit process alkylation

6. To prepare p-nitro acetanilde from acetanilide using nitration

7. To prepare Oxalic acid from canesugar using oxidation process

8. To prepare Aspirin from salicyclic acid

9. Extraction of essential oil from biomass (demonstration)

10. Purification of organic compounds by recrystallisation. (demonstration)

List of Books

1. A Laboratory hand bbok of Organic Qualitative analysis and separations By V. S. Kulkarni and S.P. Pathak

2. Vogels textbook of Practical Organic Chemistry

3. Monograph on green chemistry, Green chemistry Task Force Committee, DST

Electrical & Electronics Engineering Laboratory: CE-GES-210 P Total Credits: 01
Teaching Scheme: Practical: 2 Hours / Week
Examination Scheme: Practical P (U) : 25 Marks, P (I) : 25 Marks
Duration of University Exam: 03 Hours

1. Introduction to Electrical engineering, safety precautions, Familiar with AC & DC measuring devices and its use, voltmeter, ammeter, wattmeter, multimeter, oscilloscope, real life resistors, capacitors and Inductors.
2. DC Circuits- Ohms law, verification of KCL & KVL, Superposition theorem, Thevenin's theorem, Norton theorem.
3. Alternating current fundamentals and single phase AC circuits.
4. Three phase circuits.
5. Magnetic materials and their characteristics.
6. Single phase Transformer.
7. Characteristics of various electronics devices- BJT, UJT, FET, SCR, UJT as relaxation oscillator, etc.
8. Demonstration of various Logic gates.

Engineering Graphics: CE-GES-211 P Total Credits: 1.5
Teaching Scheme: Practical: 3Hours / Week
Examination Scheme: Practical P (U): 25 Marks, P (I): 25 Marks
Duration of University Exam: 03 Hours

1. Introduction to graphic science, dimensioning and sheet layout.
2. Curves used in engineering practice.
3. Projections of Points and straight Lines.
4. Projections of Planes.
5. Projections of Solids.
6. Orthographic projections.
7. Missing views (or interpretation of views).

8. Isometric projections.

Suggested Text Books

1. N. D. Bhatt, V. M. Panchal, Pramod R. Ingle, Engineering Drawing [Plane and Solid Geometry], 53rd edition, Charotar Publishing House Pvt. Ltd., 2014.

2. N.H. Dubey, Engineering Drawing, 15th multicoloured edition, Nandu Printers & Publishers Pvt. Ltd., 2015.

PROPOSED SCHEME OF EXAMINATION FOR B. TECH (Chemical Engineering)
THIRD SEMESTER B. TECH (CHEMICAL ENGINEERING)

Sr. No	Code Theory (T) Practical (P)	Subject	Board	Work Load (Hours)				Credit				Marks				Total Marks
				L	P	T	Total	L	P	T	Total	Theory		Practical		
												College Assessment	University	College Assessment	University	
1	CE-PCC-301T	Material & Energy Balance Computations	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100
2	CE-PCC-302T	Particle & Fluid Particle Processing	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100
3	CE-PCC-303T	Thermodynamics – II	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100
4	CE -GES - 304 T	Material Science	BGE	3	-	0	3	3	0	0	3	30	70	--	--	100
5	CE- BS - 305 T	Maths-3	BGE	3	0	0	3	3	0	0	3	30	70	--	--	100
6	CE -BS - 306 T	Elementary Molecular Approach	BGE	3	-	0	3	3	-	0	3	30	70	--	--	100
7	CE -GES - 307P	Material Science Laboratory	BGE	-	2	0	2	0	1	0	1	--	--	25	25	50
8	CE -BS - 308 P	Elementary Molecular Approach –Laboratory	BGE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50
9	CE -GES - 309 P	Engineering workshop	BGE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50
10	CE-PCC-310P	Particle & Fluid Particle Processing Lab	BCE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50
		Total		**18**	**11**	**03**	**32**	**18**	**5.5**	**3**	**26.5**	**180**	**420**	**100**	**100**	**800**

PROPOSED SCHEME OF EXAMINATION FOR B. TECH (Chemical Engineering)
FOURTH SEMESTER B. TECH (CHEMICAL ENGINEERING)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Work Load (Hours)				Credit				Marks				Total Marks
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	College Assessment	University	College Assessment	University	
1	CE-PCC-401T	Process Technology & Economics	BCE	3	0	0	3	3	0	0	3	30	70	--	--	100
2	CE-PCC-402T	Mass Transfer I	BCE	3	0	0	3	3	0	0	3	30	70	--	--	100
3	CE-PCC-403T	Fluid Mechanics	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100
4	CE-PCC-404T	Numerical Methods in Chemical Engineering	BCE	2	0	0	2	2	0	0	2	15	35	--	--	50
5	CE- BS -405 T	Inorganic Process Technology	BGE	3	0	0	3	3	0	0	3	30	70	--	--	100
6	CE- HSMC-HS -406 T	HASS II Functional English	BGE	2	0	0	2	2	0	0	2	15	35	--	--	50
7	CE-PCC-407P	Fluid Mechanics Lab	BCE	0	2	0	2	0	1	0	1	--	--	25	25	50
8	CE-PCC-408P	Numerical Methods in Chemical Engineering Lab	BCE	0	2	0	2	0	1	0	1	--	--	25	25	50
9	CE- BS -409 P	Inorganic Process Technology Laboratory	BGE	0	3	0	3	0	1.5	0	1.5	--	--	25	25	50
10	MC	Environmental Sciences	BCE	2	0	0	2	0	0	0	Audit	--	--	--	--	--
		Total		**18**	**07**	**01**	**26**	**16**	**3.5**	**01**	**20.5**	**150**	**350**	**75**	**75**	**650**

Scheme of Absorption for Old Pattern to Semester Pattern of Second Year B. Tech. (Chemical Engineering)						
As Per RashtrasantTukadojiMaharaj Nagpur University(Old Pattern)				As Per RashtrasantTukadojiMaharaj Nagpur UniversityCredit Based Semester Pattern Scheme		
Third Semester				Third Semester		
SN	**Sub CodeTheory/ Practical**	**Subject**	**Theory Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory /Practical**
1	**BTCHE 301T**	Strength of Materials	**Theory**		--	
2		--		CE-PCC-301T	Material & Energy Balance Computations	**Theory**
3		--		CE-PCC-302T	Particle & Fluid Particle Processing	**Theory**
4		--		CE-PCC-303T	Thermodynamics – II	**Theory**
5		--		CE -GES -304 T	Material Science	**Theory**
6	**BTCHE 302T**	Plant Utilities	**Theory**		--	
7	**BTCHE 303T**	Engineering Mathematics-III	**Theory**	CE- BS -305 T	Maths-3	**Theory**
8	**BTCHE 304T**	Numerical Methods & Computer Programming	**Theory**		----	
9				CE -GES -307P	Material Science Laboratory	**Practical**
10	**BTCHE 305T**	Applied Physical Chemistry - II	**Theory**	CE -BS -306 T	Elementary Molecular Approach	**Practical**
11		---		CE -GES -309 P	Engineering workshop	**Practical**
12	**BTCHE 306P**	Numerical Methods & Computer Programming	**Practical**		----	
13	**BTCHE 307P**	Applied Physical Chemistry - II	**Practical**	CE-PCC-310P	Elementary Molecular Approach –Laboratory	**Practical**
14		--		CE-PCC-310P	Particle & Fluid Particle Processing Lab	**Practical**
15	**BTCHE 308P**	Machine Drawing	**Practical**		----	

		---		CE -GES -307P	Material Science Laboratory	**Practica**

Scheme of Absorption for Old Pattern to Semester Pattern of Second Year B. Tech. (Chemical Engineering)						
As Per RashtrasantTukadojiMaharaj Nagpur University(Old Pattern)				As Per RashtrasantTukadojiMaharaj Nagpur UniversityCredit Based Semester Pattern Scheme		
Third Semester				Third Semester		
SN	**Sub CodeTheory/ Practical**	**Subject**	**Theory Practical**	**Sub CodeTheory/ Practical**	**Subject**	**Theory /Practical**
1	BTCHE 401T	Process Calculations	Theory	--	--	--
2	--	--	--	CE-PCC-401T	Process Technology & Economics	**Theory**
3	--	--		CE-PCC-402T	Mass Transfer I	**Theory**
4	--	--		CE-PCC-403T	Fluid Mechanics	**Theory**
5	BTCHE 402T	Electronics & Instrumentation	Theory	--	--	
6	BTCHE 403T	Mechanical Operations	Theory	--	--	
7	--	--		CE-PCC-404T	Numerical Methods in Chemical Engineering	**Theory**
8	BTCHE 404T	Inorganic ProcessTechnology	Theory	CE- BS -405 T	Inorganic Process Technology	**Theory**
9	BTCHE 405T	Organic ProcessTechnology	Theory	--	--	
10	--	--	--	CE- HSMC-HS -406 T	HASS II Functional English	**Theory**
11	BTCHE 406P	Electronics and Instrumentation	Practical	--	--	
12		--	--	CE-PCC-407P	Fluid Mechanics Lab	**Practical**
13	BTCHE 407P	Mechanical Operations	Practical	--	--	
14				CE-PCC-408P	Numerical Methods in Chemical Engineering Lab	**Practical**
15	BTCHE 408P	Inorganic ProcessTechnology	Practical	CE- BS -409 P	Inorganic Process Technology Laboratory	**Practical**
16	BTCHE 409P	Organic ProcessTechnology	Practical	--	--	
17		--	--	MC	Environmental Sciences	**Theory**

Science and Technology,

R.T.M. Nagpur University, Nagpur.

Syllabus for B.Tech. Chemical Engineering

(Third Semester)

Material & Energy Balance Computations (Theory)

Subject Code: CE - PCC -301 T(BCE)

Lecture : 3 Hrs **Tutorial: 1 Hr** **No. of Credits: 04**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Objective: This course will prepare students to make analysis of chemical processes through calculations, which need to be performed in the chemical processing operations. The students are introduced to the application of laws and also to formulate and solve material and energy balances in processes with and without chemical reactions.

Course outcomes: After completion of the course, students will be able:

CO1: To understand the basic concept, units, and conversion of chemical process calculations.

CO2: To understand the application of various gas laws, volume changes, humidity and saturation, solubility and crystallization.

CO3: To perform material and energy balances on chemical processes/equipment without and with reactions.

CO4: To do energy balances on chemical processes/equipment without and with reactions.

CO5: To perform energy balances on chemical processes/equipment with chemical reactions and heat and combustion problems

Unit I Basic principles, the concept of gram atom and gram mole, conversion of units from one system to another, concept of excess reactant, conversion and yield, Selectivity and degree of completion of reaction.

Unit II Ideal gases, partial pressure, vapor pressure, application of ideal gas laws, volume changes with changes of composition, dissociating gases, humidity and saturation, solubility and crystallization.

Unit III Material balance without chemical reaction, recycle, purge and bypass calculations, material balance with chemical reaction.

Unit IV Energy balance without chemical reaction, combined material and energy balances.

Unit V Energy balance with chemical reaction, combined material and energy balances, Fuels and combustion, types of fuels, heating values of fuels, theoretical and excess air, heat and combustion problems

Books Recommended :

1. Stoichiometry and Process Calculation by Narayana K.V., Laxmikutty B. , Prentice Hall of India 2006.

2. Basic Principles and Calculations in Chemical Engineering by Himmalblau D.M. & Riggs, J.B.

3.Prentice Hall of India 6 th Edition (2011)

Stoichiometry by Bhatt B.I. , Vora S.M. Tata-McGraw-Hill 4 th Edition 2004

Chemical Process Calculation by Hougen A., Watson, M. John Wiley & Sons, Third Edition 2000

Particle & Fluid Particle Processing

Subject Code : CE - PCC -302T (BCE)

Lecture : 03 Hrs **Tutorial: 01 Hr** **No. of Credits : 04**

University : 70 Marks **College Assessment :30 Marks**

Duration of Examination: 3 Hours

Objective: The course aims at providing an overview of the approaches, methods and techniques of particle and fluid particle processing. The objectives include the understanding of concepts like physical properties and handling of solids and solid-fluid mixtures, separation processes for solid-solid and solid-fluid mixtures, concepts of filtration, sedimentation, agitation and mixing of liquids , and flow through packed and fluidized beds.

Course outcomes: After completion of the course, students will be able to understand:
CO 1: Solid particle characterization & relevance of fluid and particle mechanics and mechanical operations in chemical engineering

CO 2: Crushing and screening principles and equipment's used for them.

CO 3: Handling & transportation of solids and fluid solid systems.

CO 4: Separation of solids from fluids by using sedimentation and basic principles, operation and equipment's used for them.

CO 5: Separation of solid from fluids by using Filtration, flotation and classification and basic principles, operation and equipment's used for them

Unit-I: Relevance of fluid and particle mechanics and mechanical operations in chemical engineering process. Solid particle characterization: particle size, shape and their distribution, relation among shape factors and particle dimensions, specific surface area, measurement of surface area. Flow around immersed bodies, concept of drag, boundary layer separation, skin and form drag, drag correction

Unit –II Solids: size reductions, types of equipment's used in the various stages of reductions, laws of crushing and grinding power requirements. Screening screening equipment's, effectiveness of screens, sieve analysis, particle size distribution, classification of particles, size enlargement, nucleation and growth of particles.

Unit-III Handling of solids: Belt conveyer, screw conveyer, flight conveyer, bucket conveyer, pneumatic conveyer. Capacity and power requirement of conveyer, transport of fluid solid system, terminal settling velocity, hindered settling velocity.

UNIT IV: Separation of solids from fluids: sedimentation free settling, hindered settling, Kynch theory of sedimentation, design of settling tank, sedimentation equipment's Centrifugation principles of a centrifuge. Collidal particles: stabilization, flocculation

UNIT V: Filtration: filtration theory, equipments for filtration, constant rate and constant pressure filtration filter calculation optimum filtration and filter aid, equipments used for filtration. Classification Principle of classification, equipment's for classification, design of cyclone and hydrocyclone, flotation cells and calculation for flotation cell. Application of fluidization.

List of Books :

1. McCabe, W., Smith, J. and Harriott, P. Unit Operations of Chemical Engineering, 6th

edition., McGraw Hill.

2. Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, Fifth

edition 2002.

3. Unit operation by Brown G.G., CBS publication First Edition 1995, reprint 2005

Suggested References Books

1. Rhodes, M. J., Introduction to Particle Technology, 2nd edition, John Wiley, Chichester ;

New York, 2008.

2. Allen, T., Powder Sampling and Particle Size Determination, Elsevier, 2003.

3. Masuda, H., Higashitani, K., Yoshida, H., Powder Technology Handbook, CRC, Taylor and Francis, 2006.

4. Vollath, D. Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2 nd Ed., Wiley, 2013.

Thermodynamics II

Subject Code: CE - PCC -303T (BCE)

Lecture : 3 Hrs **Tutorial: 1 Hr** **No. of Credits: 4**

University Assessment: 70 Marks **College Assessment: 30Marks**

Duration of Examination: 3 Hours

Objective: The objective of this course is to introduce the principles of Chemical Engineering Thermodynamics and illustrate their application to design of chemical process plants. To understand the laws of thermodynamics and their applications in the flow/non-flow processes. To familiarise with the estimation of volumetric and key thermodynamic properties of real fluids and mixtures, solution thermodynamics, phase and chemical reaction equilibria. To understand the applications phase and reaction equilibria which include liquid-liquid equlibria, vapour liquid-liquid equlibria, solid-liquid, and solid-vapour equilibria.

Course outcomes: After completion of the course, students will be able to:

CO 1: Understand and apply the laws and rules of thermodynamics, equilibrium and phase rule.

CO 2: Understand various thermodynamics properties and relationships, and coefficients of species and their properties.

CO 3: Understand Liquid phase properties from VLE, Models for excess Gibbs energy, heat effects and property change on mixing

CO 4: Understand different Equilibria, equilibrium criterion , evaluation of equilibrium constant and equilibrium conversion at different conditions.

CO5: Understand molecular/statistical thermodynamics

Unit I .Review of first and second law of thermodynamics ,Vapor-liquid equilibrium: phase rule, simple models for VLE;VLE by modified Raoult's law; VLE from K-value correlations; Flash calculations.

Unit II :. Solution Thermodynamics: fundamental property relationships, free energy and chemical potential, partial properties, definition of fugacity and fugacity coefficient of pure species and species in solution, the ideal solution and excess properties

Unit III: Liquid phase properties from VLE, Models for excess Gibb's energy, heat effects and property change on mixing. Introduction to UNIFAC and UNIQUAC models

Unit IV: Liquid-Liquid Equilibria; Vapor-Liquid-Liquid Equilibria; Solid-Liquid Equilibria; Solid-Gas Equilibria., Chemical reaction equilibria: equilibrium criterion, equilibrium constant, evaluation of equilibrium constant at different temperatures, equilibrium conversion of single reactions, multireaction equilibria.

Unit V: Introduction to molecular/statistical thermodynamics

Suggested Text Books

1. J.M. Smith, H.C. Van Ness and M.M. Abbott, "Introduction to Chemical Engineering Thermodynamics", 7th edition, McGraw-Hill International Edition,2005.

2. K.V.Narayanan, "Chemical Engineering Thermodynamics", Pentice Hall India 2006

Suggested References Books

1. S.Sandler, "Chemical, Biochemical and Engineering Thermodynamics", 4 th edition,Wiley,India.

2. Y.V.C.Rao, "Chemical Engineering Thermodynamics", University Press, Hyderabad,1997.

Material Science:

Subject Code: CE -GES-304 T (BGE)

Lecture : 03 Hrs **No. of Credits : 03**

University Assessment:70 Marks **College Assessment :30 Marks**

Duration of Examination: 03 Hours

Objectives:

- The objective of the course will be to give the students a basic introduction to the different classes of materials relevant to engineering in general and Chemical Engineering in particular.
- The intent of the course will be to relate the underlying molecular structure of the materials to their physical and chemical properties and their processing and performance characteristics.

Course outcomes: After completion of the course, students will be able to understand:

CO 1: Various bonding between atoms, thermal expansion, elastic modulus and melting point of materials & role of materials selection in design.

CO 2: Miller Indices, packing of atoms, close-packed structure, ionic solids, glass and polymers.

CO 3: Different imperfections, impurities, dislocations, defects, and stacking faults.

CO 4: Different structure and strength of materials, strain behaviour of metals, ceramics and polymers.

CO 5: Amorphous materials, Polymer nano-composite materials and Environmental Degradation.

Unit 1: Introduction to materials, bonding between atoms: metallic bonding, ionic bonding, covalent bonding, Van der Waals bond, thermal expansion, elastic modulus and melting point of materials, Role of materials selection in design, structure-property-processing-performance relationships.

Unit 2: Miller Indices of planes and directions, packing of atoms inside solids, close-packed structures, structure of ceramics, ionic solids, glass and polymers, density of various materials.

Unit 3: Imperfections in solids: vacancies, equilibrium concentration of vacancies, interstitial and substitutional impurities in solids, dislocations, types and characteristics of dislocations, interfacial defects, stacking faults.

Unit 4: Structure of materials and Strength of Materials: Yield strength, tensile strength and ductility of materials: stress strain behaviour of metals, ceramics and polymers, tensile test, plastic deformation, necking, creep behaviour and fatigue.

Unit 5: Amorphous materials, Polymer nano-composite materials, Environmental Degradation: Corrosion and oxidation of materials, prevention, Biomaterials.

Suggested Books

1. V. Raghavan, Materials Science and Engineering: A First Course, 5th Edition Prentice Hall India, 2004.
2. S. Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007.

Suggested Reference Books

1. R. A. L Jones, Soft Condensed Matter, Oxford University Press, 2002.
2. William D. Callister, David G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley Publisher.
3. B. S. Mitchell, An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.

Maths –III:

Subject Code: CE-BS-305 T (BGE)

Lecture: 03 Hrs **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment :30 Marks**

Duration of Examination: 03 Hours

Course objectives

1) To develop the logical understanding of the subject.
2) To acquire mathematical skills such that the students are able to apply mathematical methods and principals in order to solve engineering problems of various fields.
3) To make the students aware about the significance and interrelation between Mathematics and Engineering.

Course Outcomes:

Students will be able to

CO1 Represent the solution of Differential Equations in the form of series.
CO2 Understand Laplace transforms and inverse Laplace transforms of various functions involved in engineering field.
CO3 Apply Laplace transform to solve Ordinary and Partial Differential Equations as well as to evaluate the integral equations & solve hyperbolic, parabolic, elliptical PDEs using various Numerical methods and apply these methods to solve various engineering problems.
CO4 Apply Fourier Transform to Solve Integral Equations.
CO5 Evaluate the integration of function of complex variable. Also, able to transform the function from one plane to another.

Unit I: Series Solution and Special Function

Method of infinite series solution for ordinary D. E. when x = o as a ordinary point & x = a as a regular singular point by Fresenius method,

Special Function: Bessel's equation, Bessel's functions: recurrence relations, orthogonality property, generating function, Legendre's equation, Legendre Polynomials: Rodrigue's formula generating function, recurrence relations, orthogonality property.

Unit II: Laplace Transforms

Important Formulae, Properties of Laplace Transforms, Laplace Transform of Unit Step Function, Impulse Function, Periodic Function, Dirac Delta Function, Bessel Function, Error Function,

Inverse Laplace Transforms: Important Formulae, Properties of Inverse Laplace Transforms, Partial fraction Method, Convolution Theorem,

Unit III: Solution of Differential Equations:

i) By Laplace Transform: Solutions of ordinary differential equations, simultaneous ordinary differential equations, partial differential equations and evaluation of Integrals using Laplace Transform method.

ii)Solution of Partial Differential Equations by Numerical Techniques:

Numerical solution of parabolic, elliptic and hyperbolic Partial Differential Equations using finite difference technique.

Unit IV: Fourier Transform

Definition and Properties (excluding FFT), Fourier Integral Theorem, Relation with Laplace Transform, Applications of Fourier Transform to Solve Integral Equations.

Unit V: Complex Variables: Integration

Integration of function of complex variables, Cauchy's integral theorem and integral formula, Residue theorem and its use for evaluating Integrals of function of complex variables, evaluation real definite integrals by contour integration; conformal transformations and bilinear transformations.

References

1. Higher Engineering Mathematics by H. K. Das, Er. Rajnish Verma

2. A text book of Engineering Mathematics by N. P. Bali, Manish Goyal

3. Higher Engineering Mathematics by B. S. Grewal

Elementary Molecular Approach

Subject Code: CE -BS -306 T (BGE)

Lecture : 03 Hrs **No. of Credits : 03**

University Assessment: 70 Marks **College Assessment :30 Marks**

Duration of Examination: 03Hours

Course Objectives:

The student will be able to acquire knowledge in the concepts of Physical Chemistry for engineering applications. These concepts are required in many situations which are faced by chemical engineers in their professional career and to familiarize the students with different application-oriented topics like solution's thermodynamics, phase eutectic systems, molecular structure of compounds and applications of various spectroscopic techniques.

Course Outcomes: After completion of the course, students will be able:

CO1: To understand solution chemistry and relate it with practical problems.

CO2: To sketch the phase diagram for various solid systems and judge their metallurgical applications.

CO3: To summarize the macromolecules for designing new engineering material.

CO4: To acquire the knowledge on various photo chemical laws and **electronic spectroscopy** and apply it for interpreting the ultraviolet spectra of molecules.

CO5: To understand the basics of nuclear spin resonance spectroscopy and implement this knowledge in structure elucidation of chemical compounds.

Unit 1: Thermodynamics of solutions

A] Raoult's Law, Vapour Pressures of ideal solutions; Activity of ideal solution; chemical potential of ideal solution; Gibb- Duhem- Margules Equation; Free energy, entropy, and enthalpy of mixing

B] Vapour Pressures of real solutions, Vapour Pressure-composition and Boiling Point composition Curves of completely Miscible Binary Solutions; Binary miscible liquids (ideal and non-ideal), azeotropes, lever rule; Nernst distribution law and its Applications, Numericals.

Unit 2: Liquids and Phase equilibria

A] Phase Equilibria: Concept of phases, components and degrees of freedom; derivation of Gibbs Phase Rule for nonreactive and reactive systems; *Clausius-Clapeyron equation*: derivation and its applications to solid liquid, liquid-vapour and solid-vapour equilibria; *Phase diagram for one component systems*: water, CO2 and sulphur. *Two component Eutectic system:* Pb- Ag system, Eutectic system with congruent and incongruent melting point, *Three component systems:* water-chloroform-acetic acid system.

B] Partially miscible liquids: Systems with UCST, LCST and both LCST and UCST-phenol-water, trimethylamine-water, nicotine-water systems. Effect of temperature on CST.

Unit 3: Macromolecules

A] Basic Concepts: Introduction, *Classifications of polymer*: based on origin, structure, mode of synthesis; interparticle forces and thermal response; monomer unit, tacticity and physical properties; degree of polymerization, polydispersity index, *Molecular weights*: Number average, Weight average, Viscosity average molecular weight; *Methods of molecular weight determination*: viscosity, light scattering method, sedimentation velocity method and membrane osmotic pressure method.

B] Polymerization Techniques: *Chain growth/Addition polymerization*: free radical, cationic, anionic; Step growth polymerization; Coordination polymerization; Ziegler-Natta catalyst.

Unit 4: Molecular Absorption spectroscopy

A] Photochemistry: Thermal and photochemical reaction, Electromagnetic radiation, interaction with atoms and molecules, Lambert Beer law (derivation and deviations from it), laws of photochemistry; Quantum yield, determination of quantum yield, Reasons for high and low quantum yield, numerical; Jablonskii diagram, singlet and doublet state, fluorescence and phosphorescence.

B] Electronic spectroscopy: Characteristics of electromagnetic radiation, Various electronic transitions, Effect of solvent on electronic transitions, Ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes and conjugated polyenes. Fieser Woodward rules for conjugated dienes and carbonyl compounds, Ultraviolet spectra of molecules.

Unit 5: ^{1}H NMR SPECTROSCOPY

A] Introduction, Nuclear spin, nuclear magnetic moment, shielding of magnetic nuclei; Chemical shifts, factors influencing chemical shift, Spin-spin splitting; low- and high-resolution spectra, isotopic abundance; Factors influencing coupling constant 'J' – Classification (ABX, AMX, ABC, A2B2etc.), spin decoupling.

B] Mechanism of measurement: Chemical shift values and correlation for protons bonded to carbon: aliphatic, olefinic, aldehydic and aromatic and other nuclei: alcohols, phenols, enols, carboxylic acids, amines and amides; use of NMR in molecular structure diagnostics.

Reference Books-

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8 th Ed., Oxford University Press (2006).
2. Castellan, G. W. Physical Chemistry 4 th Ed. Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
4. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
5. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
6. Laidler, K.J. & Meiser, J.H. 2nd Edition Physical chemistry, CBS publishers, New Delhi (1999).
7. Banwel, Fundamentals of Molecular Spectroscopy, 4th Edition, McGraw Hill Education

Text Books-

1. C.N. R. Rao, University General Chemistry. Mc. Millan Publication.
2. Puri B.H., Sharma L.R. and Pathania M.S.; Principles of Physical Chemistry, Vishal Publishing Co., 42nd Edition.
3. Alka L Gupta, Polymer Chemistry, Pragati Prakashan.

4. V R Gowarikar, N V Viswanathan, J Sreedhar, Polymer Science, New Age International.
5. D.N. Sathyanarayana, Handbook of Molecular Spectroscopy.

Material Science Laboratory:

Subject Code: CE -GES -307 P (BGE)

Lecture : 0 Hrs **Practical Duration :02 Hr** **No. of Credits: 1**

University Assessment: 25 Marks **College Assessment: 25Marks**

Duration of Examination: 3 Hours

List of Experiments

1. To study the crystal structure of a given specimen.
2. To study the imperfection in crystal.
3. To study the microstructure of mild steel with the help of microscope.
4. To study heat treatment processes (annealing & tempering) applied to a given specimen.
5. To study the thermosetting plastics.
6. To study the creep behaviour of a given specimen.
7. To study the thermosetting plastics.
8. Tensile test on mild steel sample using UTM.
9. Fatigue test on the mild steel sample.

Suggested Books

1. V. Raghavan Materials Science and Engineering: A First Course, 5th Edition Prentice Hall India, 2004.
2. 2. S. Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007.

Elementary Molecular Approach Laboratory:

Subject Code: CE -BS-308 P (BGE)

Lecture : 0Hrs **Practical Duration: 03H** **No. of Credits: 1.5**

University Assessment: 25Marks **College Assessment :25 Marks**

Duration of Examination: 03Hours

Course Objectives:

- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to the concepts of Physical Chemistry for engineering applications.

- Students will be able to clearly communicate the results of scientific work in oral, written and electronic formats their professional career.
- Students will be able to explore new areas of research in solution thermodynamics, phase eutectic systems, liquid-liquid extraction, electrochemistry, concept of interfaces and surfaces chemistry, photochemistry and polymers.
- Students will be able to function as a member of an interdisciplinary problem solving team in both chemistry and allied fields of science and technology..

Course Outcomes:

CO1. To acquire practical knowledge on the basic chemistry principles for apply in chemical engineering.

CO2. To acquire training in accurate and precise data collection

CO3. To acquire practical knowledge of the phase diagrams and its application in metallurgy,

CO4. To acquire practical knowledge of analytical techniques like conductometric and spectroscopic techniques and solvent extraction process to deal with practical problems.

LIST OF EXPERIMENTS

1. To study the distribution of succinic acid in H2O- toluene, H2O-ether and comparison of distribution coefficient.
2. To study the $KI_3 \rightarrow KI + I_2$ equilibrium in aqueous solution.
3. To construct the phase diagrams of two components system (phenol- water) and study the effect of 1% NaCl, 1% succinic acid, 0.5% naphthalene on CST in phenol-water systems.
4. To study the phase diagram of ternary system (Toluene-Acetic acid-water; Ethyl acetate-acetic acid, water).
5. To study the mutual solubility of a) Nicotine-water, and b) glycerol-m-toluidine and determine consolute points.
6. To find out the constant of conductivity cell and hence determine the dissociation constant of a weak acid.
7. To determine CST of phenol and water in presence of a) 1% NaCl, b) 0.5% naphthalene and c) 1%succinic acid.
8. To determine the conductometric titration curve in the neutralization of strong /weak acids against a strong/weak bases.
9. To determine the volume percentage of pure ethanol in a given solution of it in Benzene by surface tension measurement.
10. To study the coagulation of ferric hydroxide sol with KCl, K_2SO_4 and $K_3[Fe(CN)_6]$ and find their coagulating value.

11. To determine the wavelength of maximum absorption and to verify the Beer's law for $KMnO_4$ / $K_2Cr_2O_7$ solution.
12. To determine ferrous ions in a given sample spectrophotometrically by O-phenathroline method.
13. To determine the molecular weight of a high polymer (polystyrene) by viscosity measurement.
14. Potentiometric titration of acetic acid against NaOH and to determine the dissociation constant of acid.
15. To study the molecular condition of benzoic acid in Toluene by determining the partition co-efficient between Toluene and water.

Reference books

1. Practical Physical Chemistry 3rd edition A.M.James and F.E. Prichard , Longman publication
2. Experiments in Physical Chemistry R.C. Das and B. Behra, Tata Mc Graw Hill
3. Advanced Practical Physical Chemistry J.B.Yadav, Goel Publishing House
4. Advanced Experimental Chemistry. Vol-I J.N.Gurtu and R Kapoor, S.Chand and Co.
5. B. Vishwanathan, P.S. Raghavan; Practical Physical Chemistry, Viva Books, 2010.

Engineering Workshop:

Subject Code : CE -GES-309 P (BGE)

Lecture	**:**	**0 Hrs**	**Practical Duration:03 Hr**	**No. of Credits:1.5**
University	**:**	**25 Marks**	**College Assessment : 25 Marks**	

Duration of Examination: 03Hours

Objectives:

The idea of this course is to understand the concepts involved in product realization by carrying out manufacturing shop exercises. Hands-on practice with manufacturing shop exercises and assembly leading to realization of a new product in a group. Students will also be introduced to the importance of manufacturing planning.

Course outcomes

Students will realize the importance of:

- Manufacturing planning.
- Computer numerically controlled machines.

List of Experiments

1. Introduction to the course and its objectives; mandatory briefing on shop-floor safety. Introduction to all manufacturing forms and introduction to basic tools (hand tools and power tools).

2. Overview of engineering materials and forms in which they are commonly available as raw materials. Typical component manufacture with materials like wood.

3. Overview of shape realization by manufacturing, measurement of manufactured parts. Associated with: Machine shop exercises- involving sawing, turning and drilling, milling, grinding and joining. Inspection of manufactured component using simple metrology instruments.

4. Overview of computer numerically controlled machines Machine shop exercise using CNC - Part modelling, CNC program generation and cutting part on CNC milling machine.

5. Use of plastics and composites as engineering materials. Practical: Hands-on exercise involving plastics - use of injection moulding, extrusion etc.

Texts/References

1. Elements of Workshop Technology, Vol. I by S. K. Hajra Choudhury, 13th Edition, 2003, Asia Publishing House.

2. Elements of Workshop Technology, Vol. II by S. K. Hajra Choudhury, 13rt Edition, 2003, Asia Publishing House.

3. Workshop Practice by H. S. Bawa, 1st Edition, Tata-McGraw Hill, 2004.

Particle & Fluid Processing Lab

Subject Code : CE - PCC -310P(BCE)

Lecture : 0 Hrs Practical Duration 03 H No. of Credits: 1.5

University Assessment: 25 Marks College Assessment : 25 Marks

Duration of Examination: Hours

Objective: The course aims at performing the experiments and getting hands-on experience on concepts such as, the properties, size-reduction and handling of solids and solid-fluid mixtures, separation processes for solid-solid and solid-fluid mixtures, concepts of filtration, agitation and mixing of liquids, and packed and fluidized beds

CO 1: The student would understand the physical properties, property measurement and handling of solid-solid and solid-fluid mixtures.

CO2 . The student would understand separation processes for solid-solid and solid-fluid mixtures. **CO3**. To understand the processes involved in agitation and mixing of liquids

CO4:. To understand the working and applications of solid-storage and conveying, and flow through packed and fluidized beds

List of Experiments :

1) To study relationship between the Drag coefficient and modified Reynolds number for body falling throughfluid (Cd Vs NRE)

2) To carry out the batch sedimentation test and use results to design the thickener

3) To determine the efficiency of Mineral Jig

4) To establish the filtration equation for the leaf filter system and to evaluate compressibility of cake.

5) To study the power consumption of an agitator with Reynolds and Froude number

6) To verify the laws of crushing and grinding

7) To determine the mean arithmatic diameter, mean surface diameter and mean volume diameter

8) To determine the size distribution in a given sample (Elutriation)

9) To determine the effectiveness of vibrating screen

10) To separate the various size fraction in a mixture on the basis of their settling velocities in a fluid (s ize separation)

11) To determine the efficiency of a cyclone separator.

12) To study separation in cone classifier.

13) To study the operation of hammer mill and determination of efficiency of hammer mill

14) To study working principle of froth flotation cell

15) To study the magnetic separator and to determine the efficiency of magnetic separator.

Science and Technology,

R.T.M. Nagpur University, Nagpur.

Syllabus for B.Tech. Chemical Engineering

(Fourth Semester)

Process Technology & Economics (Theory):

Subject Code: CE-PCC-401T (BCE)

Lecture : 3 Hrs Tutorial: 1 Hr No. of Credits 03

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Objectives: The objective of this course is to introduce students with basic block diagram and simplified process flow diagram for manufacture of various inorganic chemicals, Petrochemicals, Petroleum refining and cracking operations. This course also provide basic understanding for common utilities required for manufacturing process. It also provides understanding for various components of project cost and their estimation.

Course Outcomes: After completion of the course, students will be able:

CO1 :understand about Raw materials, operating conditions, basic block diagram and simplified process flow diagram for manufacturing of inorganic chemicals

CO2 :understand about R Raw materials, operating conditions, basic block diagram and simplified process flow diagram for manufacturing for Petroleum refining and cracking operations, syngas and hydrogen

CO3 : understand about RRaw materials, operating conditions, basic block diagram and simplified process flow diagram for manufacturing of various Petrochemicals

CO4:understand about R Industrially relevant fuels, coal, coal based chemicals and fuels Common utilities

CO 5: get an Idea about Introduction to project, Various components of cost of production and their estimation and analysis of working results project

Unit 1: Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of inorganic chemicals, such as: inorganic acids, chlor-alkali, ammonia, fertilizers, etc.

Unit 2: Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for Petroleum refining and cracking operations, syngas and hydrogen,

Unit 3 Description, raw material and energy sources and consumption, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of Petrochemicals: C1, C2, C3, C4, etc., benzene, toluene, xylene and other petrochemicals from these basic building blocks

Unit 4 Industrially relevant fuels, coal, coal-based chemicals and fuels Common utilities such as electricity, cooling water, steam, hot oil, refrigeration and chilled water

Unit 5: Introduction to project cost and cost of production, Various components of cost of production and their estimation, Various components of project cost and their estimation, Estimation of working capital. Analysis of working results project: Balance sheets, Project financing, concept of interest, time value of money, depreciation. Profitability Analysis of Projects

Suggested Text Books

1. Shreve's Chemical Process Industries, George T. Austin, McGraw-Hill International Editions Series, 1984
2. Dryden's Outlines of Chemical Technology, M. Gopala Rao, Marshall Sittig, East West Press, 1997
3. Chemical Project Economics, Mahajani V. V. and Mokashi S M., MacMillan India Ltd. 2005
4. Plant Design and Economics for Chemical Engineers, Max Peters, Klaus Timmerhaus, Ronald West, McGraw Hill International Edition, 2013
5. Process Equipment Design Vol 1 & 2 , S.D.Dawande Denett Publication Seventh Edition,2015

Suggested References Books

1. Chemical Process Technology, Moulijn, M. and van Dippen, Wiley, 2013

Mass Transfer I (Theory)

Subject Code: CE-PCC-402T (BCE)

Lecture : 3 Hrs **No. of Credits 03**

University Assessment:70 Marks **College Assessment: 30Marks**

Duration of Examination: 3 Hours

Objective: The objective of this course is to understand the principles of diffusion, convective mass transfer, theories of mass transfer, gas absorption and distillation. This basic knowledge will be useful to design various mass transfer equipment's.

Course Outcomes: After completion of the course, students will be able:
CO 1: To understand concept and theories of diffusion.

CO 2: To understand convective mass transfer, interphase mass transfer and theories of mass transfer and their applications.

CO 3: To understand gas absorption in plate and packed column and design; absorption in wetted wall columns, packed tower and spray tower.

CO 4: : To understand absorption in tray towers, tray efficiencies, calculation of number of trays for absorption, Equipments for Absorption

CO5: To understand Batch distillation; continuous binary fractionation Azeotropic distillation multicomponent distillation and Methods of distillation

Unit I : Constitutive laws of diffusion; unsteady state diffusion Introduction to mass transfer, concept of diffusivity, Molecular diffusion in gases, liquids and solids, diffusivities of gases and liquids, types of diffusion, Fick's and Maxwell law of diffusion, Eddy diffusion, Steady state molecular diffusion. Empirical equations used to determine diffusivity through gas and Liquid

Unit II Convective mass transfer, interphase mass transfer and mass transfer coefficients, mass transfer correlations Mass transfer theories/models Effect of chemical reaction on mass transfer Concept of mass transfer coefficients, their relationship, mass transfer under laminar and turbulent flow past solids, boundary layers, mass transfer at fluids surfaces correlation of mass transfer coefficients, J D , HTU, and NTU concepts, theories of mass transfer, interphase mass transfer and overall mass transfer coefficients, application to gas-liquid and liquid-liquid systems.

Unit III Equilibrium stages and transfer units: number and height of transfer units; stage efficiency. Gas absorption plate and packed column design; reactive absorption Mechanism of gas absorption, equilibrium in gas absorption, absorption in wetted wall columns, estimation of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculation of height of packed and spray tower.

Unit IV : Absorption in tray towers, absorption and stripping factors, tray efficiencies, calculation of number of trays for absorption, Equipment for Absorption

Unit V Batch distillation; continuous binary fractionation Azeotropic distillation; use of steam Introduction to multicomponent distillation Vapour – liquid equilibria for ideal and non-ideal systems, positive and negative deviations from ideality, relative volatility. Methods of distillation - differential, flash, low pressure, batch rectification, Continuous rectification for binary system, multistage (tray) towers, Lewis – Sorel, McCabe Thiele Method, Multiple feeds, side streams, tray efficiencies, NTU, HTU, HETP concept and calculations concept of reflux, Underwood-Fenske equation, Partial and total Condensers, reboilers, Ponchon Savarit method

Suggested Text Books

1. Binay K.Dutta, Principles of Mass Transfer and Separation Processes,2nd edition,

Prentice Hall of India,2007

2. R.E.Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, New Delhi, 1983.

3. E.D. Cussler, Diffusion - Mass Transfer in Fluid Systems, Cambridge

4. University Press, Cambridge 1984.

5. S. Foust, Principles of Unit Operations, 2nd Edition, Wiley, New York, 1980.

Suggested References Books

1. C.J. Geankoplis, Transport Processes and Unit Operations, 3rd Edition, Prentice Hall, India, 1993.

Fluid Mechanics:

Subject Code: CE - PCC-403T (BCE)

Lecture : 03Hrs **Tutorial: 01 Hr** **No. of Credits: 04**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 03Hours

Objective: The objective of this course is to understand the fundamentals of fluid flow phenomena. Deriving the mass and momentum balance equations from first principles. To learn about the transportation of fluids and flow measuring devices.

Course Outcomes: After completion of the course, students will be able:

CO1: To understand the basic properties, classification of fluid and fluid statics.

CO2: To understand the fluid energy balance, energy losses and various pipe fitting

CO3: To understand Velocity Distribution, Fluid Friction and Two-phase flow, and flow patterns in two phase flow.

CO4: To understand various flow working principle and expressions for flow rate measuring meters

CO5: To understand Transportation of fluids, Classification of pumps and their properties.

Unit –I

Introduction to fluids: fluid, Properties of fluids, Classification of fluids, Continuum hypothesis, Forces on fluids, Normal and shear stresses, Shearing and flow, characteristics of Newtonian and Non-Newtonian fluids, Shear stress distribution of fluids. Fluid statics: Pascal law, Hydrostatic equilibrium law, Pressure distribution & Manometry, U-tube, Inverted U-tube, Differential and Inclined manometers.

UNIT-II

Bernoulli`s equation, Continuity equation, Frictional loss in pipe, Hydraulic mean diameter, losses due to enlargement and contraction of pipe cross - section. Equivalent length of pipe, Pipe fittings, Gate, Globe, Check and Butterfly valves, Boundary layer development

Unit-III

Velocity Distribution for, Viscous & Turbulent flow through Pipe & Parallel plates. Fluid Friction in pipe: Friction factor, Head loss in pipe flow, Colebrook and White equation, Moody diagram, , Two-phase flow, Flow patterns in two phase flow. The Baker diagram, Erosion in two phase flow

Unit-IV

Flow measurement: Flow rate measurement, Working principle and expressions for flow rate through Pitot tube, Orifice meter, Venturimeter, variable area flow meter, Notch and Weir, Coefficient of discharge.

Unit-V

Transportation of fluids - Classification of pumps, Positive displacement pumps, Reciprocating, Pump, Plunger pump, Diaphragm pump, Metering pump, Rotary gear pump, Rotary lobe Pump, Rotary vane pump, Flexible vane pump, Mono pump, Cetrifugal pump, Volute pump, Volute pump with vortex chamber and diffuser vanes, Cavitation, Priming, Net positive suction head

Suggested Text Books

1. M. White, Fluid Mechanics, 8 th Edition, Tata-McGraw Hill, 2016.

2. V. Gupta and S. K. Gupta, Fundamentals of Fluid Mechanics, 2 nd Edition, New Age

International 2011.

3. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7 th

Edition, McGraw-Hill International Edition 2005.

4. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall of India, 2005.

5. R. W. Fox, P. J. Pritchard and A. T. McDonald, Introduction to Fluid Mechanics, 7 th

Edition, Wiley-India 2010.

6. R. Welty, C. E. Wicks, R. E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat

and

Mass Transfer, 4th Ed.,Wiley (2007).

7. R.P. Vyas, Fluid Mechanics , Second Edition, Dennet & Co. Publication,2008

Suggested References Books

8. R.K. Bansal, Fluid Mechanics and Hydraulic Mechines Laxmi Publication 7th Publication 2017

1. B. R. Munson, D. F. Young, T. H. Okiishi and W. W. Huebsch, 6 th Edition, Wiley-India

2010.

2. R. L. Panton, Incompressible Flow, 3 rd Edition, Wiley-India 2005.

3. R. B. Bird, W. E. Stewart and E. N. Lightfoot, Transport Phenomena, 2 nd Edition, Wiley-

India 2002.

Numerical Methods in Chemical Engineering

Subject Code: CE - PCC -404T (BCE)

Lecture : 02 Hrs **No. of Credits: 02**

University Assessment: 35 Marks **College Assessment :15Marks**

Duration of Examination: 03 Hours

Objective : This course has been designed to develop the understanding the computational methods to solve the problems related to the chemical engineering applications. The students are exposed to learn the basic principles, and logical skills in solving the problems using computational methods.

Course Outcomes: After completion of the course, students will be able:

CO1 : To understand and apply various linear algebraic equations to chemical engineering problems

CO2 : To understand and apply Root finding methods for solution on non-linear algebraic equations to chemical engineering problems

CO 3: To understand and apply Interpolation and Approximation various methods **to chemical engineering problems**

CO4 : To understand and apply various methods of : Numerical integration and numerical differentiation to **chemical engineering problems**

CO5 : To understand and apply various Ordinary Differential Equations **and** Partial

Differential Equations to **chemical engineering problems**

Unit I : Introduction, Approximation and Concept of Error & Error Analysis, Linear Algebraic Equations: Methods like Gauss elimination, LU decomposition and matrix inversion, Gauss-Siedel method, Chemical engineering problems involving solution of linear algebraic equations

Unit II : Root finding methods for solution on non-linear algebraic equations: Bisection, Newton- Raphson and Secant methods, Chemical engineering problems involving solution of non-linear equations

Unit III : Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, spline

interpolation, linear regression, polynomial regression, least square regression

Unit IV : Numerical integration: Trapezoidal rule, Simpson’s rule, integration with unequal segments, quadrature methods, Chemical engineering problems involving numerical differentiation and integration

Unit V : Ordinary Differential Equations: Euler method, Runge-Kutta method, Adaptive Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems involving single,and a system of ODEs . Introduction to Partial Differential Equations: Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method

Suggested Text Books

1. Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.

Suggested References Books

1. S.C. Chapra & R.P. Canale, "Numerical Methods for Engineers with Personal Computer

Applications", McGraw Hill Book Company, 1985.

2. R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.

3. Atkinson, K. E., "An Introduction to Numerical Analysis", John Wiley & Sons, 1978.

4. Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd

Edition, Cambridge University Press, 2007.

Inorganic Process Technology:

Subject Code: CE- BS-405 T(BGE)

Lecture : 03 Hrs **No. of Credits: 03**

University Assessment: 70 Marks College Assessment: 30 Marks

Duration of Examination: 03 Hours

Course Objectives:

Students will be able to understand sources and processes of manufacture of various important inorganic chemicals having industrial applications.

Course Outcomes: The student on completion of course will be able:

CO1 To understand the knowledge of unit operations and apply them in production of industrial gases & acids.

CO2 To understand the concepts, remember & apply the knowledge in the production process of different types of Industrial carbon and pigments.

CO3 To understand the concepts & remember the processes in nuclear industries.

CO4 To understand the manufacturing processes of Electrolytic & electro-thermal products

CO5 To understand the production process of different fertilizers.

Unit I Industrial gases & Acids: Manufacture of CO_2, H_2, N_2 & O_2, Ar, ammonia and C_2H_2 and their industrial applications. Manufacture of nitric acid, sulphuric acid, Phosphoric acid and their industrial applications.

Unit II Industrial Carbon & Inorganic pigments: Manufacture & applications of, Lamp black, Carbon black, Activated carbon, Graphite, Industrial diamond. Manufacture, properties & uses of white pigments- white lead, zinc oxide, titanium dioxide and Lithophone.

Unit III Nuclear industries: Nuclear fission & fusion reactions, Feed materials, extraction of Uranium, uranium enrichment, nuclear reactor, reprocessing of nuclear materials, protection from radioactivity.

Unit IV Chloro-Alkali & Electrolytic and Electrochemical industries: Manufacture of Soda ash by Solvay's & modified Solvay's process, Types of electrolytic cells for Caustic soda & Chlorine manufacture – Nelson, Hookers, Castner Kellner, De-Nora & Membrane cells. Manufacture of potassium chlorate & per- chlorate. Artificial abrasives: Calcium carbide, Silicon carbide.

Unit V Fertilizers: Classification of fertilizers, manufacture & applications of urea, ammonium nitrate, ammonium sulphate, Super phosphates & triple super phosphates, monoammonium and Diammonium phosphate, Potassic, compound & complex fertilizers.

Books Recommended:

1. Industrial Chemistry by B.K.Sharma, Goel Pub. House, Meerut.

2. Dryden, C. E. "Outlines of Chemical Technology" (Edited and Revised by M.Gopal

Rao

and Sittig .M) East West Press. Pvt. Ltd, New Delhi, 3rd Edition (1997).

3. Austin G. T,"Shreve's Chemical Process Industries", 5th ed., McGraw Hill.(1984).

4. G.N.Pandey, "Text book of Chemical Technology", Vol. I, 2nd revised edition, (1994).

5. A Text Book of Engineering Chemistry, by S.S.Dara, S.Chand & Co., New Delhi.

HASS II Functional English:

Subject Code: CE- HSMC-HS-406 T (BGE)

Lecture : 02 Hrs **No. of Credits : 02**

University Assessment: 35 Marks **College Assessment :15 Marks**

Duration of Examination: 02 Hour

Objective: At the end of the semester, students will have enough confidence to face competitive examinations (IELTES/ TOEFL/CAT/ MAT/ XAT/SNAP/GMAT/GATE etc.) to pursue master's degree. They will also acquire language skills required to write their Reviews/Projects/Reports. They will be able to organize their thoughts in English and hence face job interviews more confidently.

Scope: The Curriculum designed is student –cantered and it is guidance for their career.

Course Outcomes: After completing the course, students will:

1. Acquire knowledge of structure of language.
2. Be able to face competitive exams and the interview process and can become employable.
3. Develop business writing skills.
4. Become familiar with technology enabled communication and can develop technical and scientific writing skills.

Unit 1. Functional Grammar:

Common errors, Transformation of Sentences, Phrases, Idioms & Proverbs.

[50 sentences of common errors, 50 examples of Transformation of Sentences, (5 each type), 50 noun/prepositional phrases, 50 idioms/proverbs]

Unit II. English for Competitive Exams & Interview Techniques:

IPA (vowel & consonant phonemes), Word building (English words /phrases derived from other languages), Technical Jargons, Synonyms/Antonyms, Analogies, Give one word for, Types & Techniques of Interview

Assignment: [25 Words for teaching IPA, 25 words/phrases of foreign origin, 25 technical jargons, 25 words for Synonyms/ Antonyms, 25 words for Analogies, 50 examples of give one word for]

Unit III. Formal Correspondence

Business Letters, e-mail etiquettes [Orders, Complaints, Enquiries, Job applications and Resume Writing, Writing Memorandum, Circulars, notices], Analytical comprehension:

[Four fictional & four non-fictional unseen texts]

Unit IV. Technical & Scientific Writing:

Features of Technical Writing, Writing Scientific Projects, Technical Report writing, Writing Manuals, Writing Project Proposals, Writing Research papers.

Assignment: (Any one project/review as assignment)

Reference Books:

1. Effective technical Communication by Barun K. Mitra, Oxford University Press,
2. Technical Communication-Principles and Practice by Meenakshi Raman & Sharma, Oxford University Press, 2011, ISBN-13-978-0-19-806529-
3. The Cambridge Encyclopedia of the English Language by David Crystal, Cambridge University Press
4. Contemporary Business Communication by Scot Ober , Published by Biztantra,
5. BCOM- A South-Asian Perspective by C.Lehman, D. DuFrene & M. Sinha, Cenage Learning Pvt. Ltd.2012
6. Business English, by Dept of English, University of Delhi, Published by Dorling Kindersley (India), Pvt .Ltd.,2009, ISBN 978 81 317 2077 6
7. How to Prepare a Research Proposal: Guidelines for Funding and Dissertations in the Social and Behavioral Sciences by Krathwohl & R David
8. Technical Writing- Process and Product by Sharon J. Gerson & Steven M. Gerson, 3rd edition, Pearson Education Asia, 2000

9. Developing Communication skills by Krishna Mohan & Meera Banerjee

Fluid Mechanics Lab

Subject Code : CE - PCC -407P (BCE)

Lecture : 0 Hrs Practical Duration 02H No. of Credits :1

University Assessment: 25 Marks College Assessment :25 Marks

Duration of Examination: 3 Hours

Objective: The course aims on the properties of fluids and the energy relationships in fluid systems. The fluid mechanics approach to solve typical problems in turbulent flow, calculation of turbulent boundary layers with pressure gradient, transition from laminar to turbulent flow, volumetric and mass flow rates through the Venturi meter and Orifice meter and efficiency of pumps

CO1: The student must be able to approach and solve typical problems in fluid dynamics at the appropriate level.

CO 2. Students will be able to understand the fluid dynamics and also the principles of turbulent flow, calculation of turbulent boundary layers with pressure gradient, transition from laminar to turbulent flow.

CO3. Learn tomeasurevolumetric and mass flow rates through the Venturi meter and Orifice meter and efficiency of pumps.

CO4. Ability to understand and analyze the applications to industrial flows.

List of Experiments

1) To verify Bernoullis equation

2) To calibrate venturimeter and and obtain its coefficient of discharge

3) To calibrate orificemeter and obtain its coefficient of discharge

4) To calibrate Rotameter

5) To calibrate notched weir and and obtain its coefficient of discharge

6) To study friction factor Vs Reynolds number for flow of water in a pipe

7) To study friction factor Vs Reynolds number for flow of air in a pipe

8) To study the relationship between Fanning friction factor Vs Reynolds number for flow of fluid through coils.

9) To obtain equivalent length of pipe for various pipe fittings

10) To study the operating characteristics of centrifugal pump.

11) To study the hydrodynamic characteristics of packed bed

12) To study the hydrodynamic characteristics of a fluidized bed

13) To study two phase flow.

Numerical Methods in Chemical Engineering Lab (Practical)

Subject Code : CE - PCC -408P (BCE)

Lecture : 0 Hrs **Practical Duration :02 Hr** **No. of Credits:1**

University Assessment: 25 Marks **College Assessment: 25 Marks**

Duration of Examination: 03 Hours

List of Experiments

1. Introduction to use of computers for numerical calculations
2. Solution of linear algebraic equations using Gauss elimination, Gauss-Siedel etc.
3. Solution of a non-linear equations using bracketing and Newton-Raphson method
4. Interpolation and Approximation
5. Numerical integration
6. Euler method
7. Runge-Kutta methods for ODEs
8. Solution of system of ODEs using simple methods
9. Solution of simple PDEs

Inorganic Process Technology Laboratory:

Subject Code CE- BS-409 P (BGE)

Lecture : 0 Hrs **Practical Duration:03 Hr** **No. of Credits:1.5**

University Assessment: 25 Marks **College Assessment: 25 Marks**

Duration of Examination: 03 Hours

LIST OF EXPERIMENTS

1. To Prepare the Crystals of Chrome alum.

2. To Prepare Mohr's salt.

3. To estimate the amount of impurities in a given sample of common salt.

4. To purify the given sample of Common salt.

5. To Prepare Cuprous Chloride .

6. To estimate the % available Chlorine in a given sample of Bleaching powder.

7. To Prepare the Crystals of Sodium Thiosulphate.

8. To estimate the amount of ferrous & ferric in pigment Red Oxide.

9. To Prepare the Crystals of Ferrous Sulphate from Kipp's apparatus waste.

10. To estimate Sulphate in a given solution by EDTA method.

Environmental Sciences : MC **Audit Course**

Teaching Scheme: 2 Hours/ Week

Course Objectives:

The student on completion of course will understand the Ecosystem, Environmental issues related with social and human population, Biodiversity and its conversion.

Course Outcomes: The student on completion of course will be able:

CO 1: To understand and apply the Multidisciplinary nature of environmental studies.

CO 2: To understand the importance of Natural Resources and its conservation.

CO 3: To understand the classification of ecosystem and importance of conservation of biodiversity.

CO 4: To understand the sources of pollution, ill effects of pollution and prevention methods of pollution.

Unit 1: Multidisciplinary nature of environmental studies: Definition, scope and importance

Need for public awareness.

Unit 2: Natural Resources: **Renewable and non-renewable resources**:

Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Energy resources: Growing energy needs, renewable and non-renewable, energy sources, use of alternate energy sources. Case studies.

d) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.

Unit 3: Ecosystems; Concept of an ecosystem. Structure and function of an ecosystem. Producers, consumers and decomposers. Energy flow in the ecosystem. Ecological succession. Food chains, food webs and ecological pyramids.

Introduction, types, characteristic features, structure and function of the following ecosystem: -

a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Biodiversity and its conservation: Introduction – Definition: genetic, species and ecosystem diversity. Biogeographical classification of India, Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, National and local levels, India as a mega-diversity nation, Hot-sports of biodiversity. Threats to biodiversity.

Unit 4: Environmental Pollution

Definition • Cause, effects and control measures of: - a. Air pollution b. Water pollution c. Noise pollution d. nuclear hazards. Solid waste Management: Causes, effects and control measures of urban and industrial wastes. • Role of an individual in prevention of pollution. • Pollution case studies.

Project work: Case studies

TEXT BOOKS:

1. Erach Bharucha: "A Text Book of Environmental Studies"

2. M. N. Rao and HVN Rao: " Air Pollution"

3. S.S. Dara: "Environmental Chemistry and Pollution Control"

4. Mahesh Rangarajan: "Environmental Issues in India"

5. D.L. Manjunath: "Environmental Studies".

Science and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Technology
(First Semester)

Maths –I: CT-BS-101T **Total Credits: 02**
Teaching Scheme: Lectures: 2Hours/ Week,
Examination Scheme: T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

UNIT -I : Linear Algebra-I : Matrices, Vectors,Vector Space, Rank of a Matrix, Linear Independence, Inverse of a Matrix, Linear Systems of Equations: Existence, Uniqueness,
Solutions of Linear Systems: Gauss Elimination, Cramer's Rule, Gauss-Jordan Elimination.

UNIT -II : Linear Algebra-II : Linear Algebra: Eigenvalues, Eigen vectors of Matrix, Symmetric, Skew-Symmetric, and Orthogonal Matrices, Cayley Hamilton Theorem, Sylvester Theorem, Diagonalisation.

UNIT -III: Integral Calculus : Beta, Gamma functions, Double integration : Cartesian and polar co-ordinates, Change of order of integration, Change of variables between Cartesian and polar co-ordinates, Area as a double integral, Triple integration, Volume as a triple integral.

UNIT -IV: Vector Calculus : Vectors in 2-Space and 3-Space, Inner Product (Dot Product), Vector Product (Cross Product) Vector and Scalar Functions and Fields, Derivatives Curves. Arc Length. Curvature, Gradient of a Scalar Field, Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field.
Integral Calculus. Integral Theorems, Line Integrals, Path Independence of Line Integrals, Green's Theorem in the Plane, Surfaces for Surface Integrals

References

1. Higher Engineering Mathematics by H. K. Das, Er. Rajnish Verma
2. A text book of Engineering Mathematics by N. P. Bali, Manish Goyal
3. A text book of Engineering Mathematics (Vol- I & II) by Dr. D. T. Deshmukh
4. Higher Engineering Mathematics by B. S. Grewal

Physics CT-BS-102 T **Total Credits: 02**
Teaching Scheme: Lectures: 2Hours/ Week
Examination Scheme: T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Quantum Mechanics: Planck's Hypothesis, Properties of Photons, Compton Effect, Wave – particle duality, De-Broglie Hypothesis, Matter Waves, Davisson-Germer Experiment; Bohr's Quantization condition.
Wave Packet & Wave Equations. Heisenberg's uncertainty principle, Wave function and its probability interpretation, Schrödinger's Time dependent & time independent equations, (No derivations). Solution of Schrödinger's equation for one dimensional infinite potential well.

Unit 2: Basic Semiconductor: Qualitative idea on the formation of electron energy bands in solids, Band-theory based classification of solids into insulators, semiconductors and conductors, Intrinsic semiconductors: Germanium and silicon, Doping and Extrinsic semiconductors.
PN- junction diode; Unbiased, Forward biased & Reverse biased mode, Zener diode: Forward and reverse bias characteristics, Avalanche breakdown, Applications: Half wave rectifier & Full wave rectifier, Transistors: PNP and NPN. Configuration: - CB, CE, Bipolar Transistor action, V-I

characteristics of i) Photodiode, ii) LED.

Unit 3: Lasers: Three quantum processes: Absorption, Spontaneous emission and Stimulated emission. Metastable state, Conditions for light amplification, Pumping schemes: Three level pumping scheme, Four level pumping scheme. Optical resonator, Laser beam characteristics, Ruby laser and He-Ne laser. Numericals.

Unit 4: Optical fibres: Structure, Propagation of light through a cladded fibre, Acceptance angle, acceptance cone, Fractional refractive index change, Numerical aperture, Modes of propagation; Types of Optical fibres: Single mode step index fibre, Multimode step index fibre, Graded Index fibre, V-number. Transmission Losses, Applications: Sensor, Numericals.

Books recommended:
Text Books:

1. Fundamentals of Physics: David Halliday, Robert Resnick and Jerle Walker, John-Wiley India(8e, extended)
2. A text book of Engineering Physics: M. N. Avadhanulu and Kshirsagar S. Chand & Co.
3. Electronic Engineering Materials and Devices: John Allision, (TMH edition, 10th reprint)
4. Concepts of Modern Physics: Baiser (Tata McGraw Hill).
4. Laser: M. N. Avadhanulu, S. Chand & Co.

Reference Books:

University Physics:Young and Freedman(Pearson Education)
Solid State Physics: C. Kittel
Solid State Physics: R.L. Singhal
Quantum Mechanics: Schiff
LASERS: Theory and Applications: Thyagarajan K and Ghatak A.K.

Chemistry-I : CT-BS-103 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week
Examination Scheme: Theory T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit I Co-ordination Chemistry and Chemical bonding: Introduction to co-ordination chemistry, explanation of terms like complex, ligands, co-ordination number, co-ordination sphere. Classification of ligands, chelates & its classification. Werner's coordination theory & its application to Co (III) and Pt (IV) ammine complexes.
Valence Bond Theory and its application to 6-coordinated complexes, Crystal Field theory and Crystal field splitting in Octahedral and tetrahedral complexes, MO theory, Structure, bonding and energy levels of bonding and shapes of many atom molecules like H2, N2, and CO. **(12)**

Unit II Water: Sources, types of impurities and their effects, hardness of water & its estimation, Numerical on EDTA method, treatment of water for domestic & industrial purposes, sedimentation, coagulation, filtration, types of filters, Sterilization- chlorination, break point chlorination, Ozonization. Removal of hardness of water: Lime- soda process, Numerical on lime-soda process, Zeolite process, its advantages and disadvantages, comparison with L-S Process, Numerical based on zeolite process, Ion- exchange process, demineralization process. Boiler troubles:-Carry over- priming & foaming-causes & prevention, sludge & scales, Causes of scale formation and prevention methods, Corrosion & caustic embrittlement causes & prevention. **(12)**

Unit III Cement: Raw materials, constitutional compounds& its properties, Process parameters, Manufacture of Portland cement by wet and dry process, setting and hardening of cement,

Cement additives & admixtures.

Refractories: Definition, requisites of good refractory material, properties of refractory, raw materials, manufacture of refractory products, application in industries. **(10)**

Unit IV Chromatography: Introduction, Classification, General and fundamental concepts of TLC, Column, HPLC, GC, Ion Exchange and their applications. **(06)**

Books Recommended:

1. A Text Book of Engineering Chemistry, by S.S.Dara, S.Chand & Co., New Delhi.
2. A Text Book of Engineering Chemistry, by Jain & Jain, Dhanpat Rai Publishing Co., New Delhi.
3. Industrial Chemistry by B.K.Sharma Goel Pub. House, Meerut.
4. Advanced Inorganic Chemistry, Vol.II, by Satya Prakash, G.D.Tuli, S.K.Basu & R.D.Madan.
5. Text of Engineering Chemistry by Dr. Sunita Rattan, S. K. Kataria and Sons, New Delhi.
6. Analytical Chromatography by Dr. G. R. Chatwal, Himalaya Publication House.
7. Instrumental Methods Of Chemical Analysis By G. R. Chatwal, S. K. Anand, Himalaya Publication House.

Fundamentals of Reaction Mechanism: CT-BS-104 T **Total Credits: 02**
Teaching Scheme: Lectures: 02 Hours/Week
Examination Scheme: Theory T (U): 35 Marks T (I): 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Reactivity of organic molecules: factors influencing acidity, basicity and nucleophilicity of molecules with few examples. Introduction to Stereochemistry: Stereo-descriptors – R, S, E, Z. Enantiomers and Diastereomers. (**6L**)

Unit 2: Strategies for synthesis of organic compounds: Reactive intermediates, Mechanism of Addition, substitution, elimination, condensation, role of solvents. Technical preparation of bio-ethanol using molasses, enzymatic catalysis, commercial significance (**8L**)

Unit 3: **Mechanism and recent advancement (Green chemistry and catalysis etc.):** Basic principles of green chemistry, industrial significance, green catalysts. Technical preparation supported green route, Preparation of adipic acid, Acetanalide with mechanism, photo-halogenation of benzene etc (**6L**)

Unit 4: Nitration: Vant Hoffs factor for suitability of agents, Catalytic effect of sulfuric acid in industrial nitration, Mechanism of aromatic nitration process using Inductive and Mesomeric effect, examples, Equipments for nitration and safety aspects. Technical preparation of nitroglycerine (**6L**)

Books Recommended:

1. Engineering Chemistry – By Baskar, Wiley
2. Engineering Chemistry –I By D. GrourKrishana, Vikas Publishing
3. Green Chemistry: Theory and Practice by Paul T. Anastas, J.C. Warner; Oxford University Press
4. Unit Processes in Organic Synthesis- by P. H. Groggins
5. Reaction and Reagents- By O.P. Agarawal
6. Monograph on green chemistry, Green chemistry Task Force Committee, DST

Electrical & Electronics Engineering: CT-GES-105 T **Total Credits: 03**
Teaching Scheme: Lectures: 3 Hours/ Week
Examination Scheme: Theory T (U): 70 Marks T (I): 30 Marks
Duration of University Exam. : 03 Hours

Unit 1: **DC Circuits:** Resistor, Inductor, Capacitor, Diode, Concept of Voltage and Current sources, resistance in series and parallel, Kirchhoff's Laws, Superposition Theorem, Thevenin's theorem, Norton's theorem, Star-Delta transformation, Analysis of simple circuit with DC excitation, Node and Mesh analysis. (8L)

Unit 2: **AC Fundamentals**: Concept of AC current and voltages, difference between AC and DC, Periodic functions, Average & RMS values, Form factor and Peak factor, Steady state behaviour with sinusoidal excitation, Phosor representation, Phase and Phase difference concept. (8L)

Unit 3: **Steady State Analysis of AC circuits:** Consisting of R, L, C, RL, RC and RLC in series and parallel circuits, resonance.
Introduction to three phase AC circuits, star and delta connections, measurement of power in three phase ac circuits. (6L)

Unit 4: **Transformer modelling and analysis:** Introduction, General theory of Transformer, Basic Principles, Construction phasor diagram for transformer under no load, Transformer on load, Balance of MMF on two sides, Phasor diagrams, Equivalent Circuit, Loses in transformer, Normal and All day Efficiency, Regulation, Open- circuits and short-circuits tests. (8L)

Unit 5: Energy in Magnetic field and Principles of electromechanical Energy conversion: Working of Thermal, Hydro and Nuclear power plants. (4L)

Unit 6: Basic Electronics: BJT and its characteristics, CE and small signal model, MOSFET, SCR, Operational amplifier, Introduction to digital circuits. (8L)

Suggested Text Books

1. B.L. Thereja, A Text Book of Electrical Technology, Vol. 1, 2 and 4, S. Chand & Co., New Delhi.
2. D. P. Kothari and I. J. Nagrath, Basic Electrical Engineering, 3rd edition, Tata McGraw Hill, 2010.
3. D. C. Kulshrestha, Basic Electrical Engineering, Tata McGraw Hill, 2009.

Suggested Reference Books

1. L. S. Bobrow, Fundamentals of Electrical Engineering, Oxford University Press, 2011.
2. E. Huges, Electrical and Electronics Technology, 10th edition, PEARSON, 2010.

3. Vincent Del Toro, Electrical Engineering Fundamentals, 2nd edition, Prentice Hall India 1989.

Physics Laboratory CT -BS-106 P **Total Credits: 01**
Teaching Scheme **Examination Scheme**
Lectures: 2 Hours/ Week **P (U) : 25 Marks P (I) : 25 Marks**
Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

1. To study the characteristics of a PN-junction diode in forward and reverse bias & determine its cut in voltage, static & dynamic resistance.

2. To study the characteristics of a Zener diode in forward and reverse bias & determine its breakdown voltage.
3. To determine the Energy gap Eg of semiconductor using PN junction diode in reverse bias mode.
4. To study the V-I characteristics of a Light Emitting Diode
5. To study the V-I characteristics of a Photo Diode
6. To study PN junction diode as Half wave and Full wave rectifier and calculate ripple factor and efficiency in each case
7. To study the input and output characteristics of a transistor in Common base mode & calculate input resistance and current gain α.
8. To study the input and output characteristics of a transistor in Common emitter mode & calculate input resistance and current gain β.
9. Study of Optical Fibre kit.
10. Demonstrations of Lasers.

Chemistry-I Laboratory: CT -BS-107 P **Total Credits: 01**
Teaching Scheme: Practical: 2 Hours / Week
Examination Scheme: Practical P (U) : 25 Marks, P (I) : 25 Marks
Duration of University Exam: 03 Hours

LIST OF EXPERIMENTS

1. Estimation of Total Hardness by Complexometric Method in a given Sample of water.
2. Estimation of Calcium and Magnesium hardness in a given sample of water.
3. Estimation of Nickel by Complexometric Method in a given Sample of water.
4. Estimation of total alkalinity in the given water sample.
5. Estimation of percentage of Copper in the given solution of copper sulphate by Iodometry Method.
6. Estimation of Strength of Potassium Dichromate using Sodium Thiosulphate by Iodometry Method .
7. Determination of strength of Ferrous Ammonium Sulphate using Potassium Dichromate and SDS as an internal indicator.
8. Estimation of strength of NaOH using oxalic acid.
9. Estimation of strength of HCl using Borax.
10. To determine the number of components in a mixture using TLC.

Fundamentals of Reaction Mechanism Laboratory CT -BS-108 P **Total Credits: 01**

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**P (U) : 25 Marks P (I) : 25 Marks**

Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

1. Identification of unknown organic compounds using preliminary investigations such as Phase, Color, odour, solubility in various solvents.

2. Identification of unknown organic compounds on the basis of aromatic and aliphatic as well as saturated and unsaturated nature.

3. To detect the elements (N, S and Cl) present in given unknown organic compounds using sodium extract.

4. Identification of unknown organic compound using Functional group detection and confirmatory tests (Phenols and Napthols)

5. Identification of unknown organic compound using Functional group detection and confirmatory tests (Carbohydrates; aldehydes and ketones)

6. Identification of unknown organic compound using Functional group detection and confirmatory tests (mono carboxylic acids)

7. Identification of unknown organic compound using Functional group detection and confirmatory tests (di- carboxylic acids)

8. Identification of unknown organic compound using Functional group detection and confirmatory tests (Amides)

9. Identification of unknown organic compound using Functional group detection and confirmatory tests (Nitro)

10**.** Detection of Melting points of few organic compounds using melting point apparatus.

List of Books

1. A Laboratory hand bbok of Organic Qualitative analysis and separations By V. S. Kulkarni and S.P. Pathak
2. Vogels textbook of Practical Organic Chemistry

Electrical & Electronics Engineering Laboratory: CT-GES-109 P   Total Credits: 01
Teaching Scheme: Practical: 2 Hours / Week
Examination Scheme: Practical P (U): 25 Marks P (I): 25 Marks
Duration of University Exam: 03 Hours

About 8 to 12 experiments to illustrate the concepts learnt in Electrical and Electronics Engineering. Suitable number of experiments should be from the following categories:

1. Introduction to Electrical engineering, safety precautions, Familiar with AC & DC measuring devices and its use, voltmeter, ammeter, wattmeter, multimeter, oscilloscope, real life resistors, capacitors and Inductors.
2. DC Circuits- Ohms law, verification of KCL & KVL, Superposition theorem, Thevenin's theorem, Norton theorem.
3. Alternating current fundamentals and single phase AC circuits.
4. Three phase circuits.
5. Magnetic materials and their characteristics.
6. Single phase Transformer.
7. Characteristics of various electronics devices- BJT, UJT, FET, SCR, UJT as relaxation oscillator, etc.
8. Demonstration of various Logic gates.

Engineering Graphics: CT-GES-110 P **Total Credits: 1.5**
Teaching Scheme: Practical: 3Hours / Week
Examination Scheme: Practical P (U) : 25 Marks, P (I) : 25 Marks
Duration of University Exam: 03 Hours

Contents

1. Introduction to graphic science, dimensioning and sheet layout.

2. Curves used in engineering practice.

3. Projections of Points and straight Lines.

4. Projections of Planes.

5. Projections of Solids.

6. Orthographic projections.

7. Missing views (or interpretation of views).

8. Isometric projections.

Suggested Text Books

1. N. D. Bhatt, V. M. Panchal, Pramod R. Ingle, Engineering Drawing [Plane and Solid Geometry], 53rd edition, Charotar Publishing House Pvt. Ltd., 2014.

2. N.H. Dubey, Engineering Drawing, 15th multicoloured edition, Nandu Printers & Publishers Pvt. Ltd., 2015.

Science and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Technology
(Second Semester)

Maths –II: CT-BS-201 T **Total Credits: 03**
Teaching Scheme: Lectures: 3Hours/ Week
Examination Scheme: T (U) : 70 Marks T (I) : 30 Marks
Duration of University Exam. : 03 Hours

Unit I : Ordinary differential Equation and Higher Order Differential Equation : Differential Equations: First order first degree differential equations: Linear, reducible to linear and exact differential equations. Higher order differential equations with constant coefficient, method of variation of parameters. Cauchy's and Legendre's homogeneous differential equations, simultaneous differential equations.

Unit II : Partial Differential Equations: First order Lagrange's Linear Partial Differential Equation, Solution of higher order linear homogeneous Partial Differential Equations and linear non-homogeneous Partial Differential Equations.

Unit III : Application of Partial Differential Equations : Method of separation of variables for Partial Differential Equations, Applications of Partial Differential Equations: (i) One dimensional wave equation, (ii) One dimensional heat conduction equation in Cartesian co-ordinates and polar co-ordinates and (iii) Two dimensional steady state heat conduction equation

Unit IV : Function of Complex Variables : Basic Concepts of Complex numbers, De-Moivre's Theorem, Calculus of Functions of Complex variables : Analytic functions, Cauchy –Riemann conditions in Cartesian co-ordinates and polar co-ordinates, methods for finding conjugate functions,

Unit V: Statistics and Probability : Fitting of straight line y=a+bx, parabola and Exponential curves by method of least squares, Lines of regression and Correlation, Rank correlation.
Random variables: Discrete and Continuous random variables, Probability distribution: Binomial, Poisson, Normal Distribution.

Unit VI : Fourier Series : Fourier series, expansion of function, Even and odd function, Half range fourier series, Change of interval, Harmonic analysis.

References
1. Higher Engineering Mathematics by H. K. Das, Er. Rajnish Verma
2. A text book of Engineering Mathematics by N. P. Bali, Manish Goyal
3. Applied Engineering Mathematics (Vol- I & II) by J. N. Wartikar
4. Higher Engineering Mathematics by B. S. Grewal
5. Text book of Engineering Mathematics by Bali, Iyenger (Laxmi Prakashan)

Properties of Matter CT-BS 202 T **Total Credits: 02**
Teaching Scheme Lectures: 2 Hours/ Week Theory
Examination Scheme T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: VISCOSITY: Streamline flow, Turbulent motion, critical velocity, Viscosity, Coefficient of viscosity, Poiseulle's equation, Stokes's method, Ostwald viscometer, Numericals

Unit 2: SURFACE TENSION: Surface tension, Excess pressure inside a liquid drop and soap bubble, Angle of contact, Searl's Torsion Balance method, Quincke's method, Interfacial surface Tension, Numericals.

Unit 3: Crystal structure and X-rays : Meaning of lattice and basis, Unit cell: primitive and non primitive unit cell; Cubic crystal structure: Body and Face centered cubic structures, SC, BCC and FCC unit cells. Unit cell characteristics: Effective number of atoms per unit cell, atomic radius, nearest neighbour distance, coordination number, atomic packing fraction, void space, density; Crystal planes and Miller indices, Inter-planar distance between adjacent planes, Tetrahedral and octahedral voids, Numericals.
Production of X-Rays: Coolidge tube, Origin of X-rays, Properties of X-rays, Applications of X-Rays, Bragg's law and Bragg's X-ray spectrometer. Numericals.

Unit 4: Interference in thin film: Plane Parallel thin film, wedge shaped thin film, Newtons rings, Applications: Determination of wavelengrh and Refractive index of liquid, test of surface finish. Antireflection coating, Numericals

TEXT BOOKS

1. Brijlal and Subramaniam N., Properties of Matter , Revised Edition, S.Chand and Company,2005.
2. Murugesan R., Properties of Matter and Acoustics, Revised Edition, S.Chand and Company, 2005.
3.Thiruvadigal,..J. D, Ponnusamy,S..Sudha.D and Krishnamohan M, “Physics for Technologists”, Vibrant Publication, Chennai, 2013.
4. Dattu Joshi. R. “Engineering Physics”,Tata McGraw- Hill,New Delhi.
5. Mathur D. S, Elements of Properties of Matter, 3rd Edition, S. Chand and Company.
6. Satyaprakash and Akash Saluja, Oscillations and Waves, Pragati Prakashan, 2002

REFERENCES

1. Landau L. D., Pitaevskii L P, Kosevich A M and Lifshitz E M, “Theory of Elasticity”, Revised Edition, Butterworth-Heinemann, 2014
2. Landau L. D., Pitaevskii L P, Kosevich A M and Lifshitz E M, “Fluid Mechanics”, Revised Edition, Butterworth-Heinemann, 2014.
3. "Laboratory Experiments in College Physics", C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.

Chemistry-II: CT-BS-203 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week
Examination Scheme: Theory T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: A] Gaseous state: Gas laws, kinetic theory of gas, collision and gas pressure, derivation of gas laws from kinetic theory, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature. Maxwell's distribution of speeds. Kinetic energy distribution, calculations of average, root mean square and most probable velocities. Principle of equipartition of energy and its application.

B] Collision of gas molecules, Real gases: Collision diameter, collision number and mean free path; frequency of binary collisions; Deviation of gases from ideal behaviour; compressibility factor; Andrew's plots; van der Waals equation and its characteristic features. Existence of critical state. Critical constants in terms of van der Waals constants. Law of corresponding state, compressibility factor, and Joule-Thomson effect, Numericals. **[8L]**

Unit 2: Quantum mechanics: De Broglie equation, experimental verification, Compton effect, Heisenberg's uncertainty principle, Introduction of quantum mechanics, Postulates of quantum mechanics, Derivation of Schrodinger wave equation from postulates of quantum mechanics. wave function, normalized and orthogonal wave function, operators, properties of operators, eigen function and eigen values, (problems on operators, eigen values), numericals.

B] Application of Schrodinger wave equation to simple systems: Particle in a one dimensional box: derivation of energy and normalization and orthogonality of wave function. Graphical representation of Ψ and its square Ψ2. Schrodinger wave equation for 3-dimensional box(without derivation, in terms of r, and Φ), degeneracy, Numericals**.** **[8L]**

Unit 3: A] Rate expressions, order and molecularity of reaction, Integrated rate expression with examples, Factors influencing the reaction rates, Arrhenius equation, Energy of Activation, Half life, Methods for determining the order of chemical reaction, Numericals.
B] Steady state approximation, kinetics of consecutive (chain) reactions, parallel reactions, opposing reactions with examples, Mechanism of chain reactions with examples, general catalytic mechanisms, acid-base catalysis, catalysis by enzymes, Michaelis-Menten Equation, Photochemical reactions of hydrogen and bromine, hydrogen and chlorine and decomposition of HI. **[8L]**

Unit 4: A**] Chemical equilibrium:** Chemical equilibria of homogeneous systems, derivation of expression of equilibrium constants, Relation between Kp, Kc and Kx, Le Chatelier's principle of dynamic equilibrium. Effect of change of concentration, pressure, temperature and catalyst on equilibrium constant, Numericals.
B] Thermodynamics of Equilibrium: Introduction, partial molar properties, Chemical Potential, Gibbs-Duhem equation; fugacity of gases Van't Hoff Reaction isotherm – isochore & isobar, Numericals **[6L]**

Reference Books-

1. F. Daniel,Mathematical preparation for physical Chemistry, Mc. Graw Hill publication.
2. Maron and Pruton, Principles of Physical Chemistry, 4th Ed. Oxford and IBH publication.
3. I.N. Levine, Quantum Chemistry, 5th edition (2000), Pearson Educ., Inc. New Delhi
4. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8 th Ed., Oxford University Press (2006).
5. Ball, D. W., Physical Chemistry, Thomson Press, India (2007).
6. Castellan, G. W., Physical Chemistr,y 4 th Ed. Narosa (2004).
7. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
8. Laidler, K. J. Chemical Kinetics Pearson Education: New Delhi (2004).
9. A A Pearson, R G Frost, Kinetics and Mechanism
10. House, J. E., Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
11. Lowe, J. P. & Peterson, K., Quantum Chemistry Academic Press (2005).

Text Books-

1. C.N. R. Rao, University General Chemistry. Mc. Millan Publication.
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).

Organic Process Technology : CT-BS-204 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week,
Examination Scheme: Theory T (U): 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Introduction to unit processes, e.g. Nitration, Sulfonation, sigificance of kinetics and thermodynamics, feasibility aspects of chemical process, basic concept of flowsheet, nitration and sulfonation of benzene (**6L**)

Unit 2: (Mechanisms and recent advances (green chemistry, catalysis, etc.) Basic principles of green chemistry, industrial significance. Homogeneous and hetrogeneous catalysis with examples. Alkylation of benzene, transesterification of fatty acid to bio-diesel **(7L)**

Unit 3: Mechanisms and recent advances (green chemistry, catalysis, etc.) of following processes: Hydrogenation and alkylations, e.g. hydrogenation of nitrobenzene, petroleum hydrogenation, alkylation reactions of anilines, etc. and their flowdiagrams, Oxidation, e.g. oxidation of xylenes etc. (**8L**)

Unit 4: Recent developments in polymerisation (reaction mechanism and catalysis) Technical preparation of biodegradable plastics such as polylactic acid, rayon using waste biomass, zeolite resins and their applications in green detergents. (**5L**)

Books Recommended:

1. Chemical and Catalytic Reaction Engineering by Carberry, J.J. Dover books on chemistry
2. Engineering Chemistry by B.L.Tembe, Kamaluddin and M.S. Krishnan(NPTEL web book)
3. Green Chemistry: Theory and Practice by Paul T. Anastas, J.C. Warner; Oxford University Press
4. Unit Processes in Organic Synthesis- by P. H. Groggins, Wiley Publication
5. Monograph on green chemistry, Green chemistry Task Force Committee, DST
6. Zeolites: Molecular sieves Textbook by D.W.Breck

Thermodynamics-I : CT-GES-205 T **Total Credits: 03**
Teaching Scheme: Lectures: 3 Hours/ Week
Examination Scheme: Theory T (U): 70 Marks T (I) : 30 Marks
Duration of University Exam. : 03 Hours

Contents

Unit 1: Introduction- Scope of thermodynamics, Dimensions and Units, Temperature, Pressure, Work, Energy, Heat. Energy conservation & first law of thermodynamics; State functions; Equilibrium; Phase Rule; Reversible process; Constant P,V, T processes; Mass and energy balances for open systems; Ideal gas law, Vander Waals.
(8L)

Unit 2: Heat effects-latent heat, sensible heat, standard heats of formation, reaction and combustion. Statements of the second law; Heat engines, Carnot's theorem,; Thermodynamic

Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the second law; Entropy balance for open systems; Calculation of ideal work, Lost work.
(8L)

Unit 3: Thermodynamic property of fluids, Maxwell relations, 2-phase systems, graphs and tables of thermodynamic properties. Properties of Steam, Use of steam tables, measurement of dryness fraction, entropy of steam, temperature entropy and mollier charts.
(8L)

Unit 4: Application of thermodynamics to flow processes-pumps, compressors and turbines.
(8L)

Unit 5: Thermodynamic analysis of steam power plants; Rankine cycle; Internal combustion engine, Otto engine; Diesel engine; Jet engine. (8L)

Unit 6: The Carnot refrigerator; Vapour-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes. (8L)

Suggested Text Books

1. J. M. Smith, H.C. Van Ness and M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 7th edition, McGraw-Hill International Edition, 2005.
2. P. K. Nag, Engineering Thermodynamics, Tata McGraw-Hill Publications.
3. P. L. Ballani, Thermal Engineering, Khanna Publications.
4. M. J. Moran, H. N. Shapiro, D. D. Boettner and M. B. Bailey, Principles of Engineering Thermodynamics, 8th Edition, Willey.
5. Yunus A. Cengel, Michael A. Boles, Thermodynamics and Engineering approach, Tata McGraw-Hill Publications.

Engineering and Solid Mechanics: CT-GES-206 T **Total Credits: 03**
Teaching Scheme: Lectures: 03Hours/Week
Examination Scheme: Theory T (U): 70 Marks T (I): 30 Marks
Duration of University Exam. : 03 Hours

Unit I: **Force:** Definition, Characteristics of a force, System of forces, Resolution and composition of forces. **Resultant force:** Definition, Analytical and graphical methods for resultant force in two dimensions, Moments and Couples, Varignon's theorem of moments. **Equilibrium of rigid bodies**: Principles of equilibrium, types of equilibrium, conditions of equilibrium, free body diagrams, Analytical and graphical methods for equilibrium of rigid bodies in two dimensions. (7 Lectures)

Unit II: **Support reactions**: Types of supports and loading in beams, determination of support reactions in cantilever, simply supported and overhang beams. **Trusses and Frames**: Types of frames, Analysis of simple plane trusses in equilibrium by the method of joints and method of sections. **Friction**: Frictional forces, types, limiting friction, coefficient of friction, angle of friction, laws of friction, Equilibrium of bodies lying on rough horizontal and inclined planes, wedge friction. (8 Lectures)

Unit III: **Centroid and Moment of Inertia:** Centroid of plane standard geometric figures and composite figures, Moment of inertia (second moment of area) of plane standard geometric figures and composite figures, parallel and perpendicular axis theorems, Radius of gyration. **Simple lifting**

machines: Types of machines, efficiency of a machine, ideal machine, friction in machines, law of machine, Maximum M.A. and Maximum efficiency of a machine, reversible and non reversible machines, Differential wheel & axle, single and double purchase winch crabs. (8 Lectures)

Unit IV: **Simple stresses and strains** : Types of stresses and strains, modulus of elasticity, modulus of rigidity, bulk modulus, relation between elastic constants, stress-strain diagram for mild steel, lateral strain, Poisson's ratio, volumetric strain, triaxial loading in rectangular sections, stresses in bars of varying and composite sections, Temperature stresses and strains. (7 Lectures)

Unit V: **Stresses in beams**: Theory of simple bending, simple bending equation, bending stress, moment of resistance, assumptions in theory of simple bending, section modulus. **Shear force and bending moment**: Basic concepts, Shear force and bending moment diagrams for cantilever, simply supported and overhang beams for different loading conditions. **Slope and defection of beams**: Basic concepts, slope and deflection of cantilever and simply supported beams under standard loading conditions, Macaulay's method, simple problems. (8 Lectures)

Unit VI: **Torsion**: Theory of pure torsion, torsional moment of resistance, torsion equation, assumptions in the theory of pure torsion, polar modulus, power transmitted by solid and hollow circular shafts. **Columns and struts**: Axially loaded compression members, Euler's and Rankine's formula for buckling of columns, end conditions of column, buckling load, effective length of columns, slenderness ratio. (7 Lectures)

Suggested Text Books:

1. R. S. Khurmi, A Textbook of Engineering Mechanics, S. Chand & Co., New Delhi.
2. S. N. Saluja, A Textbook of Engineering Applied Mechanics, Satya Prakashan.
3. R. S. Khurmi and N. Khurmi, Strength of Materials, S. Chand & Co., New Delhi.
4. B. C. Punmia, Mechanics of Materials, Laxmi Publications (P) Ltd.

Suggested Reference Books:

1. F. L. Singer, Engineering Mechanics, Harper & Row Publishers.
2. S. Timoshenko and D. H. Young, Engineering Mechanics, McGraw Hill Publications.
3. Andrew Pytel and F. L. Singer, Strength of Materials, Harper & Row Publishers.

HASS I Communication Skills CT-HSMC-HS-207 T **Total Credits: Audit**
Teaching Scheme: Lectures: 2Hour/ Week
Examination Scheme: Theory T (I): 50 Marks

Unit I: Communication Skills: Introduction to Communication, Types of Communication, Barriers to communication and overcoming them **(03)**

Unit II: Listening and Reading Skills: Importance of Listening, Types of listening, Listening barriers and overcoming them, Importance of reading, Sources of Reading, Skimming, Scanning and Gist Reading, Comprehending Passage, Use of Figurative Language

Unit III: Speaking Skills: Effective Speaking Skills, Components of Public Speaking, Effective Presentation Strategies, Vocabulary Acquisition **(03)**

Unit IV: Group Discussion and Interview Techniques: Importance of Group Discussion, Techniques of Group Discussion, Types of Interviews, Interview Process, Interview Techniques **(03)**

Books Recommended:

1. Technical Communication by Meenakshi Raman and Sangeeta Sharma, OUP
2. Public Speaking and Influencing Men in Business by Dale Carnegie
3. Professional Communication Skills by Bhatia and Sheikh

4. Communication Skills by Dr. P. Prasad
5. Communication Skills by Sanjeev Kumar and Pushpalata, OUP

Properties of Matter Laboratory CT-BS 208 P **Total Credits: 01**
Teaching Scheme Practical: 2 Hours/ Week
Examination Scheme P (U) : 25 Marks P (I) : 25 Marks
Duration of University Exam. : 03 Hours

1. Elementary analytical techniques: Method of linear least squares fit to the experimental data, error estimation, calculations involving idea of significant figures.

2. To determine the coefficient of viscosity of liquid using Stoke's method.

3. Study of Ostwald's viscometer.

4. To determine the coefficient of viscosity of liquid using Poiseulle's method.

5. To determine the surface tension of liquid using Searl's Torsion Balance method

6. To determine the surface tension of liquid using Jaeger's method.

7. To determine the surface tension of liquid using Quincke's method.

8. To determine the Interfacial surface tension between the two immiscible liquids.

9. To determine the radius of curvature of a plano convex lens using Newton's rings method.

10. Interference in thin films: Study of wedge-shaped thin film.

Chemistry-II Laboratory: CT-BS-209 P **Total Credits: 01**
Teaching Scheme: Practical: 2 Hours / Week
Examination Scheme: Practical P (U) : 25 Marks, P (I) : 25 Marks
Duration of University Exam: 03 Hours

LIST OF EXPERIMENTS

1. Calibration of glass wares (Burette, pipette, volumetric flask etc.)
2. To determine the surface tension & Parachor value of liquid using Stalagnometer.
3. To Study the surface tension of liquids & to determine the concentration of given unknown solution using Stalagnometer.

4. To Study the viscosity of liquids & to determine the concentration of given unknown solution using Oswald's Viscometer.

5. To study the kinetics of the reaction between Potassium Persulphate and Potassium Iodide and to determine its energy of activation.
6. To study kinetics of saponification of ethyl acetate.
7. To study the relative strength of acids using method of kinetics.
8. To study the adsorption of acetic acid on charcoal and verify the Langmuir and Freundlich adsorption isotherm
9. To determine heat of ionization of weak acid by thermometric method.
10. To determine the heat of crystallization of $CuSO_4.5H_2O$ by thermometric method.
11. To determine the optical rotation of glucose / fructose /cane sugar by polarimeter.
12. To study the kinetics of inversion of cane sugar by polarimeter.
13. To study the kinetics of iodination of acetone.
14. To determine the molecular weight of a volatile substance by Victor-Mayer's apparatus.

Reference Books-

1. Experiments in general chemistry by C.N.R. Rao and Agrawal East West Press.
2. Experiments in Physical Chemistry by R.C. Das and Behere Tata Mc Graw Hill.
3. Experimental physical Chemistry by F. Daniel and others (International Student Edition)
4. B. Vishwanathan, P.S. Raghavan; Practical Physical Chemistry, Viva Books, 2010.

Organic Process Technology Laboratory CT -BS-210 P **Total Credits: 1.5**
Teaching Scheme **Examination Scheme**
Lectures: 3 Hours/ Week **P (U) : 25 Marks P (I) : 25 Marks**
Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

1. To prepare urea formaldehyde resin using bulk technique of polymerisation
2. To prepare phenol formaldehyde resin using solution technique of polymerisation.
3. To prepare Acetanilide from aniline using green route
4. To prepare p-bromo acetanilide from acetanilide.
5. To prepare 2-methoxy napthalene using unit process alkylation
6. To prepare p-nitro acetanilde from acetanilide using nitration
7. To prepare Oxalic acid from canesugar using oxidation process
8. To prepare Aspirin from salicyclic acid
9. Extraction of essential oil from biomass (demonstration)
10. Purification of organic compounds by recrystallisation.(demonstration)

List of Books

1. A Laboratory hand bbok of Organic Qualitative analysis and separations By V. S. Kulkarni and S.P. Pathak
2. Vogels textbook of Practical Organic Chemistry
3. Monograph on green chemistry, Green chemistry Task Force Committee, DST

Engineering and Solid Mechanics Laboratory: CT-GES-211 P   Total Credits: 1.5
Teaching Scheme: Practical: 3Hours/ Week
Examination Scheme: Practical   P (U): 25 Marks, P (I): 25 Marks
Duration of University Exam.: 03 Hours

LIST OF EXPERIMENTS

1. Study of forces in the members of Jib crane.
2. Reactions of a beam.
3. Law of Moments.
4. Verification of Polygon law of forces.
5. Inclined friction plane.
6. Forces in single roof truss element.
7. Graphical method of analysis of forces.
8. Differential wheel & axle.
9. Single purchase winch crab.
10. Double purchase winch crab.
11. Study of Universal testing machine.
12. Deflection in beams.

HASS I Communication Skills CT-HSMC-HS-212 P   Total Credits: 01
Teaching Scheme Practical   : 2Hours/ Week
Examination Scheme: P (U): 25marks, P (I): 25 Marks
Duration of University Examination. : 03 Hours

1. Barriers to Communication
2. Non-Verbal Communication
3. Listening Skills
4. Reading Skills
5. Use of Figurative Language
6. Speaking Skills
7. Presentation Skills
8. Development of Word Power
9. Group Discussion
10. Interview Techniques

PROPOSED SCHEME OF EXAMINATION FOR B. TECH (Chemical Technology)
THIRD SEMESTER B. TECH (CHEMICAL TECHNOLOGY)

Sr. No	Code Theory (T) Practical (P)	Subject	Board	Work Load (Hours)				Credit				Marks				Total Marks	Min. % of Marks Required for Passing
				L	P	T	Total	L	P	T	Total	Theory		Practical			
												College Assessment	University	College Assessment	University		
1	CT-PCC-301T	Material & Energy Balance Computations	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100	45%
2	CT-PCC-302T	Particle & Fluid Particle Processing	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100	45%
3	CT-PCC-303T	Thermodynamics – II	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100	45%
4	CT-GES-304 T	Material Science	BGE	3	-	0	3	3	0	0	3	30	70	--	--	100	45%
5	CT-BS-305 T	Maths-3	BGE	3	0	0	3	3	0	0	3	30	70	--	--	100	45%
6	CT-BS-306 T	Elementary Molecular Approach	BGE	3	-	0	3	3	-	0	3	30	70	--	--	100	45%
7	CT-GES-307P	Material Science Laboratory	BGE	0	2	0	2	0	1	0	1	-	-	25	25	50	50%
8	CT-BS-308 P	Elementary Molecular Approach – Laboratory	BGE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50	50%
9	CT-PCC-309P	Particle & Fluid Particle Processing Lab	BCE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50	50%
		Total		**18**	**8**	**03**	**29**	**18**	**4**	**3**	**25**	**180**	**420**	**75**	**75**	**750**	

PROPOSED SCHEME OF EXAMINATION FOR B. TECH (Chemical Technology)
FOURTH SEMESTER B. TECH (CHEMICAL TECHNOLOGY)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Work Load (Hours)				Credit				Marks				Total Marks	Min. % of Marks Required for Passing
												Theory		Practical			
				L	P	T	Total	L	P	T	Total	College Assessment	University	College Assessment	University		
1	CT-PCC-401T	Process Technology & Economics	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100	45%
2	CT-CS-402T	*Special Technology I	BCHT	3	0	0	3	3	0	0	3	30	70	--	--	100	45%
3	CT-PCC-403T	Fluid Mechanics	BCE	3	0	1	4	3	0	1	4	30	70	--	--	100	45%
4	CT-PCC-404T	Numerical Methods in Chemical Engineering	BCE	2	0	0	2	2	0	0	2	15	35	--	--	50	45%
5	CT-BS-405 T	Inorganic Process Technology	BGE	3	0	0	3	3	0	0	3	30	70	--	--	100	45%
6	CT-HSMC-HS -406 T	HASS II Functional English	BGE	2	0	0	2	2	0	0	2	15	35	--	--	50	45%
7	CT-PCC-407P	Fluid Mechanics Lab	BCE	0	2	0	2	0	1	0	1	--	--	25	25	50	50%
8	CT-PCC-408P	Numerical Methods in Chemical Engineering Lab	BCE	0	2	0	2	0	1	0	1	--	--	25	25	50	50%
9	CT-BS-409 P	Inorganic Process Technology Laboratory	BGE	0	3	0	3	0	1.5	0	1.5	--	--	25	25	50	50%
10	CT-GES-410 P	Engineering Workshop	BGE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50	50%
11	MC	Environmental Sciences	--	0	0	0	0	0	0	0	Audit	--	--	--	--	--	
		Total		**16**	**10**	**02**	**28**	**16**	**5**	**02**	**23**	**150**	**350**	**100**	**100**	**700**	

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- Food Technology
- Technology of Oils, Fats and Surfactants
- Petroleum Refining and Petrochemical Technology
- Pulp & Paper Technology
- Plastics & Polymer Technology
- Surface Coating Technology

Scheme of Absorption for old Scheme to New Scheme Third Semester B. Tech (Chemical Technology)						
As per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Scheme (CBS)				As per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme (CBCS)		
Sub Code (Board) Theory / Practical	**Subject**	**Theory / Practical**		**Sub Code (Board) Theory / Practical**	**Subject**	**Theory / Practical**
BTCHT 301T (BCHT)	Chemical Process Calculations	Theory		CT-PCC-301T (BCE)	Material & Energy Balance Computations	Theory
--	--	--		CT-PCC-302T (BCE)	Particle & Fluid Particle Processing	Theory
--	--	--		CT-PCC-303T (BCE)	Thermodynamics – II	Theory
BTCHT 302T (BGE)	Organic Process Technology	Theory		--	--	--
--	--	--		CT-GES-304 T (BGE)	Material Science	Theory
BTCHT 303T (BGE)	Engineering Mathematics III	Theory		CT-BS-305 T (BGE)	Maths-3	Theory
--	--	--		CT-BS-306 T (BGE)	Elementary Molecular Approach	Theory
--	--	--		CT-GES-307P (BGE)	Material Science Laboratory	Practical
--	--	--		CT-BS-308 P (BGE)	Elementary Molecular Approach –Laboratory	Practical
				CT-PCC-309P (BCE)	Particle & Fluid Particle Processing Lab	Practical
BTCHT 304T (BGE)	Electronics & Instrumentation	Theory		--	--	--
BTCHT 305T (BCHT)	*Special Technology I	Theory		--	--	--
BTCHT 306P (BGE)	Organic Process Technology	Practical		--	--	--
BTCHT 307P (BGE)	Electronics & Instrumentation	Practical		--	--	--
BTCHT 308P (BCHT)	*Special Technology I	Practical		--	--	--

Scheme of Absorption for old Scheme to New Scheme Fourth Semester B. Tech (Chemical Technology)						
As per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Scheme (CBS)				As per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme (CBCS)		
Sub Code (Board) Theory / Practical	**Subject**	**Theory / Practical**		**Sub Code (Board) Theory / Practical**	**Subject**	**Theory / Practical**
--	--	--		CT-PCC-401T (BCE)	Process Technology & Economics	Theory
BTCHT 305T	Special Technology I	Theory		CT-CS-402T (BCHT)	Special Technology I	Theory
--	--	--		CT-PCC-403T (BCE)	Fluid Mechanics	Theory
BTCHT 401T (BGE)	Strength of Materials	Theory		--	--	--
BTCHT 402T (BGE)	Applied Physical Chemistry II	Theory		--	--	--
BTCHT 403T (BGE)	Numerical Methods & Computer Programming	Theory		CT-PCC-404T (BCE)	Numerical Methods in Chemical Engineering	Theory
BTCHT 404T (BGE)	Inorganic Process Technology	Theory		CT-BS-405 T (BGE)	Inorganic Process Technology	Theory
--	--	--		CT-HSMC-HS -406 T (BGE)	HASS II- Functional English	Theory
BTCHT 405T (BCHT)	*Special Technology II	Theory		--	--	--
				CT-PCC-407P (BCE)	Fluid Mechanics Lab	Practical
BTCHT 406P (BGE)	Numerical Methods & Computer Programming	Practical		CT-PCC-408P (BCE)	Numerical Methods in Chemical Engineering Lab	Practical
BTCHT 407P (BGE)	Inorganic Process Technology	Practical		CT-BS-409 P (BGE)	Inorganic Process Technology	Practical
BTCHT 408P (BGE)	Machine Drawing	Practical		--	--	--
BTCHT 409P (BGE)	Applied Physical Chemistry II	Practical		--	--	--
--	--	--		CT-GES-410 P (BGE)	Engineering Workshop	Practical
--	--	--		MC	Environmental Sciences	Theory

Science and Technology,

R.T.M. Nagpur University, Nagpur.

Syllabus for B.Tech. Chemical Technology

(Third Semester)

Material & Energy Balance Computations (Theory)

Subject Code: CT - PCC -301 T(BCE)

Lecture: 3 Hrs **Tutorial: 1 Hr** **No. of Credits: 04**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Objective: This course will prepare students to make analysis of chemical processes through calculations, which need to be performed in the chemical processing operations. The students are introduced to the application of laws and also to formulate and solve material and energy balances in processes with and without chemical reactions.

Course outcomes: After completion of the course, students will be able:

CO1: To understand the basic concept, units, and conversion of chemical process calculations.

CO2: To understand the application of various gas laws, volume changes, humidity and saturation, solubility and crystallization.

CO3: To perform material and energy balances on chemical processes/equipment without and with reactions.

CO4: To do energy balances on chemical processes/equipment without and with reactions.

CO5: To perform energy balances on chemical processes/equipment with chemical reactions and heat and combustion problems

Unit I Basic principles, the concept of gram atom and gram mole, conversion of units from one system to another, concept of excess reactant, conversion and yield, Selectivity and degree of completion of reaction.

Unit II Ideal gases, partial pressure, vapor pressure, application of ideal gas laws, volume changes with changes of composition, dissociating gases, humidity and saturation, solubility and crystallization.

Unit III Material balance without chemical reaction, recycle, purge and bypass calculations, material balance with chemical reaction.

Unit IV Energy balance without chemical reaction, combined material and energy balances.

Unit V Energy balance with chemical reaction, combined material and energy balances, Fuels and combustion, types of fuels, heating values of fuels, theoretical and excess air, heat and combustion problems.

Books Recommended:

1. Stoichiometry and Process Calculation by Narayana K.V., Laxmikutty B. , Prentice Hall of India 2006.

2. Basic Principles and Calculations in Chemical Engineering by Himmalblau D.M. & Riggs, J.B.

3. Prentice Hall of India 6 th Edition (2011)

4. Stoichiometry by Bhatt B.I. , Vora S.M. Tata-McGraw-Hill 4 th Edition 2004

5. Chemical Process Calculation by Hougen A., Watson, M. John Wiley & Sons, Third Edition 2000

Particle & Fluid Particle Processing

Subject Code: CT - PCC -302T (BCE)

Lecture: 03 Hrs **Tutorial: 01 Hr** **No. of Credits: 04**

University: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Objective: The course aims at providing an overview of the approaches, methods and techniques of particle and fluid particle processing. The objectives include the understanding of concepts like physical properties and handling of solids and solid-fluid mixtures, separation processes for solid-solid and solid-fluid mixtures, concepts of filtration, sedimentation, agitation and mixing of liquids , and flow through packed and fluidized beds.

Course outcomes: After completion of the course, students will be able to understand:

CO 1: Solid particle characterization & relevance of fluid and particle mechanics and mechanical operations in chemical engineering

CO 2: Crushing and screening principles and equipment's used for them.

CO 3: Handling & transportation of solids and fluid solid systems.

CO 4: Separation of solids from fluids by using sedimentation and basic principles, operation and equipment's used for them.

CO 5: Separation of solid from fluids by using Filtration, flotation and classification and basic principles, operation and equipment's used for them

Unit-I: Relevance of fluid and particle mechanics and mechanical operations in chemical engineering process. Solid particle characterization: particle size, shape and their distribution, relation among shape factors and particle dimensions, specific surface area, measurement of surface area. Flow around immersed bodies, concept of drag, boundary layer separation, skin and form drag, drag correction

Unit II: Solids: size reductions, types of equipment's used in the various stages of reductions, laws of crushing and grinding power requirements. Screening screening equipment's, effectiveness of screens, sieve analysis, particle size distribution, classification of particles, size enlargement, nucleation and growth of particles.

Unit III: Handling of solids: Belt conveyer, screw conveyer, flight conveyer, bucket conveyer, pneumatic conveyer. Capacity and power requirement of conveyer, transport of fluid solid system, terminal settling velocity, hindered settling velocity.

UNIT IV: Separation of solids from fluids: sedimentation free settling, hindered settling, Kynch theory of sedimentation, design of settling tank, sedimentation equipment's Centrifugation principles of a centrifuge. Collidal particles: stabilization, flocculation

UNIT V: Filtration: filtration theory, equipments for filtration, constant rate and constant pressure filtration filter calculation optimum filtration and filter aid, equipments used for filtration. Classification Principle of classification, equipment's for classification, design of cyclone and hydrocyclone, flotation cells and calculation for flotation cell. Application of fluidization.

List of Books:

1. McCabe, W., Smith, J. and Harriott, P. Unit Operations of Chemical Engineering, 6th edition., McGraw Hill.

2. Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, Fifth edition 2002.

3. Unit operation by Brown G.G., CBS publication First Edition 1995, reprint 2005

Suggested References Books

1. Rhodes, M. J., Introduction to Particle Technology, 2nd edition, John Wiley, Chichester ; New York, 2008.

2. Allen, T., Powder Sampling and Particle Size Determination, Elsevier, 2003.

3. Masuda, H., Higashitani, K., Yoshida, H., Powder Technology Handbook, CRC, Taylor and Francis, 2006.

4. Vollath, D. Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2 nd Ed., Wiley, 2013.

Thermodynamics II

Subject Code: CT - PCC -303T (BCE)

Lecture: 3 Hrs **Tutorial: 1 Hr** **No. of Credits: 4**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Objective: The objective of this course is to introduce the principles of Chemical Engineering Thermodynamics and illustrate their application to design of chemical process plants. To understand the laws of thermodynamics and their applications in the flow/non-flow processes. To familiarise with the estimation of volumetric and key thermodynamic properties of real fluids and mixtures, solution thermodynamics, phase and chemical reaction equilibria. To understand the applications phase and reaction equilibria which include liquid-liquid equlibria, vapour liquid-liquid equlibria, solid-liquid, and solid-vapour equilibria.

Course outcomes: After completion of the course, students will be able to:

CO 1: Understand and apply the laws and rules of thermodynamics, equilibrium and phase rule.

CO 2: Understand various thermodynamics properties and relationships, and coefficients of species and their properties.

CO 3: Understand Liquid phase properties from VLE, Models for excess Gibbs energy, heat effects and property change on mixing

CO 4: Understand different Equilibria, equilibrium criterion , evaluation of equilibrium constant and equilibrium conversion at different conditions.

CO5: Understand molecular/statistical thermodynamics

Unit I: Review of first and second law of thermodynamics, Vapor-liquid equilibrium: phase rule, simple models for VLE; VLE by modified Raoult’s law; VLE from K-value correlations; Flash calculations.

Unit II: Solution Thermodynamics: fundamental property relationships, free energy and chemical potential, partial properties, definition of fugacity and fugacity coefficient of pure species and species in solution, the ideal solution and excess properties

Unit III: Liquid phase properties from VLE, Models for excess Gibb’s energy, heat effects and property change on mixing. Introduction to UNIFAC and UNIQUAC models

Unit IV: Liquid-Liquid Equilibria; Vapor-Liquid-Liquid Equilibria; Solid-Liquid Equilibria; Solid-Gas Equilibria., Chemical reaction equilibria: equilibrium criterion, equilibrium constant, evaluation of equilibrium constant at different temperatures, equilibrium conversion of single reactions, multireaction equilibria.

Unit V: Introduction to molecular/statistical thermodynamics

Suggested Text Books

1. J.M. Smith, H.C. Van Ness and M.M. Abbott, “Introduction to Chemical Engineering Thermodynamics”, 7th edition, McGraw-Hill International Edition,2005.

2. K.V.Narayanan, "Chemical Engineering Thermodynamics", Pentice Hall India 2006

Suggested References Books

1. S.Sandler, “Chemical, Biochemical and Engineering Thermodynamics”, 4 th edition,Wiley,India.

2. Y.V.C.Rao, “Chemical Engineering Thermodynamics”, University Press, Hyderabad,1997.

Material Science

Subject Code: CT -GES-304 T (BGE)

Lecture: 03 Hrs **No. of Credits: 03**

University Assessment:70 Marks College Assessment :30 Marks

Duration of Examination: 03 Hours

Objectives:

- The objective of the course will be to give the students a basic introduction to the different classes of materials relevant to engineering in general and Chemical Engineering in particular.
- The intent of the course will be to relate the underlying molecular structure of the materials to their physical and chemical properties and their processing and performance characteristics.

Course outcomes:

CO 1: At the end of this course, students will have a fair understanding of hard and soft materials, including polymers and composites, their characterization, properties, and use in engineering applications.

Unit 1: Introduction to materials, bonding between atoms: metallic bonding, ionic bonding, covalent bonding, Van der Waals bond, thermal expansion, elastic modulus and melting point of materials, Role of materials selection in design, structure-property-processing-performance relationships.

Unit 2: Miller Indices of planes and directions, packing of atoms inside solids, close-packed structures, structure of ceramics, ionic solids, glass and polymers, density of various materials.

Unit 3: Imperfections in solids: vacancies, equilibrium concentration of vacancies, interstitial and substitutional impurities in solids, dislocations, types and characteristics of dislocations, interfacial defects, stacking faults.

Unit 4: Structure of materials and Strength of Materials: Yield strength, tensile strength and ductility of materials: stress strain behaviour of metals, ceramics and polymers, tensile test, plastic deformation, necking, creep behaviour and fatigue.

Unit 5: Amorphous materials, Polymer nano-composite materials, Environmental Degradation: Corrosion and oxidation of materials, prevention, Biomaterials.

Suggested Books

1. V. Raghavan, Materials Science and Engineering: A First Course, 5th Edition Prentice Hall India, 2004.

2. S. Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007.

Suggested Reference Books

1. R. A. L Jones, Soft Condensed Matter, Oxford University Press, 2002.
2. William D. Callister, David G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley Publisher.
3. B. S. Mitchell, An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.

Maths –III:

Subject Code: CT-BS-305 T (BGE)

Lecture: 03 Hrs **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment :30 Marks**

Duration of Examination: 03 Hours

Course Outcomes:

Students will be able to

CO1: Represent the solution of Differential Equations in the form of series.

CO2: Understand Laplace transforms and inverse Laplace transforms of various functions involved in engineering field.

CO3: Apply Laplace transform to solve Ordinary and Partial Differential Equations as well as to evaluate the integral equations & solve hyperbolic, parabolic, elliptical PDEs using various Numerical methods and apply these methods to solve various engineering problems.

CO4: Apply Fourier Transform to Solve Integral Equations.

CO5: Evaluate the integration of function of complex variable. Also, able to transform the function from one plane to another.

Unit I: Series Solution and Special Function

Method of infinite series solution for ordinary D. E. when x = o as a ordinary point & x = a as a regular singular point by Fresenius method,

Special Function: Bessel's equation, Bessel’s functions: recurrence relations, orthogonality property, generating function, Legendre's equation, Legendre Polynomials: Rodrigue's formula generating function, recurrence relations, orthogonality property.

Unit II: Laplace Transforms

Important Formulae, Properties of Laplace Transforms, Laplace Transform of Unit Step Function, Impulse Function, Periodic Function, Dirac Delta Function, Bessel Function, Error Function,

Inverse Laplace Transforms: Important Formulae, Properties of Inverse Laplace Transforms, Partial fraction Method, Convolution Theorem,

Unit III: Solution of Differential Equations:

i) By Laplace Transform: Solutions of ordinary differential equations, simultaneous ordinary differential equations, partial differential equations and evaluation of Integrals using Laplace Transform method.

ii)Solution of Partial Differential Equations by Numerical Techniques:

Numerical solution of parabolic, elliptic and hyperbolic Partial Differential Equations using finite difference technique.

Unit IV: Fourier Transform

Definition and Properties (excluding FFT), Fourier Integral Theorem, Relation with Laplace Transform, Applications of Fourier Transform to Solve Integral Equations.

Unit V: Complex Variables: Integration

Integration of function of complex variables, Cauchy's integral theorem and integral formula, Residue theorem and its use for evaluating Integrals of function of complex variables, evaluation real definite integrals by contour integration; conformal transformations and bilinear transformations.

References

1. Higher Engineering Mathematics by H. K. Das, Er. Rajnish Verma

2. A text book of Engineering Mathematics by N. P. Bali, Manish Goyal

3. Higher Engineering Mathematics by B. S. Grewal

Elementary Molecular Approach

Subject Code: CT -BS -306 T (BGE)

Lecture: 03 Hrs **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment :30 Marks**

Duration of Examination: 03 Hours

Unit 1: Thermodynamics of solutions

A] Raoult's Law, Vapour Pressures of ideal solutions; Activity of ideal solution; chemical potential of ideal solution; Gibb- Duhem- Margules Equation; Free energy, entropy, and enthalpy of mixing

B] Vapour Pressures of real solutions, Vapour Pressure-composition and Boiling Point composition Curves of completely Miscible Binary Solutions; Binary miscible liquids (ideal and non-ideal), azeotropes, lever rule; Nernst distribution law and its Applications, Numericals.

Unit 2: Liquids and Phase equilibria

A] Phase Equilibria: Concept of phases, components and degrees of freedom; derivation of Gibbs Phase Rule for nonreactive and reactive systems; *Clausius-Clapeyron equation*: derivation and its applications to solid liquid, liquid-vapour and solid-vapour equilibria; *Phase diagram for one component systems*: water, CO2 and sulphur. *Two component Eutectic system:* Pb- Ag system, Eutectic system with congruent and incongruent melting point, *Three component systems:* water-chloroform-acetic acid system.

B] Partially miscible liquids: Systems with UCST, LCST and both LCST and UCST-phenol-water, trimethylamine-water, nicotine-water systems. Effect of temperature on CST.

Unit 3: Macromolecules

A] Basic Concepts: Introduction, *Classifications of polymer*: based on origin, structure, mode of synthesis; interparticle forces and thermal response; monomer unit, tacticity and physical properties; degree of polymerization, polydispersity index, *Molecular weights*: Number average, Weight average, Viscosity average molecular weight; *Methods of molecular weight determination*: viscosity, light scattering method, sedimentation velocity method and membrane osmotic pressure method.

B] Polymerization Techniques: *Chain growth/Addition polymerization*: free radical, cationic, anionic; Step growth polymerization; Coordination polymerization; Ziegler-Natta catalyst.

Unit 4: Molecular Absorption spectroscopy

A] Photochemistry: Thermal and photochemical reaction, Electromagnetic radiation, interaction with atoms and molecules, Lambert Beer law (derivation and deviations from it), laws of photochemistry; Quantum yield, determination of quantum yield, Reasons for high and low quantum yield, numerical; Jablonskii diagram, singlet and doublet state, fluorescence and phosphorescence.

B] Electronic spectroscopy: Characteristics of electromagnetic radiation, Various electronic transitions, Effect of solvent on electronic transitions, Ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes and conjugated polyenes. Fieser Woodward rules for conjugated dienes and carbonyl compounds, Ultraviolet spectra of molecules.

Unit 5: ^{1}H NMR SPECTROSCOPY

A] Introduction, Nuclear spin, nuclear magnetic moment, shielding of magnetic nuclei; Chemical shifts, factors influencing chemical shift, Spin-spin splitting; low- and high-resolution spectra, isotopic abundance; Factors influencing coupling constant 'J' – Classification (ABX, AMX, ABC, A2B2etc.), spin decoupling.

B] Mechanism of measurement: Chemical shift values and correlation for protons bonded to carbon: aliphatic, olefinic, aldehydic and aromatic and other nuclei: alcohols, phenols, enols, carboxylic acids, amines and amides; use of NMR in molecular structure diagnostics.

Reference Books-

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8 th Ed., Oxford University Press (2006).
2. Castellan, G. W. Physical Chemistry 4 th Ed. Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
4. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
5. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
6. Laidler, K.J. & Meiser, J.H. 2nd Edition Physical chemistry, CBS publishers, New Delhi (1999).
7. Banwel, Fundamentals of Molecular Spectroscopy, 4th Edition, McGraw Hill Education

Text Books-

1. C.N. R. Rao, University General Chemistry. Mc. Millan Publication.
2. Puri B.H., Sharma L.R. and Pathania M.S.; Principles of Physical Chemistry, Vishal Publishing Co., 42nd Edition.
3. Alka L Gupta, Polymer Chemistry, Pragati Prakashan.
4. V R Gowarikar, N V Viswanathan, J Sreedhar, Polymer Science, New Age International.
5. D.N. Sathyanarayana, Handbook of Molecular Spectroscopy.

Material Science Laboratory

Subject Code: CT -GES -307 P (BGE)

Lecture: 0 Hrs **Practical Duration: 02 Hr** **No. of Credits: 01**

University Assessment: 25 Marks **College Assessment: 25Marks**

Duration of Examination: 3 Hours

List of Experiments

1. To study the crystal structure of a given specimen.
2. To study the imperfection in crystal.
3. To study the microstructure of mild steel with the help of microscope.
4. To study heat treatment processes (annealing & tempering) applied to a given specimen.
5. To study the thermosetting plastics.
6. To study the creep behaviour of a given specimen.
7. To study the thermosetting plastics.
8. Tensile test on mild steel sample using UTM.
9. Fatigue test on the mild steel sample.

Suggested Books

1. V. Raghavan Materials Science and Engineering: A First Course, 5th Edition Prentice Hall India, 2004.
2. 2. S. Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007.

Elementary Molecular Approach Laboratory

Subject Code: CT -BS-308 P (BGE)

Lecture: 0 Hrs **Practical Duration: 03 Hrs** **No. of Credits: 1.5**

University Assessment: 25Marks **College Assessment :25 Marks**

Duration of Examination: 03Hours

- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to the concepts of Physical Chemistry for engineering applications.
- Students will be able to clearly communicate the results of scientific work in oral, written and electronic formats their professional career.
- Students will be able to explore new areas of research in solution thermodynamics, phase eutectic systems, liquid-liquid extraction, electrochemistry, concept of interfaces and surfaces chemistry, photochemistry and polymers.
- Students will be able to function as a member of an interdisciplinary problem solving team in both chemistry and allied fields of science and technology.

Course Outcomes:

CO1. To acquire practical knowledge on the basic chemistry principles for apply in chemical engineering.

CO2. To acquire training in accurate and precise data collection

CO3. To acquire practical knowledge of the phase diagrams and its application in metallurgy,

CO4. To acquire practical knowledge of analytical techniques like conductometric and spectroscopic techniques and solvent extraction process to deal with practical problems.

LIST OF EXPERIMENTS

1. To study the distribution of succinic acid in H_2O- toluene, H_2O-ether and comparison of distribution coefficient.
2. To study the $KI_3 \rightarrow KI + I_2$ equilibrium in aqueous solution.
3. To construct the phase diagrams of two components system (phenol- water) and study the effect of 1% NaCl, 1% succinic acid, 0.5% naphthalene on CST in phenol-water systems.
4. To study the phase diagram of ternary system (Toluene-Acetic acid-water; Ethyl acetate-acetic acid, water).
5. To study the mutual solubility of a) Nicotine-water, and b) glycerol-m-toluidine and determine consolute points.
6. To find out the constant of conductivity cell and hence determine the dissociation constant of a weak acid.

7. To determine CST of phenol and water in presence of a) 1% NaCl, b) 0.5% naphthalene and c) 1%succinic acid.
8. To determine the conductometric titration curve in the neutralization of strong /weak acids against a strong/weak bases.
9. To determine the volume percentage of pure ethanol in a given solution of it in Benzene by surface tension measurement.
10. To study the coagulation of ferric hydroxide sol with KCl, K_2SO_4 and $K_3[Fe(CN)_6]$ and find their coagulating value.
11. To determine the wavelength of maximum absorption and to verify the Beer's law for $KMnO_4$ / $K_2Cr_2O_7$ solution.
12. To determine ferrous ions in a given sample spectrophotometrically by O-phenathroline method.
13. To determine the molecular weight of a high polymer (polystyrene) by viscosity measurement.
14. Potentiometric titration of acetic acid against NaOH and to determine the dissociation constant of acid.
15. To study the molecular condition of benzoic acid in Toluene by determining the partition co-efficient between Toluene and water.

Reference books

1. Practical Physical Chemistry 3rd edition A.M.James and F.E. Prichard , Longman publication
2. Experiments in Physical Chemistry R.C. Das and B. Behra, Tata Mc Graw Hill
3. Advanced Practical Physical Chemistry J.B.Yadav, Goel Publishing House
4. Advanced Experimental Chemistry. Vol-I J.N.Gurtu and R Kapoor, S.Chand and Co.
5. B. Vishwanathan, P.S. Raghavan; Practical Physical Chemistry, Viva Books, 2010.

Particle & Fluid Particle Processing Lab

Subject Code: CT - PCC -309P(BCE)

Lecture: 0 Hrs **Practical Duration: 03 Hrs** **No. of Credits: 1.5**

University Assessment: 25 Marks **College Assessment: 25 Marks**

Duration of Examination: 3 Hours

Objective: The course aims at performing the experiments and getting hands-on experience on concepts such as, the properties, size-reduction and handling of solids and solid-fluid mixtures, separation processes for solid-solid and solid-fluid mixtures, concepts of filtration, agitation and mixing of liquids, and packed and fluidized beds

Course Outcomes:

CO 1: The student would understand the physical properties, property measurement and handling of solid-solid and solid-fluid mixtures.

CO2 . The student would understand separation processes for solid-solid and solid-fluid mixtures.

CO3. To understand the processes involved in agitation and mixing of liquids

CO4: To understand the working and applications of solid-storage and conveying, and flow through packed and fluidized beds

List of Experiments:

1) To study relationship between the Drag coefficient and modified Reynolds number for bo dy falling throughfluid (Cd Vs NRE)

2) To carry out the batch sedimentation test and use results to design the thickener

3) To determine the efficiency of Mineral Jig

4) To establish the filtration equation for the leaf filter system and to evaluate compressibility of cake.

5) To study the power consumption of an agitator with Reynolds and Froude number

6) To verify the laws of crushing and grinding

7) To determine the mean arithmatic diameter, mean surface diameter and mean volume diam eter

8) To determine the size distribution in a given sample (Elutriation)

9) To determine the effectiveness of vibrating screen

10) To separate the various size fraction in a mixture on the basis of their settling velocities in a fluid (size separation)

11) To determine the efficiency of a cyclone separator.

12) To study separation in cone classifier.

13) To study the operation of hammer mill and determination of efficiency of hammer mill

14) To study working principle of froth flotation cell

15) To study the magnetic separator and to determine the efficiency of magnetic separator.

Science and Technology
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Technology
(Fourth Semester)

Process Technology & Economics (Theory):

Subject Code: CT-PCC-401T (BCE)

Lecture: 03 Hrs **Tutorial: 1 Hr** **No. of Credits: 04**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 03 Hours

Course Objectives: The objective of this course is to introduce students with basic block diagram and simplified process flow diagram for manufacture of various inorganic chemicals, Petrochemicals, Petroleum refining and cracking operations. This course also provides basic understanding for common utilities required for manufacturing process. It also provides understanding for various components of project cost and their estimation.

Course Outcomes: After completion of the course, students will be able:

CO1: Raw materials, operating conditions, basic block diagram and simplified process flow diagram for manufacturing of inorganic chemicals.

CO2: Raw materials, operating conditions, basic block diagram and simplified process flow diagram for manufacturing for Petroleum refining and cracking operations, syngas and hydrogen.

CO3: Raw materials, operating conditions, basic block diagram and simplified process flow diagram for manufacturing of various Petrochemicals.

CO4: Industrially relevant fuels, coal, coal-based chemicals and fuels Common utilities

CO 5: Introduction to project, Various components of cost of production and their estimation and analysis of working results project.

Unit 1: Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of inorganic chemicals, such as: inorganic acids, chlor-alkali, ammonia, fertilizers, etc.

Unit 2: Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for Petroleum refining and cracking operations, syngas and hydrogen,

Unit 3 Description, raw material and energy sources and consumption, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of Petrochemicals: C1, C2, C3, C4, etc., benzene, toluene, xylene and other petrochemicals from these basic building blocks

Unit 4 Industrially relevant fuels, coal, coal-based chemicals and fuels Common utilities such as electricity, cooling water, steam, hot oil, refrigeration and chilled water

Unit 5: Introduction to project cost and cost of production, Various components of cost of production and their estimation, Various components of project cost and their estimation, Estimation of working capital. Analysis of working results project: Balance sheets, Project financing, concept of interest, time value of money, depreciation. Profitability Analysis of Projects

Suggested Text Books

1. Shreve's Chemical Process Industries, George T. Austin, McGraw-Hill International Editions Series, 1984
2. Dryden's Outlines of Chemical Technology, M. Gopala Rao, Marshall Sittig, East West Press, 1997
3. Chemical Project Economics, Mahajani V. V. and Mokashi S M., MacMillan India Ltd. 2005
4. Plant Design and Economics for Chemical Engineers, Max Peters, Klaus Timmerhaus, Ronald West, McGraw Hill International Edition, 2013
5. Process Equipment Design Vol 1 & 2 , S.D.Dawande Denett Publication Seventh Edition,2015

Suggested References Books

1. Chemical Process Technology, Moulijn, M. and van Dippen, Wiley, 2013

Food Technology I

(Chemistry of Foods)

Subject Code: CT - CS-402/1 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Objective:

The main objectives of this course is for students to differentiate chemical interactions and reactions of food components and their effect on sensory, nutritional, and functional properties of foods, and how processing influences these properties.

Course Outcome(s): By learning this course students will develop

CO1: Ability to understand the structure and composition of carbohydrates and its metabolism.
CO 2: Ability to demonstrate the structure, composition, physical and chemical properties of different types of fats.
CO 3: Ability to recognize the function of the proteins and enzymes and understand their practical implications.
CO4: Ability to describe the importance of water, colloidal systems and effect of water activity on shelf life of food products.
CO 5: Ability to understand the importance of micro nutrients in food products and able to find the energy value of different foods.

Course Content:

Unit I: Chemistry of Carbohydrates

Nomenclature, Classification and Structure of carbohydrates. Chemical Reactions of Carbohydrates. Physical and Chemical properties of sugars, starch, pectic substances, gums and other polysaccharides. Functional properties of carbohydrate in food. Digestion of carbohydrate-based food and its metabolism

Unit II: Chemistry of Lipids

Definition and classification of lipids, Chemistry of fatty acids and glycerides. Chemistry of processing of fats and oils, hydrogenation of fats, shortening confectionery fat etc. Rancidity of fats and oils, its prevention and antioxidants. Functional properties of lipids in foods. Metabolism of lipids.

Unit III: Chemistry of Proteins and Enzymes

Importance of proteins. Nomenclature, classification, structure and chemistry of amino acids, peptides and proteins. Sources and distribution of proteins, isolation, identification and purity of proteins. Denaturation, Physical, Chemical and Biochemical characterization of proteins, Metabolism of proteins, Introduction classification and nomenclature of enzymes, specificity. Industrial applications of Enzymes, kinetics, Techniques of immobilization of enzymes.

Unit IV: Water

Importance of water in foods. Structure of water and ice. Concept of bound and free water, their implications. Water Activity and its influence on shelf life of foods. Physical Properties of Food Systems. Colloidal Properties of food, Sensory perception of tastes, flavour, aroma and texture. Sensory analysis of foods.

Unit V: Micronutrients of food

Energy value of food. BMR and its measurement. Energy requirement of individuals. Nutritional evaluation of proteins. Recommended dietary allowances of proteins, fats and carbohydrates, Antinutritional factors in food, Vitamins – Classification, sources, functions and deficiency symptoms, assay of vitamins. Minerals – Micro & Macro Minerals. Loss of nutrients during processing, Enrichment and fortification.

Books Recommended:

1. Food Chemistry : L H Meyer, Van Nostrand Reinhold Co New York 1960

2. Principles of Food Science, Ed. Owen R Fennema Part I, Food Chemistry, Marcel Dekker Inc New York

3. The Chemical analysis of foods and food products : Morris B Jacob, 3rd Edition, Vam Nostrand Co, Princeton, New Jersey

4. Instrumental Methods of Analysis: Peksock and Shields

Technology of Oil, Fats & Surfactants- I

(Basics of Oils, Fats and Waxes)

Subject Code: CT - CS-402/2 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Outcomes (COs):

After final completion of the course, students will be able to:

1. Thoroughly understands the basic knowledge about sources of Oils & Fats.
2. They are able to classify oils & fats in detail, structure & composition of oil seeds.
3. Capable to differ oils & fats from its constituents.
4. Knowledge of physical & chemical characteristics their determination processes as well as Indian standards & finding adulteration becomes clear after completion of this course.
5. This course gives knowledge of various aspects in the field of waxes also it includes sources, manufacturing process, refining of wax & highly applicable Chemical reaction and Bio-chemical reactions of fats and their fatty acids in industry.

Unit I: Natural Fats and Oils

Their sources and classification, Constituents of Natural Fats, Glycerides. Phospholipids, Fatty acids, non-glyceride constituents, toxic constituents and detoxification. Nutritional functions of fats. Biosynthesis of Oils and Fats.

Unit II: Glyceride Components and Analytical Studies of Oils and Fats

Glycerides and Fatty Acids: Nomenclature, Structure, Occurrence in Oils and Fats. Physico chemical properties of fats and fatty acids, solution properties and spectral properties. Determination of Reichert – Missel, Polenske, and Kirshner values.

Unit III: Analysis of Oils and Fats

Physical and Chemical characteristics of Oils and Fats, Elementary methods of analysis of oils, fats and fatty acids. Determination of Color by Lovibond Tintometer, Determination of viscosity by Brookfield viscometer. Identification of fats and oils. Detection of adulteration in oils and fats. Indian Standards for fats and oils.

Unit IV: Natural Waxes and Synthetic waxes

Natural sources, composition, classification, extraction, refining and processing of waxes, general properties and uses of Paraffin wax, vegetable wax, Animal wax, Microcrystalline compound wax, Compound wax Mineral wax. Synthetic Wax: Esters, Ketones and Industrial waxes. Industrial applications of Waxes.

Unit V: Chemical reaction and Bio-chemical reactions of fats and their fatty acids

Modern enzymatic reaction of oils, fats and fatty acids viz; extraction of oil, transesterification, hydrogenation, polymerization, sulphation and sulphonation, interesterification. Antioxidants and synergists.

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Books Recommended:

1. Industrial Oils and Fat Products: Ed A E Bailey Vol I
2. Fatty acids: K.S. Markely, Inter Science Publishers, 2nd Edition, New York
3. Analysis of Fats and Oils: V.C. Mehlan Bacher
4. Inhibition of fat oxidation processes: K.A. Allen
5. An introduction to the Chemistry and BioChemistry of Fatty acids: Gunstone
6. Industrial Chemistry of Fats and Waxes: T Hilditch
7. B S I Methods of Analysis of Fats and Oils
8. Rancidity of Edible Fats: C H Lea
9. ISI Methods of analysis of oils and fats IS 548 (1964)
10. AOCS Methods of Analysis of Oils and Fats

Petroleum Refining and Petrochemical Technology- I

(Oil & Gas Technology)

Subject Code: CT - CS-402/3 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Objective:

- Enable the students to understand basic principles of petroleum geology.
- Enable the students to understand Drilling operations & various well Drilling Equipment.
- Enable the students to understand and follow the concepts of oil and gas production & processing techniques.

Course Outcome:

After successful completion of the course, the students are expected to

- understand & apply the knowledge of petroleum engineering.
- understand the various rocks along with migration of oil & gas from source rock to reservoir rock.
- get the knowledge about the purpose and uses of the well testing.
- create an information about the basic concepts of Enhanced Oil Recovery Mechanisms
- analyze various surface operations and associated equipment.

UNIT I Geology for Petroleum Engineers

Introduction to subject, history of petroleum, elements of petroleum geology, types & ages of rocks, lithography & classification of rocks, source rock, reservoir rock, entrapment & accumulation of hydrocarbons, traps for oil & gas along with structural details, theories of petroleum origin.

UNIT II Geophysical exploration & drilling technology

Overview of petroleum exploration, introduction to geophysical / geological methods used in petroleum exploration, introduction to oil well drilling, types of drilling – cable tool, rotary drilling rigs & components, drilling fluids, Drilling Fluids: Function, composition, and classification, casing & cementation, well control.

UNIT III Well completion & testing

Well completion: definition of well completion, types of completion, naturally flowing completions, artificial lift completions, well drill stem tests (DST); production tests, pressure tests on gas wells; formation interval testing and other well testing techniques, well stimulation techniques, acidizing concept, types of acids and additives, hydraulic fracturing.

UNIT IV EOR methods

Enhanced oil recovery techniques, introduction: historical background and review of primary and secondary recovery, injection rate and pressures in secondary recovery, gas injection, carbon dioxide flooding, polymer flooding, steam flooding, environmental factors associated with oil recovery, unconventional hydrocarbon resources, coal bed methane, gas hydrates, shale gas / oil, heavy oil.

UNIT V Field processing of Oil & gas

Gathering & collection of oil & gas, flash and stage separation of oil & gas, design of oil & gas separators. Demulsification, stabilization and desalting of crude oil. Dehydration and sweetening of gas. Special problems in oil and gas separation. Removal of suspended solid & water from oil & gas. Scrubbers and wash tank. Safety features in oil and gas separation system.

Reference Books:

- Standard Handbook of Petroleum and Natural Gas Engineering. 2nd Edition. William C Lyons, Gary C Plisga. Gulf Professional Publishing.
- Geology of Petroleum, A.I. Levorsen,2ndEdition. CBS, Publishers, 2006.
- Carl Gatlin; Petroleum Engineering: Drilling and Well Completions, Prentice Hall, Technology and Engineering, 1960.
- L.P.Dake L Elsevier, “Fundamentals of Reservoir Engineering”, Development in Petroleum Science. 1980
- Katz D.L. “Natural Gas Engineering (Production &storage)”,TataMcGraw-Hill, Singapore, 6th edition,2007

Pulp and Paper Technology- I

(Chemistry of Paper Making Raw Material)

Subject Code: CT - CS-402/4 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Outcome

a. Knowing the different raw materials used in the manufacture of paper, understanding the source of cellulose and availability.
b. Understand the anatomy of different fibrous raw material. Study the various morphological properties relevant to paper manufacture.
c. Identify the chemical composition of wood which gives an idea of cellulose, hemicelluloses, lignin and extractives present in the wood.
d. Study the chemistry of cellulose and hemicelluloses. Understanding the role played by each wood component, reactions of cellulose and hemicelluloses with chemicals.
e. Understanding the relevance of lignin, reactions of lignin with different chemicals and their effect, qualitative and quantitative analysis of lignin, utilization of lignin as different polymeric products

Unit I: Species used as papermaking raw material

Wood species, anatomy and physical properties of wood – classification of woods, non woody fibres used in pulping – bast, fruits, grass, leaf, animal, mineral and synthetic fibres. Gross structure of trunk, structural elements of wood, fiber dimensions.Water conducting system, food conducting system, bark and its structural elements.

Unit II: Anatomy of fibrous raw material and their chemistry

Fibre morphology – Cell formation and growth, fiber structure, gymnosperm and angiosperm fiber morphology, sapwood, heart wood, spring wood, summer wood, role played by growth rings, chemical composition of wood, proximate analysis of fibrous raw material, physical properties of fiber, decay of wood, physical properties of wood, extractives and it's chemical composition.

Unit III: Chemistry of cellulose

Cellulose – Chemistry and location in the cell, isolation, molecular constitution, microfibrils, crystalline and amorphous cellulose, biogenesis of cell wall polysaccharides, sorption, swelling and solution of cellulose, degradation reaction of cellulose.

Unit IV: Identification and formation of hemicelluloses and lignin

Hemicelluloses it's structure and characteristics in wood. Lignin – lignification in wood, biological and biochemical aspects of lignin formation, chemical aspects of lignin formation, lignin carbohydrate bonds, heterogenity of lignin, laboratory separation of lignin.

Unit V: Chemistry of lignin

Structure and properties of lignin, various commercial separation methods, qualitative analysis of lignin, quantitative analysis of lignin, structural analysis and utilization of lignin, low molecular weight products, polymeric products from lignin.

Books Recommended:

1) Biermann's Handbook of Pulp and Paper: Volume 1: Raw Material and Pulp Making Paperback by Pratima Bajpai Dr., Elsevier, 2018.
2) Papermaking Science and Technology, Vol- 2 Forest Resource and Sustainable Management, Joint Textbook Committee of TAPPI and Finnish Paper Association, TAPPI PRESS, 2002.
3) Papermaking Science and Technology, Vol- 3 Forest Products Chemistry, Joint Textbook Committee of TAPPI and Finnish Paper Association, TAPPI PRESS, 2002.
4) Pulping Process by S.A. Rydholm, John Wiley and Sons, New York
5) Pulp and Paper Chemistry and Chemical Technology : James P Casey, John Wiley and Sons, New

Plastics and Polymer Technology- I

(Polymer Science)

Subject Code: CT - CS-402/5 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Objective:

Enable the students to learn the basics of Polymer-structure, reaction and molecular weight.

Course Outcomes (COs):

After successful completion of the course, students will be able to

1. Select suitable raw material for the manufacture of a polymer.
2. Corelate the structure of polymer with property.
3. Apply appropriate polymerization reaction and technique for polymer synthesis.
4. Suggest suitable polymer for particular application on the basis of thermal transition.
5. Compute molecular weight of polymers by using different methods.

Unit 1: Raw Materials for Polymer

Manufacture and properties of raw materials for polymers (monomers): Ethylene, Acetylene, Tetrafluoroethylene, Propylene, Butadiene, Vinyl Chloride, Vinyl acetate, Vinylidene Chloride, Styrene, Acrylic acid, Methyl methacrylate, Acrylonitrile, Acrylamide, Dibasic acids such as Maleic acid, Adipic Acid, Terephthalic acid, Maleic Anhydride, Phenol, Urea, Formaldehyde, Isocyanate, Polyol, Caprolactam, Hexamethylene Diamine, Bisphenol A, Ethylene glycol, Epichlorohydrin, Melamine.

Unit 2: Polymer Classification and Structure

Introduction to Monomer, Oligomer, Polymer, Polymerization, Degree of polymerization, Monomer functionality and its importance, Classification of polymers, on the basis of Source, thermal behaviour, structure, Tacticity and C-C Linkages,Configuration and conformation, Co-polymers- random, alternating, block and graft. Amorphous and crystalline polymers, factors affecting crystallinity, effect of crystallinity on polymer properties, Molecular Flexibility: concept, factors affecting, properties affected.

Unit 3: Polymerization Mechanism and Techniques

Addition Polymerization: Free radical Polymerization, Ionic Polymerization-Anionic and Cationic Polymerization, Co-ordination polymerization, Kinetics of Polymerization

Step Polymerization: Polycondensation, Polyaddition polymerization and Ring opening Polymerization.

Bulk Polymerization, Solution Polymerization, Suspension Polymerization, Emulsion Polymerization, Interfacial Polymerization, Merits and demerits of different techniques.

Unit 4: Thermal Transition in Polymers

Transitions in Polymers, Glass Transition Temperature, factors affecting Glass transition temperature, Glass transition temperature of Copolymers, Relation between Glass transition temperature and Melting temperature, Practical Significance of glass transition temperature, Methods of determination of glass transition temperature.

Polymer degradation, Types: Mechanical, Oxidative, Thermal, UV Degradation, Prevention of degradation.

Unit 5: Polymer Molecular Weight

Average Molecular Weights in polymers: Number average and weight average molecular weight, viscosity average molecular weight, practical significance of molecular weight, Polydispersity and molecular weight distribution in polymers, Analytical techniques used to determine molecular weight: End group analysis, Light scattering, Viscometry, Cryoscopy, Ebulliometry, Membrane Osmometry, Ultra centrifugation.

Books Recommended:

1. Polymer Science by V. R. Gowarikar, New Age Int (P) Ltd.
2. Principles of Polymerization by George Odian, Wiley Interscience.
3. Text Book Of Polymers by Billmeyer, Wiley Interscience.
4. A Textbook of Polymer (Chem. & Tech. of Polymer) vol. I &II by M. S. Bhatnagar, S. Chand.
5. Outlines of Polymer Technology by R. P. Sinha, S. Chand.
6. Polymer Structure, Property and Applications by Deanin, ACS.
7. Physical Chemistry of Polymers by Tager, Mir Publication.
8. Advanced Polymer Materials: Structure Property Relationship by Shonaike, Advani, CRC Press.

Surface Coating Technology-1

(Chemistry and Technology of Drying Oils and Polymerization)

Subject Code: CT - CS-402/6 T(BCHT)

Lecture: 03 Hrs **Tutorial: 0 Hr** **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 3 Hours

Course Objectives: After studying this course students must able to understand the:

1. classification of the paint/coatings and role of various ingredients.
2. the concept and role of film-formation in coatings.
3. the chemistry and technology of oils.
4. modifications of oils and use of modified oils as film-former in coatings.
5. the chemistry and mechanism involved in the synthesis of polymerization.

Course Outcomes (COs)

On the successful completion of the Course, students will be able to:

CO 1: Understand and classify the paint/coatings and role of various ingredients

CO 2: Understand the concept and role of film-formation in coatings

CO 3: Understand the chemistry and technology of drying oils

CO 4: Understand the modifications of oils and use of these oils/modified oils as film-former in coatings

CO 5: Understand the chemistry and mechanism involved in the synthesis of polymer

Unit 1: Introduction to Surface Coatings: History of developments of surface coatings, Global scenario and past, present and future of Indian Coating Industry. Classification, definition of paints, varnishes, lacquer, General composition of surface coatings, function of pigments, extenders, binders, driers, additives in surface coatings.

Unit II: Film Formation: Fundamental of film formation; Chemical Composition, functionality and degree polymerization and film properties. Concept of functionality. Types of coatings, convertible and non-convertible.

Unit III: Vegetable and marine Oils : Chemistry of oils and fats, Classification of oils, and fats; Characterization of oils – physical and chemical; Sources and composition of major oils;

Fatty acids composition and characteristics of individual oils; Constitution of fatty acids, Extraction of oils; Processing of oils; Reactions in oils: Oxidation, hydrolysis, glycerolysis, sulfonation, and epoxidation; Evaluation & properties and uses of oils; Non- drying, drying and semidrying oils.

Unit IV: Drying of Oils: Chemistry and mechanism of oxidative polymerization of drying oils; Thermal polymerization of drying oils; Modification of drying oils; Stand, blown and boiled oils; Limed oils, Isomerized oils, Treated Oils. Dehydrated castor oil (DCO); Co-polymerized oils; film formation and deterioration.

Unit V: Polymerization: Linear and branched polymers; Cross-linked polymers; Degree of polymerization; Chemical classification of polymers; Addition polymerization: Monomers used in addition polymerization; Mechanism of addition polymerization; Manufacturing methods; Condensation polymerization, Characteristics of condensation polymerization; Co-polymerization and hetero-polymerization. Molecular weight of polymer, glass transition temperature

Books Recommended:

1. Organic Coating Technology, H F Payne, Vol I, John Wiley and Sons, New York
2. Paint Technology Manual, Vol I, Oil and Colour Chemists Association
3. Paint Technology Manual, Vol II, Oil and Colour Chemists Association
4. The Chemical Constitution of Natural Fats, T P Hilditch, 2nd Edition, John Wiley and Sons,
5. Protective and Decorative Coatings, J J Matellio, Vol I, John Wiley and Sons
6. Surface Coatings, Vol I, Raw Materials and their useage, Oil and Colour Chemists Association, Australia
7. Text Book of Polymer Science: W Billmeyer, Interscience Publishers Inc, New York
8. An Introduction to Polymer Chemistry: W R Moore, Aldine Publishing Co. Chicago
9 Principles of Polymer Science, by Bahadur and Sastry, Narosa Publishing House.
10. Polymer Science by Gowarikar, Johan Wiley and Sons 1986.
11. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc

Fluid Mechanics

Subject Code: CT - PCC-403T (BCE)

Lecture: 03 Hrs **Tutorial: 01 Hr** **No. of Credits: 04**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 03Hours

Objective: The objective of this course is to understand the fundamentals of fluid flow phenomena. Deriving the mass and momentum balance equations from first principles. To learn about the transportation of fluids and flow measuring devices.

Course Outcomes: After completion of the course, students will be able:

CO1: To understand the basic properties, classification of fluid and fluid statics.

CO2: To understand the fluid energy balance, energy losses and various pipe fitting

CO3: To understand Velocity Distribution, Fluid Friction and Two-phase flow, and flow patterns in two phase flows.

CO4: To understand various flow working principle and expressions for flow rate measuring meters

CO5: To understand Transportation of fluids, Classification of pumps and their properties.

Unit –I

Introduction to fluids: fluid, Properties of fluids, Classification of fluids, Continuum hypothesis, Forces on fluids, Normal and shear stresses, Shearing and flow, characteristics of Newtonian and Non-Newtonian fluids, Shear stress distribution of fluids. Fluid statics: Pascal law, Hydrostatic equilibrium law, Pressure distribution & Manometry, U-tube, Inverted U-tube, Differential and Inclined manometers.

UNIT-II

Bernoulli`s equation, Continuity equation, Frictional loss in pipe, Hydraulic mean diameter, losses due to enlargement and contraction of pipe cross - section. Equivalent length of pipe, Pipe fittings, Gate, Globe, Check and Butterfly valves, Boundary layer development

Unit-III

Velocity Distribution for, Viscous & Turbulent flow through Pipe & Parallel plates. Fluid Friction in pipe: Friction factor, Head loss in pipe flow, Colebrook and White equation, Moody diagram, Two-phase flow, Flow patterns in two phase flow. The Baker diagram, Erosion in two phase flow.

Unit-IV

Flow measurement: Flow rate measurement, Working principle and expressions for flow rate through Pitot tube, Orifice meter, Venturimeter, variable area flow meter, Notch and Weir, Coefficient of discharge.

Unit-V

Transportation of fluids - Classification of pumps, Positive displacement pumps, Reciprocating, Pump, Plunger pump, Diaphragm pump, Metering pump, Rotary gear pump, Rotary lobe Pump, Rotary vane pump, Flexible vane pump, Mono pump, Cetrifugal pump, Volute pump, Volute pump with vortex chamber and diffuser vanes, Cavitation, Priming, Net positive suction head

Suggested Text Books

1. M. White, Fluid Mechanics, 8 th Edition, Tata-McGraw Hill, 2016.

2. V. Gupta and S. K. Gupta, Fundamentals of Fluid Mechanics, 2 nd Edition, New Age International 2011.

3. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7 th Edition, McGraw-Hill International Edition 2005.

4. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall of India, 2005.

5. R. W. Fox, P. J. Pritchard and A. T. McDonald, Introduction to Fluid Mechanics, 7 th Edition, Wiley-India 2010.

6. R. Welty, C. E. Wicks, R. E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th Ed.,Wiley (2007).

7. R.P. Vyas, Fluid Mechanics , Second Edition, Dennet & Co. Publication,2008

Suggested References Books

1. R.K. Bansal, Fluid Mechanics and Hydraulic Mechines Laxmi Publication 7th Publication 2017.
2. B. R. Munson, D. F. Young, T. H. Okiishi and W. W. Huebsch, 6 th Edition, Wiley-India 2010.
3. R. L. Panton, Incompressible Flow, 3 rd Edition, Wiley-India 2005.
4. R. B. Bird, W. E. Stewart and E. N. Lightfoot, Transport Phenomena, 2 nd Edition, Wiley-India 2002.

Numerical Methods in Chemical Engineering

Subject Code: CT - PCC -404T (BCE)

Lecture: 02 Hrs **No. of Credits: 02**

University Assessment: 35 Marks **College Assessment :15Marks**

Duration of Examination: 03 Hours

Objective: This course has been designed to develop the understanding the computational methods to solve the problems related to the chemical engineering applications. The students are exposed to learn the basic principles, and logical skills in solving the problems using computational methods.

Course Outcomes: After completion of the course, students will be able:

CO1: To understand and apply various linear algebraic equations to chemical engineering problems

CO2: To understand and apply Root finding methods for solution on non-linear algebraic equations to chemical engineering problems

CO 3: To understand and apply Interpolation and Approximation various methods to chemical engineering problems

CO4: To understand and apply various methods of: Numerical integration and numerical differentiation to chemical engineering problems

CO5: To understand and apply various Ordinary Differential Equations and Partial Differential Equations to chemical engineering problems

Unit I: Introduction, Approximation and Concept of Error & Error Analysis, Linear Algebraic Equations: Methods like Gauss elimination, LU decomposition and matrix inversion, Gauss-Siedel method, Chemical engineering problems involving solution of linear algebraic equations

Unit II: Root finding methods for solution on non-linear algebraic equations: Bisection, Newton- Raphson and Secant methods, Chemical engineering problems involving solution of non-linear equations

Unit III: Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression

Unit IV: Numerical integration: Trapezoidal rule, Simpson’s rule, integration with unequal segments, quadrature methods, Chemical engineering problems involving numerical differentiation and integration

Unit V: Ordinary Differential Equations: Euler method, Runge-Kutta method, Adaptive Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems involving single,and a system of ODEs . Introduction to Partial Differential Equations:

Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method

Suggested Text Books

1. Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.

Suggested References Books

1. S.C. Chapra & R.P. Canale, "Numerical Methods for Engineers with Personal Computer
2. Applications", McGraw Hill Book Company, 1985.
3. R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.
4. Atkinson, K. E., "An Introduction to Numerical Analysis", John Wiley & Sons, 1978.
5. Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

Inorganic Process Technology

Subject Code: CT- BS-405 T(BGE)

Lecture: 03 Hrs **No. of Credits: 03**

University Assessment: 70 Marks **College Assessment: 30 Marks**

Duration of Examination: 03 Hours

Course Objectives:

Students will be able to understand sources and processes of manufacture of various important inorganic chemicals having industrial applications.

Course Outcomes: The student on completion of course will be able:

CO1 To understand the knowledge of unit operations and apply them in production of industrial gases & acids.

CO2 To understand the concepts, remember & apply the knowledge in the production process of different types of Industrial carbon and pigments.

CO3 To understand the concepts, remember & apply them in the manufacture of industrially important marine chemicals and processes in nuclear industries

CO4 To understand the manufacturing processes of Electrolytic & electro-thermal products

CO5 To understand the production process of different fertilizers.

Unit I Industrial gases & Acids: Manufacture of CO_2, H_2, N_2 & O_2, Ar, ammonia and C_2H_2 and their industrial applications. Manufacture of nitric acid, sulphuric acid, Phosphoric acid and their industrial applications.

Unit II Industrial Carbon & Inorganic pigments: Manufacture & applications of, Lamp black, Carbon black, Activated carbon, Graphite, Industrial diamond. Manufacture, properties & uses of white pigments- white lead, zinc oxide, titanium dioxide and Lithophone.

Unit III Nuclear industries: Nuclear fission & fusion reactions, Feed materials, extraction of Uranium, uranium enrichment, nuclear reactor, reprocessing of nuclear materials, protection from radioactivity.

Unit IV Chloro-Alkali & Electrolytic and Electrochemical industries: Manufacture of Soda ash by Solvay's & modified Solvay's process, Types of electrolytic cells for Caustic soda & Chlorine manufacture – Nelson, Hookers, Castner Kellner, De-Nora & Membrane cells. Manufacture of potassium chlorate & per- chlorate. Artificial abrasives: Calcium carbide, Silicon carbide.

Unit V Fertilizers: Classification of fertilizers, manufacture & applications of urea, ammonium nitrate, ammonium sulphate, Super phosphates & triple super phosphates, monoammonium and Diammonium phosphate, Potassic, compound & complex fertilizers.

Books Recommended:

1. Industrial Chemistry by B.K.Sharma, Goel Pub. House, Meerut.
2. Dryden, C. E. “Outlines of Chemical Technology” (Edited and Revised by M.Gopal Rao and Sittig .M) East West Press. Pvt. Ltd, New Delhi, 3rd Edition (1997).
3. Austin G. T,”Shreve’s Chemical Process Industries”, 5th ed., McGraw Hill.(1984).
4. G.N.Pandey, "Text book of Chemical Technology", Vol. I, 2nd revised edition, (1994).
5. A Text Book of Engineering Chemistry, by S.S.Dara, S.Chand & Co., New Delhi.

HASS II Functional English

Subject Code: CT- HSMC-HS-406 T (BGE)

Lecture: 02 Hrs. **No. of Credits: 02**

University Assessment: 35 Marks **College Assessment: 15 Marks**

Duration of Examination: 02 Hour

Objective: At the end of the semester, students will have enough confidence to face competitive examinations (IELTES/ TOEFL/CAT/ MAT/ XAT/SNAP/GMAT/GATE etc.) to pursue master's degree. They will also acquire language skills required to write their Reviews/Projects/Reports. They will be able to organize their thoughts in English and hence face job interviews more confidently.

Scope: The Curriculum designed is student –centered and it is guidance for their career

Unit 1. Functional Grammar:

Common errors, Transformation of Sentences, Phrases, Idioms & Proverbs.

[50 sentences of common errors, 50 examples of Transformation of Sentences, (5 each type), 50 noun/prepositional phrases, 50 idioms/proverbs]

Unit II. English for Competitive Exams & Interview Techniques:

IPA (vowel & consonant phonemes), Word building (English words /phrases derived from other languages), Technical Jargons, Synonyms/Antonyms, Analogies, Give one word for, Types & Techniques of Interview

Assignment: [25 Words for teaching IPA, 25 words/phrases of foreign origin, 25 technical jargons, 25 words for Synonyms/ Antonyms, 25 words for Analogies, 50 examples of give one word for]

Unit III. Formal Correspondence

Business Letters, e-mail etiquettes [Orders, Complaints, Enquiries, Job applications and Resume Writing, Writing Memorandum, Circulars, notices], Analytical comprehension:

[Four fictional & four non-fictional unseen texts]

Unit IV. Technical & Scientific Writing:

Features of Technical Writing, Writing Scientific Projects, Technical Report writing, Writing Manuals, Writing Project Proposals, Writing Research papers.

Assignment: (Any one project/review as assignment)

Reference Books:

1. Effective technical Communication by Barun K. Mitra, Oxford University Press,
2. Technical Communication-Principles and Practice by Meenakshi Raman & Sharma, Oxford University Press, 2011, ISBN-13-978-0-19-806529-
3. The Cambridge Encyclopaedia of the English Language by David Crystal, Cambridge University Press
4. Contemporary Business Communication by Scot Ober , Published by Biztantra,
5. BCOM- A South-Asian Perspective by C.Lehman, D. DuFrene & M. Sinha, Cenage Learning Pvt. Ltd.2012
6. Business English, by Dept of English, University of Delhi, Published by Dorling Kindersley (India), Pvt.Ltd.,2009, ISBN 978 81 317 2077 6
7. How to Prepare a Research Proposal: Guidelines for Funding and Dissertations in the Social and Behavioural Sciences by Krathwohl & R David
8. Technical Writing- Process and Product by Sharon J. Gerson & Steven M. Gerson, 3rd edition, Pearson Education Asia, 2000
9. Developing Communication skills by Krishna Mohan & Meera Banerjee

Fluid Mechanics Lab

Subject Code: CT - PCC -407P (BCE)

Lecture: 0 Hrs **Practical Duration: 02 Hrs** **No. of Credits: 1**

University Assessment: 25 Marks **College Assessment :25 Marks**

Duration of Examination: 3 Hours

Objective: The course aims on the properties of fluids and the energy relationships in fluid systems. The fluid mechanics approach to solve typical problems in turbulent flow, calculation of turbulent boundary layers with pressure gradient, transition from laminar to turbulent flow, volumetric and mass flow rates through the Venturi meter and Orifice meter and efficiency of pumps

CO1: The student must be able to approach and solve typical problems in fluid dynamics at the appropriate level.

CO 2. Students will be able to understand the fluid dynamics and also the principles of turbulent flow, calculation of turbulent boundary layers with pressure gradient, transition from laminar to turbulent flow.

CO3. Learn to measure volumetric and mass flow rates through the Venturi meter and Orifice meter and efficiency of pumps.

CO4. Ability to understand and analyze the applications to industrial flows.

List of Experiments

1) To verify Bernoullis equation

2) To calibrate venturimeter and and obtain its coefficient of discharge

3) To calibrate orificemeter and obtain its coefficient of discharge

4) To calibrate Rotameter

5) To calibrate notched weir and and obtain its coefficient of discharge

6) To study friction factor Vs Reynolds number for flow of water in a pipe

7) To study friction factor Vs Reynolds number for flow of air in a pipe

8) To study the relationship between Fanning friction factor Vs Reynolds number for flow of fluid through coils.

9) To obtain equivalent length of pipe for various pipe fittings

10) To study the operating characteristics of centrifugal pump.

11) To study the hydrodynamic characteristics of packed bed

12) To study the hydrodynamic characteristics of a fluidized bed

13) To study two phase flow.

Numerical Methods in Chemical Engineering Lab (Practical)

Subject Code: CT - PCC -408P (BCE)

Lecture: 0 Hrs **Practical Duration :02 Hr** **No. of Credits:1**

University Assessment: 25 Marks **College Assessment: 25 Marks**

Duration of Examination: 03 Hours

List of Experiments

1. Introduction to use of computers for numerical calculations
2. Solution of linear algebraic equations using Gauss elimination, Gauss-Siedel etc.
3. Solution of a non-linear equations using bracketing and Newton-Raphson method
4. Interpolation and Approximation
5. Numerical integration
6. Euler method
7. Runge-Kutta methods for ODEs
8. Solution of system of ODEs using simple methods
9. Solution of simple PDEs

Inorganic Process Technology Laboratory

Subject Code CT- BS-409 P (BGE)

Lecture: 0 Hrs **Practical Duration: 03 Hr** **No. of Credits:1.5**

University Assessment: 25 Marks **College Assessment: 25 Marks**

Duration of Examination: 03 Hours

LIST OF EXPERIMENTS

1. To Prepare the Crystals of Chrome alum.
2. To Prepare Mohr’s salt.
3. To estimate the amount of impurities in a given sample of common salt.
4. To purify the given sample of Common salt.
5. To Prepare Cuprous Chloride.
6. To estimate the % available Chlorine in a given sample of Bleaching powder.
7. To Prepare the Crystals of Sodium Thiosulphate.
8. To estimate the amount of ferrous & ferric in pigment Red Oxide.
9. To Prepare the Crystals of Ferrous Sulphate from Kipp’s apparatus waste.
10. To estimate Sulphate in a given solution by EDTA method.

Engineering Workshop

Subject Code: CT-GES-410 P

Lecture: 0 Hrs **Practical Duration: 03 Hrs** **No. of Credits: 1.5**

University Assessment: 25 Marks **College Assessment: 25 Marks**

Duration of Examination: 3 Hours

Objectives:

The idea of this course is to understand the concepts involved in product realization by carrying out manufacturing shop exercises. Hands-on practice with manufacturing shop exercises and assembly leading to realization of a new product in a group. Students will also be introduced to the importance of manufacturing planning.

Course outcomes

Students will realize the importance of:

- Manufacturing planning.
- Computer numerically controlled machines.

Contents:

1. Introduction to the course and its objectives; mandatory briefing on shop-floor safety. Introduction to all manufacturing forms and introduction to basic tools (hand tools and power tools).

2. Overview of engineering materials and forms in which they are commonly available as raw materials. Typical component manufacture with materials like wood.

3. Overview of shape realization by manufacturing, measurement of manufactured parts. Associated with: Machine shop exercises- involving sawing, turning and drilling, milling, grinding and joining. Inspection of manufactured component using simple metrology instruments.

4. Overview of computer numerically controlled machines Machine shop exercise using CNC - Part modelling, CNC program generation and cutting part on CNC milling machine.

5. Use of plastics and composites as engineering materials. Practical: Hands-on exercise involving plastics - use of injection moulding, extrusion etc.

Texts/References

1. Elements of Workshop Technology, Vol. I by S. K. Hajra Choudhury, 13th Edition, 2003, Asia Publishing House.

2. Elements of Workshop Technology, Vol. II by S. K. Hajra Choudhury, 13rt Edition, 2003, Asia Publishing House.

3. Workshop Practice by H. S. Bawa, 1st Edition, Tata-McGraw Hill, 2004.

Environmental Sciences: MC Audit Course

Course Objectives:

The student on completion of course will understand the Ecosystem, Environmental issues related with social and human population, Biodiversity and its conversion.

Course Outcomes: The student on completion of course will be able:

CO 1: To understand and apply the Multidisciplinary nature of environmental studies.

CO 2: To understand the importance of Natural Resources and its conservation.

CO 3: To understand the classification of ecosystem and importance of conservation of biodiversity.

CO 4: To understand the sources of pollution, ill effects of pollution and prevention methods of pollution.

Unit 1: Multidisciplinary nature of environmental studies: Definition, scope and importance, Need for public awareness.

Unit 2: Natural Resources: Renewable and non-renewable resources: Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Energy resources: Growing energy needs, renewable and non-renewable, energy sources, use of alternate energy sources. Case studies.

d) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.

Unit 3: Ecosystems: Concept of an ecosystem. Structure and function of an ecosystem. Producers, consumers and decomposers. Energy flow in the ecosystem. Ecological succession. Food chains, food webs and ecological pyramids.

Introduction, types, characteristic features, structure and function of the following ecosystem: -

a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Biodiversity and its conservation: Introduction – Definition: genetic, species and ecosystem diversity. Biogeographical classification of India, Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, National and local levels, India as a mega-diversity nation, Hot-sports of biodiversity. Threats to biodiversity.

Unit 4: Environmental Pollution: Definition • Cause, effects and control measures of: - a. Air pollution b. Water pollution c. Noise pollution d. nuclear hazards. Solid waste Management: Causes, effects and control measures of urban and industrial wastes. • Role of an individual in prevention of pollution. • Pollution case studies.

Project work: Case studies

Text Books:

1. Erach Bharucha: “A Text Book of Environmental Studies”

2. M. N. Rao and HVN Rao: “Air Pollution”

3. S.S. Dara: “Environmental Chemistry and Pollution Control”

4. Mahesh Rangarajan: “Environmental Issues in India”

5. D.L. Manjunath: “Environmental Studies”.

B.TECH CHEMICAL ENGINEERING & TECHNOLOGY

SYLLABUS – ALL SEMESTERS

Engineering and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Engineering

(First Semester)

Engineering Mathematics – I (CE (BGE) 1.01)

(Total Credits: 04)

Teaching Scheme	**Examination Scheme**
Lectures: 3Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

UNIT –I : Differential Calculus

Successive Differentiation, Standard forms to find n-th derivatives, Leibnitz`s theorem , Expansion of function in power series (Taylor's and Maclaurin's Series), Tracings of curves in Cartesian and polar coordinates , Curvature, Radius of curvature in Cartesian and polar coordinates .

UNIT-II: Partial Differentiation

Function of two variables, Partial derivatives, Euler's theorem , Chain rule, Total differentiation , Taylor's and Maclaurin's theorem , Maxima and minima of function of two function , Lagrange's method , Jacobins, Differentiation under integral sign .

UNIT- III : Statistics and Probability

Curve fitting: Method of least squares, Fitting of straight lines, Polynomials, Exponential curves etc., Random variables: Discrete and continuous random variable, Probability distribution: Binomial, Poisson and Normal Distribution

UNIT- IV: Matrices

Rank of matrix, Consistency of a system of equation, Eigen values, Eigen vector, Statement and verification of Caylay Hamilton theorem, Determination of the roots of algebraic equation by matrix method, Sylvester's theorem.

UNIT –V : Integral Calculus

Beta, Gamma functions, Double integration : Cartesian and polar co-ordinates, Change of order of integration ,Change of variables between Cartesian and polar co-ordinates, Area as a double integral, Triple integration, Volume as a triple integral.

UNIT – VI : Complex Number

Complex Numbers: Cartesian and polar forms of complex numbers, Demoivre's theorem and its application in solution of equation and expansion of $cos^n\theta, sin^m\theta, cos^n\theta . sin^m\theta$, hyperbolic functions and their inverse, logarithm of complex quantities. Separation of real & imaginary part.

Books Recommended:

1. Higher Engineering Mathematics by H.K. Das, Er.Rajnish Verma
2. A text book of engineering mathematics by N.P. Bali, Manish Goyal
3. A text book of engineering mathematics (Vol –I,Vol-II) by Dr. D.T. Deshmukh
4. Higher Engineering Mathematics by B.S. Grewal

(First Semester)

Applied Inorganic Chemistry (CE (BGE) 1.02)

(Total Credits: 03)

Teaching Scheme	Examination Scheme
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

Unit I: **General Principles and Processes of Metallurgy:** Ore dressing, roasting, calcination, smelting, fluxes & slag. Types of furnaces, refining of metals. Metallurgical industries of iron, steel, copper. **(6)**

Unit II: Co-ordinate covalent compounds (complexes): Introduction to co-ordination chemistry, explanation of terms like complex, ligands, co-ordination number, co-ordination sphere. Classification of ligands, chelates & its classification. Werner's coordination theory & its application to Co (III) and Pt (IV) ammine complexes. Nomenclature of coordination compounds, bonding in complexes, brief description of Valence bond theory (VBT), application of VBT to 6- & 4-coordinated complexes, limitations of VBT. Crystal field theory, crystal field splitting in octahedral & tetrahedral complexes. Application of chelates in industries. (**10)**

Unit III: Water: Sources, types of impurities and their effects, hardness of water & its estimation, Numerical on EDTA method, treatment of water for domestic & industrial purposes, sedimentation, coagulation, filtration, types of filters, Sterilization- chlorination, break point chlorination, Ozonization. Removal of hardness of water: Lime- soda process, types, Numerical on lime- soda process, Zeolite process, its advantages and disadvantages, comparison with L-S Process, Numerical based on zeolite process, Ion- exchange process, demineralization process. Boiler troubles:-Carry over- priming & foaming-causes & prevention, sludge & scales, Causes of scale formation and prevention methods, Corrosion & caustic embrittlement causes & prevention. **(12)**

Unit IV: Cement: Raw materials, constitutional compounds& its properties, Process parameters, Manufacture of Portland cement by wet and dry process, setting and hardening of cement, Cement additives & admixtures. Types of Portland cement. **(5)**

Unit V: Glass: Definition & Chemistry of glass making , raw materials, composition & properties of different types of glass, manufacture of glass wares such as bottles, window glass, tubes.Safety glss & coloured glass. **(5)**

Unit VI: Ceramics: Definition & types, Basic raw materials used, fabrication methods, drying & firing of ceramic products, glazing. **(4)**

Refractories: Definition, requisites of good refractory material, classification & properties of refractory, raw materials, manufacture of refractory products, application in industries. **(3)**

Books Recommended:

1. A Text Book of Engineering Chemistry, by S.S.Dara, S.Chand & Co., New Delhi.
2. A Text Book of Engineering Chemistry, by Jain & Jain, Dhanpat Rai Publishing Co., New Delhi.
3. Industrial Chemistry by B.K.Sharma Goel Pub. House, Meerut.
4. Advanced Inorganic Chemistry, Vol.II, by Satya Prakash, G.D.Tuli, S.K.Basu & R.D.Madan.

(First Semester)

Applied Organic Chemistry (CE (BGE) 1.03)

(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks **Duration of University Exam. :** 03 Hours

Unit 1 Aromatic hydrocarbon Preparation, properties and Industrial uses, and its structure determination of Benzene, Naphthalene.

Alcohol - monohydric alcohol. e.g. ethyl alcohol, di hydric alcohol. e.g. ethylene glycol, trihydric alcohol e.g. glycerol.-its study . Preparations, properties and Industrial uses.

Heterocyclic hydrocarbon- total synthesis, preparations, properties and uses of Pyrrole, Indigo.

Unit 2 Carbohydrates Industrial uses and structure determination of glucose, saccharin.

Acids and esters Preparations and properties and uses of Acetic acid, , Acetoacetic acid, Malonic acid and their esters.

Amines- Preparations and properties and uses of mono-, di -, tri- ethyl amines ,Aniline and diazotization with special reference to formation of azo dyes - e.g. Aniline yellow, Methyl Red, Congo Red.

Unit 3 Nitration, nitrating agents, Kinetics and Mechanism of aromatic nitration process, Equipments for nitration, typical industrial nitration process e.g. preparation of nitrobenzene, nitro acetanilide.

Unit 4 Halogenation, Thermodynamics and Kinetics of halogenation reactions. Apparatus and materials for construction. Technical preparation of chloral and vinyl chloride.

Unit 5 Sulphonation and sulphation: Sulphonating and sulphating agents. Mechanism of sulphonation Industrial Equipments: Technique and Technical Preparation of dodecyl Benzene Sulphonate, Sulphation of Lauryl Alcohol, Dimethyl ether.

Unit 6 Principles of Polymer Chemistry, Industrial Practices and applications, Techniques of Polymerization, Types of Polymerization Examples: Addition and Condensation Polymerization, Mechanism of Additional Polymerization. Study of Polymers e.g. PVC, PVA, Conducting Polymer- Polyaniline, Polypyrroles, Polythiophenes, .

Books Recommended:

1. Text book of Organic Chemistry- by P.L.Soni, H. M. Chawala
2. Text book of Organic Chemistry – By Arun Bahal, B.S. Bahal
3. Unit Processes in Organic Synthesis- by P. H. Groggins
4. Principles of Polymer Chemistry- by Vasant Gowarikar
5. Chemistry of Organic Natural Products Vol-1 and 2- by O. P. Agrawal

First Semester)

Applied Physics – I (CE (BGE) 1.04)

(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks **Duration of University Exam. :** 03 Hours

UNIT – I Viscosity Streamline flow, Turbulent motion, Critical velocity, Viscosity, Coefficient of viscosity, Poiseulle's equation, Stoke's method, Ostwald viscometer, Numericals

UNIT – II Surface tension Surface Tension, Excess pressure inside a liquid drop and soap bubble, Angle of contact, Searl's Torsion balance method, Jaeger's method, Quincke's method, Interfacial surface tension, Numericals

UNIT – III Interference Plane parallel thin film, Wedged shaped thin film, Newton's rings, Applications: Determination of wavelength and Refractive Index of liquid, Test of surface finish, Antireflection coating, Dielectric mirror, Numericals .

UNIT – IV Polarization of light Types of polarization: Plane polarized light, circularly polarized light, elliptically polarized light and unpolarized light. Production of plane polarized light: Polarization by reflection, refraction, scattering, selective absorption, double refraction, Nicol prism. Polarizer and Analyzer, Optic axis, Principal section. Differences between: o-ray and e-ray, positive and negative crystals, HWP and QWP. Analysis of polarized light, Optical activity and specific rotation. Numericals .

UNIT – V Lasers Three quantumn processes: Absorption, Spontaneous emission and Stimulated emission. Metastable state, Conditions for light amplification, Pumping schemes: Three level pumping scheme, Four level pumping scheme. Optical resonator, Laser beam characteristics, Ruby laser and He-Ne laser.

UNIT – VI Pumps and gauges Rotary Oil Pumps:-Rotary –vane Oil Pump, Stationary vane rotary oil pump, Geissler pump, Diffusion-Condensation pump

Guages:- McLoed Vacuum Guage, Pirani Resistance Guage, Thermocouple Guage, Knudsen Guage.

Books Recommended

1. Elements of properties of matter By D.S.Mathur

2. Text book of Engineering Physics By Avadhanulu and Kshirsagar

First Semester)

Applied Mechanics (CE (BGE) 1.05)

(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

UNIT I Basics & Statics of Particles Basic concepts System of Forces, Resolution and composition of forces , system of parallel, concurrent and non concurrent co-planer forces, Resultant.

Equilibrium Of Rigid Bodies Free body diagram , Types of supports and their reactions, requirements of stable equilibrium, Moments and Couples, Varignon's theorem , Equilibrium of Rigid bodies in two dimensions.

UNIT II Centroid and Center of Gravity Centroid of plane and composite figures, Moment of inertia of plane area, Parallel Axes Theorem, Perpendicular axes theorems.

Simple lifting machines Velocity ratio, mechanical advantage and efficiency of simple machines, Law of machine, Differential wheel and axle, Screw Jack, Single and Double purchase crabs.

UNIT III Truss Analysis of simple plane trusses by method of joints and method of sections.

Friction Types of friction, Limiting friction, Laws of Friction, static and Dynamic Frictions, Motion of Bodies.

UNIT IV Dynamics of Particles Displacement velocity and Acceleration (rectilinear and rotary), Motion with uniform and variable acceleration and projectiles , D'Alembert's principle, kinetics of rectilinear translation and rotary motion of rigid body. Dynamic equilibrium in plane motion.

UNIT V Work, Power and Energy, Conservation of Momentum and Energy.

UNIT VI Transmission of power by belts Belt Drivers - Open, Crossed and compound belt drives, length of belt, tensions - tight side, slack side, Power transmitted and condition for maximum power. gears and epicyclic gear trains.

BOOKS RECOMMENDED

1. Engineering mechanics by Timoshenko and Young.
2. Applied Mechanics by Saluja,Satya Prakash.
3. Engineering mechanics by Beer and Johnson.
4. Engineering mechanics by Singer.
5. Engineering mechanics by R.S.Khurmi.
6. Engineering Mechanics by Kumar.
7. Engineering Mechanics by Shames.

First Semester)

Applied Inorganic Chemistry (CE (BGE) 1.06)

(Total Credits: 02)

Teaching Scheme **Examination Scheme**

Practical: 3 Hours / Week **Practical**

P (U) : 25 Marks **P (I) :** 25

Marks

Duration of University Exam. **:** 06

Hours

LIST OF EXPERIMENTS

1. Estimation of Total Hardness by Complexometric Method in a given Sample of water.
2. Estimation of Calcium and Magnesium hardness in a given sample of water.
3. Estimation of Nickel by Complexometric Method in a given Sample of water.
4. Estimation of total alkalinity in the given water sample.
5. Estimation of Copper in the given solution of copper sulphate by Iodometry Method.
6. Estimation of Strength of Potassium Dichromate using Sodium Thiosulphate by Iodometry Method .
7. Estimation of Strength of Ferrous ammonium sulphate using Potassium Dichromate and SDS as an internal indicator.
8. Estimation of Strength of Ferrous ammonium sulphate using Potassium Dichromate and Potassium Ferricyanide as external indicator.
9. Estimation of Strength of Hydrogen peroxide using $KMno_4$.
10. Estimation of Strength of HCl using Borax.
11. Estimation of Chloride ions in a given solution by Argentometry method.
12. Estimation of Al^{3+} using EDTA by back titration method.

(First Semester)

Applied Organic Chemistry (CE (BGE) 1.07)

(Total Credits: 02)

Teaching Scheme **Examination Scheme**

Practical: 3 Hours / Week **Practical**

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. **:** 06 Hours

LIST OF EXPERIMENTS

1) Separation of Organic Mixtures.

2) Elemental Analysis of C, H, N, Cl, Br, I etc.

3) Functional group detection for example : COOH, $CONH_2$, Primary Amine, Secondary Amine, Tertiary Amine , Carbohydrate, Phenols, Alcohols, etc.

4) Identification of Organic Compounds.

First Semester)

APPLIED PHYSICS- I PRACTICAL (CE (BGE) 1.08)

(Total Credits: 02)

Teaching Scheme

Practical: 3 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. : 06 Hours

LIST OF EXPERIMENTS

1. To determine the coefficient of viscosity of liquid using Stoke's method.
2. Study of Ostwald's viscometer.
3. To determine the coefficient of viscosity of liquid using Poiseulle's method.
4. To determine the surface tension of liquid using Searl's Torsion Balance method.
5. To determine the surface tension of liquid using Jaeger's method.
6. To determine the surface tension of liquid using Quincke's method.
7. To determine the Interfacial surface tension between the two immiscible liquids.
8. To determine the radius of curvature of a plano convex lens using Newton's rings method.
9. To determine the principle refractive indices of double refracting Quartz prism.
10. Demonstration of Lasers.

First Semester)

ENGINEERING GRAPHICS (PRACTICAL (CE (BGE) 1.09)

(Total Credits: 02)

Teaching Scheme

Practical: 2 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. : 06 Hours

LIST OF EXPERIMENTS

NOTE – ONLY FIRST ANGLE METHOD OF PROJECTIONS SHOULD BE USED

Introduction to Engineering Drawing & Curves used in Engineering Practice:
Introduction, Use of various drawing instruments, Lettering, Types of lines used in drawing practice, Dimensioning, Types of Scales and representative fraction (R. F.) of scale.
Conic sections- Ellipse, Parabola, Hyperbola, Cycloid, Involute & Archimedean Spiral.

Projections of Points and Lines:
Basic principles of orthographic projection, reference planes, concepts of four quadrants, methods of orthographic projections: First angle projections and Third angle projections, conventions used to represent methods of orthographic projection.
Projections of points in all possible positions w.r.t. reference planes, projections of lines when it is perpendicular to one of the reference planes, when line is inclined to one & parallel to other reference plane, lines inclined to both reference planes. (lines in first quadrant only).

Projections of Planes:
Projection of planes when it is parallel to one of the reference planes, when it is perpendicular to one & inclined to other reference plane, when it is inclined to both reference planes.

Projections of Solids:
Projections of solids when axis is perpendicular to one of the reference planes, when axis is inclined to one & parallel to other reference plane, when axis is inclined to both the reference planes. (Projections of cube, right regular prisms, right regular pyramids, right circular cylinder, right circular cone, tetrahedron).

Orthographic Projections:
Conversion of pictorial view into orthographic views.

Isometric Projections:
Definition of Isometric view/projection, Isometric scale to draw Isometric projection, construction of Isometric view from given orthographic views.

PRACTICAL:
Seven Half imperial size drawing sheets as detailed below:

Sheet No. 1: Lines, Lettering and Dimensioning
Sheet No. 2: Curves (Minimum four problems)
Sheet No. 3: Projection of straight lines (Minimum four problems)
Sheet No. 4: Projection of Planes (Minimum four problems)
Sheet No. 5: Projections of solids (Minimum four problems)
Sheet No. 6: Orthographic Views (To draw three principal views from given isometric View-minimum two problems)
Sheet No. 7: Isometric Views/Projection (minimum four problems on Isometric views/projections)

Text Books:

1. N.D. Bhatt, Elementary Engineering Drawing, Charotor Publishing house, Anand, India.
2. R.K. Dhawan- Engineering Drawing-
3. K. Venu Gopal- Engineering Drawing and graphics+ Autocad-
4. D. N. Johle- Engineering Drawing, Tata McGraw-hill Publishing Co. Ltd.
5. Pakhatkar- Engg. Drawing , Nirali Prakashan

Reference Books:

1. P.S. Gill, Engineering Graphics.
2. N.D. Bhatt, Machine Drawing, Charotor Publishing house, Anand, India.

First Semester)

COMMUNICATION SKILLS (CE (BGE) 1.10)

(Total Credits: 02)

Teaching Scheme

Practical: 2 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

Following points are to be discussed with the students before conducting the practicals.

A) Principals and Practice of letter writing: Business, Job and Bank Correspondence
B) Technical Report Writing
C) Grammar:
   1. Correction of Common Errors
   2. Exercise on rewrite as directed
   3. Correct use of words, idioms, phrases, prepositions, etc.
D) 1. Principles of Public Speaking
   2. Reading Comprehension

E) 1. Professional Communication Skills (Meaning, Significance, Types, Dimensions & Barriers)

2. Group Discussion and Personal Interview (Importance of GD, Modules of GD, How to prepare for GD, Meaning, types & techniques of PI, How to prepare for PI)

Books:

1. Public Speaking and Influencing Men in Business- Dale Carnegie
2. Professional Communication Skills-Bhatia and Sheik
3. Business Communication- K.K.Sinha
4. Communication Skills- Dr.P.Prasad
5. Technical Communication- Raman and Sharma
6. High School Grammar and Composition-Wren and Martin
7. Modern English Grammar Usage an Composition –N.Krishnaswamy

Communication Skills Laboratory Practical

Sr.No	Name of the Practical	Activity to be Taken	Medium of Practical
1	Barriers to Communication	1. Intro to various kinds of barriers 2. Activity class on semantic barriers	PPT Based, Activity Based
2	Reading Skills	1. Skimming, Scanning & Gist Reading 2. Comprehending Passages	PPT Based, Activity Based
3	Development of Word Power	1. IPA, Pronunciation techniques 2. Often wrongly pronounced words 3. Word Power, homophones, synonyms/antonyms	Software based PPT Based, Activity Based
4	Non-Verbal Communication	1. Kinesics in comm./Interviews 2. Activities/ role play	Software based PPT Based, Activity Based
5	Speaking Skills	1. Intro of effective way of speaking 2. Oral presentations Extempore/ Debate/JAM	PPT Based, Activity Based
6	Group Discussion	1. GD rules 2. GD of groups in 6	Software based PPT Based, Activity Based
7	Interview Techniques	1. Various types of interviews 2. Resume making 3. Mock Interviews(one to one)	Software based PPT Based, Activity Based
8	Use of Figurative Language	1. Intro phrases/idioms/proverbs 2. Idioms related to color/Number/animals/ parts of the body/Misc.	PPT Based, Activity Based
9	Listening Skills	Listening Barriers	PPT Based, Activity Based
10	Presentation Skills	1. Preparing visual aids/ PPTs 2. Writing references	PPT Based, Activity Based

First Semester)

COMPUTATIONAL SKILL PRACTICAL (CE (BGE) 1.11)

(Total Credits: 02)

Teaching Scheme	**Examination Scheme**	
Practical: 2 Hours / Week	**Practical**	
	P (U) : --	**P (I) :** 25 Marks

Duration of Internal Practical Exam: 02 Hrs

LIST OF EXPERIMENTS

Practical 1 Multi-media
Creates a simple slide show with text, images, Inserts slides, Chooses appropriate slide design and layout, Add sounds, Creates a master slide template,Understands that a presentation is clear, concise and logical, Understands navigation buttons/hyperlinks,Recognises elements of a multi-media presentation.

Practical 2 **Internets**
Understands purpose of a browser, understands the general structure of a web address, Equates URL with web address, uses and understands the features of a browser (back, forward, stop, search, refresh, history, home buttons, address bar, loading status), Understands key features of a web page (links, site map, feedback, email),Uses and understands hyperlinks buttons.

Practical 3 **Spreadsheets**
Understands the purpose/structure of a spreadsheet, Interprets data from an existing spreadsheet, Understands terminology - column, row, cell, cell range, Understands cell addressing, Understands active cell
Enters data (labels, values) in a cell, Formats data in a cell eg. bold, alignment, Generates appropriate graphs eg. bar, column, line etc.

Practical 4 Databases
Understands structure/purpose of a database, Understands strengths and weaknesses of databases,Understands basic terminology - fields, records, files,Opens and uses a commercial database eg. electronic encyclopaedias
Locates specific information searching by subject, key word, author,Locates specific record(s) using find function
Uses relevant fields, Chooses appropriate data types for fields,Sorts data,Adds/deletes records,Edits data in an existing record

Practical 5 C Language**.**
Practical based on C language, Basic concept of C, data types, variables, constants, and there use in Program,
Program to find out the factorial, Fibonacci sequence.

Practical 6 IF Structure**.**

Write a program using IF ELSE structure,to find out the grade of the student when the marks of four subjects are given,the method of assigning grade is as follows:If per>=85 then grade A,if per<85 then B ,if per>70 & per>= 55 then C,If per<55 &per>=40 then D else E.

Practical 7 For & While Loop**.**
Write a Program in C to demonstrate the use of for and While loop.

Practical 8 Arrays
Write a program in C to search an item in an array using Linear & Binary search and also sort an array either in ascending or descending order and implement single dimensional arrays & two dimensional arrays.

Practical 9 Inheritance
Write a Program in C to demonstrate the use of Single, Multiple, Multilevel, Hybrid Inheritance.

Practical 10 Function
Write a Program in C to demonstrate the use of Function like Friend Function, Inline Function.

Books Recommended:

1. Fundamental of computers: Rajaraman V, Prentice Hall of India Ltd, New Delhi, 1990.
2. The C Programming Language: Dennis Ritchie & Brain Kernighan [Pearson].

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Engineering and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Technology

(First Semester)

Engineering Mathematics – I (CT (BGE) 1.01)

(Total Credits: 04)

Teaching Scheme	**Examination Scheme**
Lectures: 3Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

UNIT –I : Differential Calculus

Successive Differentiation, Standard forms to find n-th derivatives, Leibnitz`s theorem , Expansion of function in power series (Taylor's and Maclaurin's Series), Tracings of curves in Cartesian and polar coordinates , Curvature, Radius of curvature in Cartesian and polar coordinates .

UNIT-II: Partial Differentiation

Function of two variables, Partial derivatives, Euler's theorem , Chain rule, Total differentiation , Taylor's and Maclaurin's theorem , Maxima and minima of function of two function , Lagrange's method , Jacobins, Differentiation under integral sign .

UNIT- III : Statistics and Probability

Curve fitting: Method of least squares, Fitting of straight lines, Polynomials, Exponential curves etc., Random variables: Discrete and continuous random variable, Probability distribution: Binomial, Poisson and Normal Distribution

UNIT- IV: Matrices

Rank of matrix, Consistency of a system of equation, Eigen values, Eigen vector, Statement and verification of Caylay Hamilton theorem, Determination of the roots of algebraic equation by matrix method, Sylvester's theorem.

UNIT –V : Integral Calculus

Beta, Gamma functions, Double integration : Cartesian and polar co-ordinates, Change of order of integration ,Change of variables between Cartesian and polar co-ordinates, Area as a double integral, Triple integration, Volume as a triple integral.

UNIT – VI : Complex Number

Complex Numbers: Cartesian and polar forms of complex numbers, Demoivre's theorem and its application in solution of equation and expansion of $cos^n\theta, sin^m\theta, cos^n\theta . sin^m\theta$, hyperbolic functions and their inverse, logarithm of complex quantities. Separation of real & imaginary part.

Books Recommended:

1. Higher Engineering Mathematics by H.K. Das, Er.Rajnish Verma
2. A text book of engineering mathematics by N.P. Bali, Manish Goyal
3. A text book of engineering mathematics (Vol –I,Vol-II) by Dr. D.T. Deshmukh
4. Higher Engineering Mathematics by B.S. Grewal

(First Semester)

Applied Physical Chemistry (CT (BGE) 1.02)

(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2Hours/ Week	**Theory**
Tutorial: 1Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

Unit 1: Equation of State for ideal and real gases, Critical Phenomena, principal of corresponding states, compressibility factor, Principle of Equipartition of Energy, and Joule-Thomson effect.

Unit 2: The first law of Thermodynamics, reversible processes, enthalpy, heat capacity, isothermal and adiabatic processes, thermochemistry laws, standard heats of formation, the bomb calorimeter, flame and explosion temperatures.

Unit 3: The second law of thermodynamics, the Carnot theorem and Carnot Cycle, the refrigeration engine.

Unit 4: Entropy and irreversible processes. The free energy, work function and Gibbs Helmholtz equation, the criteria of Chemical Equilibrium.

Unit 5: Objectives of chemical Kinetics, elementary reaction steps and rate expressions, order of reaction. Factors influencing the reaction rates. Integrated rate expression with examples. Methods for determining the order of chemical reaction.

Unit 6: Radiation chemistry, photochemical reactions, laws of photochemistry, photochemical combination of hydrogen and chlorine.

Books Recommended:

Thermodynamics for chemists by S. Glasstone, D Van Nostrand Inc, New York.
Physical Chemistry by G.M. Barrow, Benjamin Publishers, New York.
Physical Chemistry by Sheehan, W.F. Prentics hall of India, Pvt Ltd., New Delhi 1963
Principles of Physical Chemistry by Puri and Sharma, S.Chand and Co. New Delhi
An Introduction to Chemical Thermodynamics by R P Rastogi and R R Mishra
Physical Chemistry through problems, S. Dogra and S. K. Dogra

(First Semester)

Applied Inorganic Chemistry (CT (BGE) 1.03)

(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

Unit I: **General Principles and Processes of Metallurgy:** Ore dressing, roasting, calcination, smelting, fluxes & slag. Types of furnaces, refining of metals. Metallurgical industries of iron, steel, copper. **(6)**

Unit II: Co-ordinate covalent compounds (complexes): Introduction to co-ordination chemistry, explanation of terms like complex, ligands, co-ordination number, co-ordination sphere. Classification of ligands, chelates & its classification. Werner's coordination theory & its application to Co (III) and Pt (IV) ammine complexes. Nomenclature of coordination compounds, bonding in complexes, brief description of Valence bond theory (VBT), application of VBT to 6- & 4-coordinated complexes, limitations of VBT. Crystal field theory, crystal field splitting in octahedral & tetrahedral complexes. Application of chelates in industries. **(10)**

Unit III: Water: Sources, types of impurities and their effects, hardness of water & its estimation, Numerical on EDTA method, treatment of water for domestic & industrial purposes, sedimentation, coagulation, filtration, types of filters, Sterilization- chlorination, break point chlorination, Ozonization. Removal of hardness of water: Lime- soda process, types, Numerical on lime- soda process, Zeolite process, its advantages and disadvantages, comparison with L-S Process, Numerical based on zeolite process, Ion- exchange process, demineralization process. Boiler troubles:-Carry over- priming & foaming-causes & prevention, sludge & scales, Causes of scale formation and prevention methods, Corrosion & caustic embrittlement causes & prevention. **(12)**

Unit IV: Cement: Raw materials, constitutional compounds& its properties, Process parameters, Manufacture of Portland cement by wet and dry process, setting and hardening of cement, Cement additives & admixtures. Types of Portland cement. **(5)**

Unit V: Glass: Definition & Chemistry of glass making , raw materials, composition & properties of different types of glass, manufacture of glass wares such as bottles, window glass, tubes.Safety glss & coloured glass. **(5)**

Unit VI: Ceramics: Definition & types, Basic raw materials used, fabrication methods, drying & firing of ceramic products, glazing. **(4)**

Refractories: Definition, requisites of good refractory material, classification & properties of refractory, raw materials, manufacture of refractory products, application in industries. **(3)**

Books Recommended:

1. A Text Book of Engineering Chemistry, by S.S.Dara, S.Chand & Co., New Delhi.
2. A Text Book of Engineering Chemistry, by Jain & Jain, Dhanpat Rai Publishing Co., New Delhi.
3. Industrial Chemistry by B.K.Sharma Goel Pub. House, Meerut.
4. Advanced Inorganic Chemistry, Vol.II, by Satya Prakash, G.D.Tuli, S.K.Basu & R.D.Madan.

First Semester)

Physics (CT (BGE) 1.04)

(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

UNIT – I Viscosity Streamline flow, Turbulent motion, Critical velocity, Viscosity, Coefficient of viscosity, Poiseulle's equation, Stoke's method, Ostwald viscometer, Numericals

UNIT – II Surface tension Surface Tension, Excess pressure inside a liquid drop and soap bubble, Angle of contact, Searl's Torsion balance method, Jaeger's method, Quincke's method, Interfacial surface tension, Numericals

UNIT – III Interference Plane parallel thin film, Wedged shaped thin film, Newton's rings, Applications: Determination of wavelength and Refractive Index of liquid, Test of surface finish, Antireflection coating, Dielectric mirror, Numericals .

UNIT – IV Polarization of light Types of polarization: Plane polarized light, circularly polarized light, elliptically polarized light and unpolarized light. Production of plane polarized light: Polarization by reflection, refraction, scattering, selective absorption, double refraction, Nicol prism. Polarizer and Analyzer, Optic axis, Principal section. Differences between: o-ray and e-ray, positive and negative crystals, HWP and QWP. Analysis of polarized light, Optical activity and specific rotation. Numericals .

UNIT – V Lasers Three quantumn processes: Absorption, Spontaneous emission and Stimulated emission. Metastable state, Conditions for light amplification, Pumping schemes: Three level pumping scheme, Four level pumping scheme. Optical resonator, Laser beam characteristics, Ruby laser and He-Ne laser.

UNIT – VI Pumps and gauges Rotary Oil Pumps:-Rotary –vane Oil Pump, Stationary vane rotary oil pump, Geissler pump, Diffusion-Condensation pump

Guages:- McLoed Vacuum Guage, Pirani Resistance Guage, Thermocouple Guage, Knudsen Guage.

Books Recommended

1.Elements of properties of matter By D.S.Mathur

2.Text book of Engineering Physics By Avadhanulu and Kshirsagar

(First Semester)
Basic Mechanical Technology (CT (BGE) 1.05)

(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

UNIT 1: Introduction to Production Technology, Fundamentals of metals and alloys, Properties testing and inspection, Ferrous metals and alloys, Non ferrous metals and alloys, heat treatment.

UNIT 2: Pattern making and Foundry, Powder Metallurgy

UNIT 3: Welding, Smithing and Forging, Mechanical Working.

UNIT 4: Bench work and Fitting, Wood and Wood working, Plastic processing, Plumbing threaded fasterns and joints, Sheet metal works.

UNIT 5: Theory of cutting, tool driving mechanism and salient features if construction of machine tools, specification, types construction and operation on lathe, Drill and Grinders. Introduction to Capstan and Turrets.

UNIT 6: Limits, fits and Surface Quality, Surface finishing processes, surface Coating of metals, Non traditional machining, introduction to numerical control of machine tools, processes planning and evaluation techniques CAD, CAM and CIM.

BOOKS RECOMMENDED:-

1) Elements Of Workshop Technology Vol -1 Manufacturing Processes -Hajra Choudhary
2) Elements Of Workshop Technology Vol 2 Machine Tools -Hajra Choudhary
3) A textbook of production technology (manufacturing processes) -P.C.Sharma
4) Introduction To Basic Manufacturing Process & Workshop Technology -Rajender Singh
5) A Textbook of Manufacturing Processes Workshop Technology -R S Khurmi, J K Gupta
6) Manufacturing Engineering and Technology -Serope Kalpakjian

(First Semester)

Ethical Science (CT (BGE) 1.06)

(Total Credits: 02)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: -	**T (U) : ---** **T (I) :** 50 Marks
	Duration of internal Exam. : 02 Hours

(First Semester)

APPLIED PHYSICAL CHEMISTRY PRACTICAL (CT (BGE) 1.07)

(Total Credits: 02)

Teaching Scheme

Practical: 3 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. **:** 06 Hours

LIST OF EXPERIMENTS

1. To determine the surface tension & Parachor value of liquid using Stalagmometer.
2. To Study the viscosity of pure liquid using Oswald's Viscometer.
3. To study the effect of addition of NaCl on the solubility of Benzoic acid.
4. To determine the heat of solution of an organic acid by the solubility method.
5. To study the distribution of Iodine between CCl_4 and water, and hence determine the partition co-efficient of Iodine between two.
6. To study the molecular condition of benzoic acid in Toluene by determining the partition co-efficient between Toluene and water.
7. To study the effect of addition of KCL on the solubility of Salicylic acid.
8. To study the kinetics of hydrolysis of Methyl acetate by a strong acid.
9. To study the kinetics of the reaction between Potassium Persulphate and Potassium-Iodide.
10. To study the miscibility of Phenol and water at various temperatures.
11. To determine the molecular weight of a compound using Rast's camphor method.
12. To study the relative strength of acids using method of kinetics.

(First Semester)

Applied Inorganic Chemistry (CT (BGE) 1.08)

(Total Credits: 02)

Teaching Scheme

Practical: 3 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. **:** 06 Hours

LIST OF EXPERIMENTS

1. Estimation of Total Hardness by Complexometric Method in a given Sample of water.
2. Estimation of Calcium and Magnesium hardness in a given sample of water.
3. Estimation of Nickel by Complexometric Method in a given Sample of water.
4. Estimation of total alkalinity in the given water sample.
5. Estimation of Copper in the given solution of copper sulphate by Iodometry Method.
6. Estimation of Strength of Potassium Dichromate using Sodium Thiosulphate by Iodometry Method .
7. Estimation of Strength of Ferrous ammonium sulphate using Potassium Dichromate and SDS as an internal indicator.
8. Estimation of Strength of Ferrous ammonium sulphate using Potassium Dichromate and Potassium Ferricyanide as external indicator.
9. Estimation of Strength of Hydrogen peroxide using $KMno_4$.
10. Estimation of Strength of HCl using Borax.
11. Estimation of Chloride ions in a given solution by Argentometry method.
12. Estimation of Al^{3+} using EDTA by back titration method.

(First Semester)

APPLIED PHYSICS- I PRACTICAL (CT (BGE) 1.09)

(Total Credits: 02)

Teaching Scheme

Practical: 3 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. : 06 Hours

LIST OF EXPERIMENTS

1. To determine the coefficient of viscosity of liquid using Stoke's method.
2. Study of Ostwald's viscometer.
3. To determine the coefficient of viscosity of liquid using Poiseulle's method.
4. To determine the surface tension of liquid using Searl's Torsion Balance method.
5. To determine the surface tension of liquid using Jaeger's method.
6. To determine the surface tension of liquid using Quincke's method.
7. To determine the Interfacial surface tension between the two immiscible liquids.
8. To determine the radius of curvature of a plano convex lens using Newton's rings method.
9. To determine the principle refractive indices of double refracting Quartz prism.
10. Demonstration of Lasers.

(Second Semester)
WORKSHOP (CT (BGE) 1.10)
(Total Credits: 02)

Teaching Scheme

Practical: 2 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. **:** 06 Hours

Teachers/Instructors are expected to introduce the students with the tools & equipments used in following workshop sections with their operations & safety precautions.

1. Fitting Shop
2. Carpentry
3. Welding
4. Smithy

Students are expected to prepare minimum four Jobs during practical periods of workshop.

Text/Reference Books:

1. Elements of Workshop Technology VOL- I by S.K. Hajra Choudhary, A.K. Hajra Choudhary, Nirjhar Roy
2. Elements of Workshop Technology VOL- II by S.K. Hajra Choudhary, A.K. Hajra Choudhary, Nirjhar Roy

(First Semester)

COMPUTATIONAL SKILL PRACTICAL (CT (BGE) 1.11)

(Total Credits: 02)

Teaching Scheme

Practical: 2 Hours / Week

Examination Scheme

Practical

P (U) : -- **P (I) :** 25 Marks

Duration of Internal Practical Exam: 02 Hrs

LIST OF EXPERIMENTS

Practical 1 Multi-media

Creates a simple slide show with text, images, Inserts slides, Chooses appropriate slide design and layout, Add sounds, Creates a master slide template,Understands that a presentation is clear, concise and logical, Understands navigation buttons/hyperlinks,Recognises elements of a multi-media presentation.

Practical 2 **Internets**

Understands purpose of a browser, understands the general structure of a web address, Equates URL with web address, uses and understands the features of a browser (back, forward, stop, search, refresh, history, home buttons, address bar, loading status), Understands key features of a web page (links, site map, feedback, email),Uses and understands hyperlinks buttons.

Practical 3 **Spreadsheets**

Understands the purpose/structure of a spreadsheet, Interprets data from an existing spreadsheet, Understands terminology - column, row, cell, cell range, Understands cell addressing, Understands active cell

Enters data (labels, values) in a cell, Formats data in a cell eg. bold, alignment, Generates appropriate graphs eg. bar, column, line etc.

Practical 4 Databases

Understands structure/purpose of a database, Understands strengths and weaknesses of databases,Understands basic terminology - fields, records, files,Opens and uses a commercial database eg. electronic encyclopaedias

Locates specific information searching by subject, key word, author,Locates specific record(s) using find function

Uses relevant fields, Chooses appropriate data types for fields,Sorts data,Adds/deletes records,Edits data in an existing record

Practical 5 C Language**.**

Practical based on C language, Basic concept of C, data types, variables, constants, and there use in Program,

Program to find out the factorial, Fibonacci sequence.

Practical 6 IF Structure**.**

Write a program using IF ELSE structure,to find out the grade of the student when the marks of four subjects are given,the method of assigning grade is as follows:If per>=85 then grade A,if per<85 then B ,if per>70 & per>= 55 then C,If per<55 &per>=40 then D else E.

Practical 7 For & While Loop**.**

Write a Program in C to demonstrate the use of for and While loop.

Practical 8 Arrays
Write a program in C to search an item in an array using Linear & Binary search and also sort an array either in ascending or descending order and implement single dimensional arrays & two dimensional arrays.

Practical 9 Inheritance
Write a Program in C to demonstrate the use of Single, Multiple, Multilevel, Hybrid Inheritance.

Practical 10 Function
Write a Program in C to demonstrate the use of Function like Friend Function, Inline Function.

Books Recommended:

1. Fundamental of computers: Rajaraman V, Prentice Hall of India Ltd, New Delhi, 1990.
2. The C Programming Language: Dennis Ritchie & Brain Kernighan [Pearson].

1

Engineering and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Engineering

(Second Semester)
Engineering Mathematics – II (CE (BGE) 2.01)
(Total Credits: 04)

Teaching Scheme	Examination Scheme
Lectures: 3Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

UNIT - I : Ordinary differential Equation and Higher Order Differential Equation

Differential Equations: First order first degree differential equations: Linear, reducible to linear and exact differential equations. Higher order differential equations with constant coefficient, method of variation of parameters. Cauchy's and Legendre's homogeneous differential equations, simultaneous differential equations.

UNIT - II : Fourier Series

Fourier series , expansion of function ,Even and odd function, Half range fourier series, Change of interval, Harmonic analysis.

UNIT - III : Series Solution

Method of infinite series solution for ordinary D. E. when x = o as a ordinary point & x = a as a regular singular point

UNIT - IV : Special Function

Bessel's equation, Bessel's functions: recurrence relations, orthogonality property, generating function, Legendre's equation, Legendre Polynomials: Rodrigue's formula generating function, recurrence relations, orthogonality property,

UNIT – V : Vector Calculus

Definition of vector scalar function & vector point function , gradient ,directional derivative , divergence and curl , Line , surface and volume integral , Gauss divergence theorem , Stokes Theorem and Green theorem(excluding proof) .

UNIT – VI : Difference equation and Numerical Method

A) Homogeneous and non – homogeneous differential equation with constant coefficient, first order linear difference equation with constant coefficient.
B) Numerical solution of ordinary and higher differential equation: Picard method , Euler's method , Taylors method and Runga – Kutta method

Books Recommended:

1. Higher Engineering Mathematics by H.K. Das, Er.Rajnish Verma
2. A text book of engineering mathematics by N.P. Bali, Manish Goyal
3. A text book of engineering mathematics (Vol –I,Vol-II) by Dr. D.T. Deshmukh
4. Higher Engineering Mathematics by B.S. Grewal

(Second Semester)
Applied Physical Chemistry (CE (BGE) 2.02)
(Total Credits: 03)

Teaching Scheme
Lectures: 2 Hours/ Week
Tutorial: 1 Hours / Week

Examination Scheme
Theory
T (U) : 80 Marks **T (I) :** 20 Marks
Duration of University Exam. : 03 Hours

Unit 1: Equation of State for ideal and real gases, Critical Phenomena, principal of corresponding states, compressibility factor, Principle of Equipartition of Energy, and Joule-Thomson effect.

Unit 2: The first law of Thermodynamics, reversible processes, enthalpy, heat capacity, isothermal and adiabatic processes, thermochemistry laws, standard heats of formation, the bomb calorimeter, flame and explosion temperatures.

Unit 3: The second law of thermodynamics, the Carnot theorem and Carnot Cycle, the refrigeration engine.

Unit 4: Entropy and irreversible processes. The free energy, work function and Gibbs Helmholtz equation, the criteria of Chemical Equilibrium.

Unit 5: Objectives of chemical Kinetics, elementary reaction steps and rate expressions, order of reaction. Factors influencing the reaction rates. Integrated rate expression with examples. Methods for determining the order of chemical reaction.

Unit 6: Radiation chemistry, photochemical reactions, laws of photochemistry, photochemical combination of hydrogen and chlorine.

Books Recommended:

1. Thermodynamics for chemists by S. Glasstone, D Van Nostrand Inc, New York.
2. Physical Chemistry by G.M. Barrow, Benjamin Publishers, New York.
3. Physical Chemistry by Sheehan, W.F. Prentics hall of India, Pvt Ltd., New Delhi 1963
4. Principles of Physical Chemistry by Puri and Sharma, S.Chand and Co. New Delhi
5. An Introduction to Chemical Thermodynamics by R P Rastogi and R R Mishra
6. Physical Chemistry through problems, S. Dogra and S. K. Dogra

(Second Semester)
APPLIED PHYSICS II (CE (BGE) 2.03)
(Total Credits: 03)

Teaching Scheme	Examination Scheme
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks **Duration of University Exam. :** 03 Hours

UNIT –I Basic Semiconductor devices Classification of solids on the basis of band gap theory into insulators, semiconductors and conductors, Symbol and formation of a diode, P-N Junction diode: Forward and reverse bias characteristics, Zener diode: Forward and reverse bias characteristics, Avalanche breakdown Applications: Half wave rectifier & Full wave rectifier, LED, Photodiode

Intrinsic semiconductors; Extrinsic semiconductor, Germanium and silicon, Transistors: PNP and NPN. Configuration: - CB, CE and Solar cell.

UNIT – II Crystal structure and X-Rays Crystal structures: SC, BCC & FCC, Miller Indices and Planes, Interplanar distance, Numericals.

Production of X-Rays: Coolidge tube, Origin of X-rays, Properties of X-rays, Applications of X-Rays, Bragg's law and Bragg's X-ray spectrometer.

UNIT – III Instrumental analysis Thermal analysis: Differential thermal analysis(DTA), Thermogravimetric analysis(TGA), Differential Thermogravimetric analysis(DTGA), Differential scanning calorimetry(DSC), Atomic absorption spectrometry(AAS).

UNIT –V Ultrasonics Magnetostriction Effect, Pierce Oscillator, Piezoelectric Effect, Piezoelectric Oscillator, properties and applications, Numericals.

UNIT – V Optical Fibres Optical fibers; structure, Propagation of light through a cladded fibre, Acceptance angle, acceptance cone, Fractional refractive index change, Numerical aperture, Modes of propagation; Types of Optical fibres: Single mode step index fibre , Multimode step index fibre,Graded Index fibre, V-number Attenuation, Dispersion: Material dispersion, Waveguide dispersion, Intermodal dispersion; Applications: Medical, Military and Communication applications; sensors. Numericals.

UNIT- VI Nanotechnology Introduction to Nanotechnology, Quantumn nature of the Nanoworld, Methods of preparation:Top Down, Bottom Up approach, Chemical vapour deposition, sol-gel process, RF Plasma, Thermolysis. Characterisation of Nano materials: Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM)**.** Applications: Energy, Medical application, Information and communication, Displays, Nanoparticles in coating.

Books Recommended

1. Text book of Engineering Physics By Avadhanulu and Kshirsagar
2. Instrumental methods of analysis By H.W.Willard
3. Material Science and Engineering By R.K.Rajput
4. Physics for Engineers By M.R.Srinivasan

(Second Semester)
Basic Electrical Engineering (CE (BGE) 2.04)
(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks **Duration of University Exam. :** 03 Hours

Unit 1:The Electrical Circuits, Concepts of Voltage, Current, Resistance, Resistance in series and in parallel, Kirchoff's laws, Super position ,Analysis of simple circuits. Effect of temperature on resistance and temperature coefficient of resistance.

Magnetic Circuits, Concepts of M M F, Flux, reluctance, Magnetising Force, Leakage Flux, B – H Curve, Hysterisis and Eddy Current Power loss, Properties of common magnetic materials. Analysis of magnetic circuits.

Unit 2:A.C. Fundamentals, Concept of A C Currents and voltages, Mathematical representations in the form of Vectors and waves, R M S and average values, Form Factors, Phase and Phase difference, Concept of Inductance, Capacitance, Reactance, Impedance, Power and Power Factor.

Unit 3:Transformers – General theory of transformers, Phasor Diagrams, Equivalent Circuits, Open and Short circuit tests, Regulation, Normal and all day Efficiency of transformer

Unit 4:General Principles of electrical Motors and Generators, Synchronous Machines, Construction, E M F and Frequency equations, Behaviour on Load, Synchronous impedance, Open Circuit and Short Circuit tests. Regulation, Principle of rotation, V Characteristics and its applications.

Unit 5:Induction Motors, Principle of rotation and construction of three phase induction motors, Phasor diagrams, operating characteristics, Induction motor starters. Working Principle and application of single phase induction motors

Unit 6:Power generation, working of thermal, hydro and nuclear power stations.

Books recommended:

1. Elements of Electrical Science by P. Mukhopadhyaya -Nem Chand & Bros.

2. A textbook of electrical technology Vol. I&II, B.L.Theraja (M/s S.Chand & Co. W. Delhi).

3. Electrical Technology: Cotton (wheeler)

4. Introduction to Electrical Engineering by Naidu, Kamakshaiah, Tata McGrawHill.

5. Basic Electrical Engineering by H. Cotton.

6. A Textbook of Electrical Engineering Electrical Engineering Vol. I & II by B.L.Theraja, S. Chand & Co.

7. A Textbook of Basic Electrical Engineering by S.B. Bodkhe, N.M.Deskar, Professional Publishing House Pvt. Ltd.

8. Electric Machinery by Nagrath, Kothari, Tata McGraw Hill.

9. Basic Electrical Engineering- S.B.Bodkhe & Deshkar

(Second Semester)

Basic Mechanical Engineering (CE (BGE) 2.05)

(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

UNIT 1: Introduction to Production Technology, Fundamentals of metals and alloys, Properties testing and inspection, Ferrous metals and alloys, Non ferrous metals and alloys, heat treatment.

UNIT 2: Pattern making and Foundry, Powder Metallurgy

UNIT 3: Welding, Smithing and Forging, Mechanical Working.

UNIT 4: Bench work and Fitting, Wood and Wood working, Plastic processing, Plumbing threaded fasterns and joints, Sheet metal works.

UNIT 5: Theory of cutting, tool driving mechanism and salient features if construction of machine tools, specification, types construction and operation on lathe, Drill and Grinders. Introduction to Capstan and Turrets.

UNIT 6: Limits, fits and Surface Quality, Surface finishing processes, surface Coating of metals, Non traditional machining, introduction to numerical control of machine tools, processes planning and evaluation techniques CAD, CAM and CIM.

BOOKS RECOMMENDED:-

1) Elements Of Workshop Technology Vol -1 Manufacturing Processes -Hajra Choudhary

2) Elements Of Workshop Technology Vol 2 Machine Tools -Hajra Choudhary

3) A textbook of production technology (manufacturing processes) -P.C.Sharma

4) Introduction To Basic Manufacturing Process & Workshop Technology -Rajender Singh

5) A Textbook of Manufacturing Processes Workshop Technology -R S Khurmi, J K Gupta

6) Manufacturing Engineering and Technology -Serope Kalpakjian

6

(Second Semester)

Ethical Sciences (CE (BGE) 2.06)

(Total Credits: 02)

Teaching Scheme
Lectures: 2 Hours/ Week
Tutorial: -

Examination Scheme
Theory
T (U) : -- **T (I) :** 50 Marks
Duration of Internal Exam. : 02 Hours

Unit-I

1. Concept of Culture and Civilization
2. Applied Humanities and Social Engineering
3. Socio-Legal Awareness: Right to Information(RIL), Public Interest Litigation(PIL), Intellectual Property Rights(IPR) & Patents, Lokpal and Lokayukta

Unit-II

1. Meaning and Scope of Industrial Psychology and Industrial Sociology
2. Fatigue, Selection and Training of Workers, Motives for work in industry
3. Transactional Analysis

Unit-III

1. Sustainable Development
2. Professional Ethics
3. Organizational Behavioral Dynamics: Leadership in Industry

Unit-IV

1. Indian Constitution and Federal System
2. Fundamental Rights and Directive Principles of State Policy
3. Role of Bureaucracy in Modern Society

Unit-V

1. Industrial Democracy
2. Works Organization: Power, Authority and Status system; Formal and Informal Organization
3. Industrialization, Urbanization: Study of Slums

Books:

1) A New Look into Social Sciences- Shabbir, Sheik and Dwadashiwar
2) An Introduction to Sociology- Vidya Bhushan and Sachdeva
3) Social Science: The Indian Scene-Yogesh Atal
4) Applied Humanities-Rajni Tandon
5) A History of World Civilizations-J.E.Swain
6) Industrial Psychology-Haire Mason
7) Introduction to Constitution of India- Durga Das Basu
8) Industrial Sociology in India-N.R.Seth
9) Human Resource Development and Management- Dr.A.M.Sheikh
10) The Economics of Sustainable Development-Surender Kumar

7

(Second Semester)

APPLIED PHYSICAL CHEMISTRY PRACTICAL (CE (BGE) 2.07)

(Total Credits: 02)

Teaching Scheme

Practical: 3 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. : 06 Hours

LIST OF EXPERIMENTS

1. To determine the surface tension & Parachor value of liquid using Stalagmometer.
2. To Study the viscosity of pure liquid using Oswald's Viscometer.
3. To study the effect of addition of NaCl on the solubility of Benzoic acid.
4. To determine the heat of solution of an organic acid by the solubility method.
5. To study the distribution of Iodine between CCl_4 and water, and hence determine the partition co-efficient of Iodine between two.
6. To study the molecular condition of benzoic acid in Toluene by determining the partition co-efficient between Toluene and water.
7. To study the effect of addition of KCL on the solubility of Salicylic acid.
8. To study the kinetics of hydrolysis of Methyl acetate by a strong acid.
9. To study the kinetics of the reaction between Potassium Persulphate and Potassium-Iodide.
10. To study the miscibility of Phenol and water at various temperatures.
11. To determine the molecular weight of a compound using Rast's camphor method.
12. To study the relative strength of acids using method of kinetics.

(Second Semester)
APPLIED PHYSICS- II PRACTICAL (CE (BGE) 2.08)

(Total Credits: 02)

Teaching Scheme

Practical: 3 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. : 06 Hours

List of Experiments

1. To study the characteristics of a pn-junction diode in forward and reverse bias & determine its cut in voltage, static & dynamic resistance.
2. To study the characteristics of a zener diode in forward and reverse bias & determine its breakdown voltage.
3. To determine the Energy gap Eg of semiconductor using PN junction diode in reverse bias mode.
4. Study of Hall Effect.
5. To study the input and output characteristics of a transistor in Common base mode & calculate input resistance and current gainα.
6. To study the input and output characteristics of a transistor in Common emitter mode & calculate input resistance and current gain β.
7. To determine the Electrical conductivity by Four Probe method.
8. Study of Optical Fibre kit.
9. To determine the wavelength of sodium light using plane diffraction grating.

9

(Second Semester)

Basic Electrical Engineering Practical (CE (BGE) 2.09)

(Total Credits: 01)

Teaching Scheme

Practical: 2Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. : 06 Hours

List of Experiments

1. Study and verify kirchoffs laws.

2. Study and verify superposition theorem.

3. To plot B-H curve for magnetic material of single phase transformer.

4 . To plot phasor diagram for series RLC circuit.

5. To plot phasor diagram for parallel RLC circuit.

6. To determines the resistance and Inductance of Choke.

7. Find efficiency and regulation for single phase transformer by open and short circuit test.

8. Find efficiency and regulation by direct loading method of single phase transformer.

9. Speed control method of slip ring induction motor by rotor resistance method.

10. Speed control and reversal of phase of induction motor by voltage variation method.

11. To find regulation of alternator by open circuit and short circuit test.

Textbook for Practical Work:

1. A text Book on Laboratory Course in Electrical Engineering by S.G. Tarnekar

& P.K. Kharbanda, M/s. S. Chand & Co., NEW DELHI.

<u>10</u>

(Second Semester)

WORKSHOP (CE (BGE) 2.10)

(Total Credits: 02)

Teaching Scheme

Practical: 2 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. **:** 06 Hours

Teachers/Instructors are expected to introduce the students with the tools & equipments used in following workshop sections with their operations & safety precautions.

1. Fitting Shop
2. Carpentry
3. Welding
4. Smithy

Students are expected to prepare minimum four Jobs during practical periods of workshop.

Text/Reference Books:

1. Elements of Workshop Technology VOL- I by S.K. Hajra Choudhary, A.K. Hajra Choudhary, Nirjhar Roy
2. Elements of Workshop Technology VOL- II by S.K. Hajra Choudhary, A.K. Hajra Choudhary, Nirjhar Roy

Engineering and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Technology

(Second Semester)
Engineering Mathematics – II (CT (BGE) 2.01)
(Total Credits: 04)

Teaching Scheme
Lectures: 3Hours/ Week
Tutorial: 1 Hours / Week

Examination Scheme
Theory
T (U) : 80 Marks **T (I) :** 20 Marks
Duration of University Exam. : 03 Hours

UNIT - I : Ordinary differential Equation and Higher Order Differential Equation

Differential Equations: First order first degree differential equations: Linear, reducible to linear and exact differential equations. Higher order differential equations with constant coefficient, method of variation of parameters. Cauchy's and Legendre's homogeneous differential equations, simultaneous differential equations.

UNIT - II : Fourier Series

Fourier series , expansion of function ,Even and odd function, Half range fourier series, Change of interval, Harmonic analysis.

UNIT - III : Series Solution

Method of infinite series solution for ordinary D. E. when $x = o$ as a ordinary point & $x = a$ as a regular singular point

UNIT - IV : Special Function

Bessel's equation, Bessel's functions: recurrence relations, orthogonality property, generating function, Legendre's equation, Legendre Polynomials: Rodrigue's formula generating function, recurrence relations, orthogonality property,

UNIT – V : Vector Calculus

Definition of vector scalar function & vector point function , gradient ,directional derivative , divergence and curl , Line , surface and volume integral , Gauss divergence theorem , Stokes Theorem and Green theorem(excluding proof) .

UNIT – VI : Difference equation and Numerical Method

A) Homogeneous and non – homogeneous differential equation with constant coefficient, first order linear difference equation with constant coefficient.
B) Numerical solution of ordinary and higher differential equation: Picard method , Euler's method , Taylors method and Runga – Kutta method

Books Recommended:

1. Higher Engineering Mathematics by H.K. Das, Er.Rajnish Verma
2. A text book of engineering mathematics by N.P. Bali, Manish Goyal
3. A text book of engineering mathematics (Vol –I,Vol-II) by Dr. D.T. Deshmukh
4. Higher Engineering Mathematics by B.S. Grewal

(Second Semester)

Applied Organic Chemistry (CT (BGE) 2.02)

(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

Unit 1 Aromatic hydrocarbon Preparation, properties and Industrial uses, and its structure determination of Benzene, Naphthalene.

Alcohol - monohydric alcohol. e.g. ethyl alcohol, di hydric alcohol. e.g. ethylene glycol, trihydric alcohol e.g. glycerol.-its study . Preparations, properties and Industrial uses.

Heterocyclic hydrocarbon- total synthesis, preparations, properties and uses of Pyrrole, Indigo.

Unit 2 Carbohydrates Industrial uses and structure determination of glucose, saccharin.

Acids and esters Preparations and properties and uses of Acetic acid, , Acetoacetic acid, Malonic acid and their esters.

Amines- Preparations and properties and uses of mono-, di -, tri- ethyl amines ,Aniline and diazotization with special reference to formation of azo dyes - e.g. Aniline yellow, Methyl Red, Congo Red.

Unit 3 Nitration, nitrating agents, Kinetics and Mechanism of aromatic nitration process, Equipments for nitration, typical industrial nitration process e.g. preparation of nitrobenzene, nitro acetanilide.

Unit 4 Halogenation, Thermodynamics and Kinetics of halogenation reactions. Apparatus and materials for construction. Technical preparation of chloral and vinyl chloride.

Unit 5 Sulphonation and sulphation: Sulphonating and sulphating agents. Mechanism of sulphonation Industrial Equipments: Technique and Technical Preparation of dodecyl Benzene Sulphonate, Sulphation of Lauryl Alcohol, Dimethyl ether.

Unit 6 Principles of Polymer Chemistry, Industrial Practices and applications, Techniques of Polymerization, Types of Polymerization Examples: Addition and Condensation Polymerization, Mechanism of Additional Polymerization. Study of Polymers e.g. PVC, PVA, Conducting Polymer- Polyaniline, Polypyrroles, Polythiophenes, .

Books Recommended:

1. Text book of Organic Chemistry- by P.L.Soni, H. M. Chawala
2. Text book of Organic Chemistry – By Arun Bahal, B.S. Bahal
3. Unit Processes in Organic Synthesis- by P. H. Groggins
4. Principles of Polymer Chemistry- by Vasant Gowarikar
5. Chemistry of Organic Natural Products Vol-1 and 2- by O. P. Agrawal

(Second Semester)
APPLIED PHYSICS II (CT (BGE) 2.03)
(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks **Duration of University Exam. :** 03 Hours

UNIT –I Basic Semiconductor devices Classification of solids on the basis of band gap theory into insulators, semiconductors and conductors, Symbol and formation of a diode, P-N Junction diode: Forward and reverse bias characteristics, Zener diode: Forward and reverse bias characteristics, Avalanche breakdown Applications: Half wave rectifier & Full wave rectifier, LED, Photodiode

Intrinsic semiconductors; Extrinsic semiconductor, Germanium and silicon, Transistors: PNP and NPN. Configuration: - CB, CE and Solar cell.

UNIT – II Crystal structure and X-Rays Crystal structures: SC, BCC & FCC, Miller Indices and Planes, Interplanar distance, Numericals.

Production of X-Rays: Coolidge tube, Origin of X-rays, Properties of X-rays, Applications of X-Rays, Bragg's law and Bragg's X-ray spectrometer.

UNIT – III Instrumental analysis Thermal analysis: Differential thermal analysis(DTA), Thermogravimetric analysis(TGA), Differential Thermogravimetric analysis(DTGA), Differential scanning calorimetry(DSC), Atomic absorption spectrometry(AAS).

UNIT –V Ultrasonics Magnetostriction Effect, Pierce Oscillator, Piezoelectric Effect, Piezoelectric Oscillator, properties and applications, Numericals.

UNIT – V Optical Fibres Optical fibers; structure, Propagation of light through a cladded fibre, Acceptance angle, acceptance cone, Fractional refractive index change, Numerical aperture, Modes of propagation; Types of Optical fibres: Single mode step index fibre , Multimode step index fibre,Graded Index fibre, V-number Attenuation, Dispersion: Material dispersion, Waveguide dispersion, Intermodal dispersion; Applications: Medical, Military and Communication applications; sensors. Numericals.

UNIT- VI **Nanotechnology** Introduction to Nanotechnology, Quantumn nature of the Nanoworld, Methods of preparation:Top Down, Bottom Up approach, Chemical vapour deposition, sol-gel process, RF Plasma, Thermolysis. Characterisation of Nano materials: Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM). Applications: Energy, Medical application, Information and communication, Displays, Nanoparticles in coating.

Books Recommended

1. Text book of Engineering Physics By Avadhanulu and Kshirsagar
2. Instrumental methods of analysis By H.W.Willard
3. Material Science and Engineering By R.K.Rajput
4. Physics for Engineers By M.R.Srinivasan

(Second Semester)

Basic Electrical Technology (CT (BGE) 2.04)

(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

Unit 1:The Electrical Circuits, Concepts of Voltage, Current, Resistance, Resistance in series and in parallel, Kirchoff's laws, Super position ,Analysis of simple circuits. Effect of temperature on resistance and temperature coefficient of resistance.

Magnetic Circuits, Concepts of M M F, Flux, reluctance, Magnetising Force, Leakage Flux, B – H Curve, Hysterisis and Eddy Current Power loss, Properties of common magnetic materials. Analysis of magnetic circuits.

Unit 2:A.C. Fundamentals, Concept of A C Currents and voltages, Mathematical representations in the form of Vectors and waves, R M S and average values, Form Factors, Phase and Phase difference, Concept of Inductance, Capacitance, Reactance, Impedance, Power and Power Factor.

Unit 3:Transformers – General theory of transformers, Phasor Diagrams, Equivalent Circuits, Open and Short circuit tests, Regulation, Normal and all day Efficiency of transformer

Unit 4:General Principles of electrical Motors and Generators, Synchronous Machines, Construction, E M F and Frequency equations, Behaviour on Load, Synchronous impedance, Open Circuit and Short Circuit tests. Regulation, Principle of rotation, V Characteristics and its applications.

Unit 5:Induction Motors, Principle of rotation and construction of three phase induction motors, Phasor diagrams, operating characteristics, Induction motor starters. Working Principle and application of single phase induction motors

Unit 6:Power generation, working of thermal, hydro and nuclear power stations.

Books recommended:

1. Elements of Electrical Science by P. Mukhopadhyaya -Nem Chand & Bros.

2. A textbook of electrical technology Vol. I&II, B.L.Theraja (M/s S.Chand & Co. W. Delhi).

3. Electrical Technology: Cotton (wheeler)

4. Introduction to Electrical Engineering by Naidu, Kamakshaiah, Tata McGrawHill.

5. Basic Electrical Engineering by H. Cotton.

6. A Textbook of Electrical Engineering Electrical Engineering Vol. I & II by B.L.Theraja, S. Chand & Co.

7. A Textbook of Basic Electrical Engineering by S.B. Bodkhe, N.M.Deskar, Professional Publishing House Pvt. Ltd.

8. Electric Machinery by Nagrath, Kothari, Tata McGraw Hill.

9. Basic Electrical Engineering- S.B.Bodkhe & Deshkar

(Second Semester)

Applied Mechanics (CT (BGE) 2.05)

(Total Credits: 03)

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**Theory**
Tutorial: 1 Hours / Week	**T (U) :** 80 Marks **T (I) :** 20 Marks
	Duration of University Exam. : 03 Hours

UNIT I Basics & Statics of Particles Basic concepts System of Forces, Resolution and composition of forces , system of parallel, concurrent and non concurrent co-planer forces, Resultant.
Equilibrium Of Rigid Bodies Free body diagram , Types of supports and their reactions, requirements of stable equilibrium, Moments and Couples, Varignon's theorem , Equilibrium of Rigid bodies in two dimensions.

UNIT II Centroid and Center of Gravity Centroid of plane and composite figures, Moment of inertia of plane area, Parallel Axes Theorem, Perpendicular axes theorems.
Simple lifting machines Velocity ratio, mechanical advantage and efficiency of simple machines, Law of machine, Differential wheel and axle, Screw Jack, Single and Double purchase crabs.

UNIT III Truss Analysis of simple plane trusses by method of joints and method of sections.
Friction Types of friction, Limiting friction, Laws of Friction, static and Dynamic Frictions, Motion of Bodies.

UNIT IV Dynamics of Particles Displacement velocity and Acceleration (rectilinear and rotary), Motion with uniform and variable acceleration and projectiles , D'Alembert's principle, kinetics of rectilinear translation and rotary motion of rigid body. Dynamic equilibrium in plane motion.

UNIT V Work, Power and Energy, Conservation of Momentum and Energy.

UNIT VI Transmission of power by belts Belt Drivers - Open, Crossed and compound belt drives, length of belt, tensions - tight side, slack side, Power transmitted and condition for maximum power. gears and epicyclic gear trains.

BOOKS RECOMMENDED

1. Engineering mechanics by Timoshenko and Young.
2. Applied Mechanics by Saluja,Satya Prakash.
3. Engineering mechanics by Beer and Johnson.

4. Engineering mechanics by Singer.
5. Engineering mechanics by R.S.Khurmi.
6. Engineering Mechanics by Kumar.
7. Engineering Mechanics by Shames.

(Second Semester)
COMMUNICATION SKILLS (CT (BGE) 2.06)

(Total Credits: 02)

Teaching Scheme **Examination Scheme**

Practical: 2 Hours / Week **Practical**

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. **:** 03 Hours

LIST OF EXPERIMENTS

Following points are to be discussed with the students before conducting the practicals.

A) Principals and Practice of letter writing: Business, Job and Bank Correspondence
B) Technical Report Writing
C) Grammar:
   1. Correction of Common Errors
   2. Exercise on rewrite as directed
   3. Correct use of words, idioms, phrases, prepositions, etc.
D) 1. Principles of Public Speaking
   2. Reading Comprehension
E) 1. Professional Communication Skills (Meaning, Significance, Types, Dimensions & Barriers)

   2. Group Discussion and Personal Interview (Importance of GD, Modules of GD, How to prepare for GD, Meaning, types & techniques of PI, How to prepare for PI)

Books:

1. Public Speaking and Influencing Men in Business- Dale Carnegie
2. Professional Communication Skills-Bhatia and Sheik
3. Business Communication- K.K.Sinha
4. Communication Skills- Dr.P.Prasad
5. Technical Communication- Raman and Sharma
6. High School Grammar and Composition-Wren and Martin
7. Modern English Grammar Usage an Composition –N.Krishnaswamy

Communication Skills Laboratory Practical

Sr.No	Name of the Practical	Activity to be Taken	Medium of Practical
1	Barriers to Communication	1. Intro to various kinds of barriers 2. Activity class on semantic barriers	PPT Based, Activity Based
2	Reading Skills	1. Skimming, Scanning & Gist Reading 2. Comprehending Passages	PPT Based, Activity Based
3	Development of Word Power	1. IPA, Pronunciation techniques 2. Often wrongly pronounced words 3. Word Power, homophones, synonyms/antonyms	Software based PPT Based, Activity Based
4	Non-Verbal Communication	1. Kinesics in comm./Interviews 2. Activities/ role play	Software based PPT Based, Activity Based
5	Speaking Skills	1. Intro of effective way of speaking 2. Oral presentations Extempore/ Debate/JAM	PPT Based, Activity Based
6	Group Discussion	1. GD rules 2. GD of groups in 6	Software based PPT Based, Activity Based
7	Interview Techniques	1. Various types of interviews 2. Resume making 3. Mock Interviews(one to one)	Software based PPT Based, Activity Based
8	Use of Figurative Language	1. Intro phrases/idioms/proverb	PPT Based, Activity

		s 2. Idioms related to color/Number/animals/ parts of the body/Misc.	Based
9	Listening Skills	Listening Barriers	PPT Based, Activity Based
10	Presentation Skills	1. Preparing visual aids/ PPTs 2. Writing references	PPT Based, Activity Based

(Second Semester)

Applied Organic Chemistry Practical (CT (BGE) 2.07)

(Total Credits: 02)

Teaching Scheme

Practical: 3 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. : 06 Hours

LIST OF EXPERIMENTS

1) Separation of Organic Mixtures.

2) Elemental Analysis of C, H, N, Cl, Br, I etc.

3) Functional group detection for example : COOH, $CONH_2$, Primary Amine, Secondary Amine, Tertiary Amine , Carbohydrate, Phenols, Alcohols, etc.

4) Identification of Organic Compounds.

(Second Semester)
APPLIED PHYSICS PRACTICAL (CT (BGE) 2.08)

(Total Credits: 02)

Teaching Scheme

Practical: 3 Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. : 06 Hours

List of Experiments

1. To study the characteristics of a pn-junction diode in forward and reverse bias & determine its cut in voltage, static & dynamic resistance.
2. To study the characteristics of a zener diode in forward and reverse bias & determine its breakdown voltage.
3. To determine the Energy gap Eg of semiconductor using PN junction diode in reverse bias mode.
4. Study of Hall Effect.
5. To study the input and output characteristics of a transistor in Common base mode & calculate input resistance and current gainα.
6. To study the input and output characteristics of a transistor in Common emitter mode & calculate input resistance and current gain β.
7. To determine the Electrical conductivity by Four Probe method.
8. Study of Optical Fibre kit.
9. To determine the wavelength of sodium light using plane diffraction grating.

(Second Semester)

Basic Electrical Technology Practical (CT (BGE) 2.09)

(Total Credits: 02)

Teaching Scheme

Practical: 3Hours / Week

Examination Scheme

Practical

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. : 06 Hours

List of Experiments

1. Study and verify kirchoffs laws.

2. Study and verify superposition theorem.

3. To plot B-H curve for magnetic material of single phase transformer.

4 . To plot phasor diagram for series RLC circuit.

5. To plot phasor diagram for parallel RLC circuit.

6. To determines the resistance and Inductance of Choke.

7. Find efficiency and regulation for single phase transformer by open and short circuit test.

8. Find efficiency and regulation by direct loading method of single phase transformer.

9. Speed control method of slip ring induction motor by rotor resistance method.

10. Speed control and reversal of phase of induction motor by voltage variation method.

11. To find regulation of alternator by open circuit and short circuit test.

Textbook for Practical Work:

1. A text Book on Laboratory Course in Electrical Engineering by S.G. Tarnekar & P.K. Kharbanda, M/s. S. Chand & Co., NEW DELHI.

10

(Second Semester)

ENGINEERING GRAPHICS (PRACTICAL (CT (BGE) 2.10)

(Total Credits: 02)

Teaching Scheme **Examination Scheme**

Practical: 2 Hours / Week **Practical**

P (U) : 25 Marks **P (I) :** 25 Marks

Duration of University Exam. **:** 06 Hours

LIST OF EXPERIMENTS

NOTE – ONLY FIRST ANGLE METHOD OF PROJECTIONS SHOULD BE USED

Introduction to Engineering Drawing & Curves used in Engineering Practice:
Introduction, Use of various drawing instruments, Lettering, Types of lines used in drawing practice, Dimensioning, Types of Scales and representative fraction (R. F.) of scale.
Conic sections- Ellipse, Parabola, Hyperbola, Cycloid, Involute & Archimedean Spiral.

Projections of Points and Lines:
Basic principles of orthographic projection, reference planes, concepts of four quadrants, methods of orthographic projections: First angle projections and Third angle projections, conventions used to represent methods of orthographic projection.
Projections of points in all possible positions w.r.t. reference planes, projections of lines when it is perpendicular to one of the reference planes, when line is inclined to one & parallel to other reference plane, lines inclined to both reference planes. (lines in first quadrant only).

Projections of Planes:
Projection of planes when it is parallel to one of the reference planes, when it is perpendicular to one & inclined to other reference plane, when it is inclined to both reference planes.

Projections of Solids:
Projections of solids when axis is perpendicular to one of the reference planes, when axis is inclined to one & parallel to other reference plane, when axis is inclined to both the reference planes. (Projections of cube, right regular prisms, right regular pyramids, right circular cylinder, right circular cone, tetrahedron).

Orthographic Projections:
Conversion of pictorial view into orthographic views.

Isometric Projections:

Definition of Isometric view/projection, Isometric scale to draw Isometric projection, construction of Isometric view from given orthographic views.

PRACTICAL:
Seven Half imperial size drawing sheets as detailed below:

Sheet No. 1: Lines, Lettering and Dimensioning
Sheet No. 2: Curves (Minimum four problems)
Sheet No. 3: Projection of straight lines (Minimum four problems)
Sheet No. 4: Projection of Planes (Minimum four problems)
Sheet No. 5: Projections of solids (Minimum four problems)
Sheet No. 6: Orthographic Views (To draw three principal views from given isometric View-minimum two problems)
Sheet No. 7: Isometric Views/Projection (minimum four problems on Isometric views/projections)

Text Books:

1. N.D. Bhatt, Elementary Engineering Drawing, Charotor Publishing house, Anand, India.
2. R.K. Dhawan- Engineering Drawing-
3. K. Venu Gopal- Engineering Drawing and graphics+ Autocad-
4. D. N. Johle- Engineering Drawing, Tata McGraw-hill Publishing Co. Ltd.
5. Pakhatkar- Engg. Drawing , Nirali Prakashan

Reference Books:

1. P.S. Gill, Engineering Graphics.
2. N.D. Bhatt, Machine Drawing, Charotor Publishing house, Anand, India.

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Engineering & Technology

Syllabus for

Third Semester B.Tech. Chemical Engineering

Subject : BTCHE 301T (BGE) **Strength of Materials (Theory)**

Lecture : 3 Hours Tutorial : 1 Hour No. of Credits : 4

University : 80 Marks College Assessment : 20 Marks

Duration of Examination : 3 Hours

Unit I Simple Stresses and Strains**:** Introduction; Definition of stress and strain; tensile and compressive stresses; shear stress, Elastic limit, Hooke's law, poission's ratio, modulus of Elasticity, modulus of Rigidity, Bulk Modulus; stresses in composite sections; Volumetric strain; Temperature stresses. Strain Energy Stresses due to different types of axial loading; Gradually applied loads, Suddenly applied loads, Impact loads.

Unit II Shear Forces and Bending moments Definitions; Concept of Shear force and Bending moment; Sign conventions; Shear force and Bending moment diagrams for cantilevers, simply supported beams and beams with overhang; point of contra flexure; member subjected to couples. **Stresses in Beams** Definition; Pure or simple bending, theory of simple bending; Neutral layer, Neutral axis, Moment of resistance, assumptions in the theory of simple bending; Section modulus for rectangular, circular, I section and T section. Flitched Beams Definition; Equivalent section, modular ratio, moment of resistance in flitched beams. Shear stress distribution in Beams sections Shear stress distribution on rectangular, circular, I section and T section.

Unit III Deflection of Beams Member bending into a circular arc; Slope, deflection and radius of curvature; Cantilevers and simply supported beams. Macaulay's method for slope and deflection in cantilevers, simply supported beams and beams with overhang.

Unit IV **Direct and Bending Stresses** Stress distribution of the section of an eccentrically loaded rectangular column; Core of Kern of the section, Circular and hollow sections. **Columns and Struts** Introduction; axially loaded compression members; crushing load; Buckling or critical load, Euler's theory of long columns, assumptions made in Euler's theory; Empirical formulae; Rankine's formula.

Unit V Torsion of Shafts Pure Torsion; Theory of pure torsion; Torsional moment of resistance; assumptions in the theory of pure torsion; Polar modulus; Power transmitted by circular and hollow shafts; Torsional rigidity. Close coiled helical springs Stiffness, deflection, shear stress and Strain energy.

Unit VI Thin Cylinders and Spheres Thin cylinders; Circumferential and Longitudinal stresses; Thin spherical shells. Riveted Connections Types of joints; Lap and Butt joints; Failure of riveted joints; Tearing strength, shearing strength and bearing strength; Efficiency of a joint.

Books Recommended :

1. Strength of Materials by S. Ramamrutham.
2. Strength of Materials by B. C. Punmia
3. Strength of Materials by R S. Khurmi.

Subject : BTCHE 302T (BGE) **Plant Utilities (Theory)**

Lecture : 3 Hours	Tutorial : 1 Hour	No. of Credits	: 4
University : 80 Marks		College Assessment	: 20 Marks
Duration of Examination : 3 Hours			

Unit I Thermodynamics**:** Laws of perfect gases, thermodynamics processes, First and Second Law of thermodynamics, Entropy, The clausius inequality, Steady Flow Processes, carnot Cycle. PROPERTIES OF STEAM**:** Use of steam tables, measurement of dryness fraction, entropy of steam, temperature entropy and mollier charts, clausius clapeynon equation, Rankine Cycle.

Unit II Steam Generators**:** General Description, Boiler Mounting and Accessories, Natural and Artificial Draught, Equivalent Evaporation and Thermal efficiency. Fuels use in boilers – liquids, gaseous and hydrocarbon

Unit III Turbine**:** Theory and working of impulse, reaction and gas turbine. Bleeding and reheating.

Unit IV: Internal Combustion Engine**:** Cycle of operation, two and four stroke cycle, general description of S.I and C. I. engines, ignition, injection and governing.

Unit V: Water: Sources, conditioning and management of water for cooling of hot gases, cooling towers, cooling ponds. Design of chimney. Constructional details and design aspects.

Unit VI: Introduction to refrigeration, various cycles, coefficient of performance. Applications of refrigeration

Books Recommended :

1. Fundamental of Engineering Thermodynamics – John and Howel
2. THERMODYNAMICS An Engineering Approach – Y.A. Cengel and M.A. Boles
3. Applied Thermodynamics – Aestop
4. Applied Thermodynamics – R N Joel

Subject : BTCHE 303T (BGE) **Engineering Mathematics – III (Theory)**

Lecture : 4 Hours	Tutorial : 1 Hour	No. of Credits	: 5
University : 80 Marks		College Assessment	: 20 Marks
Duration of Examination : 3 Hours			

Unit I Laplace Transforms: Important Formulae, Properties of Laplace Transforms, Laplace Transform of Unit Step Function, Impulse Function, Periodic Function, Dirac Delta Function, Bessel Function, Error Function, Inverse Laplace Transforms, Important Formulae of Inverse Laplace Transforms, Properties of Inverse Laplace Transforms, Partial fraction method for Inverse Laplace Transforms, Convolution Theorem, Solutions of ordinary differential equations, simultaneous ordinary differential equations, partial differential equations and evaluation of Integrals using Laplace Transform method.

Unit II Z-Transforms: Properties of Z-Transforms, Inverse Z-Transforms, , Convolution, Convolution property of casual sequence, Transforms of important sequences, Inverse of Z-Transforms by division, solutions of difference equations.

Unit III Partial Differential Equations**:** Solution of first order linear and non-linear Partial Differential Equations, Solution of higher order linear homogeneous Partial Differential Equations and linear non-homogeneous Partial Differential Equations.

Unit IV Applications of Partial Differential Equations: Method of separation of variables for Partial Differential Equations and its use in solving the Partial Differential Equations representing (i) One dimensional wave equation, (ii) One dimensional heat conduction equation in Cartesian co-ordinates and polar co-ordinates and (iii) Two dimensional steady state heat conduction equation.

Unit V Numerical solution of Partial Differential Equations**:** Numerical solution of parabolic, elliptic and hyperbolic Partial Differential Equations using finite difference technique.

Unit VI Calculus of Functions of Complex variables **:** Analytic functions, Cauchy –Riemann conditions in Cartesian co-ordinates and polar co-ordinates, methods for finding conjugate functions, Integration of function of complex variables, Cauchy's integral theorem and integral formula, Residue theorem and its use for evaluating Integrals of function of complex variables, evaluation real definite integrals by contour integration; conformal transformations and bilinear transformations.

Books Recommended :

1. Advanced Engineering Mathematics by H.K. Dass
2. A T Book of Engineering Mathematics by N.P. Bali, Manish Goyal
3. Higher Engineering Mathematics by B.S. Grewal
4. Higher Engineering Mathematics by B.V. Ramana

Subject : BTCHE 304T (BGE) **Numerical Methods & Computer Programming (Theory)**

Lecture : 3 Hours Tutorial : 1 Hour No. of Credits : 4
University : 80 Marks College Assessment : 20 Marks
Duration of Examination : 3 Hours

Unit I Introduction to programming, programming languages, algorithm, flowcharts, C Language: Features of C, data types, Identifiers, Constants, Variables, expressions, Console I/O statement, Selection statements: if-else, switch, Iteration Statements: For, while, do-while, Jump statements: return, go to, break, and continue, comments, and program using these features.

Unit II Macros, Function and Recursion, Structure and Union, Pointers, String, Basics of File handling

.Unit III Concept of Array, Matrix operations in C and Searching, Sorting: Linear search, Binary search, Bubble sort, Insertion sort, Selection Sort.

Unit IV Program to obtain roots of polynomial Equation: Newton-Rapson method, Regular Falsi Method, Muller method, Bisection method, false position method. Programs for interpolation and extrapolation using numerical methods.

Unit V Numerical Integral and Differential equations using: Initial value problems by Euler's method, modified Euler's, Taylor series, Runge-kutta methods, Regression analysis.

Unit VI Optimization techniques, integer programming, Simplex method, dynamic programming, programs for implementation of these method and case study.

Books Recommended:

1. Numerical methods for Scientific and Engg. Computations by M.K. Jain, Srk Iyengar, R.K. Jain, Wiley Eastern Ltd.
2. Numerical methods for Science & Engg. By Stanton R.G., PHI.
3. The C Programming Language: Dennis Ritchie & Brain Kernighan [Pearson].
4 ANSI C: By E Balagurusamy

Subject : BTCHE 305T (BGE) **Applied Physical Chemistry – II (Theory)**

Lecture : 3 Hours No. of Credits : 3

University : 80 Marks College Assessment : 20 Marks

Duration of Examination : 3 Hours

Unit I Thermodynamics I: The chemical potential, Gibb's Duhem equation, Fugacity, Activity, Determination of fugacity,Chemical equilibria only for Homogeneous system- Reaction Isotherm, Relation between Kp,Kc,Kx, The Van't Hoff equation

Unit II Thermodynamics II: The Clausius Clapeyron Equation, The Phase Rule and its derivation, its application to water system and CO_2 system, Simple Eutectic system- Lead Silver system, Nernst distribution law, its applications- Solvent extraction theory and principle

Unit III Thermodynamics of solutions I : Raoult's Law, Vapour Pressures of ideal solutions, Activity of ideal solution, chemical potential of ideal solution, Gibb- Duhem- Margules Equation, Free energy, entropy, and enthalpy of mixing

Unit IV Thermodynamics of solutions II : Vapour Pressures of real solutions, Vapour Pressure-composition and Boiling Point composition Curves of completely Miscible Binary Solutions, Distillation method of immiscible liquids : Fractional distillation and steam distillation, Colligative properties-vapour pressure lowering, Osmotic pressure, Elevation of boiling point, depression of freezing point

Unit V Electrochemistry I : Specific, Equivalent and Molecular conductance, effect of temperature on conductivity, Transport Number, their determination- Hittorf's method and Moving Boundary Method, Kohlrausch's Law, its applications, Debye Huckel Theory of strong electrolytes

Unit VI Electrochemistry II : Reversible electrodes, Reference electrodes, standard electrode potential, Thermodynamics of reversible electrodes, The Nernst Equation, Concentration cells with and without transference, liquid junction potential, Applications of Emf measurements, Hydrolysis of salts

Books Recommended:

1. Thermodynamics for Chemists : S.Glasston, D Van Nostrand Co,New York,USA
2. An Introduction to Thermodynamics : R P Rastogi and R R Mishra
3. Introduction to Electrochemistry : S.Glasston, D Van Nostrand Co,New York,USA
4. Physical Chemistry : G Barrow, Benjamin Publisher, New York,US

5. Physical Chemistry : Vemupalli, Wiley East West
6. Principles of Physical Chemistry : Puri Sharma and Pathania

Subject : BTCHE 306P (BGE) **Numerical Methods & Computer Programming (Practical)**

Practical : 2 Hours No. of Credits : 1

University : 25 Marks College Assessment : 25 Marks

Duration of Examination : 4 Hours

LIST OF EXPERIMENTS

1. Write a simple program in C for Addition, multiplication and division of two numbers.
2. Write a program in C to find whether given year is Leap year or not.
3. Write a program in C for Fibonacci sequence using function.
4. Write a program in C for Factorial Function.
5. Program to illustrate the uses of Array.
6. Write a program in C to demonstrate the use of Selection Statement (If, Else, Switch).
7. Write a program in C to demonstrate the use of Iterative Statement (For While Do While.).
8. Write a program in C for Transpose of matrix.
9. Write a program in C for Matrix Addition and Multiplication.
10. Write a Program in C for Binary Search.
11. Write a Program in C for Linear Search.
12. Write a Program in C for Bubble Sort.
13. Write a Program in C for Insertion Sort, Selection sort.
14. Write a program in C to find a root of non-linear equation by using Newton Raphson method.
15. Write a program in C to implement Euler modified method.
16. Write a program in C to find a root of a quadratic equation using Muller method.
17. Write a program in C to implement Runga-Kutta method.
18. Write a program in C to implement Gauss-Seidal method.
19. Write a program in C to find out equation dy/dx=x+y by using Euler method.
20. Write a program in C to implement Taylor's series.
21. Write a program in C to calculate coefficient of regression.
22. Write a program in C to implement Regula Falsi method.
23. Write a program in C to implement Simpson's 1/3 rd rule.
24. Write a program in C to implement Bisection Method.

Subject : BTCHE 307P (BGE) **Applied Physical Chemistry – II (Practical)**

Practical : 3 Hours No. of Credits : 2

University : 25 Marks College Assessment : 25 Marks

Duration of Examination : 6 Hours

LIST OF EXPERIMENTS

1. To study the $KI_3 \rightarrow KI + I_2$ equilibrium in aqueous solution.
2. To study the ternary system of Toluene-Acetic acid-water

3. To study the adsorption of acetic acid on charcoal and verify the Freundlich adsorption isotherm
4. To determine the heat of crystallization of $CuSO_4 . 5H_2O$.
5. To determine the integral and differential heats of solution of a salt.
6. To determine the thermometric titration curve in the neutralization of strong and weak acids against a strong base.
7. To find the constant of conductivity cell and hence determine the dissociation constant of a weak acid.
8. To determine the solubility of sparingly soluble salts conductometrically
9. To find the pH of buffers and the dissociation constant of an acid using Quinhydrone electrode.
10. To determine the transport number by the e.m.f. method.
11. To study the kinetics of saponification of methyl acetate by sodium hydroxide by conductometry.

Subject: BTCHE 308P (BGE) **Machine Drawing (Practical)**

Practical : 3 Hours No. of Credits : 3

University : 25 Marks College Assessment : 25 Marks

Duration of Examination : 6 Hours

LIST OF EXPERIMENTS

1 ISI Conventions covering the standard practice in Machine Drawing and also use of ISI specifications for limits and fits.

2 Simple exercise in converting pictorial and isometric views into other graphic projections. Sectional views and missing views preparation details and assembly drawing of simple machine parts from actual models.

3 Preparation of free hand proportionate dimensioned sketches of various machine elements such as:

a. Screw threads and fasteners such as nuts, bolts, studs, locking arrangements, foundation bolts, etc.
   i. Rivets and riveted joints, welded joints.
   ii. Keys, cotters and couplings.
   iii. Cottered joint and knuckle joint
   iv. Engine and machine bearing mounts
   v. Bearings and bearing mountings
   vi. Different types of valves.

4 Preparation of working drawings, part lists and assembly drawings of simple machine assemblies.

Fourth Semester B.Tech. Chemical Engineering

Subject : BTCHE 401T (BCHE) **Process Calculations (Theory)**

Lecture : 3 Hours Tutorial : 1 Hour No. of Credits : 4

University : 80 Marks College Assessment : 20 Marks

Duration of Examination : 3 Hours

Unit I Basic principles, the concept of gram atom and gram mole, conversion of units from one system to another, concept of excess reactant, conversion and yield, Selectivity and degree of completion of reaction.

Unit II Ideal gases, partial pressure, vapor pressure, application of ideal gas laws, volume changes with changes of composition, dissociating gases, humidity and saturation, solubility and crystallization.

Unit III Material balance without chemical reaction, recycle, purge and bypass calculations, material balance with chemical reaction.

Unit IV Energy balance without chemical reaction, combined material and energy balances.

Unit V Energy balance with chemical reaction, combined material and energy balances.

Unit VI Fuels and combustion, types of fuels, heating values of fuels, theoretical and excess air, heat and combustion problems

Books Recommended :

1. Stoichiometry and Process Calculation by Narayana K.V., Laxmikutty B. , Prentice Hall of India 2006.
2. Basic Principles and Calculations in Chemical Engineering by Himmalblau D.M. & Riggs, J.B. Prentice Hall of India 6th Edition (2011)
3. Stoichiometry by Bhatt B.I. , Vora S.M. Tata-McGraw-Hill 4th Edition 2004
4. Chemical Process Calculation by Hougen A., Watson, M. John Wiley & Sons, Third Edition 2000

Subject: BTCHE 402T (BGE) **Electronics & Instrumentation (Theory)**

Lecture	: 3 Hours	No. of Credits	: 3
University	: 80 Marks	College Assessment	: 20 Marks
Duration of Examination : 3 Hours			

Unit I Engineering materials: Classification & requirement of engineering materials and their applications, Selection of materials, Physical and mechanical properties of ceramic & composite materials, Polymers, Addition & Condensation polymerization, Copolymerization, Structure & properties of polymers, Plastic.

Unit II Magnetic materials: Classification of magnetic materials, Magnetic dipole, Dipole moment, Magnetic field strength, Magnetization, Magnetic permeability, Magnetic domains, B-H curve, Hard and Soft magnetic materials, Ferrites and its applications.

Unit III Band theory of solids: Energy gap in solids, Classification of solids, Intrinsic and extrinsic semiconductors, Conductivity of semiconductor materials and its temperature dependence, semiconductor devices: photo diodes, LED, Photo Cell.

Unit IV Dielectric and Ferroelectric materials**:** Dipole moment, Dielectric polarization, Dielectric constant, Types of polarization, Temperature and frequency dependence of dielectric constant, Dielectric loss, Dielectric strength, Dielectric breakdown, Ferroelectric properties of materials, Ferroelectric domains, P-E curve, Applications of dielectric and ferroelectric materials.

Unit V Conducting materials: Resistivity & Conductivity of metals, Physical and Mechanical properties of metals, Corrosion, Superconductivity, Types of superconductor, Applications of superconductivity.

Unit VI Measuring Instruments: Number systems, Logic gates, D to A and A to D converters. Working and uses of CRO, Cyclotron, Bain bridge mass spectrograph, Binocular and Research microscopes, Transducers: LVDT, Strain gauge, Thermistor, Thermocouple.

Books Recommended :

1. Material science & Engineering: V. Raghavan (Prentice-Hall of India Pub., 4th edition)
2. Advances in Material Science: R. K. Dogra & A. K. Sharma (S. K. Kataria & Sons)
3. Material Science: Khurmi and Sedha (S. Chand Pub.)
4. Science and Engineering Materials: C. M. Srivastava and C. Srinivasan (New Age International, New Delhi)
5. Material Science: I. P. Singh (New Age International, New Delhi)
6. Digital Electronics: Millman & Halkias
7. Electrical & Electronics Measurements and Instrumentation: A. K. Sawney (Dhapat Rai Pub.)

Subject : BTCHE 403T (BCHE) **Mechanical Operations (Theory)**

Lecture : 3 Hours No. of Credits : 3

University : 80 Marks College Assessment : 20 Marks

Duration of Examination : 3 Hr.

Unit I Solids: Properties of solids, screening, screening equipments, effectiveness of screens, sieve analysis, average diameter and specific surface. Size reduction, types of equipments used in the various stages of reductions. Laws of crushing & grinding power requirements.

Unit II Handling of solids: Belt conveyer, screw conveyer, flight conveyers, bucket conveyer, pneumatic conveyers. Capacity and power requirements of conveyers. Flow of solids through fluids, terminal settling velocity & hindered settling.

Unit III Classification: Principles of classification, and jigging, equipments, tabling, magnetic and electrostatic separation, cyclone separation, theory, principle and their design. Flotation cells and calculations for flotation process.

Unit IV Filtration: Filtration theory, equipment for filtration, constant pressure and constant rate filtration, filter calculations, optimum cycle time & filter aids.

Unit V Sedimentation: laboratory batch sedimentation Kynech theory , calculation of area and depth for continuous thickeners. Centrifugation principles of a centrifuge, sedimentation, equipments and calculations.

Unit VI Mixing and Agitation: theory of mixing nd agitation, types of equipment, mixing characteristics, power consumption, mixing index, rate of mixing.

Books Recommended :

1) Unit operation by Brown G.G., CBS Publishers First Edition 1995, Reprint 2005.
2) Unit operations for chemical engineers by McCabe W.L. and Smith J.C. Mc Grow Hill International Edition Seventh Edition 2005.
3) Chemical Engineering by Coulson J.N. and Richardson R.F., Butterworth Heinemann Vol. I Sixth Edition1999.

4) Chemical Engineering by Coulson J.N. and Richardson R.F., Elsevir Publication Vol. II Fifth Edition 2002.
5) Introduction to Chemical Engineering by Badger W.L. and Banchero J.T. McGraw-Hill 1955.
6) Unit Operations of Chemical Engineering by Hiramath R.S., Kulkarni A.P. Everest Publications 3rd Edition 2004.
7) Transport Processes and Separation Process Principles by Christe John Geankoplis, PHI Learning, Fourth Edition 2003

Subject : BTCHE 404T (BGE) **Inorganic Process Technology (Theory)**

Lecture : 3 Hours
No. of Credits : 3
University : 80 Marks
College Assessment : 20 Marks
Duration of Examination : 3 Hours

Unit I Industrial gases**:** Manufacture of CO, CO_2, H_2, N_2 & O_2, rare gases C_2H_2, and their industrial applications

Unit II Industrial acids: Manufacture of nitric acid, sulphuric acid, Phosphoric acid and their industrial applications

Unit III Industrial Carbon & Inorganic pigments: Manufacture & applications of, Lamp black, Carbon black, Activated carbon, Graphite, Industrial diamond. Manufacture, properties & uses of white pigments- white lead, zinc oxide, titanium dioxide and Lithophone.

Unit IV Marine chemicals & Nuclear industries: Manufacture of common salt from Sea water, by-product from bitterns, Bromine. Nuclear fission reactions, Feed materials, extraction of Uranium, uranium enrichment, nuclear reactor, reprocessing of nuclear materials, protection from radioactivity.

Unit V Chloro-Alkali & Electrolytic and Electrochemical industries**:** Manufacture of Soda ash, caustic soda &chlorine - Diaphragm cells, Mercury cathode & Mercury cells &Membrane cell. Manufacture of potassium chlorate & per- chlorate. Artificial abrasives: Calcium carbide, Silicon carbide.

Unit VI Fertilizers: Classification of fertilizers, manufacture & applications of ammonia, urea, ammonium nitrate, ammonium sulphate, Super phosphates & triple super phosphates, monoammonium and Diammonium phosphate, Potassic, compound & complex fertilizers.

Books Recommended :

1. Industrial Chemistry by B.K.Sharma, Goel Pub. House, Meerut.
2. Dryden, C. E. “Outlines of Chemical Technology” (Edited and Revised by M.Gopal Rao and Sittig .M) East West Press. Pvt. Ltd, New Delhi, 3rd Edition (1997).
3. Austin G. T,”Shreve’s Chemical Process Industries”, 5th ed., McGraw Hill.(1984).
4. G.N.Pandey, "Text book of Chemical Technology", Vol. I, 2nd revised edition, (1994).
5. A Text Book of Engineering Chemistry, by S.S.Dara, S.Chand & Co., New Delhi

Subject : BTCHE 405T (BGE) **Organic Process Technology (Theory)**

Lecture	: 3 Hours	No. of Credits	: 3
University	: 80 Marks	College Assessment	: 20 Marks
Duration of Examination : 3 Hours			

Unit I Hydrolysis reaction introduction, types of hydrolysis, mechanism of hydrolysis. Technical preparations involving hydrolysis, e.g, preparation of fatty acid, preparation of furfural from carbohydrates, preparation of glycerol .

Unit II Alkylation: introduction and type of alkylation, alkylating agents, equipments for alkylation. Technical preparation of Anisole, Tetraethyl Lead, Dimethyl Aniline.

Unit III Oxidation liquid and vapor phase oxidation, thermo chemistry of oxidation, Technical preparation of citric acid,oxalic acid, vanillin from eugenol, adipic acid mgf. from cyclohexane using green route.

Unit IV Esterification mechanism of esterification, types of esterification, technical preparation of Bio-diesel(methylesters of higher fatty acid), vinyl acetate, methyl methacrylate.

Unit V Hydrogenation, types of hydrogenation reaction, production of hydrogen from various sources, scope of hydrogenation reaction. Technical hydrogenation processes, petroleum hydrogenation, Tar hydrogenation, coal hydrogenation.

Unit VI Polymers. General introduction, types of polymerization. Study of bio-degradable polymers like polylactic acid, polyvinyl esters, polybutyric hydride. Conducting polymers like poly(acetlynes), poly(phenylenes)

Books Recommended :

1. P.H.Groggins “Unit Processes In Organic Synthesis”
2. Industrial Chemistry by B.K.Sharma,
3. Drydens “Outlines Of Chemical Technology”(edited and revised by M.Gopal Rao and Sittig) east west press New Delhi
4. Polymer Science by V. Gowarikar and Vishwanathan
5. Text book of Engineering chemistry by Khan and Khan
6. A Text book of Engineering chemistry by S. S. Dara, S. Chand Publication ,New Delhi
7. Material Chemistry by V.K. Walekar and A. Bharti, Tech-Max Publication, Pune.

Subject: BTCHE 406P (BGE) **Electronics & Instrumentation (Practical)**

Practical	: 3 Hours	No. of Credits	: 2
University : 25 Marks		College Assessment	: 25 Marks
Duration of Examination : 6 Hours			

LIST OF EXPERIMENTS

1. Measurement of Magnetic susceptibility.
2. Measurement of resistivity and conductivity.
3. To determine the cut-in-voltage of LED.
4. A study of P-E curve on CRO.
5. A study of basic & universal logic gates.

6. A study of A to D & D to A convertor.
7. Determination of activation energy of a thermistor
8. A study of cathode ray oscilloscope.
9. To study the characteristic of a photo cell.
10. Measurement of displacement by LVDT.

Subject : BTCHE 407P (BCHE) **Mechanical Operations (Practical)**

Practical : 3 Hours No. of Credits : 2

University : 25 Marks College Assessment : 25 Marks

Duration of Examination : 6 Hours

LIST OF EXPERIMENTS

1. To study the relationship between the Drag Coefficient and modified Reynolds number for body falling through fluid. (C_d vs N_{RE})
2. To carry out the batch Sedimentation test and to use the results to design a thickener.
3. To evaluate the Specific Surface of a packing material.
4. To establish the Filtration equation for the leaf filter system and to evaluate the compressibility of the cake.
5. To study the power consumption of an Agitator with Reynolds and Froud number.
6. To verify the laws of Crushing and Grinding.
7. To determine the Mean Arithmetic Diameter, Mean Surface Diameter and Mean Volume Diameter.
8. To determine the size distribution in a given sample. (Elutriation).
9. To determine the effectiveness of Vibrating Screen.
10. To separate the various size fractions in a mixture on the basis of their settling velocities in a fluid. (Size Separation).
11. To study the efficiency of a cyclone separator.

Subject : BTCHE 408P (BGE) **Inorganic Process Technology (Practical)**

Practical : 3 Hours No. of Credits : 2

University : 25 Marks College Assessment : 25 Marks

Duration of Examination : 6 Hours

LIST OF EXPERIMENTS

1. To Prepare the Crystals of Chrome alum.
2. To estimate the amount of impurities in a given sample of common salt.

3. To purify the given sample of Common salt.
4. To Prepare Mohr's salt.
5. To Prepare Cuprous Chloride .
6. To estimate the % available Chlorine in a given sample of Bleaching powder.
7. To Prepare the Crystals of Sodium Thiosulphate.
8. To analyse the pigment Red Oxide.
9. To Prepare the Crystals of Ferrous Sulphate from Kipp's apparatus waste.
10. To estimate Sulphate in a given Solution by EDTA method.
11. To estimate the amount of MnO_2 and available Oxygen in the given sample of Pyrolusite.

Subject: BTCHE 409P (BGE) **Organic Process Technology (Practical)**

Practical : 3 Hours
No. of Credits : 2
University : 25 Marks
College Assessment : 25 Marks
Duration of Examination : 6 Hours

LIST OF EXPERIMENTS

1. Quantitative estimation of Phenol
2. Quantitative estimation of Aniline
3. Quantitative estimation of Formaldehyde
4. Quantitative estimation of Acetone
5. Quantitative estimation of Acids
6. Preparation of Biodiesel
7. Preparation of Oxalic acid from sucrose
8. Preparation of Benzoic acid from benzamide
9. Preparation of meta-dinitrobenzene from nitrobenzene
10. Preparation of para-nitroacetanilide from acetanilide

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Engineering & Technology

Syllabus for

Third Semester B.Tech. Chemical Technology

Subject : BTCHT 301T (BCHT) **Chemical Process Calculations (Theory)**

Lecture : 3 Hours Tutorial : 1 Hour No. of Credits : 4

University : 80 Marks College Assessment: 20 Marks

Duration of Examination : 3 Hours

Unit I Basic principles, the concept of gram atom and gram mole, conversion of units from one system to another, concept of excess reactant, conversion and yield, Selectivity and degree of completion of reaction.

Unit II Ideal gases, partial pressure, vapor pressure, application of ideal gas laws, volume changes with changes of composition, dissociating gases, humidity and saturation, solubility and crystallization.

Unit III Material balance without chemical reaction, recycle, purge and bypass calculations, material balance with chemical reaction.

Unit IV Energy balance without chemical reaction, combined material and energy balances.

Unit V Energy balance with chemical reaction, combined material and energy balances.

Unit VI Fuels and combustion, types of fuels, heating values of fuels, theoretical and excess air, heat and combustion problems

Books Recommended :

1. Stoichiometry and Process Calculation by Narayana K.V., Laxmikutty B. , Prentice Hall of India 2006.
2. Basic Principles and Calculations in Chemical Engineering by Himmalblau D.M. & Riggs, J.B. Prentice Hall of India 6th Edition (2011)
3. Stoichiometry by Bhatt B.I. , Vora S.M. Tata-McGraw-Hill 4th Edition 2004
4. Chemical Process Calculation by Hougen A., Watson, M. John Wiley & Sons, Third Edition 2000

Subject : BTCHT 302T (BGE) **Organic Process Technology (Theory)**

Lecture : 3 Hours No. of Credits : 3

University : 80 Marks College Assessment: 20 Marks

Duration of Examination : 3 Hours

Unit I	Amination by Reduction, concept, examples. Commercial production of aniline from nitrobenzene using reducer house, catalytic reduction of nitrobenzene, technical preparationof P-phenylenediamine. Amination by ammonolysis, concept of aqueous and liquid ammonia, factors affecting the process, continuous ammonolysis of chlorobenzene.
Unit II	Alkylation: introduction and type of alkylation, alkylating agents, equipments for alkylation. Technical preparation of Anisole, Tetraethyl Lead, Dimethyl Aniline.
Unit III	Oxidation liquid and vapor phase oxidation, thermo chemistry of oxidation, Technical preparation of citric acid,oxalic acid, vanillin from eugenol, adipic acid mgf. from cyclohexane using green route.
Unit IV	Esterification mechanism of esterification, types of esterification, technical preparation of Bio-diesel(methylesters of higher fatty acid), vinyl acetate, methyl methacrylate.
Unit V	Hydrogenation, types of hydrogenation reaction, production of hydrogen from various sources, scope of hydrogenation reaction. Technical hydrogenation processes, petroleum hydrogenation, Tar hydrogenation, coal hydrogenation.
Unit VI	Polymers. General introduction, types of polymerization. Study of bio-degradable polymers like polylactic acid, polyvinyl esters, polybutyric hydride. Conducting polymers like poly(acetlynes), poly(phenylenes)

Books Recommended :

1. P.H.Groggins "Unit Processes In Organic Synthesis"
2. Industrial Chemistry by B.K.Sharma,
3. Drydens "Outlines Of Chemical Technology"(edited and revised by M.Gopal Rao and Sittig) east west press New Delhi
4. Polymer Science by V. Gowarikar and Vishwanathan
5. Text book of Engineering chemistry by Khan and Khan
6. A Text book of Engineering chemistry by S. S. Dara, S. Chand Publication ,New Delhi
7. Material Chemistry by V.K. Walekar and A. Bharti, Tech-Max Publication, Pune.

Subject : BTCHT 303T (BGE) **Engineering Mathematics III (Theory)**

Lecture : 4 Hours Tutorial: 1 Hour No. of Credits : 5

University : 80 Marks College Assessment: 20 Marks

Duration of Examination : 3 Hours

Unit I	Laplace Transforms: Important Formulae, Properties of Laplace Transforms, Laplace Transform of Unit Step Function, Impulse Function, Periodic Function, Dirac Delta Function, Bessel Function, Error Function, Inverse Laplace Transforms, Important

Formulae of Inverse Laplace Transforms, Properties of Inverse Laplace Transforms, Partial fraction method for Inverse Laplace Transforms, Convolution Theorem, Solutions of ordinary differential equations, simultaneous ordinary differential equations, partial differential equations and evaluation of Integrals using Laplace Transform method.

Unit II Z-Transforms: Properties of Z-Transforms, Inverse Z-Transforms, , Convolution, Convolution property of casual sequence, Transforms of important sequences, Inverse of Z-Transforms by division, solutions of difference equations.

Unit III Partial Differential Equations**:** Solution of first order linear and non-linear Partial Differential Equations, Solution of higher order linear homogeneous Partial Differential Equations and linear non-homogeneous Partial Differential Equations.

Unit IV Applications of Partial Differential Equations: Method of separation of variables for Partial Differential Equations and its use in solving the Partial Differential Equations representing (i) One dimensional wave equation, (ii) One dimensional heat conduction equation in Cartesian co-ordinates and polar co-ordinates and (iii) Two dimensional steady state heat conduction equation.

Unit V Numerical solution of Partial Differential Equations**:** Numerical solution of parabolic, elliptic and hyperbolic Partial Differential Equations using finite difference technique.

Unit VI Calculus of Functions of Complex variables **:** Analytic functions, Cauchy –Riemann conditions in Cartesian co-ordinates and polar co-ordinates, methods for finding conjugate functions, Integration of function of complex variables, Cauchy’s integral theorem and integral formula, Residue theorem and its use for evaluating Integrals of function of complex variables, evaluation real definite integrals by contour integration; conformal transformations and bilinear transformations.

Books Recommended:

1. Advanced Engineering Mathematics by H.K. Dass
2. A T Book of Engineering Mathematics by N.P. Bali, Manish Goyal
3. Higher Engineering Mathematics by B.S. Grewal
4. Higher Engineering Mathematics by B.V. Ramana

Subject : BTCHT 304T (BGE) **Electronics & Instrumentation (Theory)**

Lecture : 3 Hours No. of Credits : 3

University : 80 Marks College Assessment: 20 Marks

Duration of Examination : 3 Hours

Unit I Engineering materials: Classification & requirement of engineering materials and their applications, Selection of materials, Physical and mechanical properties of ceramic & composite materials, Polymers, Addition & Condensation polymerization, Copolymerization, Structure & properties of polymers, Plastic.

Unit II	Magnetic materials: Classification of magnetic materials, Magnetic dipole, Dipole moment, Magnetic field strength, Magnetization, Magnetic permeability, Magnetic domains, B-H curve, Hard and Soft magnetic materials, Ferrites and its applications.
Unit III	Band theory of solids: Energy gap in solids, Classification of solids, Intrinsic and extrinsic semiconductors, Conductivity of semiconductor materials and its temperature dependence, semiconductor devices: photo diodes, LED, Photo Cell.
Unit IV	Dielectric and Ferroelectric materials**:** Dipole moment, Dielectric polarization, Dielectric constant, Types of polarization, Temperature and frequency dependence of dielectric constant, Dielectric loss, Dielectric strength, Dielectric breakdown, Ferroelectric properties of materials, Ferroelectric domains, P-E curve, Applications of dielectric and ferroelectric materials.
Unit V	Conducting materials: Resistivity & Conductivity of metals, Physical and Mechanical properties of metals, Corrosion, Superconductivity, Types of superconductor, Applications of superconductivity.
Unit VI	Measuring Instruments: Number systems, Logic gates, D to A and A to D converters. Working and uses of CRO, Cyclotron, Bain bridge mass spectrograph, Binocular and Research microscopes, Transducers: LVDT, Strain gauge, Thermistor, Thermocouple.

Books Recommended :

1. Material science & Engineering: V. Raghavan (Prentice-Hall of India Pub., 4th edition)
2. Advances in Material Science: R. K. Dogra & A. K. Sharma (S. K. Kataria & Sons)
3. Material Science: Khurmi and Sedha (S. Chand Pub.)
4. Science and Engineering Materials: C. M. Srivastava and C. Srinivasan (New Age International, New Delhi)
5. Material Science: I. P. Singh (New Age International, New Delhi)
6. Digital Electronics: Millman & Halkias
7. Electrical & Electronics Measurements and Instrumentation: A. K. Sawney (Dhapat Rai Pub.)

Subject : BTCHT 305T (BCHT) **Special Technology I (Theory)**

Lecture : 3 Hours Tutorial : 1 Hour No. of Credits : 4

University : 80 Marks College Assessment: 20 Marks

Duration of Examination : 3 Hours

BTCHT 305T/1 **Food Technology I**

(Chemistry of Foods)

Unit I: Development of Food Chemistry: History of Food Chemistry, Nature and Origin of Life, Basic activities of animals and plants and their relations. Water and Ice: Importance of water in foods. Structure of water and ice. Concept of bound and free water, their implications. Water Activity and its influence on shelf life of foods.

Unit II: Chemistry of Carbohydrates: Nomenclature, Classification and Structure of carbohydrates. Chemical Reactions of Carbohydrates. Physical and Chemical properties of sugars, starch, pectic substances, gums and other polysaccharides. Functional properties of carbohydrate in food.

Unit III: Chemistry of Lipids: Definition and classification of lipids, Chemistry of fatty acids and glycerides. Chemistry of processing of fats and oils, hydrogenation of fats, shortening confectionery fat etc. Rancidity of fats and oils, its prevention and antioxidants. Functional properties of lipids in foods.

Unit IV: Chemistry of Proteins: Importance of proteins. Nomenclature, classification, structure and chemistry of amino acids, peptides and proteins. Sources and distribution of proteins isolation, identification and purity of proteins. Denaturation, Physical, Chemical and Biochemical characterization of proteins.

Unit V: Enzymes: Introduction, classification and nomenclature of enzymes, specificity. Assay of enzymes such as amylase, protease, lipase. Isolation and purification of enzymes and their industrial applications.

Unit VI: Analytical Techniques: Techniques of food analysis such as chromatography, electrophoresis, light and electron microscopy, spectrophotometry, tracer techniques etc. Physical Properties of Food Systems. Colloidal Properties of food, Sensory perception of tastes, flavour, aroma and texture. Sensory analysis of foods.

Books Recommended:

1. Food Chemistry : L H Meyer, Van Nostrand Reinhold Co New York 1960
2. Principles of Food Science, Ed. Owen R Fennema Part I, Food Chemistry, Marcel Dekker Inc New York
3. The Chemical analysis of foods and food products : Morris B Jacob, 3rd Edition, Vam Nostrand Co, Princeton, New Jersey
4. Instrumental Methods of Analysis: Peksock and Shields

BTCHT 305T/2 **Technology of Oils, Fats and Surfactants I**

Unit I Natural Fats and Oils: Their sources and classification. Constitutents of natural fats Glycerides. Phospholipids, fatty acids, non glyceride constituents, toxic constituents and detoxification. Nutritional functions of fats.

Unit II Glycerides and fatty acids: Nomenclature, structure, occurrence in oils and fats. Physical properties of fats and fatty acids their properties, solution properties and spectral properties.

Unit III Physical and Chemical characteristics of Oils and Fats. Elementary methods of analysis of oils, fats and fatty acids.

Unit IV Identification of fats and oils. Detection of adulteration in fats. Indian Standards for fats and oils.

Unit V Chemical reaction of fats and their fatty acids. Chemistry of hydrogenation, polymerization, autooxidation and importance of these reactions. Antioxidants and synergists.

Unit VI Chemical reactions of fats and their fatty acids. Dehydration, sulphation and sulphonation. Esterification, interesterification and hydrolysis, hydrazinolysis. Their significance and importance.

BOOKS RECOMMENDED

1. Industrrial Oils and Fat Products : Ed A E Bailey Vol I
2. Fatty acids : K.S. Markely, InterScience Publishers, 2nd Edition, New York
3. Analysis of Fats and Oils : V.C. Mehlan Bacher
4. Inhibition of fat oxidation processes : K.A. Allen
5. An introduction to the Chemistry and BioChemistry of Fatty acids : Gunstone
6. Industrial Chemistry of Fats and Waxes : T Hilditch
7. B S I Methods of Analysis of Fats and Oils
8. Rancidity of Edible Fats : C H Lea
9. ISI Methods of analysis of oils and fats IS 548 (1964)
10. AOCS Methods of Analysis of Oils and Fats

BTCHT 305T /3 **Petroleum Refining and Petrochemical Technology I**
(Geology, Exploration and Production of Gas and Oil)

Unit 1: Introduction to the subject: Outline of the gas and oil industry with main sub divisions, comparative study of various conventional and non conventional energy sources. Fuels and sources of synthetic organic chemicals.

Unit 2: History of petroleum, elements of petroleum geology, types and ages of rocks, lithography and classification of rocks, structure and stratiography of rock formation, sedimentary rocks, traps for oils and gas and their structural details.

Unit 3: Theories and origin andd accumulation of oil and gas. Kerogen composition, classification, isolation, Properties of petroleum and gas in rocks, porosity, permeability, connate water, electrical resistivity, compressibility of rocks, phase behaviour, shrinkage, viscosity, compressibility, permeability, mobility, interfacial tension, wetting capillary pressure and forces of oil and flows.

Unit 4: Methods of surface and subsurface exploration (geolotical, geophysical and geochemical) cable tool, rotary and turbo drilling, drilling of wells (vertical, deviated and horizontal). Drilling, fluids,composition and functions, rates, coring, cementing, acidization, fracturing, completion and testing of wells, logging, methods of primary recovery.

Unit 5: Well testing and control, free flow and gas lifting, mechanical pumping, work over jobs, treatment of wter for injection, enhanced oil recovery, secondary and tertiary.

Unit 6: Separation of Oil and Gas, gathering, stabilization, dehydration, desalting, sortingand mixing, transportation and storage of oil and gas, metering systems, group gathering stations and tank firms.

Books recommended:

1. An introduction to Physics and Chemistry of Petroleum : R R F Kinghorn
2. Composition and properties of Petroleum : H J Neumann, B P Lahme and B Severin
3. Fundamental Aspects of Petroleum geochemistry : Negi and Colombo
4. Modern Petroleum Technology : G D Hobson and W Pohl

BTCHT 305T /4 **Pulp and Paper Technology I**
(Chemistry of Paper Making Raw Material)

Unit I: Species, anatomy and physical properties of wood – classification of woods, plants used in pulp and paper. Gross structure of trunk, structural elements of wood, fibre dimensions.

Unit II: Water conducting system, food conducting syste, wood, bark and its structural elements, decay of wood physical properties of wood.

Unit III: Fibre morphology – Cell formation and growth, fibre structure, chemical composition of wood, non weedy fibres used in pulping – bast, fruits, grass, leaf, animal, mineral and synthetic fibres.

Unit IV: Cellulose – Chemistry and location in the cell, isolation, molecular constitution, microfibrils, crystalline and amorphous cellulose, biogenesis of cell wall, polysaccharides, sorption, swelling and solution of cellulose.

Unit V: Degradation reaction of cellulose, hemicelluloses, structure and properties of hemicelluloses. Lignin – lignification in wood, biological and biochemical aspects of lignin formation, chemical aspects of lignin formation.

Unit VI: Structure and properties of lignin, separation of lignin from woody tissues and laboratory separation, commercial separation, analysis of lignin and utilization of lignin.

Books Recommended:

1. The Chemistry of Cellulose : Emil Hauser, John Wiley and Sons, New YOrk
2. The methods of cellulose Chemistry : Charles Dorre, Chapman and Hall Ltd.
3. High Polymers Vol V (Part I to V) Ed. Emil Ott et al, Interscience Publishers
4. Pulping Process by S.A. Rydholm, John Wiley and Sons, New York
5. Pulp and Paper Chemistry and Chemical Technology : James P Casey, John Wiley and Sons, New York.

BTCHT 305T /5 **Plastics and Polymer Technology I**
(Polymer Technology)

Unit I: Basic Principles of Aromaticity, Types and Mechanism of Aromatic substitution. Manufacture of monomers, ethylene, acetylene, butadiene, styrene, formaldehyde and its properties.

Unit II: Manufacture of Vinyl Acetate, Vinyl Chloride, Dibasic acids viz Succinic, Maleic, Adipic acids and their properties. Acrylic acid, MMA, Butylacrylate and similar compounds with their properties.

Unit III: Natural polymers viz Cellulose, Lemin, Rubber, their properties and uses. Preparation and properties of cellulose acetate, carboxymethyl cellulose. Regenerate Cellulose and other Cellulose derivatives.

Unit IV: Chemistry of Polymerisation: Introduction to types of polymerization, emulsion, solution, Bulk with typical examples of PG, PVC, PS etc. Mechanism of polymerization, detailed use of Zeigler Natta Catalyst used in Polymerisation.

Unit V: Copolymerisation: Introduction, Free Radical, Ionic and Co Polycondensation, copolymerization. Kinetics of Polym,erisation, introduction, free radical chain polymerization, cationic polymerization, anionic polymerization.

Unit VI: Experimental Methods: Polymer Synthesis, Isolation and Purification of Polymers, Polymer fractionation, Molecular weight determination, Molecular weight distribution and glass transition temperature.

Books Recommended:

1. Organic Chemistry: I L Finar Vol I, Longman Group Ltd. ELBAS, London 6th Edition
2. Polymer Science: V R Gowarikar et al, Wiley Eastern Ltd, Mumbai
3. Unit Processes in Organic Synthesis: P H Groggins, Mc Graw Huill Co, New York.

BTCHT 305T /6 **Surface Coating Technology I**
(Chemistry of Drying Oils and Polymerisation)

Unit I: Introduction to Surface Coatings, classification, definition of paints, varnishes, lacquer, pigment, extender. General composition of surface coatings, function of pigments, extenders, binders, driers, additives in surface coatings. History of developments of surface coatings, Global scenario and past, present and future of Indian Coating Industry.

Unit II: Film Formation : Fundamental of film formation. Chemical Composition, functionality and degree polymerization and film properties. Concept of functionality. Types of coatings, convertible and non convertible.

Unit III: Polymeriation, additive, condensation, auto-oxidative, copolymerization and heteropolymerisation. Degree of polymerization.

Unit IV: Vegetable and marine Oils for surface coatings. Classification of oils, fats and waxes. Non drying, drying and semidrying oils. Sources and composition. Methods of extraction and refining of drying oils from vegetable and marine origin.

Unit V: Polymerisation of drying oils, thermal and oxidative. Formation of stand, blown and boiled oils. Limed oils, Treated Oils. Dehydrated oils, DCO, Copolymerised oils, film formation and deterioration.

Unit VI: Deries, mechanism of drying action. Composition of dries, drier metals, drierabsorption. Analysis of metal content. Preliminary analysis of Paints, Indian Standards specifications for paints.

Books Recommended:

1. Organic Coating Technology : H F Payne, Vol I, John Wiley and Sons, New York
2. Paint Technology Manual : Vol I, Oil and Colour Chemists Association
3. Paint Technology Manual : Vol II, Oil and Colour Chemists Association
4. The Chemical Constitution of Natural Fats : T P Hilditch, 2nd Edition, John Wiley and Sons, 1947
5. Protective and Decorative Coatings : J J Matellio, Vol I, John Wiley and Sons
6. Surface Coatings : Vol I, Raw Materials and their useage, Oil and Colour Chemists Association, Australia
7. Text Book of Polymer Science : W Billmeyer, Interscience Publishers Inc, New York 1962
8. An Introduction to Polymer Chemistry : W R Moore, Aldine Publishing Co. Chicago, 1963
9. Paints and Varnishes : A.S. Khanna, Indian Central Iolsee Committee, 1959

Subject : BTCHT 306P (BGE) **Organic Process Technology (Practical)**

Practical : 3 Hours No. of Credits : 2

University : 25 Marks College Assessment: 25 Marks

Duration of Examination : 4 Hours

Synthetic Preparation of Important Organic Compounds and calculation of Theoretical and Percent yield

1. Preparation of Methyl Esters of Fatty Acids from Soybean Oil (Bio-Diesel) using Unit Process Esterification.
2. Preparation of Oxalic Acid from Cane Sugar using Unit Process Oxidation.
3. Preparation of Urea Formaldehyde Resin using Unit Process Polymerisation.
4. Preparation of Phenol Formaldehyde Resin (PF Resin) using Acid Catalyst using Unit Process Polymerisation.
5. Preparation of P-bromo Acetanilide from Acetanilide using Unit Process Halogenation.
6. Preparation of m-Dinitrobenzene from Nitrobenzene using Unit Process Nitration.
7. Preparation of Acetanilide from Crude Aniline using Unit Process Acetylation.
8. Preparation of Pthalamide from Pthalic Anhydride using Unit Process Amination By Ammonolysis.

9. Preparation of Nerolin from β-Napthol using Unit Process Alkylation.

Subject : BTCHT 307P (BGE) **Electronics & Instrumentation (Practical)**

Practical : 3 Hours
No. of Credits : 2
University : 25 Marks
College Assessment: 25 Marks
Duration of Examination : 4 Hours

LIST OF EXPERIMENTS

1. Measurement of Magnetic susceptibility.
2. Measurement of resistivity and conductivity.
3. To determine the cut-in-voltage of LED.
4. A study of P-E curve on CRO.
5. A study of basic & universal logic gates.
6. A study of A to D & D to A convertor.
7. Determination of activation energy of a thermistor
8. A study of cathode ray oscilloscope.
9. To study the characteristic of a photo cell.
10. Measurement of displacement by LVDT.

Subject : BTCHT 308P (BCHT) **Special Technology I (Practical)**

Practical : 3 Hours
No. of Credits : 2
University : 25 Marks
College Assessment: 25 Marks
Duration of Examination : 4 Hours

BTCHT 308P /1 Food Technology Practical I

1. Estimation of reducing sugar by Lane Eynon's method
2. Estimation of nonreducing sugar by lane eynon's method
3. Estimation of amino acid (glycine) by Sorenson formal titration method
4. Estimation of glucose by iodometry titration (Wills Statter method)
5. Determination of acid value of oil or fat
6. Determination of saponification value of oil or fat
7. Determination of iodine value of oil or fat
8. Peroxide value of oils
9. Estimation of ascorbic acid (vitamin c) by titration method
10. To determine the unknow sugar by paper chromatography
11. Qualitative analysis of carbohydrate

BTCHT 308P/2 Technology of Oils, Fats & Surfactants Practical I

1. Determination of Moisture Content of Oil and Fat
2. Determination of Acid Value of Oil and Fat
3. Determination of Free Fatty Acid content of Oil and Fat
4. Determination of Saponification Value of Oil and Fat
5. Determination of Iodine Value of Oil and Fat
6. Determination of Peroxide Value of Oil and Fat

7. Determination of Refractive Index of Oil and Fat
8. Estimation of Sedimentation present in Oil / Fat
9. Estimation of Adulteration in cotton seed oil using Halphens Test
10. Estimation of Adulteration in Sesame oil using Baudin's Test
11. Determination Melting point of Fats by thels tube Method
12. Determination Smoke And Flash Point Of Oil And Fat

BTCHT 308P /3 Petroleum Refining and Petrochemical Technology I

List of Experiments

1. API gravity,
2. Aniline point ,
3. Diesel Index,
4. Cloud and Pour point,
5. Smoke point,
6. Flash point by Abel,
7. Penskey Martin and Cleaveland Open cup,
8. Sapnofication Value,
9. Dropping point of grease,
10. melting point of wax,
11. Drop melting point.

BTCHT 308P /4 Pulp & Paper Technology Practical I
(Proximate Analysis of Paper Making Materials)

1. Preparation of sample (40 + 60 mesh) of wood
2. Determination of moisture content of the sample of wood
3. Determination of ash content of the wood sample
4. Determination of cold water solubles in wood sample
5. Determination of hot water solubles in wood sample
6. Determination of 1% NaOH solubles in wood sample
7. Determination of the extractives in ethanol-benzene mixture
8. Determination of holocellulose in extract free sample of wood
9. Determination of acid soluble lignin in the sample of wood
10. Preparation of 40 + 60 mesh samples from agricultural residues.

BTCHT 308P /5 Plastics & Polymer Technology Practical I
(Polymer synthesis and Characterisation)
List of Experiments:

Part: I **Preparation of common polymers.**

1. Preparation of Polystyrene by free radical polymerisation.
2. Preparation of Polystyrene by ionic polymerisation.
3. Preparation of phenol formaldehyde resin by acid catalyst.
4. Preparation of phenol formaldehyde resin by alkali catalyst.
5. Preparation of urea formaldehyde resin by acid catalyst.
6. Preparation of alkyd resin.
7. Preparation of polymethylmethacrylate (PMMA).
8. Preparation of nylon.

Part: II **Characterization of following polymers.**

9. Polystyrene.

10. Phenol formaldehyde resin.
11. Urea formaldehyde.
12. Alkyd resin.
13. Nylon.
14. PMMA.
15. PVC.
16. Polyacrylates.

Recommended Books/References:

1. Handbook of Polymer Synthesis, Characterization, and Processing by Enrique Saldívar-Guerra, Eduardo Vivaldo-Lima. Wiley.
2. Polymer Synthesis and Characterization: Laboratory Manual by **Sandler** , **Karo** , **Bonesteel** & **Pearce**. Elsevier.
3. Laboratory experiments in polymer synthesis and characterization by Eli M. Pearce, Carl E. Wright, Binoy K. Bordoli. (Article).

BTCHT 308P /6 Surface Coating Technology Practical I

List of Experiments

1. Determination Oil Absorption of Pigment.
2. Determination of Bulk density of pigment.
3. Determination of Hiding power of pigment.
4. Determination of Tinting Strength/Reducing power of pigment.
5. Determination of Moisture content in pigment
6. Determination of Acid value of oil/oleoresins/rosin.
7. Determination of Iodine value of oil/oleoresins/rosin.
8. Determination of Saponification value of oil/oleoresins.
9. Determination of Hydroxyl value of oil/oleoresins.
10. Determination of Density of solvent.
11. Determination of Boiling Range of solvent
12. Determination of rate of evaporation of solvent
13. Determination of %residue in solvent
14. Determination of aromatic hydrocarbon content in solvent.
15. Determination of Flash point of solvent.

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Engineering & Technology

Syllabus for

Fourth Semester B.Tech. Chemical Technology

Subject : BTCHT 401T (BGE) **Strength of Materials (Theory)**

Lecture : 3 Hours Tutorial: 1Hour No. of Credits : 4

University : 80 Marks College Assessment: 20 Marks

Duration of Examination : 3 Hours

Unit I Simple Stresses and Strains**:** Introduction; Definition of stress and strain; tensile and compressive stresses; shear stress, Elastic limit, Hooke's law, poission's ratio, modulus of Elasticity, modulus of Rigidity, Bulk Modulus; stresses in composite sections; Volumetric strain; Temperature stresses. Strain Energy Stresses due to different types of axial loading; Gradually applied loads, Suddenly applied loads, Impact loads.

Unit II Shear Forces and Bending moments Definitions; Concept of Shear force and Bending moment; Sign conventions; Shear force and Bending moment diagrams for cantilevers, simply supported beams and beams with overhang; point of contra flexure; member subjected to couples. **Stresses in Beams** Definition; Pure or simple bending, theory of simple bending; Neutral layer, Neutral axis, Moment of resistance, assumptions in the theory of simple bending; Section modulus for rectangular, circular, I section and T section. Flitched Beams Definition; Equivalent section, modular ratio, moment of resistance in flitched beams. Shear stress distribution in Beams sections Shear stress distribution on rectangular, circular, I section and T section.

Unit III Deflection of Beams Member bending into a circular arc; Slope, deflection and radius of curvature; Cantilevers and simply supported beams. Macaulay's method for slope and deflection in cantilevers, simply supported beams and beams with overhang.

Unit IV **Direct and Bending Stresses** Stress distribution of the section of an eccentrically loaded rectangular column; Core of Kern of the section, Circular and hollow sections. **Columns and Struts** Introduction; axially loaded compression members; crushing load; Buckling or critical load, Euler's theory of long columns, assumptions made in Euler's theory; Empirical formulae; Rankine's formula.

Unit V Torsion of Shafts Pure Torsion; Theory of pure torsion; Torsional moment of resistance; assumptions in the theory of pure torsion; Polar modulus; Power transmitted by circular and hollow shafts; Torsional rigidity. Close coiled helical springs Stiffness, deflection, shear stress and Strain energy.

Unit VI Thin Cylinders and Spheres Thin cylinders; Circumferential and Longitudinal stresses; Thin spherical shells. Riveted Connections Types of joints; Lap and Butt joints; Failure of riveted joints; Tearing strength, shearing strength and bearing strength; Efficiency of a joint.

Books Recommended :

1. Strength of Materials by S. Ramamrutham.

2. Strength of Materials by B. C. Punmia
3. Strength of Materials by R S. Khurmi.

Subject : BTCHT 402T (BGE) **Applied Physical Chemistry II (Theory)**

Lecture : 3 Hours No. of Credits : 3
University : 80 Marks College Assessment: 20 Marks
Duration of Examination : 3 Hours

Unit I Thermodynamics I: The chemical potential, Gibb's Duhem equation, Fugacity, Activity, Determination of fugacity,Chemical equilibria only for Homogeneous system- Reaction Isotherm, Relation between Kp,Kc,Kx, The Van't Hoff equation

Unit II Thermodynamics II: The Clausius Clapeyron Equation, The Phase Rule and its derivation, its application to water system and CO_2 system, Simple Eutectic system- Lead Silver system, Nernst distribution law, its applications- Solvent extraction theory and principle

Unit III Thermodynamics of solutions I : Raoult's Law, Vapour Pressures of ideal solutions, Activity of ideal solution, chemical potential of ideal solution, Gibb- Duhem- Margules Equation, Free energy, entropy, and enthalpy of mixing

Unit IV Thermodynamics of solutions II : Vapour Pressures of real solutions, Vapour Pressure-composition and Boiling Point composition Curves of completely Miscible Binary Solutions, Distillation method of immiscible liquids : Fractional distillation and steam distillation, Colligative properties-vapour pressure lowering, Osmotic pressure, Elevation of boiling point, depression of freezing point

Unit V Electrochemistry I : Specific, Equivalent and Molecular conductance, effect of temperature on conductivity, Transport Number, their determination- Hittorf's method and Moving Boundary Method, Kohlrausch's Law, its applications, Debye Huckel Theory of strong electrolytes

Unit VI Electrochemistry II : Reversible electrodes, Reference electrodes, standard electrode potential, Thermodynamics of reversible electrodes, The Nernst Equation, Concentration cells with and without transference, liquid junction potential, Applications of Emf measurements, Hydrolysis of salts

Books Recommended:

1. Thermodynamics for Chemists : S.Glasston, D Van Nostrand Co,New York,USA
2. An Introduction to Thermodynamics : R P Rastogi and R R Mishra
3. Introduction to Electrochemistry : S.Glasston, D Van Nostrand Co,New York,USA
4. Physical Chemistry : G Barrow, Benjamin Publisher, New York,US
5. Physical Chemistry : Vemupalli, Wiley East West
6. Principles of Physical Chemistry : Puri Sharma and Pathania

Subject : BTCHT 403T (BGE) **Numerical Methods & Computer Programming (Theory)**

Lecture : 3 Hours Tutorial: 1Hour No. of Credits : 3
University : 80 Marks College Assessment: 20 Marks
Duration of Examination : 3 Hours

Unit I Introduction to programming, programming languages, algorithm, flowcharts, C Language: Features of C, data types, Identifiers, Constants, Variables, expressions, Console I/O statement, Selection statements: if-else, switch, Iteration Statements: For, while, do-while, Jump statements: return, go to, break, and continue, comments, and program using these features.

Unit II Macros, Function and Recursion, Structure and Union, Pointers, String, Basics of File handling

.**Unit III** Concept of Array, Matrix operations in C and Searching, Sorting: Linear search, Binary search, Bubble sort, Insertion sort, Selection Sort.

Unit IV Program to obtain roots of polynomial Equation: Newton-Rapson method, Regular Falsi Method, Muller method, Bisection method, false position method. Programs for interpolation and extrapolation using numerical methods.

Unit V Numerical Integral and Differential equations using: Initial value problems by Euler's method, modified Euler's, Taylor series, Runge-kutta methods, Regression analysis.

Unit VI Optimization techniques, integer programming, Simplex method, dynamic programming, programs for implementation of these method and case study.

Books Recommended:

1. Numerical methods for Scientific and Engg. Computations by M.K. Jain, Srk Iyengar, R.K. Jain, Wiley Eastern Ltd.
2. Numerical methods for Science & Engg. By Stanton R.G., PHI.
3. The C Programming Language: Dennis Ritchie & Brain Kernighan [Pearson].
4 ANSI C: By E Balagurusamy

Subject : BTCHT 404T (BGE) **Inorganic Process Technology (Theory)**

Lecture : 3 Hours No. of Credits : 3

University : 80 Marks College Assessment: 20 Marks

Duration of Examination : 3 Hours

Unit I Industrial gases**:** Manufacture of CO, CO_2, H_2, N_2 & O_2, rare gases C_2H_2, and their industrial applications

Unit II Industrial acids: Manufacture of nitric acid, sulphuric acid, Phosphoric acid and their industrial applications

Unit III Industrial Carbon & Inorganic pigments: Manufacture & applications of, Lamp black, Carbon black, Activated carbon, Graphite, Industrial diamond. Manufacture, properties & uses of white pigments- white lead, zinc oxide, titanium dioxide and Lithophone.

Unit IV Marine chemicals & Nuclear industries: Manufacture of common salt from Sea water, by-product from bitterns, Bromine. Nuclear fission reactions, Feed materials, extraction of

Uranium, uranium enrichment, nuclear reactor, reprocessing of nuclear materials, protection from radioactivity.

Unit V Chloro-Alkali & Electrolytic and Electrochemical industries**:** Manufacture of Soda ash, caustic soda &chlorine - Diaphragm cells, Mercury cathode & Mercury cells &Membrane cell. Manufacture of potassium chlorate & per- chlorate. Artificial abrasives: Calcium carbide, Silicon carbide.

Unit VI Fertilizers: Classification of fertilizers, manufacture & applications of ammonia, urea, ammonium nitrate, ammonium sulphate, Super phosphates & triple super phosphates, monoammonium and Diammonium phosphate, Potassic, compound & complex fertilizers.

Books Recommended :

1. Industrial Chemistry by B.K.Sharma, Goel Pub. House, Meerut.
2. Dryden, C. E. “Outlines of Chemical Technology” (Edited and Revised by M.Gopal Rao and Sittig .M) East West Press. Pvt. Ltd, New Delhi, 3rd Edition (1997).
3. Austin G. T,”Shreve’s Chemical Process Industries”, 5th ed., McGraw Hill.(1984).
4. G.N.Pandey, "Text book of Chemical Technology", Vol. I, 2^{nd} revised edition, (1994).
5. A Text Book of Engineering Chemistry, by S.S.Dara, S.Chand & Co., New Delhi

Subject : BTCHT 405T (BCHT) **Special Technology II (Theory)**

Lecture : 3 Hours	Tutorial: 1 Hour	No. of Credits : 4
University : 80 Marks		College Assessment: 20 Marks
Duration of Examination : 3 Hours		

BTCHT 405T/1 **Food Technology II**
(Biochemistry and Nutrition)

Unit I Enzymes – Enzyme kinetics, activators and inhibitors. Techniques of immobilization of enzymes. Allosteric regulation of enzymes. Enzyme inhibitors
Cell Membrane: Structure and Transport Mechanism

Unit II Bioenergetics – Generation of high energy phosphates and their importance.

Unit III Digestion of carbohydrate based food and its metabolism.

Unit IV Metabolism of lipids and proteins. Antinutritional factors in food. Toxic compounds, alkaloids.

Unit V Nutrition – Functions of food. Energy value of food. BMR and its measurement.
Energy requirement of individuals. Nutritional evaluation of proteins. Recommended dietary allowances of proteins, fats and carbohydrates.

Unit VI Vitamins – Classification, sources, functions and deficiency symptoms, assay of vitamins. Minerals – Micro & Macro Minerals. Loss of nutrients during processing, Enrichment and fortification.

Books Recommended:

1. Outlines of Biochemistry : E E Conn and P K Stumpf, Wiley Eastern Pvt. Ltd., New Delhi
2. Applied Nutrition : R Rajalakshmi, Oxford and IBH Publishing Co. New Delhi
3. Text Book of Biochemistry : A Lehninger
4. Biochemical and Physiological Aspects of Human Nutrition: Martha H Stipanuk, published by Saunders an imprint of Elsevier.

BTCHT 405T/2 **Technology of Oils, Fats and Surfactants II**

(Bio-Chemistry Of Oils and fats and Techniques of separation of fats and fatty acids)

Unit I Distribution of Fatty acids in oils and fats: –Theories of fatty acid distribution, Effect of fatty acid distribution on physical and chemical properties of oils and fats, Quantitative investigation of major components of glycerides.

Unit II Investigation of component fatty acids of natural and processed fats:- Lipasehydrolysis, Dilatometric measurements and their significance, Determination of color by Lavibond Tintometer, Determination of viscosity by Brookfield viscometer. Analysis of oil seeds and oil cakes

Unit III Biosynthesis of fatty acids**:-**Phospholipids and triglycerides in plants, glycol-lipids, neutral lipids, Structure of oilseed, metabolism of oils and fats in seeds, synthesis of oils in seeds, Biological utilization of fats, Essential fatty acids, Crystallization of Fats and Oils, Trans fatty acids,

Unit IV Techniques of separation of fats and fatty acids**:-**Techniques of separation of fats and fatty acids such as Low temperature crystallization, Urea adduct, Counter current distribution, salt-solvent separation etc.

Unit V Techniques of separation of fats and fatty acids**:-**Chromatographic methods of separation with specific references to Thin layer and Gas liquid chromatography, High performance liquid chromatography(HPLC),Infrared red and ultraviolet Visible spectroscopy, Nuclear magnetic resonance (NMR) analysis

Unit VI Polymorphism of fats and fatty acids**: –** Metal salts of fatty acids of alkaline earth Metals, their methods of preparation, analysis and applications, Determination of Reichert – Missel , Polenske, and Kirshner values

Books Recommended:

1. Vegetable Fats and Oils : E W Eckey
2. Rancidity of Edible fats : C H Lea
3. Fatty acids : K S Markley, Vol 3
4. Structure and Utilisation of Oilseeds: J G Vaughen
5. Gas Liquid Chromatography : S D Nagere and R S Juvet
6. This Layer Chromatography : T Bobbit
7. Industrial Chemistry of fats and waxes : T P Hilditch
8. The Lipids : H J Duel

9. Progress in the Chemistry of fats and other lipids : H T Holman, W O Lundberg
10. Lipid Chromatographic Analysis : G V Marinetti
11. Melting and Solidification of fats : A E Bailey

BTCHT 405T /3 Petroleum Refining and Petrochemical Technology II (Composition, Classification and Evaluation)

Unit I Separation of Oil and Gas, gathering, stabilization, dehydration, desalting, sortingand mixing, transportation and storage of oil and gas, metering systems, group gathering stations and tank farms.

Unit II Elementary concept of fractionation – Distillation theory (atmospheric pressure, reduced pressure, azeotropic and extractive) solvent treatment, asphaltene separation and fractionation. Absorption, chemical methods like sulphuric acid treatment, molecular complex formation, Extraction and use of data.

Unit III Composition of petroleiu, natural gas, major petroleum fractions and products (refinery gases, gasoline, naphtha, kerosene, diesel, fuel oil, lubricating oil, other oil products, waxes, asphalt, coke, acid sludge) Hydrocarbons and non hydrocarbons present (Type, name, structure, role) chemical aspects of origin of petroleum and natural gas.

Unit IV Classification and description of various crudes. General methods of classification and correlations. N-d-M ring analysis method, comparison of structural group analysis by spectroscopic and physical property methods. MW determination, correlation method for structure of solid saturated hydrocarbons.

Unit V Principles and uses of modern physico chemical analysis techniques such as UV, IR, NMR, MS, GLC etc. in petroleum and product analysis.

Unit VI Evaluation of crude and petroleum fractions and use of data with reference to physical, thermal, electrical, optical and other test properties. Significance of these tests and national and international significance.

Books recommended:

1. Modern Petroleum Technology : G D Hobson and W Pohl
2. Petroleum Refining Engineering : W L Nelson
3. Chemical Technology of Petroleum : W A Gruce and Stevens
4. The Chemistry and Technology of Petroleum : James G Speight
5. Petroleum refining, Technology and Economics : J H Gary and G E Handwork.

BTCHT 405T /4 Pulp and Paper Technology II (Pulping Process II)

Unit I Order of pulp wood operation, measurement, wood yard layout, wood preparation plant, debarking of pulp wood logs, pulp wood storage and conveying.

Unit II Preparation of pulp wood chips handling and conveying chip storage.

Unit III Manufacture of mechanical pulp, woods used, types, grades and uses, advantages and limitations.

Unit IV Equipments for ground wood pulping process, pulp mill operations, variables affecting the process, power requirements, water and pulp showers.

Unit V Semichemical pulping, NSSC process, wood preparation, digestors, fibrizing, washing, cleaning and chemical recovery and effluent disposal, properties and uses.

Unit VI Acid sulphite, semichemical pulping, bisulphate semichemical pulping, Kraft semichemical ar d cold soda semichemical processes.

Books Recommended:

1. Pulping process : Rydholm
2. Pulp and Paper Science and Technology : Vol I C E Libby
3. Pulp and Paper Chemistry and Technology : Vol I J P Casey
4. Pulp and Paper Manufacture : Vol I and III Mc Donald
5. Handbook of Pulp and Paper Technology : K W Britt, 2nd Edition

BTCHT 405T /5 **Plastics and Polymer Technology II (Polymer Materials)**

Unit I Chemical nature of Plastics and their behaviour. Elementary ideas of polymerization. Historical developments in Polymer materials, Basic raw materials for polymers, polymerization methods and applications.

Unit II Types of polymers and orientation. Relationship of structure to thermal and mechanical properties. Study of electrical, optical and chemical properties. Various engineering plastics, acrylic polymers, styrene polymers.

Unit III Additives for plastics and elementary ideas of processing and flow properties. Thermal stability, melt procdesing, thermoset technology, elastomer technology, basic raw materials, manufacture, compounding, vulcanization etc.

Unit IV Preparation, polymerization, general physical and chemical properties and application of polyethylene, PVC, Polyvinyl acetate and its derivatives. Acrylic plastics.

Unit V Plastics based on polystyrene and HIPS, ABS, TPS, Styrene Maleic anhydride, SBR and other polymers their properties and applications.

Unit VI Preparation, properties of, Phenolic, polyamides, cellulosic, MF, PF, UF, Polyurethane, Silicones and other heat resistant materials.

Books Recommended:

1. Plastic Materials : J A Brydson 6th Edition, Butterworth Heinemann Ltd., 1995
2. Vinyl and Diene Polymers : Part I and II, E C Lenord, Wiley Interscience, New York, 1970

3. Manufacture of Plastics by W M Smith, Reinhold Publishing Co., New York 1972
4. Introduction to Rubber : F R Elrich, Academic Press, 1978
5. Polymer Process : Schild Knecht, John Wiley and Sons, New York, 1979

BTCHT 405T /6 **Surface Coating Technology II**
(Chemistry of Film Forming Materials I)

Unit I Resins and resinous state, natural and synthetic resins. Classification of resins. Occurrence, composition, purification and uses. Modification of natural resins with special reference to rosin, ester gum, maleic modified. Detailed study of resins like Congo Copal Shellac, Gum and Wood Rosin, Sandarac, Damar.

Unit II Phenolic Resins, Composition, Types of Phenols used, ratio of formaldehyde, Phenolic condensates, Rosin modified Phenolics, Reactive and non Reactive type 100% phenolics. Baking phenolics, coumarone-ir dene resins. Petroleum resins, C N S L and B N S L resins and their industrial applications.

Unit III Amino resins, urea melamine formaldehyde resins. Chemistry of amino resins, conditions of reaction and products. Modification of urea formaldehyde resins. Butylated resins, general applications of urea and melamine resins in surface coatings.

Unit IV Alkyd resins, raw materials, Functionality concepts, use of polyfunctional acids and alcohols, phthalic acid resins and manufacture, types of oil modifications and properties of modified alkyd resins.

Unit V Polyster resins and styrenated resins. Unsaturated polyesters resins for surface coatings. Mechanism of curing and air inhibition.

Unit VI Polyaamide resins. Structure of polyamides, modifications necessary to make them suitable for coatings their properties and uses.

Books Recommended:

1. Organic Coating Technology: H F Payne, John Wiley & Sons, New York, 1954
2. Paint Technology Manual : Oil Colour Chemists Association, Vol 1, Vol 2 and Vol 3
3. Text Book of Polyer Science : W Billmeyer, Interscience Publishers Inc. New York, 1962
4. An Introduction to Polymer Chemistry : W R Moore, Aldine Publishing Co.

Subject : BTCHT 406P (BGE) **Numerical Methods & Computer Programming (Practical)**
Practical : 2 Hours No. of Credits : 1
University : 25 Marks College Assessment: 25 Marks
Duration of Examination : 4 Hours

LIST OF EXPERIMENTS

1. Write a simple program in C for Addition, multiplication and division of two numbers.
2. Write a program in C to find whether given year is Leap year or not.

3. Write a program in C for Fibonacci sequence using function.
4. Write a program in C for Factorial Function.
5. Program to illustrate the uses of Array.
6. Write a program in C to demonstrate the use of Selection Statement (If, Else, Switch).
7. Write a program in C to demonstrate the use of Iterative Statement (For While Do While.).
8. Write a program in C for Transpose of matrix.
9. Write a program in C for Matrix Addition and Multiplication.
10. Write a Program in C for Binary Search.
11. Write a Program in C for Linear Search.
12. Write a Program in C for Bubble Sort.
13. Write a Program in C for Insertion Sort, Selection sort.
14. Write a program in C to find a root of non-linear equation by using Newton Raphson method.
15. Write a program in C to implement Euler modified method.
16. Write a program in C to find a root of a quadratic equation using Muller method.
17. Write a program in C to implement Runga-Kutta method.
18. Write a program in C to implement Gauss-Seidal method
19. Write a program in C to find out equation dy/dx=x+y by using Euler method.
20. Write a program in C to implement Taylor's series.
21. Write a program in C to calculate coefficient of regression.
22. Write a program in C to implement Regula Falsi method.
23. Write a program in C to implement Simpson's 1/3 rd rule.
24. Write a program in C to implement Bisection Method.

Subject : BTCHT 407P (BGE) **Inorganic Process Technology (Practical)**
Practical : 3 Hours
University : 25 Marks
Duration of Examination : 4 Hours
No. of Credits : 2
College Assessment: 25 Marks

LIST OF EXPERIMENTS

1. To Prepare the Crystals of Chrome alum.
2. To estimate the amount of impurities in a given sample of common salt.
3. To purify the given sample of Common salt.
4. To Prepare Mohr's salt.
5. To Prepare Cuprous Chloride .
6. To estimate the % available Chlorine in a given sample of Bleaching powder.
7. To Prepare the Crystals of Sodium Thiosulphate.
8. To analyse the pigment Red Oxide.
9. To Prepare the Crystals of Ferrous Sulphate from Kipp's apparatus waste.
10. To estimate Sulphate in a given Solution by EDTA method.
11. To estimate the amount of MnO_2 and available Oxygen in the given sample of Pyrolusite.

Subject : BTCHT 408P (BGE) **Machine Drawing (Practical)**
Practical : 3 Hours
University : 25 Marks
Duration of Examination : 6 Hours
No. of Credits : 3
College Assessment: 25 Marks

LIST OF EXPERIMENTS

1 ISI Conventions covering the standard practice in Machine Drawing and also use of ISI specifications for limits and fits.

2 Simple exercise in converting pictorial and isometric views into other graphic projections. Sectional views and missing views preparation details and assembly drawing of simple machine parts from actual models.

3 Preparation of free hand proportionate dimensioned sketches of various machine elements such as:

Screw threads and fasteners such as nuts, bolts, studs, locking arrangements, foundation bolts, etc.

i. Rivets and riveted joints, welded joints.
ii. Keys, cotters and couplings.
iii. Cottered joint and knuckle joint
iv. Engine and machine bearing mounts
v. Bearings and bearing mountings
vi. Different types of valves.

4 Preparation of working drawings, part lists and assembly drawings of simple machine assemblies.

Subject : BTCHT 408P (BGE) **Applied Physical Chemistry II (Practical)**

Practical : 3 Hours No. of Credits : 2

University : 25 Marks College Assessment: 25 Marks

Duration of Examination : 4 Hours

LIST OF EXPERIMENTS

1. To study the $KI_3 \rightarrow KI + I_2$ equilibrium in aqueous solution.
2. To study the ternary system of Toluene-Acetic acid-water
3. To study the adsorption of acetic acid on charcoal and verify the Freundlich adsorption isotherm
4. To determine the heat of crystallization of $CuSO_4 . 5H_2O$.
5. To determine the integral and differential heats of solution of a salt.
6. To determine the thermometric titration curve in the neutralization of strong and weak acids against a strong base.
7. To find the constant of conductivity cell and hence determine the dissociation constant of a weak acid.
8. To determine the solubility of sparingly soluble salts conductometrically
9. To find the pH of buffers and the dissociation constant of an acid using Quinhydrone electrode.
10. To determine the transport number by the e.m.f. method.
11. To study the kinetics of saponification of methyl acetate by sodium hydroxide by conductometry.

Rashtrasant Tukadoji Maharaj Nagpur University

Direction No.22 of 2014

Direction issued under section 14(8) of the Maharashtra Universities Act, 1994, relating to B.Tech. V & VI Semester for the award of Degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology Full Time in the Faculty of Engineering and Technology.

Whereas, the Maharashtra Universities Act No. XXXV of 1994 has come into force with effect from 22nd July, 1994

AND

Whereas, the amendment to the said Act came to be effected from 12th May, 2000

AND

Whereas, the Board of Studies in General Engineering, Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology have decided to make amendment related to V & VI Semester B. Tech. in Credit Based Semester Pattern for award of degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology Full time in the Faculty of Engineering and Technology.

AND

Whereas, the Faculty of Engineering and Technology in its meeting held on 28th May 2014 has considered and approved the V & VI Semester Credit Based Scheme of Examination, Syllabus and Absorption Scheme with the recommendations of the Board of Studies in General Engineering, Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology for its implementation from the academic session 2014-15 and onwards.

AND

Whereas, the recommendations made by the Board of Studies in General Engineering, Chemical Engineering, Chemical Technology and Biotechnology as approved by the Vice Chancellor pertains to Examination leading to the B.Tech. (Semester- V and Semester- VI) for award of degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology.

AND

Whereas, it is expedient to provide an Ordinance for the purposes of describing examination in the Credit Based semester pattern leading to the V and VI Semester for the award of Degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology, indicating there in the syllabus and scheme of examination including absorption scheme and C.G.P.A and S.G.P.A.

AND

Now, therefore, I. Anoop Kumar, Vice Chancellor of Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur in exercise of powers vested in me under section 14(8) of the Maharashtra Universities Act, 1994, do hereby issue the following Direction pertaining to the amendment as made for Semester-V and Semester–VI for award of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology.

1. This Direction shall be called “Direction regarding Credit Based Semester Pattern Scheme and Examination leading to B. Tech. Semester-V and Semester – VI to the Degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur.
2. Subject to the compliance with the provisions of this Direction and any other Ordinance which is in force from time to time shall be applicable

3. The Credit Based Scheme of Examination & Absorption Scheme Appendix for Semester–V and Semester-VI shall be as detailed in the following Table-1

TABLE-1

Sr. No.	**B.Tech. (Branch)**	**Board of Studies**	**Credit Based Scheme of Examinations & Absorption Scheme Appendix**
1.	Chemical Engineering	Chemical Engineering	**A**
2.	Chemical Technology	Chemical Technology	**B**
3.	Biotechnology	Biotechnology	**C**

The A.T.K.T. Rules shall be as given in Table – 2, given below:

TABLE – 2

Admission to Semester	**Candidate should have passed in all subject heads of following examination of the university**	**Candidate should have passed in all subject heads except in 1/3 passing subject heads of the following examination taken together**
I	As per eligibility	---
II	----	---
III	----	I and II Semester
IV	----	I and II Semester
V	I and II Semester	III and IV Semester
VI	I and II Semester	III and IV Semester
VII	III and IV Semester	V and VI Semester
VIII	III and IV Semester	V and VI Semester

4. Students falling under old scheme shall be provided maximum five attempts to clear the subject(s), after which they shall be absorbed in the new scheme.

   Whereas, any student willing to opt for New Credit Based Semester Scheme shall be absorbed as per the appendices mentioned in **Table-1** at equivalent Credit Based Semester Scheme level. However, student will have to appear for the examinations under Credit Based Semester Scheme for the subjects in which student has not cleared the subject in Yearly Pattern Scheme

5. (i) The Scope of subject shall be as indicated in the syllabus.

   (ii) The medium of instruction and examination shall be English.

6. The provisions of Ordinance No. 3 of 2007 relating to the award of grace marks for passing an examination or for securing higher division/class and for securing distinction in subject(s) as updated from time to time shall apply to the examination under this ordinance.

7. An Examinee who does not pass or who fails to present himself/herself for the examination(s) shall be eligible for **reappearing** in the same examination on payment of a fresh fee and as such other fees as may be prescribed from time to time. However, **readmission** to semester should be allowed only when a regular session is running for a particular semester.

8. The computation of Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) of an examinee shall be implemented progressively as from the academic session 2014-15 onwards.

   The marks will be allotted in all examinations which will also include college assessment marks. The total marks for each Theory/Practical subject head shall be converted into Grade points as per **Table - 3.**

SGPA shall be calculated based on Grade Points earned corresponding to percentage of marks as given in **Table - 3** and the Credits allotted to respective Theory/Practical subject head shown in the scheme of examination for respective semester.

9. SGPA shall be computed for every semester and CGPA shall be computed only in VIII semester. The CGPA of VIII semester shall be calculated based on **SGPA** of V to VIII semester as per following computation:-

$$\mathbf{SGPA} = \frac{\sum_{i=1}^{m} C_i.G_i}{\sum_{i=1}^{m} C_i} = \frac{C_1.G_1 + C_2.G_2 + \ldots + C_m.G_m}{C_1 + C_2 + \ldots + C_m}$$

Where, m = Number of subject heads in a given Semester.

$$\mathbf{CGPA} = \frac{\sum_{j=1}^{n} C_j.G_j}{\sum_{j=1}^{n} C_j} = \frac{C_1.G_1 + C_2.G_2 + \ldots + C_n.G_n}{C_1 + C_2 + \ldots + C_n}$$

Where, n = Number of subject heads from V to VIII Semester taken together.

Ci or Cj = Credit of individual subject head (Theory/Practical).

Gi or Gj = Grade Point earned in individual subject head (Theory/practical).

10. CGPA equal to 6.75 and above shall be considered as equivalent to First Division and CGPA equal to 8.25 and above shall be considered as equivalent to Distinction on Grade Card of VIII Semester as a foot note. Equivalent percentage calculation will be based on the following formula:

Equivalent % = (CGPA – 0.75) x 10

TABLE-3

THEORY			PRACTICAL		
Grade	**Percentage of Marks**	**Grade Points**	**Grade**	**Percentage of Marks**	**Grade Points**
AA	80 ≤Marks≤ 100	10	AA	85 ≤Marks≤ 100	10
AB	70 ≤Marks< 80	9	AB	80 ≤Marks< 85	9
BB	60 ≤Marks< 70	8	BB	75 ≤Marks< 80	8
BC	55 ≤Marks< 60	7	BC	70 ≤Marks< 75	7
CC	50 ≤Marks< 55	6	CC	65 ≤Marks< 70	6
CD	45 ≤Marks< 50	5	CD	60 ≤Marks< 65	5
DD	40 ≤Marks< 45	4	DD	50 ≤Marks< 60	4
FF	00 ≤Marks< 40	0	FF	00 ≤Marks< 50	0
ZZ	Absent in Examination	-	ZZ	Absent in Examination	-

11. As Soon as possible, after the examination, the Board of Examinations shall publish a list of successful examinees and the Degree shall be awarded based on V to VIII Semester SGPA and CGPA calculated thereon.

12. I, further directed that the aforesaid Direction shall come into force from the date of issuance and shall remain in force till the relevant Ordinance comes into being in accordance with the provisions of Maharashtra Universities Act, 1994 and the relevant provisions published by this Direction shall be physically repealed from the existing Ordinance.

Sd/-
. (Anoop Kumar)
Vice Chancellor

Nagpur:

Dated::18/6/2014

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APPENDI X – A
SCHEME OF EXAMINATION
RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIFTH SEMESTER B.TECH (CHEMICAL ENGINEERING)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Teaching Scheme, hr.				Credit				MARKS				Total Marks
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHE 501T	Fluid Mechanics	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
2.	BTCHE 502T	Chemical Engineering Thermodynamics	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
3.	BTCHE 503T	Mass Transfer	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
4.	BTCHE 504T	Heat Transfer	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
5.	BTCHE 505T	Biochemical Engineering	BCHE	3	-	-	3	3	-	-	3	20	80	-	-	**100**
6.	BTCHE 506P	Fluid Mechanics	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
7.	BTCHE 507P	Mass Transfer	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
8.	BTCHE 508P	Heat Transfer	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
			Total	**15**	**9**	**4**	**28**	**15**	**6**	**4**	**25**	**100**	**400**	**75**	**75**	**650**

SCHEME OF EXAMINATION
RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SIXTH SEMESTER B.TECH (CHEMICAL ENGINEERING)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Teaching Scheme, hr.				Credit				MARKS				**Total Marks**
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHE 601T	Separation Processes	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
2.	BTCHE 602T	Environmental Engineering	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
3.	BTCHE 603T	Process Equipment Design	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
4.	BTCHE 604T	Chemical Reaction Engineering	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
5.	BTCHE 605T	Elective-I	BCHE	3	-	-	3	3	-	-	3	20	80	-	-	**100**
6.	BTCHE 606P	Environmental Engineering	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
7.	BTCHE 607P	Process Equipment Design	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
8	BTCHE 608P	Separation Processes	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
8.	BTCHE 609P	Minor Project	BCHE	-	2	-	2	-	1	-	1	-	-	50	-	**50**
			Total	**15**	**11**	**4**	**30**	**15**	**7**	**4**	**26**	**100**	**400**	**125**	**75**	**700**

Elective	Subject Name				
	BOARD				
	BTCHE				
Elective-I	1.Human Behavior in Organization	2. Materials Management	3. Marketing Management	4. Advanced Materials	5. Renewable Energy Sources

Scheme of Absorption for Old Pattern to Semester Pattern of 5th Semester B. Tech. (Chemical Engineering)							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				**As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme**			
Fifth Semester B. Tech (Chemical Engineering)				**Fifth Semester B. Tech (Chemical Engineering)**			
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	
1	5SCE1 (BChE)	Fluid Mechanics	Theory	BTCHE 501T	Fluid Mechanics	Theory	
2	5SCE2 (BChE)	Chemical Engineering Thermodynamics	Theory	BTCHE 502T	Chemical Engineering Thermodynamics	Theory	
3	------	------		BTCHE 503T	Mass Transfer*	Theory	
4	------	------		BTCHE 504T	Heat Transfer*	Theory	
5	5SCE3 (BChE)	Environmental Eng. and Biotechnology	Theory	BTCHE 505T	Biochemical Engineering	Theory	
6	5SCE4 (BChE)	Applied Mathematics III	Theory	------	------		
7	5SCE5 (BChE)	Plant Design –I	Theory	------	------		
8		Fluid Mechanics	Practical	BTCHE 506P	Fluid Mechanics	Practical	
9		------	------	BTCHE 507P	Mass Transfer**	Practical	
10		------	------	BTCHE 508P	Heat Transfer**	Practical	
11		Industrial Waste Treatment	Practical	------	------		

*** Students to appear in university theory examination as per the new scheme**
**** Students to appear in university practical examination as per the new scheme**

Scheme of Absorption for Old Pattern to Semester Pattern of 6th Semester B. Tech. (Chemical Engineering)								
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme**			
Sixth Semester B. Tech (Chemical Engineering)					**Sixth Semester B. Tech (Chemical Engineering)**			
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	
1	6SCE1 (BChE)	Organic Chemical Process Industries	Theory		------	------		
2	------	------			BTCHE 601T	Separation Processes*	Theory	
3	------	------			BTCHE 602T	Environmental Engineering*	Theory	
4	------	------			BTCHE 603T	Process Equipment Design*	Theory	
5	6SCE2 (BChE)	Heat Transfer	Theory		------	------		
6	6SCE 3 (BChE)	Mass Transfer – I	Theory		------	------		
7	6SCE4 (BChE)	Chemical Reaction Engineering- I	Theory		BTCHE 604T	Chemical Reaction Engineering	Theory	
8	6CSE5 (BChE)	Process Control – I	Theory		------	------		
9	------	********			BTCHE 605T	Elective-I$	Theory	
10	------	------			BTCHE 606P	Environmental Engineering**	Practical	
11	------	------			BTCHE 607P	Process Equipment Design**	Practical	
12	------	------			BTCHE 608P	Minor Project**	Practical	
13		Heat Transfer	Practical		------	------		
14		Organic Chemical Technology	Practical		------	------		
15		Instrumental Methods of Analysis	Practical		------	------		

*** Students to appear in university theory examination as per the new scheme**

**** Students to appear in university practical examination as per the new scheme**

$ This subject is exempted

APPENDIX – B
SCHEME OF EXAMINATION
B. TECH (CHEMICAL TECHNOLOGY)
FIFTH SEMESTER B.TECH (CHEMICAL TECHNOLOGY)

Sr. No	Code Theory (T) Practical (P)	Subject	Board	Workload				Credit				MARKS				Total Marks
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHT501T	Fluid Flow Operation	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
2.	BTCHT502T	Solid Fluid Operations	BCHT	3	-	-	3	3	-	-	3	20	80	-	-	100
3.	BTCHT503T	Chemical Equipment Design	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
4.	BTCHT 504T	Process Plant Utilities	BGE	3	-	-	3	3	-	-	3	20	80	-	-	100
5.	BTCHT505T	*Special Technolog-III	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
6.	BTCHT506P	Fluid Flow Operation	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
7.	BTCHT507P	Solid Fluid Operations	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
8.	BTCHT508P	Chemical Equipment Design	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
Total				15	9	3	27	15	6	3	24	100	400	75	75	650

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- Food Technology
- Technology of Oils, Fats and Surfactants
- Petroleum Refining and Petrochemical Technology
- Pulp & Paper Technology
- Plastics & Polymer Technology
- Surface Coating Technology

SCHEME OF EXAMINATION
B. TECH (CHEMICAL TECHNOLOGY)
SIXTH SEMESTER B.TECH (CHEMICAL TECHNOLOGY)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Workload				Credit				MARKS				Total Marks
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHT 601T	Process Engineering Thermodynamics	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
2.	BTCHT602T	Heat Transfer Operations	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
3.	BTCHT603T	Chemical Process Control	BCHT	3	-	-	3	3	-	-	3	20	80	-	-	100
4.	BTCHT604T	Environmental Engineering	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
5.	BTCHT605T	*Special Technology IV	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
6.	BTCHT606P	Heat Transfer Operations	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
7	BTCHT607P	Environmental Engineering	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
8.	BTCHT608P	*Special Technology II	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
9.	BTCHT 609P	Minor Project	BCHT	-	2	-	2	-	1	-	1			50	--	50
Total				15	11	4	30	15	7	4	26	100	400	125	75	700

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- Food Technology
- Technology of Oils, Fats and Surfactants
- Petroleum Refining and Petrochemical Technology
- Pulp & Paper Technology
- Plastics & Polymer Technology
- Surface Coating Technology

Scheme of Absorption for Old Pattern to Semester Pattern of Third Year B. Tech. (Chemical Technology)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme		
Fifth Semester B. Tech (Chemical Technology)				Fifth Semester B. Tech (Chemical Technology)		
Sr. No	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**
1	5S.CT.1 (BChE)	Fluid Mechanics and Mechanical Operations	Theory	BTCHT 501T (BCHT)	Fluid Flow Operation	Theory
2				BTCHT 502T (BCHT)	Solid Fluid Operations	Theory
3	5S.CT.2 (BChE)	Plant Design	Theory	BTCHT 503T (BCHT)	Chemical Equipment Design	Theory
4	---	-----	---	[1]BTCHT 504T (BGE)	Process Plant Utilities	Theory
5	5S.CT.3 (BChE)	Heat Transfer	Theory	---	-----	---
6	5S.CT.4 (BGE)	Organic Chemical Process Industries	Theory	---	-----	---
7	5S.CT.5 (BCT)	Special Technology III	Theory	BTCHT 505T (BCHT)	Special Technology III	Theory
8	5S.CT.6 (BChE)	Unit Operations	Practical	BTCHT 506P (BCHT)	Fluid Flow Operation	Practical
9				BTCHT507P (BCHT)	Solid Fluid Operations	Practical
10	------	--------	--------	BTCHT508P (BCHT)	Chemical Equipment Design	Practical
11	5S.CT.7 (BChE)	Heat Transfer	Practical	--------	---------	--------
12	5S.CT.8 (BGE)	Organic Chemical Technology	Practical	---------	---------	--------

[1]Subject is covered in Fourth Semester for Old Pattern according to subject (4S.CT.2) Plant Utilities (Theory). They may be exempted.

Scheme of Absorption for Old Pattern to Semester Pattern of Third Year B. Tech. (Chemical Technology)							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme**		
Sixth Semester B. Tech (Chemical Technology)					**Sixth Semester B. Tech (Chemical Technology)**		
Sr. No	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**		**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**
1	6S.CT.1 (BGE)	Applied Mathematics III	Theory		---	-----	---
2	6S.CT.2 (BChE)	Mass Transfer	Theory		---	-----	---
3	6S.CT.3 (BChE)	Environmental Engineering and BioTechnology	Theory		BTCHT 604T (BCHT)	Environmental Engineering	Theory
4	6S.CT.4 (BChE)	Chemical Engineering Thermodynamics	Theory		BTCHT 601T (BCHT)	Process Engineering Thermodynamics	Theory
5	6S.CT.5 (BCT)	Special Technology IV	Theory		BTCHT 605T (BCHT)	Special Technology IV	Theory
6	6S.CT.6 (BChE)	Mass Transfer	Practical		---	-----	---
7	6S.CT.7 (BGE)	Industrial Waste Treatment	Practical		---	-----	---
8	6S.CT.8 (BCT)	Special Technology II	Practical		BTCHT 608P (BCHT)	Special Technology II	Practical
9	---	-----	---		BTCHT 603T (BCHT)	Chemical Process Control	Theory
10	---	-----	---		[1]BTCHT 602T (BCHT)	Heat Transfer Operations	Theory
11	---	-----	---		[2]BTCHT 606P (BCHT)	Heat Transfer Operations	Practical
					BTCHT607P (BCHT)	Environmental Engineering	Practical
12	---	-----	---		BTCHT 609P (BCHT)	Minor Project	Practical

[1]Subject is covered in Fifth Semester for Old Pattern according to subject (5S.CT.3) Heat Transfer (Theory). They may be exempted.

[2]Subject is covered in Fifth Semester for Old Pattern according to subject (5S.CT.7) Heat Transfer (Practical). They may be exempted

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Engineering & Technology
Syllabus for

Fifth Semester B.Tech. Chemical Engineering

Subject	**: BTCHE 501T** (BCHE)		**Fluid Mechanics (Theory)**	
Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

UNIT 1: Classification of fluid mechanics, Properties of fluids, Classification of fluids, Shearing and flow, characteristics of Newtonian and Non-Newtonian fluids, Shear stress distribution of fluids, Pressure measurement, U-tube, Inverted U-tube, Differential and Inclined manometers, Reynolds number, Friction factor

UNIT 2 : Bernoulli`s equation, Frictional loss in pipe, Continuity equation, Velocity distribution for, laminar flow and turbulent flow, Hydraulic mean diameter, losses due to enlargement and contraction of pipe cross - section.

UNIT 3 : Equivalent length of pipe, Pipe fittings, Gate , Globe, Check and Butterfly valves, Boundary layer development, Two-phase flow, Flow patterns in two phase flow. The Baker diagram, Erosion in two phase flow.

UNIT 4 : Flow rate measurement, Working principle and expressions for flowrate through Pitot tube, Orifice meter, Venturimeter, Nozzle, Rotameter, Notch and Weir, Coefficient of discharge, Wet gas flowmeter, Pressure recovery in Orificemeter, Venturimeter and Nozzle.

UNIT 5 : Pumping of fluids, Classification of pumps, Positive displacement pumps, Reciprocating, Pump, Plunger pump, Diaphragm pump, Metering pump, Rotary gear pump, Rotary lobe Pump, Rotary vane pump, Flexible vane pump, Mono pump, Cetrifugal pump, Volute pump, Volute pump with vortex chamber and diffuser vanes, Cavitation, Priming,Net positive suction head ,Multistage centrifugal pumps. Specific speed and operating characteristics of centrifugal pump.

UNIT 6 : Fluid flow in packed column, Classification of packings, Characteristics of packing material, Loading and flooding in packed column,Specific surface of packed column, Permeability coefficient, Modified Reynolds number, Modified friction factor, Kozeny`s,Carman`s, Sawistowski`s and Ergun`s equations for packed column. Characteristics of fluidization, Aggregative and particulate fluidization, Incipient fluidization velocity, equations for pressure drop across fluidized column, Applications of packed and fluidized column.

Books Recommended:

1. R. P. Vyas, Fluid Mechanics, Second edition, Denett & Co. Publication, 2008.
2. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. I: Fluid Flow, Heat Transfer and Mass Transfer, Sixth Edition, Butterworth-Heinemann an imprint of Elsevier
3. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. II: Particle Technology and Separation Processes, Fifth Edition, Butterworth-Heinemann an imprint of Elsevier
4. G.G. Brown, Unit Operations, CBS Publishers Pvt. Ltd, 2005.

5. W.L. Badger, J.T. Banchero, Introduction to Chemical Engineering, Tata McGraw Hill Education, 1997.
6. W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill Publication, 2005.

Subject : **BTCHE 502T** (BCHE) **Chemical Engineering Thermodynamics (Theory)**
Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

Unit I: Basics of Thermodynamics

Review of laws of thermodynamics, Equations of state, Maxwell relationships, homogeneous phases, residual properties, heat effects, two-phase systems, Clausius- Clapeyron equation

Unit II: Compression of Fluid

Flow of compressible fluids, measurement of flow of compressible fluids, convergent-divergent nozzles, supersonic flow, Compression of fluids, single and multistage compression, centrifugal and reciprocating compressors-construction and working

Unit III: Refrigeration

Review of refrigeration cycles, Joule-Thomson expansion, compression and absorption refrigeration, refrigerants and their properties, estimation of power requirements of refrigeration systems, heat pumps.

Unit IV: Solution Thermodynamics

Fundamental property relations, chemical potential, criteria for phase equilibrium, partial properties, ideal gas mixtures, fugacity and fugacity coefficients for pure species, for species in solution, ideal solutions, Excess properties, VLE data- fugacity, Activity coefficients, Excess Gibb's energy, Margules and Van Laar equation, Property changes of mixing

Unit V: Phase Equilibria

Vapour – liquid equilibrium: The nature of equilibrium, criteria of equilibrium, phase rule, Duham's theorem, Raoult's law, VLE by modified Raoult's law, dew point and bubble point calculations, Flash calculations, Determine whether azeotrope exist**,** Equilibrium and stability, liquid -liquid equilibrium, solid-liquid equilibrium, VLL equilibrium

Unit VI: Chemical Reaction Equilibria

Criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant. Effect of temperature on equilibrium constant, evaluation of the equilibrium constant, relation of equilibrium constant to composition, calculation of equilibrium conversion for single reaction, The phase rule and Duhem's theorem for reacting systems, multireaction Equilibria

Books Recommended:

1) J.M. Smith, H.C. Van Ness, M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 6th Edition, McGraw Hill, 2001.
2) K.V. Narayanan, Chemical Engineering Thermodynamics, Prentice-Hall India, 2006.
3) Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press, 1997.
4) B.G. Kyle, Chemical & Process Thermodynamics, 3rd Edition, Prentice Hall, New Jersey, 1999.
5) O.A. Hougen, K.M. Watson, and R.A. Ragatz, Chemical Process Principles Part II, Thermodynamics, John Wiley, 1970.
6) R. Reid, J. Praunitz, T. Sherwood, The Properties of Gases and Liquids, 3rd Edition, McGraw-Hill, New York, 1977.

Subject **: BTCHE 503T** (BCHE) **Mass Transfer (Theory)**

Lecture	: 3 Hours	Tutorial:1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit I: **Introduction to Mass Transfer and Molecular Diffusion**

Introduction to mass transfer, concept of diffusivity, Molecular diffusion in gases, liquids and solids, diffusivities of gases and liquids, types of diffusion, Fick's and Maxwell law of diffusion, Eddy diffusion, Steady state molecular diffusion. Empirical equations used to determine diffusivity through gas and liquid

Unit II: **Mass Transfer Coefficient and Interphase Mass Transfer**

Concept of mass transfer coefficients, their relationship, mass transfer under laminar and turbulent flow past solids, boundary layers, mass transfer at fluids surfaces correlation of mass transfer coefficients, J_D, HTU, and NTU concepts, theories of mass transfer, interphase mass transfer and overall mass transfer coefficients, application to gas-liquid and liquid-liquid systems.

Unit III: **Humidification and Dehumidification**

General principles, vapour-liquid equilibria, enthalpy of pure substances, wet bulb temperature relation, psychrometric chart, Lewis relation, methods of humidification and dehumidification, cooling towers & calculation of height of cooling tower – HTU, NTU concept,.

Unit IV: **Drying**

Introduction and Principles of drying, equilibrium in drying, type of moisture binding, mechanism of drying, continuous drying, time required for drying, mechanism of moisture movement in solid, heat & mass balance in drying, drying equipments and their design principles.

Unit V: **Adsorption and Ion Exchange**

Basic principle and equilibria in adsorption. Types of adsorption – Physical and chemical, adsorption isotherms- Langmuir and Freundlich, Single gases and vapors, Introduction to pressure Swing Adsorption (PSA), and Temperature Swing Adsorption (TSA), Equipments: Continuous Contact: steady state– moving bed Absorbers. Ion Exchange- Principles of Ion Exchange, Techniques and applications, Equilibria and rate of ion exchange, equipments

Unit VI: **Crystallisation**

Crystallization fundamentals, solubility and saturation, Miers theory of crystallization, crystal nucleation, crystal growth, population balance and size distribution, material and energy balances, crystallization equipments, fractional crystallization, freeze crystallization, , calculations of yield.

Books Recommended:

1. R.E. Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, 1980.
2. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. I: Fluid Flow, Heat Transfer and Mass Transfer, Sixth Edition, Butterworth-Heinemann an imprint of Elsevier
3. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. II: Particle Technology and Separation Processes, Fifth Edition, Butterworth-Heinemann an imprint of Elsevier.
4. C.J. Geankoplis, Transport Processes and Separation Process Principles, 4 Edition, Prentice Hall, 2003.

5. B.K. Dutta, Principles of Mass transfer and separation processes. PHI Learning, 2013.
6. W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill Publication, 2005.

Subject : **BTCHE 504T** (BCHE) **Heat Transfer (Theory)**

Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4

University : 80 Marks College Assessment : 20 Marks

Duration of Examination: 3 Hours

Unit I: Concept of Heat Transfer

Introduction & mechanism of heat transfer. Development and use of general differential equation for heat transfer rate & temperature distribution for steady state heat conduction for various shapes & geometries of solids with various boundary conditions, with & without heat generation.

Unit II: Unsteady State Heat Transfer, Fins & Insulation

Use of lumped capacitance, Heisler charts and error function methods for unsteady state heat transfer. Classification of fins. Fin efficiency and overall effectiveness. Classification and selection of various types of thermal insulations. The concept of critical and economical thickness of insulation and its evaluation for cylindrical and spherical heat transfer equipment.

Unit III: Natural & Forced Convection: Heat Transfer without Phase Change

Introduction to natural and forced convection in laminar and turbulent flow over flat plate, over cylinder & sphere and through closed channels. Concept and use of thermal & hydrodynamic boundary layer and its significance. Prediction of heat transfer coefficient using theoretical, empirical and analogies concepts.

Unit IV: Condensation & Boiling : Convection Heat Transfer with Phase Change

Mechanism of condensation: Nusselt's approach and its extension. Heat transfer in saturated pool & forced convection boiling of liquids. Study of Boiling curve : Its significance and relevance in constant wall temperature & constant heat flux boiling with specific reference to critical (Maximum) heat flux and minimum heat flux (Ladenfrost point).

Unit V: Heat Exchangers & Evaporators

Concept of fouling resistance & overall heat transfer coefficient in heat exchangers. Classification of heat exchangers. Design and rating of double pipe, shell and tube heat exchangers by LMTD and ε-NTU methods. Compact heat exchangers: Plate heat exchangers, helical coil heat exchangers, spiral heat exchangers, regenerators. Classification of evaporators. Steam economy and capacity of multiple effect evaporators. Design considerations of evaporators..

Unit VI: Radiation & Special Cases of Heat Transfer

Radiation fundamentals, properties of materials and heat exchange. Use of solar energy & thermic fluids. Heat transfer in furnaces, agitated vessels, fluidized beds, packed beds, jacketed vessels, immersed helical and spiral coil equipment.

Books Recommended:

1. B.K. Dutta, Heat transfer Principles and Applications, PHI Private Limited, 2001.
2. S.D. Dawande, Principles of Heat Transfer and Mass Transfer, Denett & Co, 2009.
3. R.K. Rajput, Heat and Mass Transfer, S. Chand & Company Ltd., 2007.
4. C.J. Geankoplis, Transport Processes and Separation Process Principles, 4 Edition, Prentice Hall, 2003
5. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. I: Fluid Flow, Heat Transfer and Mass Transfer, Sixth Edition, Butterworth-Heinemann an imprint of Elsevier

6. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. II: Particle Technology and Separation Processes, Fifth Edition, Butterworth-Heinemann an imprint of Elsevier
7. J. M. Coulson, J. F. Richardson, R. K. Sinnott, Chemical Engineering Vol. 6 - Design, Pergamon Press, 1983
8. W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill Publication, 2005.
9. D.S. Kumar, Basics of Heat & Mass Transfer, Eight Edition, S.K. Kataria & Sons, 2010.
10. W.L. Badger, J.T. Banchero, Introduction to Chemical Engineering, Tata McGraw Hill Education, 1997.

Subject : **BTCHE 505T** (BCHE) **Biochemical Engineering (Theory)**

Lecture : 3 Hours No. of Credits : 3

University : 80 Marks College Assessment : 20 Marks

Duration of Examination: 3 Hours

Unit I: Introduction to bio-processing fundamentals, overview of microbiology, importance of microbiology, introduction to biochemistry

Unit II: Classification of enzymes, immobilization of enzymes, industrial applications of enzymes, requirement of fermentation process, media design for fermentation, aerobic and anaerobic fermentation processes, solid state fermentation and submerged fermentation.

Unit III: Kinetics of microbial growth, kinetic models, substrate and product inhibition and cell growth, design equations based on biochemical reactions, design of ideal reactors, multiple reactors, related examples etc.

Unit IV: Bioreactors and Fermenters, monitory and control of fermentation processes, various accessories, cultivation and media optimization, product recovery by various unit operations

Unit V: Rheology and mixing in fermentation broths, evolution of rheological data, heat and mass transfer in bioprocessing

Unit VI: Importance of sterilization, thermal death kinetics, batch and continuous sterilization, design and analysis of bioreactor, chemical and biological methods of effluent treatment

Books Recommended:

1. D.G. Rao, Introduction to Biochemical Engineering, Tata McGraw Hill Education, 2010.
2. M. L Shuler, F. Kargi, Bioprocess Engineering – Basic Concepts, 2nd Edition, Prentice Hall Publication, 2003.
3. J.E. Bailey, D.E. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw-Hill, Inc., 1986.
4. A. Whitekar, P. F. Stanbury, S. J. Hall, Principles of Fermentation Technology, 2nd Edition, Butterworth-Heinemann, 1999.
5. S. Aiba, A. E. Humphrey and N. F. Millis, Biochemical Engineering, 2nd Edition, Academic Press, New York, 1973.
6. B. Atkinson, Biochemical reactors, Pion Limited, London, 1974.

Subject	**: BTCHE 506P** (BCHE)	**Fluid Mechanics (Practical)**	
Practical	: 3 Hours	No. of Credits	: 2
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. Verification of Bernoulli's equation
2. To calibrate venturimeter and obtain its coefficient of discharge
3. To calibrate orificemeter and obtain its coefficient of discharge
4. To calibrate rotameter
5. To calibrate notched weir and obtain its coefficient of discharge
6. Friction factor vs. Reynolds number for flow of water in pipe
7. Friction factor vs. Reynolds number for flow of air in pipe
8. To study the relationship between fanning friction factor and Reynolds number for a fluid flowing though coils
9. To obtained equivalent length of pipe for various fitting.
10. Operating characteristics of centrifugal pump
11. To study the hydrodynamic characteristics of a packed bed
12. To study the hydrodynamic characteristics of a fluidized bed
13. Studies in two phase flow

Subject	**: BTCHE 507P** (BCHE)	**Mass Transfer (Practical)**	
Practical	: 3 Hours	No. of Credits	: 2
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. Winkelmann's method – To find the diffusion Coefficient of vapour in still air
2. Liquid Diffusion – To find the Diffusion Coefficient for a liquid –liquid system
3. To calculate rate of Drying.
4. Studies of crystallization phenomena in Batch Crystallization
5. To evaluate the performance of Cooling Tower.
6. To find the mass transfer coefficient in a wetted wall Column
7. Determination of solid-liquid mass transfer coefficient.
8. Evaporation from free surface.
9. Determination of HTU in packed bed.
10. Study of Ion exchange process.
11. Removal of impurities by use of adsorption techniques.

Subject	**: BTCHE 508P** (BCHE)	**Heat Transfer (Practical)**	
Practical	: 3 Hours	No. of Credits	: 2
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. To determine total thermal resistance and thermal conductivity of composite wall
2. To determine thermal conductivity of lagging material
3. To determine the air film heat transfer coefficient by natural convection using fin concept.
4. To determine the air film heat transfer coefficient by forced convection using fin concept.
5. To determine Stefan – Boltzman constant for radiation heat transfer
6. To determine convective heat transfer coefficient (while cooling and heating) from the transient response data, with the help of Heisler chart for an infinite cylinder
7. To determine convective heat transfer coefficient (while cooling and heating) from the transient response data, with the help of Heisler chart for Rectangular bar
8. Prediction of thermal conductivity of unknown material using Heisler chart
9. To determine the overall heat transfer coefficient for heating in jacketed enamelled kettle
10. To study boiling phenomenon in a jacketed kettle with and without stirring.
11. To determine overall heat transfer coefficient in shell and tube heat exchanger
12. To determine the overall heat transfer coefficient in CSTR
13. To study the heat transfer in plate type heat exchanger and calculate the overall heat transfer coefficient
14. To verify Dittus- Boelter equation for vertical tube exchanger
15. To determine and verify the relationship between overall heat transfer coefficient and velocity of fluid as suggested by Wilson
16. To determine heat transfer in fin and finless heat exchanger and evaluate fin effectiveness and fin efficiency
17. Verification of Nussult equation for filmwise condensation on the outer surface of inner tube in vertical concentric tube heat exchanger

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Engineering & Technology
Syllabus for

Sixth Semester B.Tech. Chemical Engineering

Subject **: BTCHE 601T** (BCHE) **Separation Processes (Theory)**
Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

Unit I & II: Distillation

Vapour – liquid equilibria for ideal and non-ideal systems, positive and negative deviations from ideality, relative volatility. Methods of distillation - differential, flash, low pressure, batch rectification, Continuous rectification for binary system, multistage (tray) towers, Lewis – Sorel, McCabe Thiele Method, Multiple feeds, side streams, tray efficiencies, concept of reflux, Underwood-Fenske equation, Partial and total Condensers, reboilers, Ponchon Savarit method, steam distillation, extractive and azeotropic distillation, Reactive Distillation, Packed towers for distillation, NTU, HTU, HETP concept and calculations, Equipments, Design Aspects

Unit III: Gas Absorption

Mechanism of gas absorption, equilibrium in gas absorption, absorption in wetted wall columns, estimation of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculation of height of packed and spray tower. Absorption in tray towers, absorption and stripping factors, tray efficiencies, calculation of number of trays for absorption, Equipments for absorption

Unit IV: Liquid – Liquid Extraction

Liquid-liquid equilibria, single stage extraction, multistage crosscurrent, countercurrent and cocurrent extraction, calculations based on triangular diagrams, stage efficiency, Continuous contact extraction in packed towers, HTU and NTU concept, Equipments for extraction

Unit V: Solid – Liquid Extraction

General principles, continuous leaching, ideal stage equilibrium, Calculation for number of stages, constant and variable underflow, stage efficiencies, right angle triangle diagram, Leaching equipments

Unit VI: Novel Techniques

Introduction and types of membrane separation processes, Membrane separation techniques- microfiltration, ultrafiltration. Nanofiltration, reverse osmosis, dialysis, pervaporation, gas permeation membrane process, molecular sieves. Other advanced separation processes, selection of separation processes for downstream processing.

Books Recommended:

1. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. I: Fluid Flow, Heat Transfer and Mass Transfer, Sixth Edition, Butterworth-Heinemann an imprint of Elsevier

2. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. II: Particle Technology and Separation Processes, Fifth Edition, Butterworth-Heinemann an imprint of Elsevier
3. R.E. Treybal, Mass Transfer Operations, 3rd edition, McGraw Hill, 1980.
4. C.J. Geankoplis, Transport Processes and Separation Process Principles, 4 Edition, Prentice Hall, 2003
5. S. L. Pandharipande, Principles of Distillation, Dennet and Co.
6. W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill Publication, 2005.
7. B.K. Dutta, Principles of Mass transfer and separation processes, PHI Learning, 2007.
8. J. D. Seader, E. J. Henley, Separation Process Principles, Wiley, 1998.

Subject : **BTCHE 602T** (BCHE) **Environmental Engineering (Theory)**

Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4

University : 80 Marks College Assessment : 20 Marks

Duration of Examination: 3 Hours

Unit I: Environmental Pollutants

Sources & characterization of various pollutants. Concepts of biodegradability, biosorption, biomagnifications. Measurement : COD, BOD, TOD, ThOD, soluble, suspended, volatile solids, ammonical nitrogen. Mathematical model for BOD. Re-oxygenation and de-oxygenation in natural purification process.

Unit II: Natural Process of Water & Air Pollution Control

Mathematical analysis by Streeter-Phelps of oxygen sag curve in natural purification of waste water. Determination of stack height and plume rise. Meteorological parameters and their effects on dilution/dispersion of pollutants present in flue/exhaust gases coming out from stationery and moving sources. Prediction of pollutant concentration downstream of discharge point. Plume behavior.

Unit III: Air Pollution Management

Basic design and operating principles of wet & dry equipments for removal of particulate and gaseous pollutants. Control of air pollution by process changes.

Unit IV: Water Pollution Management

Principles of primary secondary, tertiary and advanced treatment of waste water. Aerobic and anaerobic processes in ponds and lagoons. Basic process design and operating principles of various activated sludge (suspended growth) processes. trickling filter & rotating biological contactor (Attached growth). Special reactors.

Unit V: Solid Waste Pollution Management:

Solid waste management by dumping, landfill, incineration, composting, vermiculture; using bioremediation for specific pollutants like chromium. Mercury, ammonia / urea, phenolic sludge. E-waste. Hazardous waste management.

Unit VI: Pollution Control in Selected Process Industries & Major Issues

Pollution in fertilizer industries, petroleum refineries and petrochemical units, pulp and paper industries, Sugar industries, Dairy, Alcohol industries. Radioactive wastes. Case studies. Environmental impact assessment (EIA), Environmental audit, Major disasters, global environmental policies and national strategies.

Books Recommended:

1. Metcalf and Eddy, Wastewater Engineering: Treatment, Disposal and Reuse, Tata McGraw-Hill Pub.Co.Ltd., New Delhi, 1979.
2. S.P. Mahajan, Pollution Control in Process Industry, Tata McGraw Hill Publishers, 1987.
3. G.N. Pandey, G.C. Camey, Environmental Engineering, Tata McGraw-Hill Pub.Co.Ltd., 1992.
4. H.S. Peavy, D.R. Rowe, G. Tchobanoglous, Environmental Engineering, McGraw-Hill, 1986.
5. C.N. Sawyer, P.L. McCarty, G.F. Parkin, Chemistry for Environmental Engineering, Tata-McGraw-Hill Edition, 2003.
6. B.C. Punmia, A.K. Jain, A. K. Jain, Wastewater Engineering, Laxmi Publications, 2005.
7. S.K. Garg , Sewage Disposal and Air Pollution Engineering, Khanna Publishers, 2010.
8. M.N. Rao, H.V. Rao, Air Pollution, McGraw-Hill Europe, 1989.

Subject	**: BTCHE 603T** (BCHE)		**Process Equipment Design (Theory)**	
Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit I: Introduction to Principles of Design

Nature of process equipments, general design procedure, basic considerations in design, standards, codes, and their significance, equipment classification and their selection, design pressure, design temperature, design stress, review of fabrication techniques and environmental considerations in design procedure. Principal stresses, theories of failure . Materials of construction and selection for process equipments, linings and coatings for equipments.

Unit II: Pressure Vessel

Proportioning of pressure vessels, selection of L/D ratio, optimum proportions of vessels. Design of unfired pressure vessels subjected to combined loading, purging of vessels.

Selection and design of various heads such as flat, hemispherical, torispherical, elliptical and conical, Opening/ nozzles, manholes, Nozzle reinforcement design, etc. Flanged joints, classification of flanges, design of non standard flanges, types of Gaskets their selection, and design. Bolt design and selection.

Unit III: Design of Pressure Vessels Subjected To External Pressure and High Pressure Vessels

Pressure vessels subjected to external pressure: Design of shell, heads, nozzles, flanged joint, stiffening rings.

Design of thick cylinder, pre-stressing, Analysis and design of high pressure vessels: monoblock and compound (multilayer), etc.

Unit IV: Vessel Support

Introduction and classification of supports, design of skirt supports, stresses due to dead weight, wind load, seismic load, and period of vibration, design of base plate, skirt, bearing plate, anchor bolts, bolting chairs, design of bracket supports. Design of saddle supports, ring stiffeners, etc.

Unit V: Storage Vessels

Various types of storage vessels and applications, Atmospheric vessels, vessels for storing volatile and nonvolatile liquids, storage of gases, Losses in storage vessels, Various types of roofs used for storage vessels, manholes, nozzles and mountings. Design of cylindrical and spherical storage vessels; should include base plates, shell plates, roof plates, wind girders, curb angles for self supporting and column supported roofs.

Unit VI: Agitators and Reaction Vessels

Types of agitators, their selection, applications, baffling, power consumption which includes twisting moment, equivalent bending moment, design of blades etc.

Reaction vessels- Introduction, classification, heating systems, design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil. Study and design of internal coil reaction vessels, Heat transfer coefficients in coils.

Books Recommended:

1. S. D. Dawande, Process Equipment Design, Denett & Co, 2009
2. M.V. Joshi, V. V. Mahajani, Process Equipment Design, Macmillan India.
3. B.C. Bhattacharya, Introduction to Chemical Equipment Design, CBS Publications, 1985.
4. J. M. Coulson, J. F. Richardson, R. K. Sinnott, Chemical Engineering Vol. 6 - Design, Pergamon Press, 1983.
5. E.E. Ludwig, Applied Process Design for Chemical and Petrochemical Plants, Vol. 1 and 2, Gulf Publishing Co., 1997.
6. S. M. Walas, Chemical Process Equipment: Selection and Design, Butterworth-Heinemann, 1990.
7. L. E. Brownell, E. H. Young, Process Equipment Design - Vessel Design, John Wiley and Sons, Inc., 1959.
8. Indian standards Institution, 'Code for unfired pressure vessels', IS – 2825.

Subject	**: BTCHE 604T** (BCHE)		**Chemical Reaction Engineering (Theory)**	
Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit I: Kinetics of homogeneous reactions

Irreversible and reversible reactions, Equilibrium; Order and molecularity of reaction. Elementary and non elementary reactions; Fractional conversion and equilibrium conversion. Rate of reaction based on all components of the reaction and their interrelation. Law of mass action, Rate Constant-Based on thermodynamic activity, Temperature dependency of rate Constant -Arrhenious law, Transition state theory and collision theory. Temperature and conversion profiles for exothermic and endothermic reactions

Unit II: Batch Reactor Data

Batch reactor concept, Constant volume Batch reactor system; Design equation for zero, first, second order irreversible and reversible reactions, graphical interpretation of these equations and their limitations, Variable volume Batch reactors. Design equation for first and second order irreversible and reversible reactions, Graphical interpretation of their limitations, Multiple reactions-stoichiometry and rate equations for series and parallel reactions, Non elementary single reactions Development of rate expression; Chain reactions development of rate expressions, Batch recycle reactors, Semi-batch reactor, related examples etc.

Unit III: Flow Reactors

Types of flow reactors and their differences, space-time and space velocity, Design equation for plug flow reactor and CSTR; Size comparison of single reactors; Different reactor arrangements, optimum size determination; Performance of Recycle reactors, Auto-catalytic (recycle) reactors, Yield and selectivity, Best operating condition for mixed and plug flow reactors, Multiple reactions in CSTR and PFR reactors. Maximization of desired product rate in a plug flow reactor and back mixed reactor, product distribution in multiple reactions, related examples etc.

Unit IV: Temperature and Pressure Effects

Equilibrium Conversion, Optimum temperature progression, Adiabatic and non adiabatic operations, Temperature and conversion profiles for exothermic and endothermic reactions and related examples etc.

Unit V: Residence Time Distribution

Residence time distribution in reactors: E, F and C curve, and their relationship, conversion in reactors having nonideal flow; models for non-ideal flow: Dispersion model, dispersion number, Tank in Series model, Multi parameter model, mixing of fluids: Self-mixing of single fluid. Two parameter models.

Unit VI: Catalysis

Catalysis in homogeneous and heterogeneous reactions, catalyst classification, preparation, poisoning and regeneration, Promoters and inhibitors, Catalyst deactivation, Mechanism of deactivation, catalyst effectiveness, related examples etc.

Books Recommended:

1. O. Levenspeil, Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, 2001.
2. H. S. Fogler, Elements of Chemical Reaction Engineering, 3rd Edition, PHI, 2002.

3. S.D. Dawande, Chemical Reaction Engineering, 3rd Edition, Denett & Co, 2009.
4. S. M. Walas, Reaction Kinetics for Chemical Engineers, McGraw Hill, 1959.
5. J.M. Smith, Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, 1987.

Subject: BTCHE 605T (BCHE) **Elective – I: Human Behavior in Organization (Theory)**

Lecture	: 3 Hours	No. of Credits	: 3
University	: 80 Marks	College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit I: **Fundamentals of Organizational Behavior**

The Dynamics of People and Organizations, Models of Organizational Behavior, Managing Communications, Social Systems and Organizational Culture

Unit II: **Motivation, Needs, contents and Processes**

Motivation, Theories of motivation, Performance Appraising and Rewarding system

Unit III: **Leadership and Empowerment**

Leadership, Empowerment and Participation

Unit IV: **Individual and Interpersonal Behavior**

Transactional Analysis

Unit V: **Group Behavior and Emerging Aspects of Organizational Behavior**

Informal and Formal Groups, Team and Team Building, Organizational Behavior across Cultures

Unit VI: **Organisational Change and Its Effects**

Forces of change, Resistance to change, Approaches to managing organisational changes, Conflict management, Managing Stress, Stress and Counselling

Books Recommended:

1. J. Newstrom, Organizational Behavior: Human Behavior at Work, 13thEdition. McGraw-Hill. 2010.
2. Dessler, Gary. Human Resource Management, 8th Edition. Prentice-Hall. 2000
3. Kreitner, Robert and Kinicki, Angelo. Organizational Behavior 6th Ed. McGraw Hill 2005
4. Robbins, Stephen. Organizational Behavior, 8th Edition. Prentice-Hall. 1998
5. Subba Rao S.V. Human Resource Management and Industrial Relation. Himalaya Publishing House 1st Edition, 1997.
6. Fred Luthans, Organisational Behaviour, Mc-Graw Hill 8th International Edition 2000.
7. K. Aswathappa, Organizational Behaviour, Himalaya Publishing House, Revised and Enlarged Edition 1998.

Subject **: BTCHE 605T** (BCHE) **Elective – I: Materials Management (Theory)**

Lecture	: 3 Hours	No. of Credits	: 3
University	: 80 Marks	College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit I: Introduction

Introduction to materials management and productivity, functions of material management, organization structures in material management, role of material management techniques in improved material productivity.

Unit II: Material planning

Objectives, material requirement planning, manufacturing resource planning, JIT production planning, strategic material planning, material control: acceptance, sampling, inspection, make or buy decision, simple cost analysis, economic analysis, break even analysis, break even point theory, whether to add or drop a product line store management and warehousing, product explosion.

Unit III: Purchasing

Importance of good purchasing system, organization of purchasing functions, purchase policy and procedures, responsibility and limitations, purchasing decisions, purchasing role in new product development, role of purchasing in cost reduction, negotiations and purchase, purchasing research: identification of right sources of supply, vendor rating, standardization, vendor certification plans, vendor and supply reliability, developing new source of supply.

Unit IV: Cost reduction

Cost control v/s cost reduction, price analysis, material cost reduction techniques, variety reduction, cost reduction and value improvement, techniques of cost control, standard costing, cost effectiveness, cost analysis for material management, material flow cost control.

Unit V: Inventory management-I

Inventory v/s stores, types of inventory, inventory control, inventory build –up, EOQ, various inventory models, inventory models with quantity discount, exchange curve concept, coverage analysis, optimal stocking and issuing policies

Unit VI: Inventory management-II

Inventory management of perishable commodities, ABC – VED analysis, design of inventory distribution systems, surplus management, information system for inventory management, case studies

Books Recommended:

1. W.R. Stelzer Jr., Materials Management, Prentice-Hall, 1970
2. D.S. Ammer, Materials Management and Purchasing, Richard D. Irwin, Homewood, IL, 1980.
3. A. K. Dutta, Materials Management: Procedures, Texts and Case, Prentice-Hall of India, 2004
4. P. Gopalakrishnan, M. Sundersen, Material management- An integrated approach, Prentice-Hall of India, 1977.
5. K.C. Jain, L.N. Aggrawal, Production Planning Control and industrial Management, Khanna Publishers.

Subject **: BTCHE 605T (BCHE)** **Elective – I: Marketing Management (Theory)**

Lecture	: 3 Hours	No. of Credits	: 3
University	: 80 Marks	College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit I: **Fundamentals of Marketing**

Meaning of Marketing & Marketing Management, Core Marketing concepts, Scope of Marketing, Importance / Role of Marketing, Marketing management philosophies, Marketing Mix, Limitation of Marketing Concept

Unit II: **Marketing Research & Marketing Information System**

Meaning of marketing information system and marketing research, Importance of marketing research, Scope & role of marketing research, Types of marketing research, Steps in marketing research

Unit III: **Consumer behavior, Market Segmentation, Targeting and Positioning**

Meaning of Consumer Behavior, Factors affecting Consumer Behavior, Types of Buying Decisions, Stages in Buying Decision Process

Market Segmentation, Need for Market Segmentation & Benefits of Market Segmentation, Bases of Segmenting Consumer Market, Target Marketing and Positioning

Unit IV: **Product Management, Product Life cycle & New Product Development**

Concept of product, Levels of products, Classification of products, Product Line Decision, Product Mix Decision, Meaning of Product Life Cycle (PLC), Stages of P.L.C. and marketing strategies, Meaning of new product, New product development process

Unit V: **Strategic Planning and Forecasting**

Concept of strategic planning, Factors affecting planning for future.

Unit VI: **Distribution & Logistic Management, Promotion strategy**

Marketing Channels - Structure, Functions and Significance, Types of intermediaries in distribution channel & their functions, Distributions strategies, Physical distribution, marketing logistics and supply chain management, Importance, Functions of marketing logistics, Promotion Mix, Advertising, Personal Selling & Direct marketing, Sales Promotion, Publicity and public relations

Books Recommended:

1. P. Kotler, K. L. Keller, A. Koshy, M. Jha, Marketing Management: A south Asian Perspective. Pearson Education -Prentice Hall, 13th edition, 2009.
2. A. Kumar, N. Meenakshi, Marketing Management: Comprehensive Text, Best Practices and Corporate Insights, Vikash Publishing House, 1st edition, 2006.
3. K. Kaunakaran, Marketing Management: Text and Cases In Indian Context, Himalaya Publishing House, 2nd & revised, 2008.
4. S.A. Chunawalla, D.R. Patel, Production and Operations Management, Himalaya Publishing House, 2010.
5. S. A. Sherlekar, Marketing Management, Himalaya Publishing House, 13th Revised edition, 2005.
6. S. H. H. Kazmi, Marketing Management: Text and Cases, Excell Books, 1st edition, 2007.

Subject : BTCHE 605T (BCHE) Elective – I: Advanced Materials (Theory)

Lecture	: 3 Hours	No. of Credits	: 3
University	: 80 Marks	College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit I: Introduction to Advanced Materials

Introduction to materials, Properties of materials, structure-property correlationships, selection of materials, Physics and Chemistry of materials, Need of advance materials.

Unit II: Metallic Materials

Introduction and properties of metals and alloys, advanced metallic systems, steels for special applications: such as stainless steels, Ti- alloys, A & Al-Mg and Cu- alloys. Cast Iron, special steels, Superalloys

Unit III: Advanced Polymeric materials

Introduction of basic polymeric materials, properties of polymers, visco-elastic behaviour of polymers. Advanced Polymeric Materials, New polymeric materials such as Kevlar, Nomex, UHMWPE and Fiber Technology, polymer composites, synthetic rubber. Engineering polymers: polyamide, polycarbonates etc. Specialty polymers: liquid-crystal polymers, conductive polymers etc. Applications

Unit IV: Ceramic Materials

Introduction of Ceramic materials, structures of ceramics, Advanced ceramic materials such as Si alloys, toughened ceramics, glasses and glazes, Advances in powder synthesis techniques, Advances in processing methods, Microsrtucutral design and grain boundary engineering, case studies.

Unit V: Composite and Special Materials

Physics of materials with a focus on applications to electronic and other materials

Electrical conduction, Intrinsic and extrinsic semiconductors, Semiconductor devices, Optical properties of materials, Magnetic properties of materials, Mechanical properties, Superconductive materials.
Introduction to Composite Materials, Factors influencing the properties of composite materials like fiber parameter, matrix, interface and molding methods, Phase selection criteria, Reinforcing mechanisms, Interfaces, advantages and disadvantages, Polymer Composites, Reinforcing and matrix materials, Fiber winding techniques, Fabrication techniques, Laminates, Mechanical behaviour, etc.

Unit VI: Nano and Bio materials

Historical development of nanotechnology, Future trends, Introduction, Characterization, Properties of Individual nanoparticles, Methods of synthesis, Carbon nanostructures, Nanostructured materials, Self-assembly and Catalysis, Biological nanomaterials, Nanoelectronics, Nanomachines and nanodevices, Bio-materials, Implants, devices and sensors, drug delivery systems.

Books Recommended:

1. D. R. Askeland, M. Phule, The Science and Engineering of Materials, 5th Edition, Thomsom Learning, 2005.
2. W. D. Callister, Materials Science and Engineering: An Introduction, 7th Edition, Wiley, 2005.
3. B.S. Narang, Material Science, CBS Publishers & Distributors, 1991.
4. L. H. Van Vlack, Elements of Materials Science and Engineering, 6th Edition, Prentice Hall, 1989.
5. V. Raghavan, Materials Science and Engineering, PHI Learning Pvt. Ltd., 2004.

6. B.S. Murty, P. Shankar, B. Raj, B B Rath, J. Murday, Textbook of Nanoscience and Nano technology, University Press, 2012.
7. O.P. Khana, Materials Science and Metallurgy, Dhnapat Rai Publications, 1995.

Subject : BTCHE 605T (BCHE) Elective–I: Renewable Energy Sources (Theory)

Lecture	: 3 Hours	No. of Credits	: 3
University	: 80 Marks	College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit I: Solar-Energy.

Solar radiation its measurements and prediction, solar flat plate thermal collectors concentrating collectors-applications-heating, cooling, desalination, power generation, drying, cooking etc. Principle of photovoltaic conversion of solar energy, types of solar cells and fabrication. Photovoltaic applications: battery charger, domestic lighting, street lighting, and water pumping, power generation schemes.

Unit II: Wind Energy.

Atmospheric circulation- classification, factors influencing-wind shear-turbulence-wind speed monitoring-Aerodynamics of wind turbine rotor-site selection-wind resource assessment-wind energy conversion devices-classification, characteristics and applications. Hybrid systems-safety and environmental aspects.

Unit III: Bio-Energy.

Biomass resources and their classification,- chemical constituents and physicochemical characteristics of biomass- Biomass conversion processes-Thermo chemical conversion: direct combustion, gasification, hydrolysis and liquefaction- biochemical conversion: anaerobic digestion, alcohol production from biomass- chemical conversion process: hydrolysis and hydrogenation. Biogas- generation-types of biogas Plants applications.

Unit IV: Hydrogen and Fuel Cells:

Thermodynamics and electrochemical principles-basic design, types and applications, production methods, Biophotolysis: hydrogen generation from algae biological pathways, storage gaseous, cryogenic and metal hydride an transportation. Fuel cell: principle of working, various types, construction and applications.

Unit V& VI: Other Types of Energy and Energy Audit

Ocean energy resources, principles of ocean thermal energy conversion systems, ocean thermal power plants, principles of ocean wave energy conversion and tidal energy conversion, hydropower, site selection, construction, environmental issues, geothermal energy, types of geothermal energy sites, site selection and geothermal power plants.

Concept of energy of audit, analysis of the cost effectiveness of renewable energy sources, present status, comparison, forecast.

Books Recommended:

1. D. P. Kothari, K.C. Singal, R. Rajan, Renewable Energy Sources and Emerging Technologies, PHI Learning Pvt. Ltd, 2009.
2. G.D. Rai, Non-conventional Energy Sources, Khanna Publishers, 2007
3. J. Twidel, T. Wier, Renewable Energy Sources, Taylor & Francis Publishers, 2005
4. S.P. Sukhatme, Solar Energy, Tata McGraw Hill Publishing Company Limited, 2006
5. K.C. Khandelwal, S.S. Mahdi, Biogas Technology- A Practical Handbook, Tata McGraw Hill, 1986.
6. Y P Abbi, S. Jain, Handbook on Energy Audit and Environment Management, TERI, 2006.

Subject	**: BTCHE 606P** (BCHE)	**Environmental Engineering (Practical)**	
Practical	: 3 Hours	No. of Credits	: 2
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. To determine the concentration of CO_2 present in waste water sample
2. Analysis of cation exchange effluents from thermal power plant (Determination of Ca^{2+} & $Mg^{2+)}$
3. To determine the alkalinity of a waste water sample by Warden method
4. Analysis of ferrous and ferric ions from pickling waste effluents
5. Determination of dissolved oxygen (DO) present in water sample
6. To determine the percentage of available chlorine present in bleaching powder
7. Determination of chemical oxygen demand (COD) present in waste water sample
8. Determination biological oxygen demand (BOD) present in waste water sample
9. Analysis of fly ash sample to determine the loss on ignition
10. Measurement of Air quality
11. Water softening using molecular sieves
12. Analysis and removal of TDS from waste water.
13. Removal of suspended particles from waste water.
14. Determination of Monod Kinetic constants
15. Determination of Specific Growth rate and maximum specific growth rate

Subject : BTCHE 607P (BCHE) **Process Equipment Design (Practical)**

Practical	: 3 Hours	No. of Credits	: 2
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Minimum 8 sheets related to design and drawing mentioned below should be drawn. Out of 8, two drawing should be performed/demonstrated on AutoCAD.

1. Design of Pressure Vessels
2. Design of Vessel Supports
3. Design of Storage Tanks
4. Design of Heat Exchangers
5. Design of Tray Towers
6. Design of Packed Towers
7. Process Flow Symbols
8. Process Flow Diagram
9. Piping & Instrumentation Diagram
10. Equipment Layout
11. Use of AutoCAD

Subject	**: BTCHE 608P** (BCHE)	**Separation Processes (Practical)**	
Practical	: 3 Hours	No. of Credits	: 2
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. To verify Rayleigh's Equation for Simple Distillation
2. To construct the boiling point diagram for binary – miscible system
3. Distillation using Sieve Plate, Bubble Cap Column
4. To determine the thermal and vaporization efficiencies in Steam Distillation
5. Single/multiple stage extraction studies
6. To prepare the ternary phase diagram.
7. Soxhlet Extraction
8. Absorption studies in packed column
9. Absorption studies in bubble column
10. Batch/ Continuous Leaching
11. Membrane separation

Subject	**: BTCHE 609P** (BCHE)	**Minor Project (Practical)**	
Practical	: 2 Hours	No. of Credits	: 1
University	: Nil	College Assessment	: 50 Marks

The minor project will be for a group of three/four students under the guidance of departmental faculty of the institute and will carry 1 credit. The minor project will involve work based on analytical/experimental/design/industrial/combination of these topics in consultation with guide.

Each group of Students has to submit a typed and bound report (2 copies) at the end of the sixth semester to the respective guides. All students must go for minimum one relevant industry visit during the semester

Internal assessment marks will be awarded after the completion of the said project based on the work and presentation made by them in front of departmental committee.

Teaching load of minor project will be maximum 2 hours per week for each faculty.

Rashtrasant Tukadoji Maharaj Nagpur University

Direction No. 22 of 2014

Direction issued under section 14(8) of the Maharashtra Universities Act, 1994, relating to B.Tech. V & VI Semester for the award of Degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology Full Time in the Faculty of Engineering and Technology.

Whereas, the Maharashtra Universities Act No. XXXV of 1994 has come into force with effect from 22nd July, 1994

AND

Whereas, the amendment to the said Act came to be effected from 12th May, 2000

AND

Whereas, the Board of Studies in General Engineering, Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology have decided to make amendment related to V & VI Semester B. Tech. in Credit Based Semester Pattern for award of degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology Full time in the Faculty of Engineering and Technology.

AND

Whereas, the Faculty of Engineering and Technology in its meeting held on 28th May 2014 has considered and approved the V & VI Semester Credit Based Scheme of Examination, Syllabus and Absorption Scheme with the recommendations of the Board of Studies in General Engineering, Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology for its implementation from the academic session 2014-15 and onwards.

AND

Whereas, the recommendations made by the Board of Studies in General Engineering, Chemical Engineering, Chemical Technology and Biotechnology as approved by the Vice Chancellor pertains to Examination leading to the B.Tech. (Semester- V and Semester- VI) for award of degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology.

AND

Whereas, it is expedient to provide an Ordinance for the purposes of describing examination in the Credit Based semester pattern leading to the V and VI Semester for the award of Degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology, indicating there in the syllabus and scheme of examination including absorption scheme and C.G.P.A and S.G.P.A.

AND

Now, therefore, I. Anoop Kumar, Vice Chancellor of Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur in exercise of powers vested in me under section 14(8) of the Maharashtra Universities Act, 1994, do hereby issue the following Direction pertaining to the amendment as made for Semester-V and Semester–VI for award of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology.

1. This Direction shall be called “Direction regarding Credit Based Semester Pattern Scheme and Examination leading to B. Tech. Semester-V and Semester – VI to the Degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur.
2. Subject to the compliance with the provisions of this Direction and any other Ordinance which is in force from time to time shall be applicable

3. The Credit Based Scheme of Examination & Absorption Scheme Appendix for Semester–V and Semester-VI shall be as detailed in the following Table-1

TABLE-1

Sr. No.	**B.Tech. (Branch)**	**Board of Studies**	**Credit Based Scheme of Examinations & Absorption Scheme Appendix**
1.	Chemical Engineering	Chemical Engineering	**A**
2.	Chemical Technology	Chemical Technology	**B**
3.	Biotechnology	Biotechnology	**C**

The A.T.K.T. Rules shall be as given in Table – 2, given below:

TABLE – 2

Admission to Semester	**Candidate should have passed in all subject heads of following examination of the university**	**Candidate should have passed in all subject heads except in 1/3 passing subject heads of the following examination taken together**
I	As per eligibility	---
II	----	---
III	----	I and II Semester
IV	----	I and II Semester
V	I and II Semester	III and IV Semester
VI	I and II Semester	III and IV Semester
VII	III and IV Semester	V and VI Semester
VIII	III and IV Semester	V and VI Semester

4. Students falling under old scheme shall be provided maximum five attempts to clear the subject(s), after which they shall be absorbed in the new scheme.

   Whereas, any student willing to opt for New Credit Based Semester Scheme shall be absorbed as per the appendices mentioned in **Table-1** at equivalent Credit Based Semester Scheme level. However, student will have to appear for the examinations under Credit Based Semester Scheme for the subjects in which student has not cleared the subject in Yearly Pattern Scheme

5. (i) The Scope of subject shall be as indicated in the syllabus.

   (ii) The medium of instruction and examination shall be English.

6. The provisions of Ordinance No. 3 of 2007 relating to the award of grace marks for passing an examination or for securing higher division/class and for securing distinction in subject(s) as updated from time to time shall apply to the examination under this ordinance.

7. An Examinee who does not pass or who fails to present himself/herself for the examination(s) shall be eligible for **reappearing** in the same examination on payment of a fresh fee and as such other fees as may be prescribed from time to time. However, **readmission** to semester should be allowed only when a regular session is running for a particular semester.

8. The computation of Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) of an examinee shall be implemented progressively as from the academic session 2014-15 onwards.

   The marks will be allotted in all examinations which will also include college assessment marks. The total marks for each Theory/Practical subject head shall be converted into Grade points as per **Table - 3.**

SGPA shall be calculated based on Grade Points earned corresponding to percentage of marks as given in **Table - 3** and the Credits allotted to respective Theory/Practical subject head shown in the scheme of examination for respective semester.

9. SGPA shall be computed for every semester and CGPA shall be computed only in VIII semester. The CGPA of VIII semester shall be calculated based on **SGPA** of V to VIII semester as per following computation:-

$$\mathbf{SGPA} = \frac{\sum_{i=1}^{m} C_i.G_i}{\sum_{i=1}^{m} C_i} = \frac{C_1.G_1 + C_2.G_2 + \ldots.. + C_m.G_m}{C_1 + C_2 + \ldots\ldots + C_m}$$

Where, m = Number of subject heads in a given Semester.

$$\mathbf{CGPA} = \frac{\sum_{j=1}^{n} C_j.G_j}{\sum_{j=1}^{n} C_j} = \frac{C_1.G_1 + C_2.G_2 + \ldots.. + C_n.G_n}{C_1 + C_2 + \text{-------} + C_n}$$

Where, n = Number of subject heads from V to VIII Semester taken together.

Ci or Cj = Credit of individual subject head (Theory/Practical).

Gi or Gj = Grade Point earned in individual subject head (Theory/practical).

10. CGPA equal to 6.75 and above shall be considered as equivalent to First Division and CGPA equal to 8.25 and above shall be considered as equivalent to Distinction on Grade Card of VIII Semester as a foot note. Equivalent percentage calculation will be based on the following formula:

Equivalent % = (CGPA – 0.75) x 10

TABLE-3

THEORY			PRACTICAL		
Grade	**Percentage of Marks**	**Grade Points**	**Grade**	**Percentage of Marks**	**Grade Points**
AA	80 ≤Marks≤ 100	10	AA	85 ≤Marks≤ 100	10
AB	70 ≤Marks< 80	9	AB	80 ≤Marks< 85	9
BB	60 ≤Marks< 70	8	BB	75 ≤Marks< 80	8
BC	55 ≤Marks< 60	7	BC	70 ≤Marks< 75	7
CC	50 ≤Marks< 55	6	CC	65 ≤Marks< 70	6
CD	45 ≤Marks< 50	5	CD	60 ≤Marks< 65	5
DD	40 ≤Marks< 45	4	DD	50 ≤Marks< 60	4
FF	00 ≤Marks< 40	0	FF	00 ≤Marks< 50	0
ZZ	Absent in Examination	-	ZZ	Absent in Examination	-

11. As Soon as possible, after the examination, the Board of Examinations shall publish a list of successful examinees and the Degree shall be awarded based on V to VIII Semester SGPA and CGPA calculated thereon.
12. I, further directed that the aforesaid Direction shall come into force from the date of issuance and shall remain in force till the relevant Ordinance comes into being in accordance with the provisions of Maharashtra Universities Act, 1994 and the relevant provisions published by this Direction shall be physically repealed from the existing Ordinance.

Sd/-

. (Anoop Kumar)

Vice Chancellor

Nagpur:

Dated::18/6/2014

APPENDI X – A
SCHEME OF EXAMINATION
RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIFTH SEMESTER B.TECH (CHEMICAL ENGINEERING)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Teaching Scheme, hr.				Credit				MARKS				**Total Marks**
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHE 501T	Fluid Mechanics	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
2.	BTCHE 502T	Chemical Engineering Thermodynamics	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
3.	BTCHE 503T	Mass Transfer	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
4.	BTCHE 504T	Heat Transfer	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
5.	BTCHE 505T	Biochemical Engineering	BCHE	3	-	-	3	3	-	-	3	20	80	-	-	**100**
6.	BTCHE 506P	Fluid Mechanics	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
7.	BTCHE 507P	Mass Transfer	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
8.	BTCHE 508P	Heat Transfer	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
			Total	**15**	**9**	**4**	**28**	**15**	**6**	**4**	**25**	**100**	**400**	**75**	**75**	**650**

SCHEME OF EXAMINATION
RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SIXTH SEMESTER B.TECH (CHEMICAL ENGINEERING)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Teaching Scheme, hr.				Credit				MARKS				**Total Marks**
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHE 601T	Separation Processes	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
2.	BTCHE 602T	Environmental Engineering	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
3.	BTCHE 603T	Process Equipment Design	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
4.	BTCHE 604T	Chemical Reaction Engineering	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
5.	BTCHE 605T	Elective-I	BCHE	3	-	-	3	3	-	-	3	20	80	-	-	**100**
6.	BTCHE 606P	Environmental Engineering	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
7.	BTCHE 607P	Process Equipment Design	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
8	BTCHE 608P	Separation Processes	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
8.	BTCHE 609P	Minor Project	BCHE	-	2	-	2	-	1	-	1	-	-	50	-	**50**
			Total	**15**	**11**	**4**	**30**	**15**	**7**	**4**	**26**	**100**	**400**	**125**	**75**	**700**

Elective	Subject Name				
	BOARD				
	BTCHE				
Elective-I	1.Human Behavior in Organization	2. Materials Management	3. Marketing Management	4. Advanced Materials	5. Renewable Energy Sources

Scheme of Absorption for Old Pattern to Semester Pattern of 5^{th} Semester B. Tech. (Chemical Engineering)							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				**As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme**			
Fifth Semester B. Tech (Chemical Engineering)				**Fifth Semester B. Tech (Chemical Engineering)**			
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	
1	5SCE1 (BChE)	Fluid Mechanics	Theory	BTCHE 501T	Fluid Mechanics	Theory	
2	5SCE2 (BChE)	Chemical Engineering Thermodynamics	Theory	BTCHE 502T	Chemical Engineering Thermodynamics	Theory	
3	------	------		BTCHE 503T	Mass Transfer*	Theory	
4	------	------		BTCHE 504T	Heat Transfer*	Theory	
5	5SCE3 (BChE)	Environmental Eng. and Biotechnology	Theory	BTCHE 505T	Biochemical Engineering	Theory	
6	5SCE4 (BChE)	Applied Mathematics III	Theory	------	------		
7	5SCE5 (BChE)	Plant Design –I	Theory	------	------		
8		Fluid Mechanics	Practical	BTCHE 506P	Fluid Mechanics	Practical	
9		------	------	BTCHE 507P	Mass Transfer**	Practical	
10		------	------	BTCHE 508P	Heat Transfer**	Practical	
11		Industrial Waste Treatment	Practical	------	------		

*** Students to appear in university theory examination as per the new scheme**
**** Students to appear in university practical examination as per the new scheme**

Scheme of Absorption for Old Pattern to Semester Pattern of 6th Semester B. Tech. (Chemical Engineering)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				**As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme**		
Sixth Semester B. Tech (Chemical Engineering)				**Sixth Semester B. Tech (Chemical Engineering)**		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	6SCE1 (BChE)	Organic Chemical Process Industries	Theory	------	------	
2	------	------		BTCHE 601T	Separation Processes*	Theory
3	------	------		BTCHE 602T	Environmental Engineering*	Theory
4	------	------		BTCHE 603T	Process Equipment Design*	Theory
5	6SCE2 (BChE)	Heat Transfer	Theory	------	------	
6	6SCE 3 (BChE)	Mass Transfer – I	Theory	------	------	
7	6SCE4 (BChE)	Chemical Reaction Engineering- I	Theory	BTCHE 604T	Chemical Reaction Engineering	Theory
8	6CSE5 (BChE)	Process Control – I	Theory	------	------	
9	------	********		BTCHE 605T	Elective-I$	Theory
10	------	------		BTCHE 606P	Environmental Engineering**	Practical
11	------	------		BTCHE 607P	Process Equipment Design**	Practical
12	------	------		BTCHE 608P	Minor Project**	Practical
13		Heat Transfer	Practical	------	------	
14		Organic Chemical Technology	Practical	------	------	
15		Instrumental Methods of Analysis	Practical	------	------	

*** Students to appear in university theory examination as per the new scheme**
**** Students to appear in university practical examination as per the new scheme**
$ This subject is exempted

APPENDIX – B
SCHEME OF EXAMINATION
B. TECH (CHEMICAL TECHNOLOGY)
FIFTH SEMESTER B.TECH (CHEMICAL TECHNOLOGY)

Sr. No	Code Theory (T) Practical (P)	Subject	Board	Workload				Credit				MARKS				Total Marks
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHT501T	Fluid Flow Operation	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
2.	BTCHT502T	Solid Fluid Operations	BCHT	3	-	-	3	3	-	-	3	20	80	-	-	100
3.	BTCHT503T	Chemical Equipment Design	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
4.	BTCHT 504T	Process Plant Utilities	BGE	3	-	-	3	3	-	-	3	20	80	-	-	100
5.	BTCHT505T	*Special Technolog-III	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
6.	BTCHT506P	Fluid Flow Operation	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
7.	BTCHT507P	Solid Fluid Operations	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
8.	BTCHT508P	Chemical Equipment Design	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
Total				15	9	3	27	15	6	3	24	100	400	75	75	650

*

- Food Technology
- Technology of Oils, Fats and Surfactants
- Petroleum Refining and Petrochemical Technology
- Pulp & Paper Technology
- Plastics & Polymer Technology
- Surface Coating Technology

SCHEME OF EXAMINATION
B. TECH (CHEMICAL TECHNOLOGY)
SIXTH SEMESTER B.TECH (CHEMICAL TECHNOLOGY)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Workload				Credit				MARKS				Total Marks
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHT 601T	Process Engineering Thermodynamics	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
2.	BTCHT602T	Heat Transfer Operations	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
3.	BTCHT603T	Chemical Process Control	BCHT	3	-	-	3	3	-	-	3	20	80	-	-	100
4.	BTCHT604T	Environmental Engineering	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
5.	BTCHT605T	*Special Technology IV	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
6.	BTCHT606P	Heat Transfer Operations	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
7	BTCHT607P	Environmental Engineering	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
8.	BTCHT608P	*Special Technology II	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
9.	BTCHT 609P	Minor Project	BCHT	-	2	-	2	-	1	-	1			50	--	50
Total				15	11	4	30	15	7	4	26	100	400	125	75	700

*

- Food Technology
- Technology of Oils, Fats and Surfactants
- Petroleum Refining and Petrochemical Technology
- Pulp & Paper Technology
- Plastics & Polymer Technology
- Surface Coating Technology

Scheme of Absorption for Old Pattern to Semester Pattern of Third Year B. Tech. (Chemical Technology)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				**As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme**		
Fifth Semester B. Tech (Chemical Technology)				**Fifth Semester B. Tech (Chemical Technology)**		
Sr. No	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**
1	5S.CT.1 (BChE)	Fluid Mechanics and Mechanical Operations	Theory	BTCHT 501T (BCHT)	Fluid Flow Operation	Theory
2				BTCHT 502T (BCHT)	Solid Fluid Operations	Theory
3	5S.CT.2 (BChE)	Plant Design	Theory	BTCHT 503T (BCHT)	Chemical Equipment Design	Theory
4	---	-----	---	[1]BTCHT 504T (BGE)	Process Plant Utilities	Theory
5	5S.CT.3 (BChE)	Heat Transfer	Theory	---	-----	---
6	5S.CT.4 (BGE)	Organic Chemical Process Industries	Theory	---	-----	---
7	5S.CT.5 (BCT)	Special Technology III	Theory	BTCHT 505T (BCHT)	Special Technology III	Theory
8	5S.CT.6 (BChE)	Unit Operations	Practical	BTCHT 506P (BCHT)	Fluid Flow Operation	Practical
9				BTCHT507P (BCHT)	Solid Fluid Operations	Practical
10	------	--------	--------	BTCHT508P (BCHT)	Chemical Equipment Design	Practical
11	5S.CT.7 (BChE)	Heat Transfer	Practical	--------	---------	--------
12	5S.CT.8 (BGE)	Organic Chemical Technology	Practical	---------	---------	--------

[1]Subject is covered in Fourth Semester for Old Pattern according to subject (4S.CT.2) Plant Utilities (Theory). They may be exempted.

Scheme of Absorption for Old Pattern to Semester Pattern of Third Year B. Tech. (Chemical Technology)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				**As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme**		
Sixth Semester B. Tech (Chemical Technology)				**Sixth Semester B. Tech (Chemical Technology)**		
Sr. No	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**
1	6S.CT.1 (BGE)	Applied Mathematics III	Theory	---	-----	---
2	6S.CT.2 (BChE)	Mass Transfer	Theory	---	-----	---
3	6S.CT.3 (BChE)	Environmental Engineering and BioTechnology	Theory	BTCHT 604T (BCHT)	Environmental Engineering	Theory
4	6S.CT.4 (BChE)	Chemical Engineering Thermodynamics	Theory	BTCHT 601T (BCHT)	Process Engineering Thermodynamics	Theory
5	6S.CT.5 (BCT)	Special Technology IV	Theory	BTCHT 605T (BCHT)	Special Technology IV	Theory
6	6S.CT.6 (BChE)	Mass Transfer	Practical	---	-----	---
7	6S.CT.7 (BGE)	Industrial Waste Treatment	Practical	---	-----	---
8	6S.CT.8 (BCT)	Special Technology II	Practical	BTCHT 608P (BCHT)	Special Technology II	Practical
9	---	-----	---	BTCHT 603T (BCHT)	Chemical Process Control	Theory
10	---	-----	---	[1]BTCHT 602T (BCHT)	Heat Transfer Operations	Theory
11	---	-----	---	[2]BTCHT 606P (BCHT)	Heat Transfer Operations	Practical
				BTCHT607P (BCHT)	Environmental Engineering	Practical
12	---	-----	---	BTCHT 609P (BCHT)	Minor Project	Practical

[1]Subject is covered in Fifth Semester for Old Pattern according to subject (5S.CT.3) Heat Transfer (Theory). They may be exempted.

[2]Subject is covered in Fifth Semester for Old Pattern according to subject (5S.CT.7) Heat Transfer (Practical). They may be exempted

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Engineering & Technology
Syllabus for

Fifth Semester B.Tech. Chemical Technology

Subject:BTCHT501T (BCHT) **Fluid Flow Operation**
(Theory)

Lecture: 3 Hours | No. of Credits: 4
Tutorial: 1 Hour | University: 80 Marks
Duration of Examination: 3 Hours | College Assessment: 20 Marks

UNIT 1: Classification of fluid mechanics, Properties of fluids, Classification of fluids, Shearing and flow, characteristics of Newtonian and Non-Newtonian fluids, Shear stress distribution of fluids, Pressure measurement, U-tube, Inverted U-tube, Differential and Inclined manometers, Reynolds number, Friction factor

UNIT 2 : Bernoulli`s equation, Frictional loss in pipe, Continuity equation, Velocity distribution for, laminar flow and turbulent flow, Hydraulic mean diameter, losses due to enlargement and contraction of pipe cross - section.

UNIT 3 : Equivalent length of pipe, Pipe fittings, Gate , Globe, Check and Butterfly valves, Boundary layer development, Two-phase flow, Flow patterns in two phase flow. The Baker diagram, Erosion in two phase flow.

UNIT 4 : Flow rate measurement, Working principle and expressions for flowrate through Pitot tube, Orifice meter, Venturimeter, Nozzle, Rotameter, Notch and Weir, Coefficient of discharge, Wet gas flowmeter, Pressure recovery in Orificemeter, Venturimeter and Nozzle.

UNIT 5 : Pumping of fluids, Classification of pumps, Positive displacement pumps, Reciprocating, Pump, Plunger pump, Diaphragm pump, Metering pump, Rotary gear pump, Rotary lobe Pump, Rotary vane pump, Flexible vane pump, Mono pump, Cetrifugal pump, Volute pump, Volute pump with vortex chamber and diffuser vanes, Cavitation, Priming,Net positive suction head ,Multistage centrifugal pumps. Specific speed and operating characteristics of centrifugal pump.

UNIT 6 : Fluid flow in packed column, Classification of packings, Characteristics of packing material, Loading and flooding in packed column,Specific surface of packed column, Permeability coefficient, Modified Reynolds number, Modified friction factor, Kozeny`s,Carman`s, Sawistowski`s and Ergun`s equations for packed column. Characteristics of fluidization, Aggregative and particulate fluidization, Incipient fluidization velocity, equations for pressure drop across fluidized column, Applications of packed and fluidized column.

Books Recommended:

1. R. P. Vyas, Fluid Mechanics, Second edition, Denett & Co. Publication, 2008.

2. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. I: Fluid Flow, Heat Transfer and Mass Transfer, Sixth Edition, Butterworth-Heinemann an imprint of Elsevier
3. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. II: Particle Technology and Separation Processes, Fifth Edition, Butterworth-Heinemann an imprint of Elsevier
4. G.G. Brown, Unit Operations, CBS Publishers Pvt. Ltd, 2005.
5. W.L. Badger, J.T. Banchero, Introduction to Chemical Engineering, Tata McGraw Hill Education, 1997.
6. W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill Publication, 2005.

Subject:BTCHT502T (BCHT)	**Solid Fluid Operation (Theory)**
Lecture: 3 Hours	No. of Credits: 3
Tutorial: -----	University: 80 Marks
Duration of Examination: 3 Hours	College Assessment: 20 Marks

Unit I: Solids

Properties of solids, screening, screening equipments, effectiveness of screens, sieve analysis, average diameter and specific surface. Size reduction, types of equipments used in the various stages of reductions. Laws of crushing & grinding power requirements.

Unit II: Handling of solids

Belt conveyer, screw conveyer, flight conveyers, bucket conveyer, pneumatic conveyers. Capacity and power requirements of conveyers. Flow of solids through fluids, terminal settling velocity & hindered settling.

Unit III: Classification

Principles of classification, and jigging, equipments, tabling, magnetic and electrostatic separation, cyclone separation, theory, principle and their design. Flotation cells and calculations for flotation process.

Unit IV: Filtration

Filtration theory, equipment for filtration, constant pressure and constant rate filtration, filter calculations, optimum cycle time & filter aids.

Unit V: Sedimentation

Laboratory batch sedimentation Kynech theory , calculation of area and depth for continuous thickeners. Centrifugation principles of a centrifuge, sedimentation, equipments and calculations.

Unit VI: Mixing and Agitation

Theory of mixing and agitation, types of equipment, mixing characteristics, power consumption, mixing index, rate of mixing.

Text Books:

1) Unit operation by Brown G.G., CBS Publishers First Edition 1995, Reprint 2005.
2) Introduction to Chemical Engineering by Badger W.L. and Banchero J.T. McGraw-Hill 1955.

References Books:

1) Unit operations for chemical engineers by McCabe W.L. and Smith J.C. Mc Grow Hill International Edition Seventh Edition 2005.
2) Chemical Engineering by Coulson J.N. and Richardson R.F., Butterworth Heinemann Vol. I Sixth Edition1999.
3) Chemical Engineering by Coulson J.N. and Richardson R.F., Elsevir Publication Vol. II Fifth Edition 2002.
4) Unit Operations of Chemical Engineering by Hiramath R.S., Kulkarni A.P. Everest Publications 3rd Edition 2004.
5) Transport Processes and Separation Process Principles by Christe John Geankoplis, PHI Learning, Fourth Edition 2003.

Subject:BTCHT503T (BCHT) **Chemical Equipment Design (Theory)**

Lecture: 3 Hours	No. of Credits: 4
Tutorial: 1 Hour	University: 80 Marks
Duration of Examination: 3 Hours	College Assessment: 20 Marks

Unit I: Introduction to Principles of Design

Nature of process equipments, general design procedure, basic considerations in design, standards, codes, and their significance, equipment classification and their selection, design pressure, design temperature, design stress, review of fabrication techniques and environmental considerations in design procedure. Principal stresses, theories of failure . Materials of construction and selection for process equipments, linings and coatings for equipments.

Unit II: Pressure Vessel

Proportioning of pressure vessels, selection of L/D ratio, optimum proportions of vessels. Design of unfired pressure vessels subjected to combined loading, purging of vessels.

Selection and design of various heads such as flat, hemispherical, torispherical, elliptical and conical, Opening/ nozzles, manholes, Nozzle reinforcement design, etc. Flanged joints, classification of flanges, design of non standard flanges, types of Gaskets their selection, and design. Bolt design and selection.

Unit III: Design of Pressure Vessels Subjected To External Pressure and High Pressure Vessels

Pressure vessels subjected to external pressure: Design of shell, heads, nozzles, flanged joint, stiffening rings.

Design of thick cylinder, pre-stressing, Analysis and design of high pressure vessels: monoblock and compound (multilayer), etc.

Unit IV: Vessel Support

Introduction and classification of supports, design of skirt supports, stresses due to dead weight, wind load, seismic load, and period of vibration, design of base plate, skirt, bearing plate, anchor bolts, bolting chairs, design of bracket supports. Design of saddle supports, ring stiffeners, etc.

Unit V: Storage Vessels

Various types of storage vessels and applications, Atmospheric vessels, vessels for storing volatile and nonvolatile liquids, storage of gases, Losses in storage vessels, Various types of roofs used for storage vessels, manholes, nozzles and mountings. Design of cylindrical and spherical storage vessels; should include base plates, shell plates, roof plates, wind girders, curb angles for self supporting and column supported roofs.

Unit VI: Agitators and Reaction Vessels

Types of agitators, their selection, applications, baffling, power consumption which includes twisting moment, equivalent bending moment, design of blades etc.

Reaction vessels- Introduction, classification, heating systems, design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil. Study and design of internal coil reaction vessels, Heat transfer coefficients in coils.

Books Recommended:

1. S. D. Dawande, Process Equipment Design, Denett & Co, 2009
2. M.V. Joshi, V. V. Mahajani, Process Equipment Design, Macmillan India.
3. B.C. Bhattacharya, Introduction to Chemical Equipment Design, CBS Publications, 1985.
4. J. M. Coulson, J. F. Richardson, R. K. Sinnott, Chemical Engineering Vol. 6 - Design, Pergamon Press, 1983.
5. E.E. Ludwig, Applied Process Design for Chemical and Petrochemical Plants, Vol. 1 and 2, Gulf Publishing Co., 1997.
6. S. M. Walas, Chemical Process Equipment: Selection and Design, Butterworth-Heinemann, 1990.
7. L. E. Brownell, E. H. Young, Process Equipment Design - Vessel Design, John Wiley and Sons, Inc., 1959.
8. Indian standards Institution, ‘Code for unfired pressure vessels’, IS – 2825.

Subject:BTCHT504T (BCHT)	**Process Plant Utilities (Theory)**
Lecture: 3 Hours	No. of Credits: 3
Tutorial: -----	University: 80 Marks
Duration of Examination: 3 Hours	College Assessment: 20 Marks

Unit I: Thermodynamics

Laws of perfect gases, thermodynamics processes, First and Second Law of thermodynamics, Entropy,The clausius inequality, Steady Flow Processes, carnot Cycle.

Unit II: Steam Generators

General Description, Boiler Mounting and Accessories, Natural and Artificial Draught, Equivalent Evaporation and Thermal efficiency.Design of chimney. Constructional details and design aspects.

Unit III: Turbine

Theory and working of impulse, reaction and gas turbine. Bleeding and reheating.

Unit IV: Internal Combustion Engine

Cycle of operation, two and four stroke cycle, general description of S.I and C. I. engines, ignition, injection and governing.Cooling of I C Engine.

Unit V: **Properties of Steam**

Use of steam tables, measurement of dryness fraction, entropy of steam, temperature entropy and mollier charts, clausius clapeynon equation, Rankine Cycle.

Unit VI: Refrigeration

Introduction to refrigeration, various cycles, coefficient of performance. Applications of refrigeration.

Text Books:

1. Engineering Thermodynamics , P. K. Nag, McGraw Hill Education (India) Ltd
2. Thermal Engineering, R. K. Rajput

Reference Books:

1. Fundamental of Engineering Thermodynamics – John and Howel
2. THERMODYNAMICS An Engineering Approach – Y.A. Cengel and M.A. Boles
3. Applied Thermodynamics – Aestop
4. Applied Thermodynamics – R N Joel

Subject:BTCHT505T (BCHT) **Special Technology-III (Theory)**

Lecture: 3 Hours No. of Credits: 4
Tutorial: 1 Hour University: 80 Marks
Duration of Examination: 3 Hours College Assessment: 20 Marks

BTCHT505T/1 Food TechnologyIII (Theory)
(Microbiology and Molecular Biology)

Unit 1: Historical background of microbiology. Classification of microorganisms. Structure of typical bacterial cell. Study of bacteria, yeasts, molds and actinomyces with respect to morphology, physiological requirements, reproduction. Introduction to viruses.

Unit 2: Nutritional requirements of microorganisms. Autotrophic and heterotrophic mode of nutrition. Composition of nutrient media. Comparison of natural, synthetic, differential, selective and enrichment media. Methods of isolation and characterization of microorganisms.

Unit 3: Growth of microorganisms. Phases of growth curve. Specific growth rate and generation time. Synchronized and balanced growth. Enumeration of microorganism. Bacteriological analysis of food and water. Food borne diseases and food poisoning. Microbial toxins.

Unit 4: Effect of temperature on growth of microorganisms. D_{10} value, F value, Z value and TDT curve. Control of microorganisms by high and low temperature. Structure and operation of autoclave. Sterilization by dry and moist heat.

Unit 5: Control of microorganisms by physical and chemical methods. Effect of water activity, irradiation and chemicals on growth of microorganisms. Preservation by chemicals – Role of chemicals in food preservation. Classification of preservatives and their role in various food. Method of evaluation of antimicrobial agents. Microbial Quality assurance system in food industry. Detection methods for *E.coli, Staphylococci, Clostridium botulinum, Salmonella* in food samples.

Unit 6: Structure and functions of nucleic acids. DNA replication and protein biosynthesis. Genetic code. Mutations and mutagens. Identification and isolation of mutants. Introduction to fermentation processes. Types of fermentation. Role of microorganisms in fermentation.

Books Recommended:

1. Microbiology, Vol I & II by C B Powar and H F Daginawala
2. Microbiology by M J Pelczar, R D Reid and C S Chan, Tata McGraw Hill Pub.Co, Ltd, New Delhi
3. Food Microbiology by W C Frazier, Tata McGraw Hill Pub.Co.Ltd., New Delhi

BTCHT 505T/2 Oil Technology III (Theory)
(Technology of Oils and Oil bearing materials)

Unit 1: Natural sources of oils and fats
Domestic and world production of oil seeds and oils, handling, drying, storage, sampling and grading, pretreatment of oil seeds prior to oil extraction. Mechanical extraction of oil seeds, plants and processes involved newer methods in extraction of oil seeds.

Unit 2: Processing of oils and fats
Plants and processes employed for recovery of oils and fats by solvent extraction, solvents, their availability and selection, advantages and limitations, refining, bleaching and deodorization of oils and fats, batch and continuous plants and processes, recent trends.

Unit 3: Processing of oils and fats
Hydrogenation oils and fats, pretreatment prior to hydrogenation , methods of production and analysis of hydrogen gas and nickel catalyst for hydrogenation. Different methods of hydrogenation, their advantages and disadvantages. Quality control in hydrogenated products. Designing and processes engineering aspects of hydrogenation.

Unit 4: Processing of oils and fats
Manufacture of butter, ghee, margarine and Transesterified oils and fats, winterization of oils, cooking and salad oils, plastic shortening agents. Confectionary fats and their Characteristics,

Unit 5: Up gradation of oilseeds and oils
General methods of upgrading and utilization of oils and fats, Oil Seed Proteins and Byproduct Utilization, oil cakes and allied products. Detoxification of oilseed and oil meal, Chemical composition of oilseed, utilization of oilseed meal, isolation of proteins and processing of protein products.

Unit 6: Lipid Associates and Applications of non-traditional oils such as Karanja, Neem, Mahua, Sal, Rubber seed, Jojoba, Jatropha, Kokum etc., Fish Oils, Rendering of Animal Fats. Membrane Processing of Fats and Oils, Utilization of waste products from oil processing industries.

Reference Books:

1. Refining of Oils& Fats, Anderson, A. J. C, The MacMillan Co., New York.
2. Fats and Oils, D O'Brien, Third Edition, CRC Press,London
3.Bailey’s Industrial Oil and Fat Products, 6 Volumes, Wiley-Interscience Publication,New York

4. Confectionary fats Handbook, Timms, R. E. The Oily Press Lipid Library, UK
5. Practical Short Course on Processing and Products of Vegetable Oil / Biodiesel ,College Station, Texas,Held on October 18-22, 2009
6. Vegetable Oils in Food Technology (Chemistry and Technology of Oils and Fats), Frank Gunstone, Wiley Blackwell; USA
7. Edible Oils and Fats--A Global Overview of Technological Developments, Guinness Centre, Taylors Lane,, Ireland.
8. Seed Structure and Anatomy, the Seed Biology Place, Gerhard, Leubner, Germany

BTCHT505T/3 Petroleum Refining and Petrochemical Technology III (Chemistry of Hydrocarbons & Speciality Products)

Unit1: Low & high molecular weight paraffin's, olefins, aromatics, naphthenes & dienes. Their thermodynamic stability & reactivity & their relationship with performance characteristics.

Unit 2: Zeolite synthesis reaction, unit cell structure, classification, acidity & basicity in zeolites, cation exchange, dealumination & isomorphous substation principles.

Unit 3: Applications of zeolites in catalysis & in separation processes with few case studies.

Unit 4: General information on intermediate and final chemicals obtainable from natural gas, naphtha etc. & their processing strategy. Naphtha and gas cracking to produce C_1-C_4 Olefins, Dienes and Aromatics.

Unit 5: Lubricating oils, specifications, characteristics, production of lube specialities, additives, refining of lubricating oil-solvent chemicals & hydrogenation method, dewaxing, deasphalting etc. Re-refining of lubricating oil.

Unit 6: Petroleum speciality products like grease, waxes. Manufacture of specialty oils viz. Insulating oil, transformer oil, white oil, etc.
Asphalt & asphalt specialties, air blowing & emulsification techniques.

Books Recommended:

1. Modern Petroleum Technology by G.D. Hobson
2. Chemicals from Petroleum by L. Waddams
3. Zeolite Molecule Sieves: Structure, Chemistry & Use by W.D.Breek, A Willy International Publication.
4. Chemistry & Technology of Basic Organic & Petrochemical Synthesis Vol 1 & Vol 2 by N.N. Lebdev, Mir Publishers MOSCOW.
5. Zeolite synthesis, American Chemical Society Symposium Series by L. Occelli, ACS, (Ed) & Roboson H.E., Washington DC.

BTCHT 505T/4 **Pulp and Paper Technology III**
(Pulping Processes III)

Unit 1: Refiner Mechanical Pulping Process, pulp properties and uses, single-stage and two-stage processes, plate designs, steam cooking. Thermomechanical Process, variables, pulp characteristics and applications.

Unit 2: Hot sulfite chemimechanical process, variables, properties and uses, chemigroundwood pulping, applications, properties and uses.

Unit 3: Pulping of non-woody fibres : batch and continuous processes, recovery of chemicals, bleaching of non-woody fiber pulps, dissolving grade pupls.

Unit 4: Rags in paper making, collection, sorting, use of cotton linters in pulping, pulp characteristics and uses.

Unit 5: Secondary fibers, classification, deinking, processes and chemicals, ink grades, bleaching, shrinkage and yield values.

Unit 6: Environment friendly technologies for the pulp and paper industry, need, chemical applications. Biological applications to pulp and paper processing, bio-bleaching of pulps.

Books Recommended:

1. Pulping Process by Rydholm
2. Pulp & Paper Science and Technology, by C.E. Libby Vol I
3. Pulp and Paper Chemistry and Chemical Technology by J.P. Casey
4. Pulp and Paper Manufacture Vol-I, II and III by Macdonald
5. Hand book of Pulp and Paper technology by K.W. Britt.
6. Environment Friendly Technologies for pulp and Paper industry by Young R.A., Akhtar M.

BTCHT 505T/5 **Plastics& Polymer Technology III**
(Structure Property Relationship and Compounding of Polymers)

Unit 1: **Chemical composition and Molecular size and shape**
Chemical Composition of polymer molecule, Monomer ingredients in final polymer Molecular size and shape: Effect of molecular size on processing, mechanical, thermal, electrical optical and chemical properties.

Unit 2: **Intermolecular Order, Molecular Flexibility and Glass Transition temperature Intermolecular Order:** Amorphous and crystalline polymers. Factors determining crystallanity, effect of crystallanity on polymer properties.
Molecular Flexibility: Freedom of rotation, restriction of rotation.

Glass transition temperature: Glass transition temperature (Tg), Transition and associate properties, factors affecting Tg, significance of Tg

Unit 3: **Orientation and Intermolecular BondingOrientation:** Relations between orientation and crystallization, importance of mobility on orientation, axes of orientation, orientation during processing, effect of orientation on thermal, mechanical, thermal properties.

Intermolecular bonding: effect of polarity on polymer structure, effect of polarity on thermal, chemical, mechanical properties, cross linking and its effect on thermal, mechanical and chemical properties

Polymer Compounding

Unit 4: Polymer compound ingredients

Plasticizers & its mechanism, Lubricants and Flow Promoters , Anti-aging Additives(Antioxidants, Antiozonants, Stabilizers, Ultraviolet absorbers and related materials), processing aids, flame retardants, antistatic agents, nucleating agents, blowing agents , colorants, Cross-linking Agents etc.

Unit 5: Polymer compound ingredients

fillers and reinforcements viz. carbon black, ZnO, calcium carbonate,titanium oxide, nano clay, glass fibers, organic fillers, nanofillers.

Mixers: Batch and internal mixers, single screw extruder, kneaders, modular co-rotating and counter rotating twin screw extruders, Two roll mills, sigma mixer, co-kneader, cavity mixers, pin mixers, slotted fight mixers, variable depth mixers, planetary gear mixers, CRD mixers.

Unit 6: Rubber compounding Ingredient

Peptizers, role of peptizers, antioxidants- classification and examples, antiozonants, accelerators-classification according to cure rate, criteria for selection, mode of functioning, activators, methods of incorporation of reinforcements, chords and fabrics. Blowing agents, colorants, processing aids, tackifiers, softeners, extender oils.

Compounding formulations: Based on polyvinyl chloride, polyolefins, polystyrene, polyester, epoxy, compounding lines, post compounding operations.

Reference Books:

1. Introduction to Polymer Science and Technology, S. D. Dawande, Denett & Co., 2006.
2. Polymer Science, V.R Gowariker, New Age International Publishers, 2005.
3. Polymer Chemistry, C. E. Carrshar, Marcel Dakker Inc, 2003.
4. Plastic Materials, J A Brydson, Butterworth-Heinmann, 1999
5. Relating Materials, Properties to Structure; Handbook and Software for Polymer calculations and Materials Properties, D. J. David and Ashok Mishra, Technical Publishing Company, Inc, 1999.
6. Materials Properties to structure, D. J. David, Relating Technical Publishing Company Inc, 1999.
7. Text Book of Polymer Science, F.W.Billmeyer, Wiley International Publishers.1984.
8. Physical chemistry of Polymers, A. Tager, Mir Publishers, 1978.
9. Polymer Structure, Properties and application, R.D.Deanin, American Chemical Society, 1974.
10. Mixing and Compounding of Polymer Theory and Practice, 2nd Ed., I. M. Zloczwero, Hanser Publications, 2009.
11. Thermoplastic and Rubber Compounds Technology and Physical Chemistry, J.L. White, K. J. Kim, Hanser Gardner Publications Ltd., USA, 2007.
12. Polymer Mixing Technology and Engineering, J.L. White, A.L. Coran and A. Moet, Hanser Gardner Publications Ltd., USA, 2001.
13. Rubber Technology Compounding and Testing for Performance, Ed. J. S. Dick, Hanser Gardner Publications Ltd., USA, 2001.

14. Understanding Compounding, R. H. Wildi and C. Maier, HanserGardner Publications Ltd., USA, 1998.
15. Rubber Technology and Manufacturer, C.M.Blow, Butterworth, London, 1982.

BTCHT 505T/6 **Surface Coating Technology III (Theory)**
(Chemistry of Film forming Materials-II)

Unit 1: Epoxy resins, various types of reactions and resin characteristics. Curing agents and their chemistry. Epoxy esters, epoxy modified polyester epoxy, acrylates, epoxy phosphates, and epoxy amine adducts. Application of epoxy resins in coatings.

Unit 2: Cellulose derivatives in Surface Coatings, cellulose nitrate and types, nomenclature of different types of cellulose nitrates, cellulose acetate, ethyl and methyl cellulose. Preparation, manufacture and properties of cellulose nitrate, cellulose acetate, ethyl cellulose and methyl cellulose.

Unit 3: Natural and synthetic rubber. Occurrence, processing, properties and uses of natural rubber. Chemical composition of natural rubber latex. Modification of natural rubber. Preparation, properties and use of chlorinated rubber, cyclized and synthetics rubber and their properties. Application of rubber resins in coatings.

Unit 4: Vinyl and acrylic resins in surface coatings, composition, substituted ethylenes and copolymers, methods of polymerization and processes, polyvinyl chloride resins, vinyl chloride-vinyl acetate copolymers, cyclic ester resins, chemical composition and properties, methods of polymerization, acrylic ester resin emulsions. Polystyrene, polymethacrylate, polymethylmethacrylate, etc.

Unit 5: Silicone resins, structure of silicones, preparation of silicone polymers for surface coatings, ethyl silicates and titanium esters.

Unit 6: The Urethane reaction and uses of urathenes in surface coatings, Urethane Oils. Bituminous materials: Occurance, classification, properties and uses of bituminous materials. Bitumen, Asphalt, Gilsonite, Grahamite, Petroleum bitumen, Pitch, Coal tar pitch, Oil tar pitch, etc.

Books Recommended:

1. Organic Coating Technology by H F Payne, Vol I, John Wiley & Sons, New York, 1954
2. Paint Technology Manual Vols I, II and III, Oil, Colour Chemists Association
3. Text Book of Polymer Science by Billmeyer W, Interscience Publishers Inc., New York, 1962
4. An Introduction to Polymer Chemistry by Moore W R, Aldine Publishing Co, Chicago, US, 1963

Subject: BTCHT506P(BCHT) Fluid Flow Operation **(Practical)**

Practical : 3 Hours
University : 25 Marks
Duration of Examination: 6 Hours

No. of Credits : 2
College Assessment : 25 Marks

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. Verification of Bernoulli's equation
2. To calibrate venturimeter and obtain its coefficient of discharge
3. To calibrate orificemeter and obtain its coefficient of discharge
4. To calibrate rotameter
5. To calibrate notched weir and obtain its coefficient of discharge
6. Friction factor vs. Reynolds number for flow of water in pipe
7. Friction factor vs. Reynolds number for flow of air in pipe
8. To study the relationship between fanning friction factor and Reynolds number for a fluid flowing though coils
9. To obtained equivalent length of pipe for various fitting.
10. Operating characteristics of centrifugal pump
11. To study the hydrodynamic characteristics of a packed bed
12. To study the hydrodynamic characteristics of a fluidized bed
13. Studies in two phase flow

Subject: BTCHT507P(BCHT) **Solid Fluid Operations (Practical)**

Practical : 3 Hours
University : 25 Marks
Duration of Examination: 6 Hours

No. of Credits : 2
College Assessment : 25 Marks

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. To study the relationship between the Drag Coefficient and modified Reynolds number for body falling through fluid. (C_d vs N_{RE})
2. To carry out the batch Sedimentation test and to use the results to design a thickener.
3. To evaluate the Specific Surface of a packing material.
4. To establish the Filtration equation for the leaf filter system and to evaluate the compressibility of the cake.
5. To study the power consumption of an Agitator with Reynolds and Froud number.
6. To verify the laws of Crushing and Grinding.

7. To determine the Mean Arithmetic Diameter, Mean Surface Diameter and Mean Volume Diameter.
8. To determine the size distribution in a given sample. (Elutriation).
9. To determine the effectiveness of Vibrating Screen.
10. To separate the various size fractions in a mixture on the basis of their settling velocities in a fluid. (Size Separation).
11. To study the efficiency of a cyclone separator.

Subject: BTCHT508P (BCHT) **Chemical Equipment Design (Practical)**

Practical	: 3 Hours	No. of Credits	: 2
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Minimum 8 sheets related to design and drawing mentioned below should be drawn. Out of 8, two drawing should be performed/demonstrated on AutoCAD.

1. Design of Pressure Vessels
2. Design of Vessel Supports
3. Design of Storage Tanks
4. Design of Heat Exchangers
5. Design of Tray Towers
6. Design of Packed Towers
7. Process Flow Symbols
8. Process Flow Diagram
9. Piping & Instrumentation Diagram
10. Equipment Layout
11. Use of AutoCAD

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Engineering & Technology
Syllabus for

Sixth Semester B. Tech. Chemical Technology

Subject: BTCHT 601T (BCHT) **Process Engineering Thermodynamics (Theory)**

Lecture: 3 Hours	No. of Credits: 4
Tutorial: 1 Hour	University: 80 Marks
Duration of Examination: 3 Hours	College Assessment: 20 Marks

Unit I: Basics of Thermodynamics

Review of laws of thermodynamics, Equations of state, Maxwell relationships, homogeneous phases, residual properties, heat effects, two-phase systems, Clausius- Clapeyron equation

Unit II: Compression of Fluid

Flow of compressible fluids, measurement of flow of compressible fluids, convergent-divergent nozzles, supersonic flow, Compression of fluids, single and multistage compression, centrifugal and reciprocating compressors-construction and working

Unit III: Refrigeration

Review of refrigeration cycles, Joule-Thomson expansion, compression and absorption refrigeration, refrigerants and their properties, estimation of power requirements of refrigeration systems, heat pumps.

Unit IV: Solution Thermodynamics

Fundamental property relations, chemical potential, criteria for phase equilibrium, partial properties, ideal gas mixtures, fugacity and fugacity coefficients for pure species, for species in solution, ideal solutions, Excess properties, VLE data-fugacity, Activity coefficients, Excess Gibb's energy, Margules and Van Laar equation, Property changes of mixing

Unit V: Phase Equilibria

Vapour – liquid equilibrium: The nature of equilibrium, criteria of equilibrium, phase rule, Duham's theorem, Raoult's law, VLE by modified Raoult's law, dew point and bubble point calculations, Flash calculations, Determine whether azeotrope exist**,** Equilibrium and stability, liquid -liquid equilibrium, solid-liquid equilibrium, VLL equilibrium

Unit VI: Chemical Reaction Equilibria

Criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant. Effect of temperature on equilibrium constant, evaluation of the equilibrium constant, relation of equilibrium constant to composition, calculation of equilibrium conversion for single reaction, The phase rule and Duhem's theorem for reacting systems, multireaction Equilibria

Books Recommended:

1) J.M. Smith, H.C. Van Ness, M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 6th Edition, McGraw Hill, 2001.
2) K.V. Narayanan, Chemical Engineering Thermodynamics, Prentice-Hall India, 2006.
3) Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press, 1997.
4) B.G. Kyle, Chemical & Process Thermodynamics, 3rd Edition, Prentice Hall, New Jersey, 1999.
5) O.A. Hougen, K.M. Watson, and R.A. Ragatz, Chemical Process Principles Part II, Thermodynamics, John Wiley, 1970.
6) R. Reid, J. Praunitz, T. Sherwood, The Properties of Gases and Liquids, 3rd Edition, McGraw-Hill, New York, 1977.

Subject: BTCHT 602T (BCHT)	**Heat Transfer Operations (Theory)**
Lecture: 3 Hours	No. of Credits: 4
Tutorial: 1 Hour	University: 80 Marks
Duration of Examination: 3 Hours	College Assessment: 20 Marks

Unit I: **Concept of Heat Transfer**

Introduction & mechanism of heat transfer. Development and use of general differential equation for heat transfer rate & temperature distribution for steady state heat conduction for various shapes & geometries of solids with various boundary conditions, with & without heat generation.

Unit II: **Unsteady State Heat Transfer, Fins & Insulation**

Use of lumped capacitance, Heisler charts and error function methods for unsteady state heat transfer. Classification of fins. Fin efficiency and overall effectiveness. Classification and selection of various types of thermal insulations. The concept of critical and economical thickness of insulation and its evaluation for cylindrical and spherical heat transfer equipment.

Unit III: **Natural & Forced Convection: Heat Transfer without Phase Change**

Introduction to natural and forced convection in laminar and turbulent flow over flat plate, over cylinder & sphere and through closed channels. Concept and use of thermal & hydrodynamic boundary layer and its significance. Prediction of heat transfer coefficient using theoretical, empirical and analogies concepts.

Unit IV: **Condensation & Boiling : Convection Heat Transfer with Phase Change**

Mechanism of condensation: Nusselt's approach and its extension. Heat transfer in saturated pool & forced convection boiling of liquids. Study of Boiling curve : Its significance and relevance in constant wall temperature & constant heat flux boiling with specific reference to critical (Maximum) heat flux and minimum heat flux (Ladenfrost point).

Unit V: **Heat Exchangers & Evaporators**

Concept of fouling resistance & overall heat transfer coefficient in heat exchangers. Classification of heat exchangers. Design and rating of double pipe, shell and tube heat exchangers by LMTD and ε-NTU methods. Compact heat exchangers: Plate heat exchangers, helical coil heat exchangers, spiral heat exchangers, regenerators. Classification of evaporators. Steam economy and capacity of multiple effect evaporators. Design considerations of evaporators..

Unit VI: **Radiation & Special Cases of Heat Transfer**

Radiation fundamentals, properties of materials and heat exchange. Use of solar energy & thermic fluids. Heat transfer in furnaces, agitated vessels, fluidized beds, packed beds, jacketed vessels, immersed helical and spiral coil equipment.

Books Recommended:

1) B.K. Dutta, Heat transfer Principles and Applications, PHI Private Limited, 2001.
2) S.D. Dawande, Principles of Heat Transfer and Mass Transfer, Denett & Co, 2009.
3) R.K. Rajput, Heat and Mass Transfer, S. Chand & Company Ltd., 2007.
4) C.J. Geankoplis, Transport Processes and Separation Process Principles, 4 Edition, Prentice Hall, 2003
5) J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. I: Fluid Flow, Heat Transfer and Mass Transfer, Sixth Edition, Butterworth-Heinemann an imprint of Elsevier
6) J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. II: Particle Technology and Separation Processes, Fifth Edition, Butterworth-Heinemann an imprint of Elsevier
7) J. M. Coulson, J. F. Richardson, R. K. Sinnott, Chemical Engineering Vol. 6 - Design, Pergamon Press, 1983
8) W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill Publication, 2005.
9) D.S. Kumar, Basics of Heat & Mass Transfer, Eight Edition, S.K. Kataria & Sons, 2010.
10) W.L. Badger, J.T. Banchero, Introduction to Chemical Engineering, Tata McGraw Hill Education, 1997.

Subject: BTCHT 603T (BCHT) **Chemical Process Control (Theory)**

Lecture: 3 Hours No. of Credits: 3

Tutorial: ----- University: 80 Marks

Duration of Examination: 3 Hours College Assessment: 20 Marks

Unit 1: Laplace Transforms, forcing functions, transient response of the first and second order systems, time constants, damping coefficients, transfer functions for liquid level and mixing processes, linearization,

Unit 2: Response of first order system in series, transfer functions and transient response of interacting and non interacting systems, transportation lag,

Unit 3: Linear closed loop systems, chemical reactor control systems, block diagram, pneumatic and electronic controllers and final control elements, choice of controllers, stabilization time, characteristics of proportional, integral and derivative control modes, transient response of simple control systems, comparison of controllers,

Unit 4: Concept of stability of linear systems, Raouth Criteria, Root locus diagram for negative feed back systems,

Unit 5: Control system design by frequency response method, Bode stability criteria, gain and phase margins, Ziegler- Nichols controller settings,

Unit 6: Instrumentation diagrams of temperature control, level control, pressure control and composition control. Thermocouples and their characterization, measurement of temperature, level, pressure and composition

Text Books:
1)Process Systems Analysis and Control – Coughanowr and Koppel
2) Process Control and Instrumentation - R.P. Vyas

Reference Books:
1) Process Control - Peter Harriot
2) Automatic Process Control – D.P.Eckman
3) Industrial Instrumentation -D.P. Eckman

Subject: BTCHT 604T (BCHT) | **Environmental Engineering (Theory)**
Lecture: 3 Hours | No. of Credits: 4
Tutorial: 1 Hour | University: 80 Marks
Duration of Examination: 3 Hours | College Assessment: 20 Marks

Unit I: **Environmental Pollutants**

Sources & characterization of various pollutants. Concepts of biodegradability, biosorption, biomagnifications. Measurement : COD, BOD, TOD, ThOD, soluble, suspended, volatile solids, ammonical nitrogen. Mathematical model for BOD. Re-oxygenation and de-oxygenation in natural purification process.

Unit II: **Natural Process of Water & Air Pollution Control**

Mathematical analysis by Streeter-Phelps of oxygen sag curve in natural purification of waste water. Determination of stack height and plume rise. Meteorological parameters and their effects on dilution/dispersion of pollutants present in flue/exhaust gases coming out from stationery and moving sources. Prediction of pollutant concentration downstream of discharge point. Plume behavior.

Unit III: **Air Pollution Management**

Basic design and operating principles of wet & dry equipments for removal of particulate and gaseous pollutants. Control of air pollution by process changes.

Unit IV: **Water Pollution Management**

Principles of primary secondary, tertiary and advanced treatment of waste water. Aerobic and anaerobic processes in ponds and lagoons. Basic process design and operating principles of various activated sludge (suspended growth) processes. trickling filter & rotating biological contactor (Attached growth). Special reactors.

Unit V: **Solid Waste Pollution Management:**

Solid waste management by dumping, landfill, incineration, composting, vermiculture; using bioremediation for specific pollutants like chromium. Mercury, ammonia / urea, phenolic sludge. E-waste. Hazardous waste management.

Unit VI: **Pollution Control in Selected Process Industries & Major Issues**

Pollution in fertilizer industries, petroleum refineries and petrochemical units, pulp and paper industries, Sugar industries, Dairy, Alcohol industries. Radioactive wastes. Case studies. Environmental impact assessment (EIA), Environmental audit, Major disasters, global environmental policies and national strategies.

Books Recommended:

1. Metcalf and Eddy, Wastewater Engineering: Treatment, Disposal and Reuse, Tata McGraw-Hill Pub.Co.Ltd., New Delhi, 1979.
2. S.P. Mahajan, Pollution Control in Process Industry, Tata McGraw Hill Publishers, 1987.
3. G.N. Pandey, G.C. Camey, Environmental Engineering, Tata McGraw-Hill Pub.Co.Ltd., 1992.
4. H.S. Peavy, D.R. Rowe, G. Tchobanoglous, Environmental Engineering, McGraw-Hill, 1986.
5. C.N. Sawyer, P.L. McCarty, G.F. Parkin, Chemistry for Environmental Engineering, Tata-McGraw-Hill Edition, 2003.
6. B.C. Punmia, A.K. Jain, A. K. Jain, Wastewater Engineering, Laxmi Publications, 2005.
7. S.K. Garg , Sewage Disposal and Air Pollution Engineering, Khanna Publishers, 2010.
8. M.N. Rao, H.V. Rao, Air Pollution, McGraw-Hill Europe, 1989.

Subject: BTCHT 605T (BCHT) | **Special Technology IV**
Lecture: 3 Hours | No. of Credits: 4
Tutorial: 1 Hour | University: 80 Marks
Duration of Examination: 3 Hours | College Assessment: 20 Marks

BTCHT 605T/1 **Food Technology IV**
(Principles of Food Preservation)

Unit 1: **Food Spoilage :**
Food Spoilage Micro-organisms. Roles of Physical, Chemical and Microbiological factors in food spoilage. Intrinsic & Extrinsic factors affecting food spoilage. Food materials handling and process control. Primary, Secondary and Tertiary level of Food Processing. Basic principles and unit operation in food processing & preservation.

Unit 2: Preservation by application of heat – Cooking, Blanching, Pasteurization and Sterilization. Thermal Processing of Foods: Thermal conductivity of foods. Rate of heat penetration. Calculation of process time. Unit operations in canning. Irradiation – Effect of irradiation on food.Preservation by ionizing radiations, ultrasonics.

Unit 3: Dehydration – Role of water activity in food. Calculation of drying rate. Methods of dehydration. Drying equipments and potential applications. Drying effects on foods. Freeze drying. Evaporation – Principles of Evaporator operation. Boiling point estimation. Evaporator performance. Type of evaporators. Evaporation with feed preheating.

Unit 4: Freezing – Unit operations in freezing. Calculation of freezing time. Slow and fast freezing, cold storage, chilling of foods. Freezing equipments. Effect of freezing, frozen storage and thawing on the food quality. Storage & transportation of frozen foods. Freeze Concentration – Principles of freeze concentration. Equipments used in freeze concentration. IQF. Application of freezing in food industry.

Unit 5: Membrane concentration – Driving forces for membrane processes. Types of membranes and equipments. Applications in food industry. Principles of high pressure technology and hurdle technology. Application of filtration techniques in food. Extraction processes- super critical extraction, solid liquid extraction, liquid-liquid extraction.

Unit 6: Packaging – Principles of packaging. Types and function of packaging, materials. Filling and sealing of containers like metallic, glass and plastic containers. Flexible packaging, laminated packaging and retortable pouches. Calculation of shelf life and requirement for packaging. Testing of packaging materials.

Books Recommended:

1. Principles of Food Science, Part II – Principles of Food Preservation. Edited by Owen R. Fennema. Printed in the United States of America.
2. Food Processing Technology – Principles and Practice by Dr. P. Fellow. Published jointly by Ellis Horwood Limited, Chichester, England and VCH Verlagsgesellschaft mbH, Weinheim Federal Republic of Germany.
3. Fundamental of Food Engineering by Charm SE. AVI Publishing Company Inc. Westport, Connecticur, USA.
4. Food Microbiology by W.C. Frazier. Tata Mc Graw Hill Publishing Co. Bombay.

Reference Books:

1. Food Processing Operation by M.A. Josyln and J.L. Heid. AVI publishing Company Inc. Westport, Connecticut, USA
2. Practical Canning by Lock A. Food Trade Press Garrick Street, W.C. 2, London.
3. Technology of Food Preservation by Desrosier Norman W. AVI Publishing Company Inc. Westport, Connecticut.
4. The Freezing Preservation of Foods, Vol. I, II, III, IV. Edited by Eople M.J. and Tressler D.K. AVI Publishing Company Inc. Westport, Connecticut, USA.

5. Food Dehydration, Vol. I, II by Copley. M.J. and Van Arsdel W.B. AVI Publishing Company Inc Westport,

BTCHT 605T/2 **Oil Technology IV (Theory)**
(Technology Of Soaps, Surfactants and Glycerin)

Unit 1: **Surfactants**
Concept and Theory of Surface action, structure of surfactant molecule, Hydrophilic – lipophilic balance, methods for measurement of surface activity. Mechanism of detergency, Uses in different fields. Classification of surfactants, Anionic, Cationic, Nonionic and Amphoteric surfactants, their classification, manufacture, evaluation and industrial applications

Unit 2: **Detergents**

Raw materials used in the manufacture of synthetic detergents and their functions. Manufacture and testing of household synthetic detergents, plants and processes employed for powders, liquids and cake detergents. Modern developments in the detergent industry. Recent trends and modern developments in the Detergent industry

Unit 3: **Soap**

Cleansing action of soaps, General principles of soap making , chemistry of soap boiling, Raw materials for soaps, their Classification and selection of oils and fat, role of INS factor, solubility ratio and hardness number, quality specifications and properties of oils and fats, Selection of builders and their functions, fillers and other auxiliary raw materials.

Unit 4: **Plants and process employed in soap manufacture**

Manufacture of household and toilet soaps by age old and newer techniques, details of machinery employed and quality specifications, , Continuous processes of soap manufacture. Modern process and plants for the production of house hold and toilet soaps from Fatty acid based soaps,

Unit 5: **Analysis of soaps and detergents**

BIS methods of testing, Properties of soaps and soap solutions, phase separation in soap boiling, various types of soaps andcleaning Preparations,

Unit 6: **Technology of Glycerol**

Sources, properties, grades, and types of glycerol, recovery and purification of glycerin from fat splitting crudes and waste soap lye’s, analysis and industrial uses of glycerol. Synthetic glycerin

Reference Books:

1. The Handbook Of Soap Manufacture, Simmons ,W. H. and Appleton ,H. A. Kindle Books, USA.
2 .Soap, Detergent & Perfume Industry,Srivastava S.B ,Small Industry Research Institute,New Delhi.
3 .Sulphonation Technology In The Detergent Industry, Herman W. and De Groot, Springer-Verlag New York.
4. Surface Active Agents , Goliath Company,The Gale Group, USA
5. Powdered Detergents , Showell, M. The Procter & Gamble Company, Cincinnati, Ohio, USA.
6. Synthetic Detergents,. Davidson, A.,and Mılwidsky, B.M.,John Willey Sons,New York.
7.The manufacture of glycerol,by Martin, G. Technical Press, London
8. Handbook Of Detergents, Waldhoff, H.,and Henkel K.CRC Press, USA.
9. Soap-Chemistry and Technology, Kane,J. G.,
10. The Manufacture of Soaps, Other Detergents, and Glycerine,Woollatt, Edgar, Mountainview Books, PA, U.S.A.
11.Detergent Of Speciality Surfactants,Ed, Fredil,F.E.,Marcel Dekker, Inc.New York.
12. The Handbook of Soap Manufacture, by W. H. Simmons and H. A. Appleton,
13. Handbook of Detergents,Edited by Uri Zoller,CRC Press,London.

BTCHT 605T/3 Petroleum Refining and Petrochemical Technology IV
(Advanced Petroleum Refining)

Unit 1: COKING AND THERMAL PROCESSES

Types, Properties, and Uses of Petroleum Coke, Process Description & Operation -Delayed Coking Process Description—Flexi coking& Fluid Coking, Yields from Flexi coking and Fluid Coking, Capital Costs and Utilities for Flexi coking and Fluid Coking, Visbreaking, Case-Study Problem: Delayed Coker.

Unit 2: CATALYTIC CRACKING

Fluidized-Bed Catalytic Cracking , New Designs for Fluidized-Bed Catalytic Cracking Units, Cracking Reactions, Cracking of Paraffin's, Olefin Cracking, Cracking of Naphthenic Hydrocarbons, Aromatic Hydrocarbon Cracking, Cracking Catalysts, FCC Feed Pre-treating, Process Variables, Heat Recovery, Yield Estimation, Capital and Operating Costs, Case-Study Problem: Catalytic Cracker.

Unit 3: CATALYTIC HYDROCRACKING

Hydrocracking Reactions, Feed Preparation, The Hydrocracking Process, Hydrocracking Catalyst, Process Variables, Hydrocracking Yields, Investment and Operating Costs, Modes of Hydrocracker Operation , Case-Study Problem: Hydrocracker.

Unit 4: HYDROPROCESSING AND RESID PROCESSING

Composition of Vacuum Tower Bottoms, Processing Options, Hydroprocessing, Expanded-Bed Hydrocracking Processes, Moving-Bed Hydroprocessors, Solvent Extraction, Summary of Resid Processing Operations. Hydro treating**,** Hydro treating Catalysts, Aromatics Reduction, Reactions, Process Variables, Construction and Operating Costs, Case-Study Problem: Hydrotreaters. Supporting Processes**,** Hydrogen Production and Purification, Gas Processing Unit, Acid Gas Removal, Sulphur Recovery Processes etc.

Unit 5: CATALYTIC REFORMING AND ISOMERIZATION

Reactions, Feed Preparation, Catalytic Reforming Processes, Reforming Catalyst, Reactor Design, Yields and Costs, Isomerization, Capital and Operating Costs, Isomerization Yields, Case-Study Problem: Naphtha Hydrotreater, Catalytic Reformer, and Isomerization Unit.

Unit 6: ALKYLATION AND POLYMERIZATION

Alkylation Reactions, Process Variables, Alkylation Feedstock, Alkylation Products, Catalysts, Hydrofluoric Acid Processes, Sulphuric Acid Alkylation Processes, Comparison of Processes, Alkylation Yields and Costs, Polymerization, Case-Study Problem: Alkylation and Polymerization.

Books Recommended:

1.Petroleum Refining –Technology & Economics by J.H. Gary & G.E. Handwek
2.Petroleum Processing, Principles and Applications by R J Hengstebeck
3. Modern Petroleum Technology by G.D. Hobson

BTCHT 605T/4 **Pulp and Paper Technology IV**
(Pulping Processes IV)

Unit 1: Chemical Pulping, general considerations, various chemicals used, Alkaline pulping origin, alkali as delignification agent, Soda process, Sulfate or Kraft pulping process, flowsheet, description, unit operations and unit processes, composition of liquor, role of sodium oxide in alkaline pulping, standard kraft pulping terms.

Unit 2: Cyclic nature of Kraft pulping, variables associated with wood and pulping process, kinetics of Kraft process, batch and continuous digesters, direct and indirect cooking.

Unit 3: Blow tank operation, pulp washing, dilution factor, knotters, pulp screening and refining, and energy balance calculations of digester, blow tank and brownstock washers. Introduction to chemical recovery process, flow diagram, unit operations and unit processes.

Unit 4: Single and multiple effect evaporation, problems associated with the concentration of black liquor, optimization of steam pressure to evaporators, different feed arrangements, design considerations of multiple effect evaporators, cascade/ direct contact evaporators.

Unit 5: Combustion of black liquor, recovery furnace concept, composition of smelt, flue gases, salt cake reduction, heating value of black liquor solids, various heat losses during combustion, evaluation of thermal efficiency of a recovery furnace. Steam generation capacity. Characteristics and causticizing of green liquor, calcining of lime. Analysis of liquors.

Unit 6: Sulfite pulping, outline of the process, delignification, raw materials and technology, sulfur burning, sulfur dioxide absorption system, standard terms in the process, recovery of heat. Digesters, steam requirements, pulping variables, sodium, ammonium and magnesium based pulping recovery systems.

Books Recommended:

1. Pulping Process by Rydholm
2.Pulp and Paper Science and Technology by C.E.Libby Vol I
3.Pulp and Paper Chemistry and Chemical Technology by J.P. Casey
4.Pulp and Paper Manufacture Vol- I by MacDonald
5.Hand book of Pulp and Paper Technology by K.W. Britt.

BTCHT 605T/5 **Plastics & Polymer Technology IV**
(Elastomer Technology, Testing and Characterization)

Unit 1: **Natural Rubber**

Brief history of Natural Rubber (NR), Derivatives of NR, Preparation of NR-Taping, stabilization, coagulation, mastication.

Synthetic Rubber

Classification of Synthetic Rubber (SR) with reference to their applications. Structure, Synthesis, properties (raw and vulcanisate), curing systems, grades, trade names and application of general purpose synthetic rubbers like butyl rubber, SBR, BR, EPDM, NBR, CR, IR, Silicon rubber, Polysulphide Rubber.

Unit 2: **Vulcanization**

Introduction to vulcanizations & need for vulcanizations. Stress-strain relationships for vulcanized rubber, vulcanization by sulphur, peroxides and by other methods, types of vulcunisates, kinetics of vulcanization, chemical reactions, factors affecting rate of vulcanization.

Testing and properties

Determination of cure rate of rubbers, testing and analysis of raw rubber, ,testing of finished rubber products, permeability and cure adhesion, test methods for determination of free sulfur, ash content and total solid content, tear resistance, heat resistance, flex fatigue resistance, compression set, resilience, accelerated ageing, ozone resistance.

Unit 3: **Manufacturing and formulations**

Manufacturing and formulations of tyres, tubes, conveyor belts and flat belts, cellular products, hose technology, cables, footwear and latex goods, latex products such as dipped goods, foams, rubbers used in power transmission, O-rings, gaskets and seals.

Unit 4: **Mechanical Properties & Optical properties**

Mechanical Properties: Introduction, Tensile tests, Flexural properties, Compressive properties, Impact properties, Shear strength, Abrasion, Fatigue resistance, Hardness Tests.

Optical properties: Introduction, Refractive Index, Luminous Transmittance and Haze, Visual Color evaluation, Gloss.

Unit 5: **Thermal Properties, Electrical Properties & Chemical Properties**

ThermalProperties: Introduction, Tests for elevated temperature performance-Heat distortion temperature, Vicat softening temperature, Long term heat resistance test, Thermal conductivity, Thermal expansion, Brittleness temperature

Electrical Properties: Introduction, Dielectric strength, Dielectric constant and dissipation factor, Electrical resistance test, Arc resistance.

Chemical Properties: Immersion tests, Stain resistance test, Solvent stress cracking resistance, Environmental stress cracking resistance, Fluorescent UV Exposure of Plastics (ASTM D4329, ISO 4892-5)

Unit 6: **Polymer Characterization**

Basic fundamentals of FTIR, GPC, NMR, XRD, DSC and their applications in polymer characterization.

References:

1. Thermoplastic and Rubber Compounds Technology and Physical Chemistry, J.L. White, K. J. Kim, Hanser Gardner Publications Ltd., USA, 2007
2. Introduction to Polymer Science and Technology, S. D. Dawande, Denett & Co.,2006
3. Polymer Science, V.R Gowariker, New Age International Publishers, 2005
4. Rubber Technology Compounding and Testing for Performance, Ed. J. S. Dick, Hanser Gardner Publications Ltd., USA, 2001
5. Plastics Materials", J. A. Brydson, Jordon Hill, Oxford, 1999.
6. Polymer mixing technology", George Mathews , Applied science, London,1984
7. Rubber Technology and Manufacturer, C.M.Blow, Butterworth, London, 1982.
8. Physical chemistry of Polymers, A. Tager, Mir Publishers, 1978.
9. Handbook of plastics testing and failure analysis, Vishu Shah, Wiley International Publishers,2007
10. ASTM Manual 35,36,37
11. BIS and TST Manual

BTCHT 605T/6 **Surface Coating Technology IV**
(Chemistry and Technology of Pigments)

Unit 1: Pigments – Classification of pigments and extenders, composition of pigments, appearance, colour, hidin power, tinting strength, size and shape of pigments particules and its effect on the coating performance, oil absorptior specific gravity and bulking value, pigments flooding and floating.

Unit 2: General methods of manufacture of pigments, crushing and grinding, vapourisation, precipitation, roasting chemical reaction. Metal pigments and metallic pigments, aluminium powder and paste, bronze powders, lead powder and paste, metallic stearates.

Unit 3: Extenders, composition and properties, occurrence and manufacture of calcium carbonate extenders, calcium sulphate extenders, barium sulphate extenders, clay extenders.

Unit 4: White pigments, composition and comparison of properties, occurrence and manufacture of Titanium dioside, zinc oxide and sulphide, white lead, lithophone and antimony oxide. Black pigments, comparison of various black pigments and their composition, carbon black.

Unit 5: Coloured inorganic pigments, comparison of properties and their composition, methods of manufacture, natural earth colour, synthetic iron oxide pigments, chrome yellow and orange pigments, molybdate orange, zinc yellow pigments, Venetian red, red lead pigments, cadmium coloured pigments, mercadium pigments, copper maroon pigments, ultramarine blue, iron blue pigments, chromium oxide green and hydrated chromium oxide.

Unit 6: Organic dyes and pigments, general characteristics, primaries and intermediates, colour in organic materials, chromophores, organic dyes and pigments containing nitro and nitroso groups, azo groups, anthraquinone, di and tri phenyl methane dyes, azines, phthalocyanine lakes and toners, manufacturing methods for commercial organic pigments.

Books Recommended:

1. Organic Coating Technology, Volume I, by H F Payne, John Wiley and Sons, New York, 1954
2. Organic Coating Technology, Volume II, by H F Payne, John Wiley, New York, 1954
3. Protective and Decorative Coatings, Vol II, by J J Matellio, John Wiley and Sons, New York
4. Protective and Decorative Coatings, Vol III by J J Matellio, John Wiley and Sons, New York
5. Paint Technology Manual

Subject	**: BTCHT 606P**(BCHT)	**Heat Transfer Operations(Practical)**	
Practical	: 3 Hours	No. of Credits	: 2
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. To determine total thermal resistance and thermal conductivity of composite wall
2. To determine thermal conductivity of lagging material
3. To determine the air film heat transfer coefficient by natural convection using fin concept.
4. To determine the air film heat transfer coefficient by forced convection using fin concept.
5. To determine Stefan – Boltzman constant for radiation heat transfer
6. To determine convective heat transfer coefficient (while cooling and heating) from the transient response data, with the help of Heisler chart for an infinite cylinder
7. To determine convective heat transfer coefficient (while cooling and heating) from the transient response data, with the help of Heisler chart for Rectangular bar
8. Prediction of thermal conductivity of unknown material using Heisler chart
9. To determine the overall heat transfer coefficient for heating in jacketed enamelled kettle
10. To study boiling phenomenon in a jacketed kettle with and without stirring.
11. To determine overall heat transfer coefficient in shell and tube heat exchanger
12. To determine the overall heat transfer coefficient in CSTR

13. To study the heat transfer in plate type heat exchanger and calculate the overall heat transfer coefficient
14. To verify Dittus- Boelter equation for vertical tube exchanger
15. To determine and verify the relationship between overall heat transfer coefficient and velocity of fluid as suggested by Wilson
16. To determine heat transfer in fin and finless heat exchanger and evaluate fin effectiveness and fin efficiency
17. Verification of Nussult equation for filmwise condensation on the outer surface of inner tube in vertical concentric tube heat exchanger

Subject	**: BTCHT 607P**(BCHT)	**Environmental Engineering (Practical)**	
Practical	: 3 Hours	No. of Credits	: 2
University	: 25 Marks	College Assessment	: 25 Marks
Duration of Examination: 6 Hours			

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. To determine the concentration of CO_2 present in waste water sample
2. Analysis of cation exchange effluents from thermal power plant (Determination of Ca^{2+} & $Mg^{2+)}$
3. To determine the alkalinity of a waste water sample by Warden method
4. Analysis of ferrous and ferric ions from pickling waste effluents
5. Determination of dissolved oxygen (DO) present in water sample
6. To determine the percentage of available chlorine present in bleaching powder
7. Determination of chemical oxygen demand (COD) present in waste water sample
8. Determination biological oxygen demand (BOD) present in waste water sample
9. Analysis of fly ash sample to determine the loss on ignition
10. Measurement of Air quality
11. Water softening using molecular sieves
12. Analysis and removal of TDS from waste water.
13. Removal of suspended particles from waste water.
14. Determination of Monod Kinetic constants
15. Determination of Specific Growth rate and maximum specific growth rate

Subject:BTCHT 608P (BCHT) **Special Technology II (Practical)**
Practical: 3 Hours No. of Credits: 2
University: 25 Marks College Assessment: 25 Marks
Duration of Examination: 4 Hours

BTCHT 608P/1 Food Technology Practical II

1. Estimation of reducing sugar by using 3,5 – dinitrosalicylic acid method
2. Estimation of protein by BIURET METHOD
3. Estimation of protein by Folin-Lowry method
4. Estimation of starch by Anthrone Method
5. Estimation of Amylose and Amylopectin content
6. Estimation of iron content
7. Estimation of phosphorus content
8. Preparation and sterilization of the media
9. Staining Techniques
10. Studying the effect of sugar concentration on yeast fermentation
11. Determination of number of microorganisms in a given milk sample by standard plate count method
12. Microbiological analysis of milk by Dye reduction method
13. Determination of adequacy of pasteurization of milk by phosphatase test
14. Determination of the turbidity of milk by sterility test.
15. Studying the effect of size of inoculums and temperature on the curdling of milk.

BTCHT 608P/2 Oil Technology Practical II

1. Beliers Test (Turbidity Temp.) Acetic Acid Method
2. Determination of Flash point
3. Detection of Colour by Tintometer Method
4. Estimation of RM and Polenske Value
5. Extraction of oil by Soxhlet Method
6. Extraction of essential oil by Clevenger's Assembly
7. Isolation and detection of Protein Content from deoiled cake
8. Estimation of Unsaponifiable Matter in oil
9. Preparation of Mixed Fatty Acids and its analysis
10. Preparation of Bio-diesel and its analysis
11. Preparation of Malenized oil and its analysis
12. Analysis of Mono and Diglycerides in oil and fats.

LIST OF REFERENCE BOOKS

1. Analysis of Oil and Soaps by R.N.Mathur
2. AOCS, official and tentative methods Da 2a-48, (For moisture and volatile matter of soap and soap products) 1973.
3. Bailey's Industrial Oil and Fat Products, 6th Edition, Wiley-Interscience Publication,New York .
4. The Analysis of Fats and Oils, Mehlenbacher, V. C., The Garrard Press, Champaign, Illinois.
5. AOCS Official and Tentative Methods forAnalysis ofOils and fats, Vol. 1and 2,, Third Edition, AOCS, Champaign IL,USA.

BTCHT 608P/3 Petroleum Refining and Petrochemical Technology II

1. Ash from Petroleum
2. ASTM distillation of Gasoline
3. ASTM distillation of Kerosine
4. ASTM distillation of Diesel fractions
5. Deemulsification number
6. Molecular Weight determination by Steam Distillation
7. Mercaptan sulphur content
8. Oxidation Stability Test
9. Penetration of Bitumen and Grease
10. Bromine Number by Color Indicator method
11. Bromine Number by Electrometric Titration method
12. Conradson Carbon Residue
13. Sulphonation
14. Water content by Dean and Start method
15. Viscosity Index
16. Electrical Strength of a Transformer Oil
17. Calorific value of fuel
18. Flue Gas Analysis by Orsat Analysis.
19. Total sulfur estimation by bomb method.

BTCHT 608P/4 Pulp & Paper Technology Practical II

Analysis of non fibrous materials used in Pulp and Paper Industry

1. Analysis of caustic soda as Na_2O

2. Analysis of Soda ash as Na_2O
3. Analysis of lime
4. Analysis of limestone
5. Analysis of Alum as combined and total Alumina
6. Analysis of rosin for acid no. and saponification no.
7. Analysis of Bleaching powder as available chlorine
8. Analysis of hypo solution
9. Analysis of Salt-cake as Na_2O
10. Analysis of filler and loading materials such as Calcium Carbonate, Clay, TiO_2
11. Preparation and analysis of White liquor, Black liquor, Green liquor
12. Analysis of waste water for COD, Suspended solids and dissolved solids

Books Recommended

TAPPI Standards, U S A

BTCHT 608P/5 Special Technology II (Practical)

(Plastics& Polymer Technology II)

1. Determination of specific gravity of polymers (Solid & liquid).
2. Identification of polymers by
    i. Preliminary Tests like Cut Test, Drop Test, Float Test
    ii. Heating Tests, Solubility Tests
    iii. Confirmatory tests of specific polymers
3. Measurement of viscosity average molecular weight of polymer.
4. To determine the plasticizer absorption percentage of PVC.
5. Determination of MFI of given polymer sample.
6. Determination of acid value, amine value & saponification value.
7. To study the Thermo Gravimetric Analysis (TGA).
8. To study the Thermal Transition of Plastic Materials via Differential Scanning Calorimeter (DSC).
9. To study Gel Permeation Chromatography for determination of molecular weight & MWD.
10. To study the FTIR Spectroscopy of Polymers.
11. To study the X-ray Diffraction technique & identification of % crystallinity via XRD.

BTCHT 608P/6 Surface Coating Technology II (Practical)
(Processing and modification of Resins)

1. Preparation and evaluation of Stand Oil.
2. Preparation and evaluation of Blown Oil.
3. Preparation and evaluation of Alkyd Resin by mono-glyceride process.
4. Preparation and evaluation of Alkyd Resin by fatty acid process.
5. Preparation and evaluation of Urea-formaldehyde resin.
6. Preparation and evaluation of Melamine formaldehyde resin.
7. Preparation and evaluation of Epoxy resin
8. Preparation and evaluation of Phenolic resin.
9. Preparation and evaluation of Polyamide/polyesteramide resins
10. Preparation and evaluation of Polyester resin.
11. Preparation and evaluation of Polyurethane resin
12. Preparation and evaluation of Urethane oils.
13. Preparation Acrylic resin by Bulk, Emulsion, Suspension, and Solution polymerization techniques.
14. Preparation and evaluation of Rosin ester/Ester gum.
15. Preparation and evaluation of short oil/long oil resin varnishes
16. Preparation and evaluation of Cellulose esters
17. Preparation and evaluation of synthetic rubber, chlorinated rubber, etc.

Subject:BTCHT 609P (BCHT) **Minor Project**
Practical: 2 Hours No. of Credits: 1
University: --- College Assessment: 50
Duration of Examination: 6 Hours

The minor project will be for a group of three/four students under the guidance of departmental faculty of the institute and will carry 1 credit. The minor project will involve work based on analytical/experimental/design/industrial/combination of these topics in consultation with guide.
Each group of Students has to submit a typed and bound report (2 copies) at the end of the sixth semester to the respective guides. All students must go for minimum one relevant industry visit during the semester
Internal assessment marks will be awarded after the completion of the said project based on the work and presentation made by them in front of departmental committee.
Teaching load of minor project will be maximum 2 hours per week for each faculty.

Rashtrasant Tukadoji Maharaj Nagpur University

Structure & Syllabus of 7th and 8th Semester B. Tech. (Chemical Engineering)

SCHEME OF EXAMINATION
RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SEVENTH SEMESTER B.TECH (CHEMICAL ENGINEERING)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Teaching Scheme, hr. per week				Credits				MARKS				**Total Marks**
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHE 701T	Transport Phenomena	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
2.	BTCHE 702T	Process Control and Instrumentation	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
3.	BTCHE 703T	Chemical Reactor Design	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
4.	BTCHE 704T	Elective-II	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
5.	BTCHE 705T	Finishing Techniques	BCHE	2	-	-	2	2	-	-	2	50	-	-	-	**50**
6.	BTCHE 706P	Chemical Reactor Design	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
7.	BTCHE 707P	Seminar	BCHE	-	3	-	3	-	2	-	2	-	-	100	-	**100**
8.	BTCHE 708P	Project/Dissertation - Stage I	BCHE		3		3		2		2	-	-	50	-	**50**
			Total	**14**	**09**	**04**	**27**	**14**	**06**	**04**	**24**	**130**	**320**	**175**	**25**	**650**

Elective	Subject Name			
	BOARD			
	BTCHE			
Elective-II	1. Non-Newtonian Flow	2. Chemical Hazards and Safety	3. Nanotechnology	4. Catalysis

SCHEME OF EXAMINATION
RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
EIGHTH SEMESTER B.TECH (CHEMICAL ENGINEERING)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Teaching Scheme, hr. per week				Credits				MARKS				**Total Marks**
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHE 801T	Computational Chemical Engineering	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
2.	BTCHE 802T	Process Dynamics and Control	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
3.	BTCHE 803T	Entrepreneurship and Project Management	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
4.	BTCHE 804T	Elective -III	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
5.	BTCHE 805P	Computational Chemical Engineering	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
6.	BTCHE 806P	Process Control	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
7.	BTCHE 807P	Project/Dissertation-Stage II	BCHE	-	6	-	6	-	3	-	3	-	-	-	150	**150**
			Total	**12**	**12**	**04**	**28**	**12**	**07**	**04**	**23**	**80**	**320**	**50**	**200**	**650**

Elective	Subject Name			
	BOARD			
	BTCHE			
Elective-III	1. Computational Fluid Dynamics	2. Piping Engineering	3. Polymer Engineering	4. Chemical Process Synthesis and Design

Scheme of Absorption for 7th semester B.Tech. Old Pattern to CBS Pattern of 7th Semester B. Tech. (Chemical Engineering)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Semester Pattern)				**As Per Rashtrasant Tukadoji Maharaj Nagpur University (Credit Based Semester Pattern Scheme)**		
7th Semester B. Tech (Chemical Engineering)				**7th Semester B. Tech (Chemical Engineering)**		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	7 S. CE.1	Transport Phenomena	Theory	BTCHE 701T	Transport Phenomena	Theory
2	7 S. C.E. 2	Mass Transfer-II [#]	Theory		----	
3		----		BTCHE 702T	Process Control and Instrumentation[$]	Theory
4	7 S. C.E. 3	Chemical Reaction Engineering –II	Theory	BTCHE 703T	Chemical Reactor Design	Theory
5	7 S. C.E. 4	Plant Design – II	Theory		----	
6		----		BTCHE 704T	Elective-II	Theory
				BTCHE 705T	Finishing Techniques	Theory
7	7 S. C.E. 5	Mass Transfer [#]	Practical		----	
8	7 S. C.E. 6	Process Equipment Drawing	Practical		----	
9		----		BTCHE 706P	Chemical Reactor Design	Practical
10	7 S. C.E.7	Seminar	Practical	BTCHE 707P	Seminar	Practical
11		----		BTCHE 708P	Project/Dissertation- Stage I	Practical

Students will have to appear in University theory and practical examination as per the new scheme.

[#] Students have to attend the classes and practicals and appear in University examination (Theory & Practical) of the subject Separation Processes of Sixth semester B. Tech (Chemical Engineering) (CBS) which is equivalent to Mass Transfer-II (Theory) and Mass Transfer (Practical)) of Seventh Semester B.Tech (Chemical Engineering) old Semester pattern respectively.

[$] Students are exempted if they have cleared the Process Control –I (Theory) of Sixth Semester B. Tech (Chemical Engineering) old semester pattern.

Scheme of Absorption for 8th semester B.Tech. Old Pattern to CBS Pattern of 8th Semester B. Tech. (Chemical Engineering)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Semester Pattern)				**As Per Rashtrasant Tukadoji Maharaj Nagpur University (Credit Based Semester Pattern Scheme)**		
8th Semester B. Tech (Chemical Engineering)				**8th Semester B. Tech (Chemical Engineering)**		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	8 S. CE.1	Mathematical Methods and Computer Aided Design in Chemical Engineering	Theory	BTCHE 801T	Computational Chemical Engineering	Theory
2	8 S. CE.2	Process Control- II	Theory	BTCHE 802T	Process Dynamics and Control	Theory
3	8 S. CE.3	Project Management & Industrial Economics	Theory	BTCHE 803T	Entrepreneurship and Project Management	Theory
4	8 S. CE.4	Elective	Theory	BTCHE 804T	Elective -III	Theory
5		---		BTCHE 805P	Computational Chemical Engineering	Practical
6	8 S. CE 5	Process Control	Practical	BTCHE 806P	Process Control	Practical
7	8 S. CE.6	Dissertation/Project Work	Practical	BTCHE 807P	Project/Dissertation-Stage II	Practical

Students will have to appear in University theory and practical examination as per the new scheme.

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Engineering & Technology
Syllabus for

Seventh Semester B.Tech. Chemical Engineering

Subject	**: BTCHE 701T** (BCHE)		**Transport Phenomena (Theory)**	
Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction to transport phenomena. Basics of momentum transfer. Newtonian & Non-Newtonian fluids. Overall momentum, heat and mass balance. Substantial derivative, curvilinear coordinates, Differential equation of continuity.

Unit 2: Shell momentum balances for momentum flux & velocity distribution for flow of Newtonian fluids for various situations. Navier-Stokes equation and its applications.

Unit 3: Shell energy balances for heat flux & temperature distribution in solids by conduction with and without heat generation. Temperature distribution in laminar flow. General equation of heat transfer and its applications.

Unit 4: Shell mass balance for concentration distribution in solids & in laminar flow conditions, General equation for Mass transfer and its applications. Diffusion with chemical reaction.

Unit 5: Momentum, Heat and Mass transfer in boundary layers. Analogies of momentum, heat & mass transfer.

Unit 6: Introduction to turbulent transport phenomena. Theories of mass transfer. Introduction to transport phenomena in Bio-systems.

Books Recommended:

1. R. B. Bird, W.E. Stewart, E.W. Lighfoot, Transport Phenomena, 2nd Edition, John Wiley, 2002
2. C. J. Geankoplis, Transport Processes and Separation Process Principles, Prentice- Hall Inc., 4th Edition 2003.
3. C. O. Bennett, J. O. Myers, Momentum, Heat and Mass Transfer, 2nd International Student Edition Mc-Graw Hill, 1983.
4. W.J. Thomson, Introduction to Transport Phenomena , Pearson Education Asia, Singapore, 2000.

Subject : **BTCHE 702T** (BCHE) **Process Control and Instrumentation (Theory)**

Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits : 4
University	: 80 Marks		College Assessment : 20 Marks

Duration of Examination: 3 Hours

UNIT 1: Control system representation using block diagram, Control configuration representation, Block diagram algebra, Forcing functions, First order system, Examples of first order system, Transfer functions of continuous stirred tank reactor, mercury thermometer , mixing process, liquid level tank, stirred tank heater, pure capacitive system, response equations of first order system to various forcing functions, step response, ramp response, impulse response, sinusoidal response, Dynamic error, time lag.

UNIT 2: Dynamic behaviour of multicapacity systems, Transfer functions of interacting and non-interacting multicapacity systems, Effect of interaction, Linearization, Transportation lag, response of multicapacity systems, Servo and regulator control problems. Offset for servo and regulator control.

UNIT 3: Dynamics of second order systems, response equations of second order system to various forcing functions for under damped. Critically damped and over damped systems. Overshoot, Decay ratio, response time, rise time, period of oscillation, natural period of oscillation.

UNIT 4: Working mechanism and transfer functions of flapper-nozzle Pneumatic, Hydraulic and Electronic proportional, proportional-integral, proportional derivative and proportional-integral – derivative controllers, Functions of different modes of control, On-off two position controller, Working principle and dynamic behaviour of pneumatic control valve, applications of control valve, hysteresis of control valve.

UNIT 5: Microprocessor based digital control system, Hardware elements of control configuration, Transmission lines hold element, multiplexer, Supervisory control, Programmable logic controller, Distributed control system, Direct digital feedback control, examples of direct digital feedback control, stirred tank heater, heat exchanger, continuous stirred reactor with exothermic and endothermic reactions, distillation column, drum boiler, level unit, jacketed kettle, evaporator, extraction column.

Unit 6: Classification of measurement, Classification of instruments, Characteristics of instruments, Classification of transducers, primary and secondary, analog, digital, active and passive transducers Temperature measurement instruments, glass thermometer, pressure thermometer, liquid in metal thermometer, platinum resistance thermometer, thermistors, Thermocouples, Radiation and Optical pyrometer, pressure measurement instruments, Ionization gauge, Pirani gauge, Bell differential pressure gauge, Pneumatic pressure meter, Level measurement instruments , float and shaft ,float and tape, linear and rotary potentiometer , radiation and laser level unit.

Books Recommended:

1. R.P. Vyas, Process control and Instrumentation, Seventh Edition, Denett & Co. publication, 2015.
2. R.P. Vyas, Measurement and Control, Denett & Co. Publication 2010.
3. D. R. Coughanour, Process system analysis and control, 2nd Edition, McGraw Hill publication, 1991.
4. G. Stephanopoulos, Chemical process control: An introduction to theory and practice, Prentice Hall of India private limited, 2008.
5. F.G. Shinskey, Process control systems, 2nd Edition, McGraw Hill book Company publication, 1979.

Subject **: BTCHE 703T** (BCHE) **Chemical Reactor Design (Theory)**

Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit 1: Fluid-Particle Reactions (Non-Catalytic Systems) Selection of a model for gas-solid non catalytic reaction, Un-reacted core model, Shrinking core model, Rate controlling resistances, Determination of the rate controlling steps, Various contacting patterns and their performance equations, Application of models to design problems.

Unit 2: Fluid-Fluid Reactions (Non-Catalytic Systems)

Introduction to heterogeneous fluid - fluid reactions, Rate equation for instantaneous , Fast and slow reaction, Equipment used in fluid- fluid contacting with reaction, Application of fluid -fluid reaction rate equation to equipment design, Towers for fast reaction, Towers for slow reactions

Unit 3: Solid Catalyzed Reactions

The Rate Equation for Surface Kinetics, Pore Diffusion Resistance Combined with Surface Kinetics, Porous Catalyst Particles, Heat Effects During Reaction, Performance Equations for Reactors Containing Porous Catalyst Particles, Experimental Methods for Finding Rates, Product Distribution in Multiple Reactions, The Packed Bed Catalytic Reactor

Unit 4: Gas-Liquid Reactions on Solid Catalyst

Trickle Beds, Slurry Reactors, Three Phase Fluidized Beds, The General Rate Equation, Performance Equations under various conditions, selection of various types of Contactor, Applications

Unit 5: Polymerization Reaction Systems

Pseudo-Steady-State Hypothesis (PSSH), Searching for a Mechanism, Step Polymerization, Free-Radical Polymerization, Development of Rate Laws for the Net Rate of Reaction, Modeling a Batch Polymerization Reactor, Molecular Weight Distribution and Properties of Distribution, Design Aspects

Unit 6: Steady State Non-isothermal Reactor Design

The Energy Balance, Non-isothermal continuous flow reactors, equilibrium conversion, non-adiabatic reactor operations, multiple steady states, non-isothermal multiple chemical reactions

Books Recommended:

1. O. Levenspiel, Chemical Reaction Engineering, 3rd Edition, Wiley India, 2006.
2. H. S. Fogler, Elements of Chemical Reaction Engineering, 4th Edition, PHI, 2005.
3. J.M. Smith, Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, 1981.
4. S.D. Dawande, Principles of Reaction Engineering, Denett & Co, 2007
5. S. M. Walas, Reaction Kinetics for Chemical Engineers, McGraw Hill, 1959.

Subject	**: BTCHE 704T** (BCHE)	**Elective-II: Non Newtonian Flow (Theory)**		
Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks
Duration of Examination: 3 Hours				

Unit 1: Non-Newtonian fluids

Introduction, Classification of fluid: Time-independent, Time-dependent , Visco-elastic . Dimensional considerations for visco-elastic fluids.

Unit 2: Rheometry for non-Newtonian fluids

Introduction, Various viscometers, Yield stress measurements, Normal stress measurements, Oscillatory shear measurements, High frequency techniques, The relaxation time spectrum etc.

Unit 3: Flow in pipes

Introduction, Laminar flow in circular tubes, Criteria for transition from laminar to turbulent flow, Friction factors for transitional and turbulent conditions, Laminar flow between two infinite parallel plates, Laminar flow in a concentric annulus. Gas-non Newtonian liquid two phase flow.

Unit 4: Particulate systems

Introduction, Drag force on a sphere, , Motion of bubbles and drops, Flow of a liquid through beds of particles, Flow through porous media of particles, Liquid-solid fluidization.

Unit 5: Heat transfer characteristics of non-Newtonian fluids in pipes

Introduction, Thermo-physical properties, Laminar flow in circular tubes, Fully-developed heat transfer to power-law fluids in laminar flow, Isothermal tube wall, Constant heat flux at tube wall, etc.

Unit 6: Mixing of Liquids.

Introduction, Liquid mixing, Gas-liquid mixing, heat transfer. Selection of mixing equipments. Mixing in continuous system.

Books Recommended:

1. R.P. Chhabra, J.F. Richardson, Non-Newtonian Flow and Applied Rheology: Engineering Applications, 2nd Edition, Butterworth-Heinemann, 2008.
2. Christopher W. Macosko, RHEOLOGY: Principles, Measurements and Applications, WILEY-VCH, 1994.
3. Alexander Ya. Malkin, Rheology Fundamentals, ChemTech Publishing, 1994.
4. R. B. Bird, W.E. Stewart, E.W. Lighfoot, Transport Phenomena, 2nd Edition, John Wiley, 2002

Subject (Theory) **: BTCHE 704T (BCHE)** **Elective-II: Chemical Hazards and Safety**

Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction

Chemical Process Classification, Process Design and Safety parameters, Chemicals and their hazards, importance of safety consciousness etc.

Unit 2: Chemical Hazards

Hazards in Chemical Process plants, Hazards code, explosive limits, electrical safety, static electricity hazards. LEL, UEL of various compounds, hazards due to leakages, flammable liquid hazards, fire ball hazards. Safety in handling gases, liquids and solids. Case studies.

Unit 3: Disasters and Detectors

Disaster in Chemical process plants, emergencies, explosion, BLEVE, UVCE, On-site and off-site emergency plan, fire detectors, smoke detectors, heat detectors, instruments for monitoring toxic and flammable process areas.

Unit 4: Hazard Assessment and Control

Hazards assessment, F & EI, Safety audit, safety equipments, HAZOP, FTA and ETA, FMEA, Combating Chemical fires, fire fighting foams dry chemical systems etc.

Unit 5: Risk Assessment

Risk assessment, objectives, FAFR, risk identification and analysis, role of communication, crisis communication, systematic maintenance, risk management plan etc.

Unit 6: Personal Safety & Legal Aspects

Personal safety, importance of plant layout, safety checklist, general safety rules, safety checklist during start up and errors, importance of training, role of human errors, protective devices, safety management. Role of Government, safety organizations. Management and trade Unions in promoting Industrial safety..

Books Recommended:

1. S.D. Dawande, Chemical Hazards and Safety, Denett & Co. 2007
2. W. Handley, Industrial Safety Hand Book, 2nd Edition, McGraw-Hill Book Company, 1977.
3. R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Vol. 6, Elsevier India, 2006.
4. Welb G.L. Safety in Process Plant Design, George Godwin Limited, John Wiely & Sons New York 1980..
5. Ridley Safety at Work, VII Edition, Butterworth Heinman 2007.
6. T. Kletz, What Went Wrong?**:** Case Studies of Process Plant Disasters, Gulf Professional Publishing, 1998.
7. H.W. Heinrich, P.E. Dan Peterson, Nester Rood. Industrial Accident Prevention, McGraw-Hill Book Co., 1980
8. H. H. Fawatt, W.S. Wood, Safety and Accident Prevention in Chemical Operation, Interscience, 1965.
9. D.A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall 2011.

Subject	**: BTCHE 704T (BCHE)**		**Elective-II: Nanotechnology (Theory)**	
Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction

Nano Scale, history and Scope of Nano Technology., Nanomaterials, Morphology. Enhanced properties at nano scale. Comparison with bulk materials.

Unit 2: Fabrication of Nanomaterials

Top Down Approach, Grinding, Planetary milling and Comparison of particles, Bottom Up Approach, Wet Chemical Synthesis Methods, Micro emulsion Approach, Colloidal Nanoparticles Production, Sol Gel Methods, Sonochemical Approach, Microwave and Atomization, Gas phase Production Methods : Chemical Vapour Depositions.

Unit 3: Introduction to Instrumentation and characterization

Instrumentation Fractionation principles of Particle size measurements, Particle size and its distribution, XRD, Zeta potential, SEM, TEM, AFM, STM, DLS, Spectroscopy. etc.

Unit 4: Kinetics at Nanoscale

Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface Charges, Zeta Potential and pH

Unit 5: Carbon Nanomaterials

Synthesis of carbon buckyballs, List of stable carbon allotropes extended fullerenes, metallofullerenes solid C60, bucky onions nanotubes, nanocones Difference between Chemical Engineering processes and nanosynthesis processes.

Unit 6: Applications of Nano Technology.

Applications in Chemical Engineering like nanocatalyst, bio analytical tools, nano/micro arrays, nanodevices, lab-on-a-chip.

Books Recommended:

1. Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, Capital Publishing Company, 2007.
2. Gabor L. Hornyak., H.F. Tibbals, Joydeep Dutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2008.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, 2005.
4. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
5. Poole C., and Owens F., Introduction to Nanotechnology, John Wiley, New Jersey, 2003.
6. Singh Nalwa, 10 Volume Enclypedia of Nanoscience and NanoTechnology, 2004.Catherine Brechignac, Philippe Houdy, Marcel Lahmani (Editors)Nanomaterials and Nanochemistry, Springer-Verlag Berlin Heidelberg, 2007.
7. Internet resources.

Subject	**: BTCHE 704T (BCHE)**		**Elective-II: Catalysis (Theory)**	
Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit 1:

Introduction to Catalysis. Biocatalysts – enzymes, lipases and microbes as catalysts, Application to industrial processes – one example from various Chemical and allied industries. Types of catalysts.

Unit 2:

Heterogeneous Catalysis: Introduction, Phase transfer and tri-phase catalysis, liquid – liquid and solid – liquid catalysis, mechanism. Mechanism of participation of enzymes in a few typical reaction, engineering problems, mass transfer considerations. Reactor types etc.

Unit 3:

Gas – solid catalytic reactions. Adsorption theories and concept of active site, Adsorption isotherm and Langmuir – Hinshelwood approach, Diffusion effect, Michaelis – Menten Kinetics for biocatalyst

Unit 4:

Preparation of catalysts – Supported metal and metal oxide catalyst, Major steps involved in catalysts preparation and formation. Physical methods of catalyst characterization for determination of surface area, pore volume and average pore size. BET equation, Inhibition. Reactions and denaturation of two biopolymers

Unit 5:

Zeolites – Structural considerations. Templeted molecular sieves, size and shape selectivity, 4 – 5 industrial applications of zeolites. Modification of zeolites

Unit 6: Recent developments in catalytic processes. Case studies.

Books Recommended:

1. H. S. Fogler, Elements of Chemical Reaction Engineering, 4th Edition, PHI, 2005.
2. J.M. Smith, Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, 1981.
3. C. N. Satterfield, Heterogeneous Catalysis in Industrial Practices, 2nd Edition, McGraw-Hill International Editions, 1993.
4. J. Bailey, D. Ollis, Biochemical Engineering Fundamentals, 3rd Edition, McGraw Hill, 1986.
5. J. J. Carberry, Chemical and Catalytic Reaction Engineering, 2nd Edition, McGraw Hill, New York, 1976.
6. J.M. Thomas, W.J. Thomas, Principles and practice of Heteregenous Catalysis, John Weily & Sons 2nd Edition, 2014.
7. Internet sources.

Subject : BTCHE 705T (BCHE) **Finishing Techniques (Theory)**

Theory: 2 Hours

No. of Credits : 2

College Assessment : 50 Marks

With a view to meet the trained human resource requirements of the Chemical Process and allied industries, students of B.Tech Chemical Engineering will go through Finishing Techniques. The training of students will be conducted in order to improve their personality. This course has an objective of helping them to find suitable jobs by inculcating soft skills components through appropriate training.

Art of Communication, Importance of internal and external communication. General Communication process, verbal & Non-verbal Communication. Effective Listening skils.

Interpersonal Skills, Effective presentation skills, Self awareness. Dealing with emotions. Team work. Leadership qualities.

Professional etiquettes, Importance of per-placement talks. How to prepare for a Campus interview. Asking right questions during and after pre-placement talks. Collecting relevant information about the visiting company.

Preparation of resume Effective Interview and group discussion techniques. Effective body language. Undestanding psychology of interviewers. NLP (Neuro-linguistic programming) & NAC (Neuro-Associative conditioning) techniques. Mock interviews and Group Discussion.

Effective goal setting. Developing a vision mission and purpose for successful professional life (Designing your career). Creative visualization. Power of positive thinking. Art of Living and leaving for professional success. Eustress & distress. Management of stress and strain through meditation & yoga.

Books Recommended:

1. Stephen R. Covey, The 7 habits of highly effective people, Free Press 1989.
2. Stephen R. Covey, The 8th habit, Free Press 1989.
3. Napoleon Hill, Think and grow rich, The Napoleon Hill Foundation, 2012.
4. Anthony Robins, Awaken the giant within, Free Press; New edition, 1992.
5. Nasha Fitter, You’re hired, Penguin India, 2009.

Subject	**: BTCHE 706P** (BCHE)	**Chemical Reactor Design (Practical)**	
Practical	: 3 Hours	No. of Credits	: 2
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practicals from the list given below:

1. To calculate value of rate constant ‘k’ for the saponificaton of ethyl acetate with NaOH in a batch reactor – I (Where M=1)
2. To calculate value of rate constant ‘k’ for the saponificaton of ethyl acetate with NaOH in a batch reactor – II (Where M=2)
3. Verification of Arrhenius law.
4. To study the kinetics of selected reaction in CSTR
5. To study the kinetics of selected reaction in PFR
6. To study the performance of mixed flow reactor/PFR
7. Study of various combinations of PFR and CSTR in series.
8. Residence time Distribution in CSTR.
9. Residence time Distribution in PFR.
10. RTD studies in a packed Bed reactor.
11. Studies in recycle bed reactor.
12. Studies in Semibatch Reactor.
13. Finding conversion and rate of polymerization reactions using gravimetric method.
14. Studies in Trickle bed reactor.

Subject	**: BTCHE 707P** (BCHE)	**Seminar (Practical)**	
Practical	: 3 Hours	No. of Credits	: 2
		College Assessment	: 100 Marks

Each student has to select the topic of Seminar in Chemical Engineering in consultation with his/her guide. The student will make an oral presentation for 10 to 15 minutes followed by question and answer session in front of an internal assessment committee. Two neatly typed copies of seminar report along with its soft copy should to be submitted.

Reading: Journals, Books, Magazines & Internet sources, etc

Subject	**: BTCHE 708P** (BCHE)	**Project/Dissertation –Stage I (Practical)**	
Practical	: 3 Hours	No. of Credits	: 2
		College Assessment	: 50 Marks

Each student will undertake an independent project/dissertation. The student is required to choose the topic in consultation with his/her Guide. Student should undertake dissertation/project concerning Chemical Engineering applications such as production of chemical, design and development, experimental work, industry based problems, generation of new ideas and concept, modification in the existing process/system, development of computer programs, modelling and simulation etc. A preliminary work is to be carried out in this stage of the project/dissertation. Two neatly typed copies of the Report on the completed work at stage I should be submitted at end on the 7th semester and internal assessment marks will be awarded for this stage of the project/dissertation based on the work and presentation made by them in front of Departmental committee.

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Engineering & Technology

Syllabus for

Eighth Semester B.Tech. Chemical Engineering

Subject **: BTCHE 801T** (BCHE) **Computational Chemical Engineering (Theory)**

Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction to Modeling and simulation, different types of models, application of mathematical modeling, principles of model formulation, chemical system modeling

Unit 2: Numerical methods of solution, (Bisection, False position, Newton-Raphson, Secant method etc.) of non-linear algebraic and transcendental equations applied to Chemical Engineering problems.

Unit 3: Methods of solution of simultaneous linear (Gauss elimination, Gauss-Jordon, Gauss-Seidal etc.) and non-linear algebraic equations. Application to chemical engineering problems

Unit 4: Curve fitting techniques: Least squares regression (linear, polynomial, multiple linear etc.). Interpolation. Application to Chemical Engineering problems.

Unit 5: Formulation and numerical solution of ordinary differential equations with emphasis on chemical process systems. Initial Value Problems (Euler's method, modified Euler's method, 4^{th} order Runge Kutta Method etc), boundary value problems (Shooting Method, Finite Difference method etc.)

Unit 6: Formulation and numerical solution of partial differential equations (Finite difference method, Crank-Nicholson method, methods of lines etc.). Application to chemical engineering problems.

Books Recommended:

1. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6^{th} Edition, Tata-McGraw Hill Publications, 2012.
2. W. L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.
3. B. V. Babu, Process Plant Simulation, Oxford University Press, 2004.
4. B. A. Finlayson, Introduction to Chemical Engineering Computing, Wiley Interscience, New Jersey, 2006.
5. S.K. Gupta, Numerical Methods for Engineers, 2^{nd} Edition, New Age International, 2010.

Subject : **BTCHE 802T** (BCHE) **Process Dynamics and Control (Theory)**
Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

UNIT 1: Concept of stability for linear systems, Routh's stability criterion, Root-locus diagram for positive and negative feedback systems. Applications of root-locus diagram, Effect of transportation lag on root locus diagram, Magnitude criterion for root-locus diagram.

UNIT 2: Control system design by frequency response, Bode diagram for controllers and for control systems, Bode stability criterion, Phase and Gain margins, Ziegler- Nichols optimum controller settings, Applications of control system design.

UNIT 3: Discrete time control systems, Block diagram algebra, Routh's stability criterion and root-locus diagram in Z-domain for discrete time control, Transfer functions of Zero order hold, First order hold, Exponential hold, Effect of hold element on root locus diagram an stability of discrete time control.

UNIT 4: Nyquist stability criterion, Nyquist diagram for control systems, Direct digital ratio control, Examples of ratio control, Integral of square error, Integral of absolute value of error, Integral of time weighted absolute value of error, Transportation lag compensation.

UNIT 5: Feed forward control configuration, applications of direct digital feed forward control of stirred tank heater, heat exchanger, continuous stirred tank reactor for exothermic and endothermic reactions, distillation column, drum boiler, level control unit, jacketed kettle, evaporator, extraction column.

UNIT 6: Cascade control configuration, Functions and tuning of primary and secondary controllers, Applications of microprocessor based digital cascade control of stirred tank heater, heat exchanger, continuous stirred tank reactor for exothermic and endothermic reactions, distillation column, level control unit, jacketed kettle, evaporator, furnace.

Books Recommended:

1. R.P. Vyas, Process Dynamics and Control, First Edition Denett & Co. publication, 2015.
2. R.P. Vyas, Process Automation and Modeling, Denett & Co. Publication 2007.
3. D. R. Coughanour, Process system analysis and control, 2nd Edition, McGraw Hill publication, 1991.
4. G. Stephanopoulos, Chemical process control: An introduction to theory and practice, Prentice Hall of India private limited, 2008.
5. F.G. Shinskey, Process control systems, 2nd Edition, McGraw Hill book Company publication, 1979.

Subject : BTCHE 803T (BCHE) **Entrepreneurship and Project Management (Theory)**

Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit 1. Entrepreneur, Enterprise & Entrepreneurship. Charms of being an entrepreneur. Motivation. Achievement motivation. Need for achievement.
Entrepreneurial competencies. Goal setting. Different types of goals. Planning, decision-making for entrepreneur. Time & stress management.

Unit 2. Emotional Intelligence: what are emotions for? Anatomy of an emotional highjacking. Nature of emotional intelligence. The emotional competence framework. NLP (Neuro Linguistic Programming) & NAC associative Conditioning).

Unit 3. Identification and Selection of good business opportunity (Business opportunity guidance), Searching for an opportunity and selecting the right Product/ Project. Market survey and research. Technoeconomic feasibility assessment: Preliminary and detailed Project Report. Location & Layout.

Unit 4. Soureces of finance. Support from Financial & Non financial , Government & Non Governmet agencies. Managing for production and productivity. Production Planning & Control. Total Quality Management Fixed Assets and working capital management. Break even and sensitivity analysis. Concepts and implications. Estimating product costs, other costs, revenues, profits & earning for process plants, problem situation for estimation. Principle of accounting analysis of financial statement- problem situations for economic decision-making.

Unit 5. Material, management: Classes of materials, Purchasing, objectives of purchasing. Functoins of purchase department. Inventory management and control. Economic Order Quantity(EOQ),ABC analysis.

Unit 6. Marketing for small business, marketing research, Advertising & sales promotion, Channels of distributions. Managing your business for successful growth. Seven business crisis and techniques to beat them.
Monitoring progress through network analysis (PERT & CPM techniques).Evaluation and selection of industrial projects various modern methods of projects evaluation, economic selection of alternatives on the basis of annual costs, present worth, rate of return and payout period etc. problem situation for selection of alternative profile, replacement problem.

Books Recommended:

1. M. Peter, K. Timmerhaus, R. West, Plant Design and economics for Chemical Engineers, 5th Edition, McGraw-Hill Science/Engineering/Math, 2002
2. R. K. Sinnott, Coulson and Richardson's Chemical Engineering, Volume 6, Second Edition: Chemical Engineering Design (Chemical Engineering Technical Series), 2nd Edition, Pergamon, 1993
3. P.C.Jain, Handbook for new entrepreneur, Oxford University Press, 2012.
4. V.G. Patel, The Seven-Business Crisis. How to beat them? Tata McGraw-Hill Co. Ltd, 1995.
5. Daniel Goleman, Working with emotional intelligence, Butam Books, 2000.
6. John Happel, Donald G. Jordan, Chemical process economics, 2nd Edition, Marcel Dekker, Inc., New York, 1976.
7. Ernest E. Ludwig, Applied project management for the process industries, Gulf Pub. Co., 1974.

Subject : BTCHE 804T (BCHE) **Elective –III: Computational Fluid Dynamics (Theory)**

Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

Unit 1: Introduction to CFD
Introduction and basic concepts, overview of CFD, basic transport equations, Application of CFD

Unit 2: Discretization methods
Nature of numerical methods, Methods of deriving the discretization equations, Control volume formulation. Discretization 1-D, 2-D and 3-D equations for steady state and unsteady state conduction. Various methods, Over-relaxation, Under-relaxation, Discretization of convection and diffusion terms, Upwind Scheme, Exact solution, Exponential scheme, Hybrid scheme, Power law scheme, other schemes etc. False diffusion.

Unit 3: Calculation of the Flow Field
Difficulties related pressure gradient term and continuity equation, Staggered grid, Momentum equation, Pressure and velocity correction, Pressure correction equations, SIMPLE, SIMPLER algorithms.

Unit 4: Turbulence Modeling
Introduction to turbulence, Mean flow equations, Nature of turbulence, Classification, Zero order equation models, One equation models, Two-equation models, Turbulent stress models, other models, Problems.

Unit 5: Reactor Engineering and Flow Modelling
Introduction to reactor engineering and flow modelling, Reactive flow processes, Multiphase flow processes, Reactor Engineering Methodology, Introduction to various CFD softwares.

Unit 6: CFD Case Studies
Design of stirred tank reactor, jet mixed tanks, bubble column, fluidized bed, submerged jets, flow in curved pipe, turbulent flow and heat transfer in finned tubes, melting around a vertical pipe, transient combined mixed convection and radiation from vertical aluminium fin, heat transfer in rotary kiln reactors, heat transfer in metal and alloy solidification, membrane reactors etc.

Books Recommended:

1. J.D. Anderson, Computational Fluid Dynamics: The Basics with Applications, McGraw Hill, 1995.
2. S. V. Patankar, Numerical heat transfer and fluid flow, Mc Graw-Hill Book Company, 1st Edition, 1980.
3. P. S. Ghoshdastidar, Computer simulation of flow and heat transfer, Tata McGraw-Hill Publishing, 1st edition, 1998.
4. V.V. Ranade, Computational Flow Modeling for Chemical Reactor Engineering, Academic Press, 2002.
5. H. K. Versteeg and W. Malalasekera, "An introduction to CFD", Longman Scientific and Technical, 1st edition, 1995.
6. E. S. Oran and J. P. Boris, Numerical Simulation of Reactive Flow, Cambridge University Press, 2nd edition, 2001.
7. J. H. Ferriger, M. Peric, Computational methods for fluid dynamics, Springer, 1st edition, 1996.
8. K. Muralidhar and T. Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publications, 2nd Edition, 2003.

Subject : **BTCHE 804T** (BCHE) **Elective –III: Piping Engineering (Theory)**

Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4

University : 80 Marks College Assessment : 20 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction to piping, piping fundamentals, applications, codes and standards. Review of friction factor, pressure drop for Incompressible and Compressible fluid, pipe sizing, and economic velocity. Analysis of pipe line networks for flow in branches. Pipe line design on fluid dynamic parameter.

Unit 2: Line size calculation; details and types of pressure relief valve / safety valve; control valves, gaskets, Pipe fittings and pipe connectors. Desirable properties of Material of Construction (MOC) for pipe, valves, flanges, gaskets etc.

Unit 3: Unit plot plan, process P&ID, utility P&ID, equipment layout and utility layouts within battery limits. Isometrics (2D, 3D), material-take-off (MTO), piping spool drawings, Piping insulation, colour codes and hazardous area classification details.

Unit 4: Common ASME, ASTM and IS specifications for seamless/ ERW pipes, pipe fitting flanges and fasteners, gasket, and valve materials, types of gaskets and their selection etc.

Unit 5: Design of flanges and gaskets; design of nuts & bolts; applications of NFPA codes in piping system design; Standards for piping insulation (detail engineering). Gas Pipe stress analysis (internal and external pressure). Selection & codes for pipe supports.

Unit 6: Design of piping systems and accessories: Crude oil, natural gas, pressurised steam, condensate, hazardous chemicals etc.

Books Recommended:

1. McAllister E.W., Pipeline Rules of Thumb Handbook, 7th Edition, Gulf Publication, 2009
2. Kellogg, Design of piping System, 2nd Edition, M.W. Kellogg Co. 2009
3. Weaver R., Process Piping Design Vol. 1 and 2 ., Gulf Publication, 1989
4. G. A. Antaki, Piping and Pipeline Engineering: Design, Construction, Maintenance, Integrity, and Repair (Mechanical Engineering), 1st Edition, CRC Press, 2003.
5. Ed Bausbacher, Roger Hunt, Process Plant Layout and Piping Design, 1st Edition, Prentice Hall, 1993.
6. Robert A. Rhea, Roy A Parisher, Pipe Drafting and Design, 3rd Edition, Gulf Professional Publishing, 2011.
7. John McCketta, Piping Design Handbook, 1st Edition, CRC Press, 1992.
8. Crane Co. Staff, Flow of Fluids Through Valves, Fittings and Pipe, Crane Co.1985.
9. Peter Smith**,** Piping Materials Guide, Gulf Publishing, 2005.
10. Mohinder Nayyar, Piping Data Handbook, 1st Edition, McGraw-Hill Professional, 2002.

Subject : **BTCHE 804T** (BCHE) **Elective –III: Polymer Engineering (Theory)**

Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

Unit 1: Introduction to polymers, Molecular Weight Determination

Introduction and Classification of Polymers. Thermosets, Thermoplastics, Linear Branch, Cross Linked Polymers. Factors influencing the polymer properties. Monomers used for polymer synthesis.

Molecular Weights, Mn, Mw, Mv, Polydispersity Index. Different Methods of determination of Molecular weight. Effect of Molecular weight on Engg. Properties of Polymers, Numerical based on theory

Unit 2: Polymerization Processes and Techniques

Addition & Condensation polymers, Polymerization Techniques, Bulk, Solution, Emulsion, Suspension, Interfacial Polymerization with their merits & Demerits.

Unit 3: Kinetics and Mechanism of Polymers Synthesis

Kinetics of free radical polymerization (initiation propagation & termination.) Kinetic of Step growth polymerization. Copolymers & its Kinetics Coordination Polymerization. Ziegler Natta polymerization Processes, Chain transfer agents. Smith Ewart Kinetics for emulsion polymerization.

Unit 4: Polymerization reactors

Polymerization reactors, types and mode of operation. Polymerization reactor design, control of polymerization, Post polymerization unit operations and unit processes High Performance and Specialty Polymers, Polymer additives, compounding. Fillers plastisizers lubricants colourants Different moulding methods of polymers,

Unit 5: Polymers Testing and Waste Management

Mechanical Properties of Polymers, Thermodynamics of Polymer Mixtures, ASTM and ISO methods for testing of polymers. Plastic waste management.

Unit 6: Manufacturing of polymers with flow-sheet, properties & applications

PE, PP, Polyesters, Nylons, Polystyrene, ABS, Thermosets like Epoxies, unsaturated polyesters, phenolics.; etc.

Books Recommended:

1. G. Odian, Principals of Polymerization, Wiley-Interscience, 4th Edition, 2004.
2. V.R. Gowarikar, N.V. Vishwanathan, J. Sreedhar Polymer Science, New Age International, 2010.
3. J. Fried, Polymer Science and Technology, Prentice Hall, 2^{nd} edition, 2003.
4. J.A.Brydson, Plasitc Materials, Butterworth-Heinemann, 7^{th} edition, 1999.
5. R. Sinha, Outlines of Polymer Technology: Manufacture of Polymers, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
6. S.D. Dawande, Introduction to Polymer Science & Technology, Denett & Co. 2006.

Subject **: BTCHE 804T** (BCHE) **Elective –III: Chemical Process synthesis And Design (Theory)**

Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit 1: **Introduction of Chemical Process and Product Design**

Introduction, Approach to Process Development, Different Considerations, development of Particular Process, Overall Process design, Onion Model, Case studies of product design.

Unit 2: **Choice of Reactor**

Reaction Path, Types of Reaction Systems, Performance of Reactor, Idealized Reactor Models, Effect of various process variables.

Unit 3: **Choice of Separator**

Separation of Homogeneous and Heterogeneous Mixtures, Distillation, Azeotropic Distillation, Absorption, Evaporation, Drying etc.

Unit 4: **Heat Exchanger Networks**

Energy Targets, Composite Curves, Heat Recovery Pinch, Threshold Problems, Problem Table Algorithm, Process Constraints, Utility Selection, Furnaces, Combined Heat and Power, Integration of Heat Pump, Integration of Refrigeration Cycles, Overall Heat Exchanger Network and Utilities

Unit 5: **Distillation Sequencing**

Distillation Sequencing using simple columns, Heat Integration of Sequences of Simple Distillation Columns, Distillation Sequencing using thermal coupling, Optimization of Reducible Structure reactions

Unit 6: **Safety and Health Considerations**

Toxic Release, Fire, Explosion, Intensification of hazardous Materials, Attenuation of Hazardous Materials, Quantitative Measures of Inherent Safety, Overall Safety and Health Considerations. Malfunctions in columns leading to potential hazards. Safety factors used in design of columns

Books Recommended:

1. Robin Smith, Chemical Process design and Integration, Wiley-Blackwell, 2 Sub edition, 2005.
2. J. Douglas, Conceptual Design of Chemical Processes, New York, NY: McGraw-Hill, 1988.
3. L. Biegler, I. E. Grossmann, A. W. Westerberg, Systematic Methods of Chemical Process Design, Upper Saddle River, NJ: Prentice Hall PTR, 1997.
4. W. D. Seider, J. D. Seader, D. R. Lewin, Product and Process Design Principles: Synthesis, Analysis, and Evaluation, 2nd ed. New York, NY: Wiley, 2003.
5. D. F. Rudd, G. J. Powers, J. J. Siirola, Process Synthesis, Englewood Cliffs, NJ: Prentice Hall, Inc., 1973.
6. R. Turton, R. C. Bailie, W. B. Whiting, J. A. Shaeiwitz, Analysis, Synthesis, and Design of Chemical Processes, Upper Saddle River, NJ: Prentice Hall PTR, 1997
7. P.H. Grogins, Unit process in organic synthesis, McGraw-Hill, Second Edition, 1938.

BTCHE 805P (BCHE) **Computational Chemical Engineering (Practical)**

Practical : 3 Hours No. of Credits : 2
University : 25 Marks College Assessment : 25 Marks
Duration of Examination: 6 Hours

Before starting the practical sessions students will be made acquainted with theoretical aspects of mathematical softwares and commercial simulators.

Students have to perform minimum eight practicals using MS-Excel, MATLAB/Scilab, POLYMATH, Mathcad, ASPEN PLUS/HYSYS/ CHEMCAD software for design/simulation of chemical engineering problems.

Subject **: BTCHE 806P** (BCHE) **Process Control (Practical)**

Practical : 3 Hours No. of Credits : 2
University : 25 Marks College Assessment : 25 Marks
Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practicals from the list given below:

List of experiments:

1. To determine the time constant of mercury in glass thermometer.
2. To determine the time constant of thermocouple sensor.
3. To determine the time constant of RTD (PT100) sensor.
4. To determine the time constant of thermister sensor
5. To determine damping coefficient, decay ratio, overshoot and characteristics time for step response of mercury manometer.
6. To study the dynamic response of liquid level in single tank system.
7. To study the dynamic response of liquid level in two tanks non-interacting liquid level system and to compare experimental and theoretical responses.
8. To study the dynamic response of liquid level in two tank interacting liquid level system and to compare experimental and theoretical responses.
9. To study the characteristic of PID controller by estimating time required to reach PV and to estimate the offset.
10. To study the transient response of a P control.
11. To study the transient response of a P +D control.
12. To study the transient response of a P+I control.
13. To study the transient response of a P+I+D control.
14. To determine the characteristics pneumatic control valve.
15. To study the tuning of PID controller by open loop method, using Zeigler-Nichols tuning rule.
16 Use of MATLB/Scilab for control Experiments .

Subject	**: BTCHE 807P** (BCHE)	**Project/Dissertation-Stage II (Practical)**	
Practical	: 6 Hours/week	No. of Credits	: 3
University	: 150 Marks		

Project/dissertation work undertaken in the first stage in Seventh semester will be continued and completed at the end of Eighth semester. Two neatly typed and bound copies of the report consisting of stage I and Stage II combined together along with its soft copy should be submitted at the end of Eighth semester. Assessment would be made on the basis of the submitted report and the presentation cum viva-voce examination conducted by the board of examiners.

SCHEME OF EXAMINATION FOR
B. TECH. (Chemical Technology)
SEVENTH SEMESTER B.TECH (CHEMICAL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHT 701T (BCHT)	Mass Transfer Operations	3	-	1	4	3	-	1	4	20	80	-	-	100
2.	BTCHT 702T (BCHT)	Chemical Reaction Engineering	3	-	1	4	3	-	1	4	20	80	-	-	100
3.	BTCHT 703T (BCHT)	*Special Technology V	3	-	1	4	3	-	1	4	20	80	-	-	100
4.	BTCHT 704T (BCHT)	*Special Technology VI	3	-	1	4	3	-	1	4	20	80	-	-	100
5.	BTCHT 705P (BCHT)	Mass Transfer Operations	-	3	-	3	-	2	-	2	-	-	25	25	50
6.	BTCHT 706P (BCHT)	*Special Technology III	-	6	-	6	-	4	-	4	-	-	50	50	100
7.	BTCHT 707P (BCHT)	Seminar and Industrial Training	-	3	-	3	-	2	-	2	-	-	100	-	100
Total			12	12	4	28	12	8	4	24	80	320	175	75	650

*

- Food Technology
- Technology of Oils, Fats and Surfactants
- Petroleum Refining and Petrochemical Technology
- Pulp & Paper Technology
- Plastics & Polymer Technology
- Surface Coating Technology

SCHEME OF EXAMINATION FOR
B. TECH. (Chemical Technology)
EIGHTH SEMESTER B.TECH (CHEMICAL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHT 801T (BCHT)	Mathematical Modelling & Computer Aided Design	3	-	-	3	3	-	-	3	20	80	-	-	100
2.	BTCHT 802T (BCHT)	Project Management	3	-	-	3	3	-	-	3	20	80	-	-	100
3.	BTCHT 803T (BCHT)	*Special Technology VII	3	-	1	4	3	-	1	4	20	80	-	-	100
4.	BTCHT 804T (BCHT)	*Special Technology VIII	3	-	1	4	3	-	1	4	20	80	-	-	100
5.	BTCHT 805P (BCHT)	*Special Technology IV	-	6	-	6	-	4	-	4	-	-	50	50	100
6.	BTCHT 806P (BCHT)	*Project work/ Dissertation	-	6	-	6	-	4	-	4	-	-	100	100	200
Total			12	12	2	26	12	8	2	22	80	320	150	150	700

*

- Food Technology
- Technology of Oils, Fats and Surfactants
- Petroleum Refining and Petrochemical Technology
- Pulp & Paper Technology
- Plastics & Polymer Technology
- Surface Coating Technology

Scheme of Absorption for Old Pattern to Semester Pattern of Fourth Year B. Tech. (Chemical Technology)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme		
Seventh Semester B. Tech (Chemical Technology)				Seventh Semester B. Tech (Chemical Technology)		
Sr. No	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**
1	7S.CT.1 (BChE)	#Process Control	Theory	--------	--------	--------
2	7S.CT.2 (BChE)	$Mathematical Methods & Computer Aided Design in Chemical Technology	Theory	--------	--------	--------
3	7S.CT.3 (BCT)	Special Technology V	Theory	BTCHT 703T (BCHT)	Special Technology V	Theory
4	7S.CT.4 (BCT)	Special Technology VI	Theory	BTCHT 704T (BCHT)	Special Technology VI	Theory
5	7S.CT.5 (BCT)	Special Technology III	Practical	BTCHT 706P (BCHT)	Special Technology III	Practical
6	7S.CT.6 (BChE)	@Process Equipment Drawing	Practical	--------	--------	--------
7	(BCT)	Seminar, Industrial Training and Tour Report	Practical	BTCHT 707P (BCHT)	Seminar and Industrial Training	--------
8	(BCT)	$Project Work / Dissertation	Practical	--------	--------	--------
9	--------	--------	--------	BTCHT 701T (BCHT)	*Mass Transfer Operations	Theory
10	--------	--------	--------	BTCHT 702T (BCHT)	Chemical Reaction Engineering	Theory
11	--------	--------	--------	BTCHT 705P (BCHT)	**Mass Transfer Operations	Practical

As per CBS scheme the subject is covered in sixth semester. So the students of absorption scheme shall have to appear for the examination of subject no. (BTCHT603T) Chemical Process Control (Theory).

@ As per CBS scheme the subject is covered in fifth semester. So the students of absorption scheme shall have to appear for the examination of subject no. (BTCHT508P) Chemical Equipment Design (Practical).

*Subject is covered in Sixth Semester according to Old Pattern subject no. (6S.CT.2) Mass Transfer (Theory). They may be exempted.

** Subject is covered in Sixth Semester according to Old Pattern subject no. (6S.CT.6) Mass Transfer (Practical). They may be exempted.

$ Subject will be covered in eighth semester as per the CBS scheme.

Scheme of Absorption for Old Pattern to Semester Pattern of Fourth Year B. Tech. (Chemical Technology)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				**As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme**		
Eighth Semester B. Tech (Chemical Technology)				**Eighth Semester B. Tech (Chemical Technology)**		
Sr. No	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**
1	8S.CT.1 (BChE)	*Chemical Reaction Engineering	Theory	--------	--------	--------
2	8S.CT.2 (BChE)	Project Management & Industrial Econimics	Theory	BTCHT 802T (BCHT)	Project Management	Theory
3	8S.CT.3 (BCT)	Special Technology VII	Theory	BTCHT 803T (BCHT)	Special Technology VII	Theory
4	8S.CT.4 (BCT)	Special Technology VIII	Theory	BTCHT 804T (BCHT)	Special Technology VIII	Theory
5	8S.CT.5 (BCT)	Special Technology IV	Practical	BTCHT 805P (BCHT)	Special Technology IV	Practical
6	8S.CT.6 (BCT)	*Seminar, Industrial Training and Tour Report	Practical	--------	--------	--------
7	8S.CT.7 (BCT)	Project Work / Dissertation	Theory	BTCHT 806P (BCHT)	Project Work / Dissertation	Practical
8	------	--------	--------	BTCHT 801T (BCHT)	Mathematical Modelling & Computer Aided Design	Theory

*The subject is covered in seventh semester according to CBS scheme.

SYLLABUS FOR SEVENTH SEMESTER

Subject: BCHT701T(BCHT) — **Mass Transfer Operations (Theory)**

Lecture: 3 Hours	No. of Credits: 4
Tutorial: 1 Hour	University: 80 Marks
Duration of Examination: 3 Hours	College Assessment: 20 Marks

Unit 1: Molecular diffusion in fluids, Diffusion in solids. Interphase Mass Transfer. Mass transfer coefficients and their correlations / H T U and N T U, concept of Jd factor. Mass transfer in packed and fluidized beds.Concept of effective diffusivity.Diffusion through membranes and applications.

Unit 2: Distillation – Vapor liquid equilibrium for ideal and non-ideal binary systems, T-x, y and P-x, y diagrams, estimation of VLE using vapor pressure data and relative volatility. Vapor liquid equilibrium for multicomponent mixtures. Differential Simple distillation, equilibrium distillation.

Unit 3: Gas Absorption – Equilibrium relationship, mass transfer theories, concept of driving force, individual and over all mass transfer coefficients. Plate column for absorption, analytical, and graphical calculation of number of plates.Humidity and air conditioning. Cooling towers and spray ponds.

Unit 4: Liquid Liquid Extraction – Equilibrium for immiscible and partially miscible systems. Use of triangular diagram.Calculation of number of stages for cocurent and countercurrent contacting.

Unit 5: Drying- Drying characteristics of the materials. Theory and mechanism of drying.Evaluation of drying rates, design and performance of continuous and batch dryers.Industrial drying equipments.Crystallisation, Miers theory, Nuclei formation, crystal growth.Theory of crystallization.Batch and continuous crystallization.Fractional crystallization.

Unit 6: Adsorption – Gas Solid isotherms for one and more sorbates, chemisorption, liquid solid isotherms. Adsorption Unit – Fixed bed equations, isothermal operation, non isothermal operation, pressure swing adsorption. Solid liquid Extraction.

Books Recommended:

1. Chemical Engineering by Coulson and Richardson
2. Mass Transfer Operation by Treybal
3. Unit Operation by G. G. Brown
4. Absorption and Extraction by Sherwood and Pigford
5. Elements of Fractional Distillation by Robinson and Gilliand

Subject: BCHT702T(BCHT) **Chemical Reaction Engineering (Theory)**

Lecture: 3 Hours No. of Credits: 4

Tutorial: 1 Hour University: 80 Marks

Duration of Examination: 3 Hours College Assessment: 20 Marks

Unit 1: Conversion and Reactor Sizing

Definition of conversion, Batch Reactor Design Equations, Design Equations for Flow Reactors, Applications of the Design Equations for Continuous-Flow Reactors, Reactors in Series, Some further Definitions

Unit 2:Rate Laws and Stoichiometry

Basic definitions, The Reaction order and the rate law, The Reaction Rate Constant, Present Status of our Approach to Reactor Sizing and Design, Batch systems, Flow Systems

Unit 3:Isothermal Reactor Design

Design structure for isothermal reactors, Scale up of liquid phase batch reactor data to the design of CSTR, Tubular reactors, Pressure drops in reactors, Synthesizing the Design of a Chemical Plant, Mole Balances on CSTRs, PFRs, PBRs and Batch Reactors, Micro reactors, Membrane Reactors, Unsteady-State Operation of Stirred Reactors, Practical Side

Unit 4:Collection and Analysis of Rate Data

The Algorithm for Data Analysis, Batch reactor data, Method of initial rates, method of half-lives, Differential reactors, Experimental Planning, Evaluation of Laboratory Reactors

Unit 5: Multiple Reactions

Definitions, Parallel Reactors, Maximizing the Desired Product in Series Reactions, Algorithm for solution for complex Reactions, Multiple Reactions in a PFR/PBR, Multiple Reactions in a CSTR, Membrane Reactors to Improve Selectivity in multiple Reactions, Complex Reactions of Ammonia Oxidations.

Unit 6: Distribution of Residence Times for Chemical Reactors

General characteristics, Measurement of RTD, Characteristics of the RTD, the RTD in ideal reactors, Diagnostics and Troubleshooting, Reactor modelling with the RTD, Zero parameter models, Using software Packages, RTD and Multiple Reactions

Books Recommended

1. Elements of Chemical Reaction Engineering by H. Scott Fogler, published by Prentice Hall Fourth Edition
2. Chemical Reaction Engineering by O.Levenspiel, published by Wiley Eastern
3. Chemical Engineering Kinetics by J.M. Smith, published by McGraw-Hill
4. Chemical Reactor Design, Vol.1 & 2 by H.W. Rao
5. Principles of Reaction Engineering by S.D. Dawande (Second Edition) published by Central Techno Publication, 2003.

Subject: BCHT703T(BCHT)	**Special Technology- V (Theory)**
Lecture: 3 Hours	No. of Credits: 4
Tutorial: 1 Hour	University: 80 Marks
Duration of Examination: 3 Hours	College Assessment: 20 Marks

BCHT703T/1 (BCHT) **FOOD TECHNOLOGY - V (FOOD PROCESSING I)**

UNIT 1:PROCESS TECHNOLOGY 0F CEREALS:

Composition of cereal grains & their fractions.Process technology of milling of wheat, rice & corn.Isolation, processing and applications of starch from different cereal sources.By products of milling industry.Processing of malt.

UNIT 2:PROCESS TECHNOLOGY OF LEGUMES & OILSEEDS:

Milling of legumes.Processing of oilseeds.Oil extraction, refining & hydrogenation. Manufacture of margarine, shortening agents, Lecithin & GMS. Edible oilseed flour, Protein concentrate and Protein isolate.

UNIT 3:PROCESS TECHNOLOGY OF BAKED FOODS:

Role and quality parameters of raw materials, Rheology of dough.Changes during dough formation, fermentation & baking.

Manufacture of bread, biscuits, cookies, crackers, cakes, wafers and other bakery products.

UNIT 4:PROCESS TECHNOLOGY OF TEA & COFFEE:

Composition & processing of tea &coffee.Flavour& aroma development & evaluation.

PROCESS TECHNOLOGY OF COCOA & CHOCOLATE:

Processing of cocoa beans, and production of cocoa powder.Types of chocolates, Production of Milk crumb and chocolates.Quality control in chocolates.

UNIT 5: PROCESS TECHNOLOGY OF SUGAR CONFECTIONARY:

Sugar crystallisation& its control.Types of confectionary products. Production of fondant, fudge, toffee, pulled confections, lozenges.

Standardization and processing of traditional sweets, such as batasha, pedha, sandesh, Rasogolla, chikki and flour based sweets.

UNIT 6:CONVINIENCE FOODS

Manufacture of breakfast cereals, puffed cereals. Extrusion process & extruded products, meat analogue.Fast foods & ready mixes.Agglomeration technique &instantised foods.

SPECIALITY FOODS: Weaning & baby food, space foods, probiotic foods, neutraceuticals

Reference books

1. Cereal technology by Matz Samuel A, AVI publishing co. Inc Westport Connecticut 1970
2. Modern Cereal Chemistry by Kent Jones W.D. & Amos A.J., Food Trade Press Ltd. London 1976
3. Snack food technology Matz S.A, AVI publishing Co.1976.
4. Bakery technology Matz Samuel
5. Sugar confectionary &chocalate manufacture by E.B Jackson & Lees R, Leonard Hill Books 24, market sqareAylesbury.
7. Processed plant protein food stuff edited by Aultschul A.M., Academic press London 1958
8. Wheat chemistry & technology, edited by Pomeranz Y. American Association of cereal chemists, Minnesota 1978
9. Bakery materials & methods by Daniel A.R., Mc Larene& sons Ltd.London 1947
10. Manufacture of biscuits cakes & wafers by Fritsch J. &Grosspicrre, London 1932.

BTCHT703T/2 Oil Technology V (Theory)
(BCHT)(Technology of Fat Splitting, Essential Oils and Other Fat Products)

Unit 1: Technology of fat splitting:

Chemistry of fat splitting, Hydrolysis of oils and fats, composition of partially split fats, Effect of temperature, pressure, catalyst and ratio of reactants in hydrolysis of fats; Degree of splitting, Plants and processes employed for fat splitting, Twitchell process, enzymatic fat splitting. Semi, continuous and modern processes of fat splitting

Unit 2: Separation and purification of fatty acid mixtures:

Fractional distillation, Solvent crystallization, analysis and purification of reaction products of fat splitting, Recent advances in the field.

Unit 3: Essential oils:

Chemistry, Classification and chemical constituents of essential oils, Raw materials, general methods of manufacture from roots, stems, leaves, flowers and seeds. Production of important oils viz., rose, jasmine, khus, sandal wood, palmarosa, lemongrass, lemon, clove, eucalyptus oils.

Unit 4: Properties and composition of Essential oils:

Analysis for physico-chemical characteristics such as specific gravity, refractive index, optical rotation, solubility, acid value, total alcohols, aldehydes and ketones. Industrial uses of essential oils

Unit 5: Natural and Synthetic perfumery materials:

Important isolates, synthesis perfumery materials and fixatives e.g., menthol, camphor, thymol, geraniol, citral, eugenol, terpeniol, vanillin, coumarins, musks, benzyl acetate, benzyl benzoate etc. perfumes.their blending and industrial uses.

Unit 6: Technology of other fat products:

Mechanism and industrial utilization of important chemical reactions of fats and fatty acids such as esterification, inter-esterification, Epoxidation, Pyrolysis, Halogenations, Hydroxylation, Ozonalysis, polymerization.

LIST OF REFERENCE BOOKS

1. Bailey's Industrial Oil and Fat Products, Edible Oil and Fat Products: Chemistry, Properties, and Health Effects, 6th Edition, John Wiley & Sons, USA.

2. The production of essential oils,Guenther, E. Krieger Publ. Co., Malabar, FL.

3.The Chemistry of Essential Oils and Artificial Perfumes. Parry, E.J.,D. Vannostrand Co.,NewYork.

4.Hand Book of Oils, Fats and Derivatives with Refining and Packaging Technology, Published by Indian Institute of Consultants, Engineers India Research Institute, New Delhi

5.Essential Oils and Culinary Herbs*James E. Simon

6. Industrial Fatty Acids and their Applications," edited by E. Scott Pattison, Reinhold Publ. Corp. New York.

BTCHT703T/3 Petroleum Refining and Petrochemical Technology – V
(BCHT) (Petroleum Refinery Engineering)

Unit 1: Multicomponent vapor liquid equilibrium, application of Raoult's law and Dalton's law in multicomponent flash equilibrium calculations, ideal and non ideal systems, Concept of K, Methods of successive approximations, Lockhart-Mc Henry method, Bubble point and Dew point calculations, and their applications.

Unit 2: Petroleum Refinery distillations, TBP, ASTM and EFV. Experimental details, their comparison and inter relations by Nelson and Edmister correlations. Analysis of TBP products, mid percent curves and yield curves, blending, phase behavior of petroleum systems, construction of phase diagrams, Cox charts and successive flash vaporization.

Unit 3: Multicomponent distillation, (MCD), concept of key components, distribution of non key components and their estimation, non key components influence in design of MCD. Calculation of minimum reflux and number of plates, feed plate location. Estimation by short cut and longer methods, temperature and pressure estimations, components influence in design of MCD.

Unit 4: Complex system (Petroleum) fractionation, their comparison with MCD, Topping tower design concepts by Nelson and Watkins, types of refluxes used in crude topping towers and their calculations, concept of over flash, Estimation of tower top, bottom and side draw temperatures. Pseudo multicomponent design by Van Winkle for simple tower operation. Tube still heaters, important features and types, Radiation from flames, design of convection and radiant sections, Wilson, Lobo and Hottel equation, their limitations, Lobo and Evans method, Pipe Still design.

Unit 5: Multicomponent liquid - liquid equilibrium relations, estimation of number of stages by triangular and rectangular diagrams for complex petroleum oils. Multicomponent absorption and stripping in refinery operations, absorption and stripping factors and their significance.Mathematical analysis of multi- component absorbers and strippers, Kremser-Brown absorption factor methods.

Unit 6: Adsorption, Breakthrough phenomena, concept of adsorption zone height, Unsteady state fixed bed operation, LUB concept, design of adsorbers using above concepts. Sorbex technologies and its concepts.Isosive process.

Books Recommended

1. Petroleum Refinery Engineering, W.L.Nelson, 4thed, Mac Graw Hill Book Co, 1958.
2. Petroleum Refinery Distillation, R.N.Watkins, 2nded, Gulf Publishing Co, 1979.
3. Data Book on Hydrocarbons, J.B.Maxwell, Princeton, N.J; D.vanNostrand Co, 1965.
4. Distillation, Van Winkle, Mac Graw Hill Book Co, 1967.
5. Petroleum Processing, Principles and Applications, R.J.Hengstebeck, Mc Graw Hill Book Co, 1959.
6. Applied Hydrocarbon Thermodynamics, W.C.Edmister, Gulf Publishing Co, 1961.
7. Hand Book of Petroleum Refining Process, Robert. A.Meyers, 2nded, Mac Graw Hill Book Co, 1997.

BTCHT703T/4 **Pulp and Paper Technology-V**
(BCHT) **(Bleaching & Stock Preparation)**

Unit 1: Bleaching of wood pulp, basic principles of chlorination and alkali extraction, oxidation bleaching agents- hypochlorite, chlorine dioxide, peroxide and other bleaching agents, reducing agents, acidification and combination stages, determination of bleach requirements.

Unit 2: Modern bleaching processes with following agents Chlorine–di-oxide, Oxygen, Ozone,Peroxide per acids, enzyme and chelating agents. Their reactions, process variables, pulp properties, advantages disadvantages and equipment selections.Bio-bleaching, fundamentals and economics. Bleaching of post-consumer office waste and deinked newspaper.

Unit 3: Stock preparation, beating and refining, effect on fiber structure, theory of beating, factors affecting beating, stock preparation systems

Unit 4: Internal sizing of paper, rosin size and synthetic sizes, wax emulsions, asphalt emulsions, theory of internal sizing, various precipitants, alkaline sizing, fortified sizing

Unit 5: Filling and loading: objectives, survey of filler properties, manufacture of fillers, preparation and addition of fillers, filler retention, adverse effects of fillers, commercial filling and loading materials, refractive index and scattering coefficient

Unit 6: Special additives for wet and dry strength, general considerations and properties, coloring, theory, terms used, dyes and pigments, fastness test, methods of coloring, coloring of special papers.

Books recommended:

1. Pulp and Paper Science & Technology Vol. I & II by C.E.Libby
2. Pulp & Paper Manufacture Vol. I, II, III by Mac Donald
3. Hand Book of Pulp and Paper Technology by K.W. Britt 2nd edition

BTCHT703T/5 **Plastics & Polymer Technology V**
(BCHT) **(Polymer Processing)**

UNIT 1: Extrusion

Introduction, design features of extruders, Zones in extruders, mechanism of extrusion, compression ratios, screen changers, single screw and twin screw extruder, effect of material properties, process parameters and their effect on product quality, process control in extrusion, extrusion dies for tapes, filaments, blow film, cast film, wire coating ,rods and simple profiles, thermoplastic foams, coating and lamination.

UNIT 2: Injection Molding

Introduction, shot capacity, process parameters, molding cycle, injection moulding of thermoplastics and thermosets, gas assisted and water assisted injection moulding, instrumentation and process control in injection moulding, trouble shooting of injection molding.

UNIT 3: Blow Molding and Rotational Molding

Blow moulding: extrusion blow moulding, injection blow moulding, stretch blow moulding, perform, parison, parison programming, Single and multi layer injection blow molding, single and multi layer extrusion blow molding, process controls for blow molding machine, trouble shooting in blow molding.

Rotational molding: Basic process, materials and products parameters, cycle time, temperature, speed, cooling effect on product quality, control system, multilayer rotational molding, batch type and continuous type machines, trouble shooting in rotational molding.

UNIT 4: Compression Molding and Transfer Molding

Compression Molding: Introduction, compressing molding process, types of moulds-flash, positive and semipositive, compression molding cycle, process parameters of compression moulding, troubleshooting, molding of thermosets and rubber, types of compression molding.

Transfer molding: Introduction, transfer molding cycle, types of transfer molding, resin transfer molding, advantages, limitations, troubleshooting.

UNIT 5: Thermoforming

Definition, methods of forming, thermoforming machinery, heating of sheet, heating cycle, thermoforming machines and plants, thermoforming materials, analysis of sheet heating, stretching and wall thickness distribution, simple vacuum forming, drape forming, air-slip forming, pressure forming, drape forming, blister forming, solid-phase pressure forming, plug-assist forming. Advantages and limitation of thermoforming. Process factors in thermoforming, defects in thermoformed articles and remedies, hot strength, blistering, sags, cooling and trimming the parts, heat balance, shrinkage, trimming operations, finishing and machining of plastics.

UNIT 6: Calendaring and Casting

Calendaring: Introduction to calendaring, types of calendar units, 2, 3, 4 roll calendars, Z type calender, L type calender, heating systems, temperature control and process control parameters, roll bending, calendaring lines- film and sheet lines, laminating and embossing lines, applications and advances in calendaring.

Casting: Introduction, types of castings, solvent casting of PVC film.

Cellular Plastics: Expandable polystyrene foam moulding, structural foam moulding.

References:

1. SPI Plastics Engineering Handbook, Michel L. Berins, Chapman & Hall
2. Polymer Extrusion, Chris Rauwandaal, Hanser
3. Plastic Extrusion Technology, Hensen, Hanser
4. Extrusion of Plastics, E. G. Fisher, Newness Butterworths, London, 1974
5. Injection Molding Handbook, Dominick V. Rosato and D. V. Rosato, CBS Publisher, 2000
6. Polymer Processing by Morton and Jones, Chapman & Hall, 2007
7. Plastic Processing Data Handbook by D. V. Rosato, Springer, 2001
8. Blow Moulding Handbook, Rosato, John welley& sons
9. Blow Moulding Plastics, Illuffee Books, London 1979
10. Compression & transfer molding, J. Butler, McMillan India
11. Handbook of Thermoforming, Throne, Hanser
12. Basic Principles of Thermoforning, P. F. Bruins, gorden and Beach Science Pub, New York, 1972
13. Basic Principle of Thermoforming, Bruins, SPC

BTCHT703T/6 Surface Coating Technology – V
(BCHT) (Miscellaneous constituents and formulations of Coatings)

Unit 1: Plasticizers, general uses, requirement of plasticizers and desirable characteristics, Types of plasticizers and their evaluation Solvents, their types and chemical structure, effect of volatile solvent on film properties, solvent characteristics, true and latent solvents, types of volatile solvents and their use in surface coatings, Toxicity of solvents.

Unit 2: Test methods for film forming compositions, percentage solids, viscosity, colour, acid number and bulk density. Measurement of film thickness, Performance tests for varnishes and resins, namely drying, skinning, gasproofing, hardness, flexibility, cold check, impact resistance, abrasion resistance, adhesion, exterior durability, water resistance, permeability to water, soap and alkali solutions, alcohol and chemical resistance, electrical resistance.

Unit 3: Performance testing of coatings: Resistance to heat, light, drying, skinning gasproffing, hardness, flexibility, cold check, impact resistance, abrasion resistance, adhesion, exterior durability, water resistance, permeability to water, soap and alkali solutions, alcohol and chemical resistance, electrical resistance, Weatherometer tests, Outdoor exposure tests.

Unit 4: Principles of formulations, Four steps formulation, production, application, drying and aging. Formula calculations, concept, Binder properties and performance, Effect of binder properties and vehicle characteristics on the performance of the coatings, Effect of pigment characteristics like particle size, shape, oil absorption and bulking value on the performance of the coating, pigment volume concentration (PVC), use of additives in paints and coatings.

Unit 5: Fundamentals of pigmented coatings, Appearance of coatings, colour, hiding power, spreading power, critical pigment concentration, consistency and flow properties, effect of vehicle on consistency. Rheology of Coatings, Newtonian and Non Newtonian flow, Thixotropy, Chemicals for inducing thixotropy in paints.

Unit 6: Colour, Nature of light, Light sources, the vision, Trichromatic colour system, Munsellcolour system, Colour measuring instruments, practical applications of colour measurement, Colour standardization, metamerism, Colour aesthetics.

Books Recommended:

1. Payne, H.F., “Organic Coating Technology” Volume one, John Wiley & Sons, New York, 1954.
2. Payne, H.F., “Organic Coating Technology” Volume Two, John Wiley & Sons, New York, 1954.
3. Matellio, J.J., “Protective and Decorative Coatings” Volume Two, John Wiley & Sons.
4. Matellio, J.J., “Protective and Decorative Coatings” Volume Three, John Wiley & Sons.
5. Durrans, T.H., “Solvents” D. Van Nostrand Co., New York, 1950.
6. Oil, Colour Chemists; Association, “Paint Technology Mannuals”, Vol 1.
7. Oil, Colour Chemists; Association, “Paint Technology Mannuals”, Vol 2.
8. Oil, Colour Chemists; Association, “Paint Technology Mannuals”, Vol 3.
9. Oil, Colour Chemists; Association, “Paint Technology Mannuals”, Vol 4.
10. Oil, Colour Chemists; Association, “Surface Coatings-Vol 1-Raw materials and their usage”, OCCA, Australia, 1983.
11. Long J. S. and Myers R. R., “Treatise on Coatings Vol 4 – Formulations”, Marcle& Dekker, N. Y. 1975.
12. GerritsonFrans, “Theory and Practice of Colour”, Studio vista, N. Y., 1975.
13. Billmeyer F. W. (Jr), and Satzzman Max, “Principles of Colour Technology”, Second Edition, John Wiley & Sons, N. Y., 1981.

Subject: BCHT703T(BCHT) **Special Technology- V (Theory)**

Lecture: 3 Hours No. of Credits: 4

Tutorial: 1 Hour University: 80 Marks

Duration of Examination: 3 Hours College Assessment: 20 Marks

BTCHT704T/1 FOOD TECHNOLOGY VI
(BCHT) (FOOD PROCESSING II)

UNIT 1: PHYSIOLOGY OF FRUITS & VEGETABLES:

Quality assessment of fruits & vegetables Structure, chemistry & physiology of plant tissues.Texture of fruits & vegetables. Plant pigments. Effect of processing on colour and texture.

Post harvest changes in Climacteric and nonclimacteric fruits.CA and MA storage. Dehydration of fruits & vegetables.

UNIT 2: PROCESS TECHNOLOGY OF FRUITS & VEGETABLES:

Processing & canning of fruits & vegetables and their products. Process technology of fruits & vegetable products such as purees, concentrates, jams, jellies marmalades, preserves, candied fruits, pickles, chutnies. RTS beverages, carbonated beverages.

UNIT 3: CHEMISTRY & PHYSIOLOGY OF ANIMAL MUSCLES:

Structure & chemical composition of muscle proteins, haemoglobin, myoglobin, collagen &gelatine. Post mortem changes in muscles, rigor mortis. Live stock& poultry preparation.Various cuts of meats.Texture of meat.Effect of cooking & processing on texture, palatability & tenderness of meat.

UNIT 4: PROCESS TECHNOLOGY OF MEAT FISH & POULTRY:

Preservation & packing of meat, poultry & their products, Processing of fish.Quality control & microbiological standards of meat, fish & poultry products.Processing of eggs.

By products in meat, poultry& fish processing industry.

UNIT 5: PROCESS TECHNOLOGY OF MILK & MILK PRODUCTS:

Composition of milk.Processing, storage & distribution of milk. Manufacture of cream, butter, ghee, evaporated, condensed & skimmed milk, cheese, yoghurt. Whole & skimmed milk powder.Preparation of Indian milk products like Khoa, Channa, Curd, & their products.Simulated milk products.

UNIT 6: FOOD ADDITIVES AND FOOD LAWS

Classification and importance of food additives. Various food additives such as preservatives, antioxidants, colours, flavours, emulsifiers, sequesterants, humectants, stabilizers, acidulants, etc. with respect to chemistry, functions and limitations in formulations. Processing of Spices.

Food Laws such as FSSAI, Agmark, ISO, BIS, and Codex alimentaris. Quality assuarance in Food industry.TQM, GMP, hygiene and sanitation.

Reference books

1. Preservation of fruits & vegetables by Girdharilal&Sidappa G.S.,ICAR. New Delhi.
2. Fruits & vegetables juice processing technology edited by Tressler D.K. & Joslyn M.A., AVI publishing Co. Westport, Connecticut 1971
3. The meat handbook by Levie A. AVI publishing Co. Connecticut 1970
4. The science of meat & meat products by Price J.F. &SchweigertB.s., W.H. Freeman, San Francisco, 1970
5. Poultry products technology by Moutney G.J., AVI publishing Co. Inc. Westport Connecticut, 1976

6. Fishery Byproducts technology by Brody J., AVI publishing Co Inc Westport, Connecticut, 1965.
7. Fish as Food Vol 1, 2, 3, & 4 edited by Borgstrom G., Academic press, New york& London, 1961.
8. Drying of milk & milk products by Hall C.W. & Hedrick T.I., AVI publishing Co., Westport,Connecticut, 1966.
9. Modern dairy products by Lampert I.M., Eurasia publishing House Ramnagar New Delhi, 1970.
10. Byproducts from milk by Webb B.H. & Whittier E.O., AVI publishing Co., Connecticut, 1970.
11. Meat Technology by Gerrard F., Leonard Hill London, 1971.
12. The chemistry & testing of dairy products by Newlander J.A. &Artherton H.V., Olsen publishing Co., MilwalieWisconsis, 1964.
13. Food Adulteration by Jacob T., Mc Millan & Co. India Ltd 1976.

BTCHT704T/2 **Oil Technology VI (Theory)**
(BCHT) **(Technology of Cosmetics)**

Unit 1: Classification of cosmetics and cosmetic preparations:
Cosmetic preparations such as Shampoos and Conditioners, their Ingredients, types, Functions, formulation, Production techniques, evaluation and safety considerations,

Unit 2:Face care products:
Beauty Masks , face creams, Cleansing and Emollient Creams and Lotions, Vanishing Creams, Foundation Makeup., face/body Formulation,Hand Creams and Lotions , Skin Lighteners and Bleach Creams ,sun care cosmetics, Rouge, Moisturizing Creams etc.

Unit 3:Face care products:
Lipsticks,face powders, talcum powders, Eye makeup cosmetics, Hormone Creams,Bath and shower products

Unit 4: Shaving soaps and creams:
After shave products, hair oils, hair dyes, Hair Conditioners, brilliantine's.

Unit 5: Dentifrices:
Toothpaste, tooth powders, Mouthwashes, teeth whiteners, evaluation of cosmetic preparations, Plant and Machinery used in cosmetic manufacture. Lay out and Hygiene aspect of cosmetic.

Unit 6: Miscellaneous Cosmetics:
Anti per spirants and deodorants, depilatories, Baby Toiletries, nail lacquers and polishes,recent trends and other miscellaneous cosmetic preparations

LIST OF REFERENCE BOOKS:
1. Handbook of Cosmetic Science and Technology, Barel,A.. Paye,M.,Howard I. and Maibach,H. I. Marcel Dekker, Inc.270 Madison Avenue, New York.
2.Cosmetics Formulations, Technology & Project Estimations, Institute of Natural & Modern Cosmetech,USA.
3. Cosmetic Formulation of Skin Care Products, Series EditorEricJungermann ,Jungermann Associates, Inc. New York.
4. Cosmetics-Science and Technology, Vol-2, 2nd Ed,Sagarin, E. andBalsam, M,Wiley India Pvt. Ltd,New Delhi.
5.Analysis of Cosmetic Products,Salvador,E.,Elsevier, New York.

BTCHT704T/3 Petroleum Refining and Petrochemical Technology - VI
(BCHT) (Petrochemical Processes)

Unit 1: Starting materials for Petrochemicals and their preparation, principal reactions of Methane, ethane, propane and butane. Preparation of gaseous hydrocarbons, separation of Liquid hydrocarbons by fractionation, adsorption and crystallization etc.

Unit 2: Derivatives of ethylene and acetylene, polyethylene, ethylene oxide, ethyl alcohol and ethyl benzene. Vinyl chloride, acrylonitrile, neoprene and vinyl acetate.

Unit 3: Propylene and C_4 hydrocarbon derivatives, polypropylene, isoprene, propylene oxide, Iso-propyl alcohol, cumene. Butadiene by oxidative dehydogenation

Unit 4: Chemicals from synthesis gas (and also from olefins), ammonia, methanol and higher alcohols. Petroleum aromatics, styrene, phenol, cyclohexane, caprolactum and naphthalene.

Unit 5: Polymerization fundamentals, Ziegler Natta catalysts, polymerization of simple olefins such as ethylene and propylene. Synthetic rubbers, manufacture, general characteristics, raw materials for synthesis, Range of synthetic rubbers, PBR, SBR, NBR, Butyl rubber.

Unit 6: Synthetic detergents from petroleum, field of application of Surface-active agents, classification, alkylarylsulphonates, linear alkyl benzenes, sulphonal. Engineering plastics, PTFE, polyacrylonitrile, polycarbonates, PVC, epoxy polymers,polyurethanes and silicones.

The subject is to be taught with increase in order of depth, different routes, flow schems for the most favored route, future trends, physico-chemical and chemical engineering principles and engineering problems encountered, unit operations and unit process involved.

Books Recommended

1. Acetylene, vol I and II, S.A.Miller,
2. Ethylene and its Indutrial Derivatives, S.A.Miller.
3. Propylene and its Industrial Derivatives, E.G.Hancock.
4. Benzene and its Industrial Derivatives, E.G.Hancock.
5. Oxidation of Hydrocarbons, S.B.Chandalia.
6. Oxidation of Petrochemicals,T.Dumas and W.Bulani.
7. Production of Polymers and Plastic Iintermediates from Petroleum, R,Long
8. A Text Book on Petrochemicals, B.K.Bhaskara Rao.
9. Toluene, Xylenes and their Industrial Derivatives, E.G.Hancock.
10. Fundamentals of Petroleum Chemicals Technology, P.Belov.

BTCHT704T/4 **Pulp & Paper Technology-VI**
(BCHT) **(Paper & Board Manufacture-I)**

Unit 1: Flow behaviour of pulp suspension, equation of continuity, mechanical energy balance and frictional losses in mixing of pulp suspensions, role of viscosity, critical consistency, network strength, flocculation

Unit 2: Introduction to types of paper machines, history and development of Fourdrinier paper machine, birds eye view, auxiliary equipments-stock chests, stock proportionars, consistancy regulators, approach flow systems, head box and slices, different types

Unit 3: Drainage and sheet formation on Fourdrinier, breast roll, table rolls, forming boards, wire, suction boxes, dandy rolls, couch rolls, wire pit, miscellaneous equipments, twin wire formers, ventri formers

Unit 4: Pick up and press section, concept of suction pick up, plain and suction presses, mechanism of water removal, factors affecting water removal and moisture distribution, paper machine felts, felt conditioning and treatment

Unit 5: Drying of paper, need, means, major characteristics, theory, mechanism of water removal, drying rate curves, critical and equilibrium moisture contents, multi-cylinder drying, different phases of drying, Mechanism of heat and mass transfer.

Unit 6: Cyclic nature of paper drying, Yankie and MG drying, factors affecting heat and mass transfer uniformity, effect of drying on sheet properties, methods of expressing the moisture content of a wet sheet and their inter relationship. Performance calculations, determination of centre line temperature distribution, air drying, radiant drying, psychrometry, heat requirements, ventilation, cost economics

Books recommended:

1. Pulp and Paper Science & Technology Vol. I & II by C. E. Libby
2. Pulp & Paper Manufacture Vol. I, II, III by Mac Donald
3. Hand Book of Pulp and Paper Technology by K.W. Britt 2nd edition.

BTCHT704T/5 Plastics & Polymer Technology VI

UNIT 1: Mould Design

Introduction to mould design, mould making materials, design of positive, semi positive and flash type moulds, single and multi cavitymoulds, calculation of number of cavities, allowance for shrinkage etc, transfer moulds, injection moulds, design of ejection system, design of sprue, runner and gate system, hot runner moulds, runnerless injection moulds, mould defects, mould cooling system.

UNIT 2: Spinning

Introduction to spinning technology, essential properties of fibres, characteristics of fibre forming polymers, fundamentals of fibre formation, melt spinning, dry spinning and wet spinning of fibres, spinnerets for wet spinning. Drawing and stretching of synthetic fibres, high speed spin drawn, formation and arrangement of crystallites in fibres, preparation of viscose rayon, high tenacity nylon fibre and high oriented nylon fibre.

UNIT 3: Polymer Rheology

Basic rheological concept, Newtonian fluids, Non-Newtonian and its types, Rheological Models, Power law relationship, power law index, shift factor, expression for shear rate, Carreau equation, effect of temperature, pressure and molecular weight on viscosity, Viscoelastic behaviour of polymer solutions and melts, mathematical models of viscoelasticity, Viscosity change during extrusion, weissenberg effect, Extrudate effect, Draw resonance, Melt fracture, Capillary entry flow patterns, Abnormal fringe patterns in calendaring, Pressure hole error, Parallel plate separation, Tubeless siphon, Uebler effect.

UNIT 4: Viscometers

Capillary tube viscometer, cone and plate viscometer, brook field viscometer Sandwich or parallel plate viscometer, Rotating cylinder viscometer, Concentric cylinder rotary viscometer, Mooney viscometer.

UNIT 5: Biopolymers

Introduction, classification, applications, advantages and disadvantages, Biopolymers vs polymers, Biopolymers vs Biodegradable polymers, introduction of different types of biopolymers like polypeptides, nucleic acid, sugar based, poly lactic acid, PHBV , biodegradation and its classification, degradation - Intracellular biodegradation , extra cellular biodegradation , thermal degradation , hydrolytic degradation ,environmental degradation , criteria used in the evaluation of biodegradable polymers.

UNIT 6: Plastics Waste Management

Sorting and segregation of waste, Plastics identification, Plastics waste: Composition, quantities and disposal, Four R’s of plastics waste management, Need for recycling, alternative types of recycle methods, recycling of plastics from urban waste, Waste management of plastics packaging

References:

1. Plastics Mould Engineering, J. H. Dubois
2. Injection mould&moulding, Dym
3. Injection mould Design, R.G.W.Pye, Longman Scientific and Technical, 4th Edition, 1989
4. Design of Plastics Moulds& Dies, Sors
5. Injection Mould Design, 4th edition, Pie
6. Text Book of fibre Technology, S. P. Mishtra
7. Rheometry, K. Walters, Chapman and Hall, Londan, 1975
8. Rheology of Polymers, G. V. Vinogradov, A. Ya. Malkin, Mir Publications, 1980

9. Introduction to Polymer Viscoelasticity, J. J. Alkonics, W. J. Macknight, Wiley Inter Science, New York, 1982
10. Melt Rheoloy and it role in Plastics Processing, Dealy
11. Chemistry & Technology of Biodegradable Polymers, G.J.L.Griffin Blackie(ed.), Academic & Professional London, 1stEdition,1994
12. Biodegradable Plastics & Polymers, Yoshiharu Doi , Kazuhiko Fukuda(ed.), Elsevier, 1stEdition, 1994
13. Polymeric Biomaterials, Piskin and A S Hoffmann, MartinusNijhoff Publishers. (Dordrecht.), 2nd Edition, 1986
14. Biomaterials - An introduction, J.B. Park, Plenum Press, 2nd Edition, 1979

BTCHT704T/6 Surface coating Technology – VI
(Manufacturing Methods and application of Surface Coatings)

Unit 1: Paint manufacture, steps in manufacture, mixing, grinding, letting down, tinting, straining, filling. Types of coatings, primers, topcoats, corrosion resistant finishes, clear finishes.

Unit 2: Types of machinery required for various steps and their working, construction, designing and function of various parts. Details of machinery for Mixing, edge runners, paint mills (single, twin, three and four roll mills), Ball and pebble mills, sand grinders, attritors, kadymillk, high speed impellers, Filling and labeling machines.

Unit 3: Varnish manufacture Oleoresinous varnishes, constituents of varnishes and their function, film properties of varnishes, Types of furnaces and their design, types of kettles and their advantages and disadvantages, design of resin kettle, thinning and cooling tanks, storage of raw materials and finished products, filling and labeling machines.

Unit 4: Coating/printing inks/varnish industry plant layout, flow of material and finishing schedule, sampling of coatings for testing, recording, costing of coatings, Paint Film Defects, their causes and remedies.

Unit 5: Surface preparation for coating, solvent vipeoff, vapour degreasing, alkali cleaning, chemical cleaning, burn off and flame cleaning, mechanical cleaning with hand and power tools, sand blasting, phosphate treatment, treatments for alluminium and magnesium.

Unit 6: Application of coat/paint, brush and roller coating, spray painting (ordinary, Electrostatic, power, airless, two component, hot spray), dipping, flow coating, fluidised bed coating, pressure curtain coating, knife and roller coating, tumbling barrel, silk screen coating, centrifugal coating, design of spray booths.

Books Recommended

1. Payne, H.F., “Organic Coating Technology” Volume one, John Wiley & Sons, New York, 1954.
2. Payne, H.F., “Organic Coating Technology” Volume Two, John Wiley & Sons, New York, 1954.
3. Matellio, J.J., “Protective and Decorative Coatings” Volume Two, John Wiley & Sons.
4. Matellio, J.J., “Protective and Decorative Coatings” Volume Three, John Wiley & Sons.
5. Durrans, T.H., “Solvents” D. Van Nostrand Co., New York, 1950.
6. Oil, Colour Chemists; Association, “Paint Technology Mannuals”, Vol 1.
7. Oil, Colour Chemists; Association, “Paint Technology Mannuals”, Vol 2.
8. Oil, Colour Chemists; Association, “Paint Technology Mannuals”, Vol 3.
9. Oil, Colour Chemists; Association, “Paint Technology Mannuals”, Vol 4.
10. Oil, Colour Chemists; Association, “Surface Coatings-Vol 1-Raw materials and their usage”, OCCA, Australia, 1983.
11. Tank, G. F., “Industrial Paint Finishing Techniques and Processes”, Ellis Horwood Ltd., 1991.
12. Bigos Joseph, “Steel Structure Painting Mannual, Vol. I and Vol. II”, Steel Structures Painting Council, Pittsburg, USA, 1955

Subject : BCHT705P **Mass Transfer Operations (Practical)**

Practical	: 3 Hours	No. of Credits	: 2
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 3 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. Winkelmann’s method – To find the diffusion Coefficient of vapour in still air
2. Liquid Diffusion – To find the Diffusion Coefficient for a liquid –liquid system
3. To calculate rate of Drying.
4. Studies ofcrystallization phenomenain Batch Crystallization
5. To evaluate the performanceof Cooling Tower.
6. To find the mass transfer coefficient in a wetted wall Column
7. Determination of solid-liquid mass transfer coefficient.
8. Evaporation from free surface.
9. Determination of HTU in packed bed.
10. Study of Ion exchange process.
11. Removal of impurities by use of adsorption techniques.
12. To verify Rayleigh’s Equation for Simple Distillation
13. To construct the boiling point diagram for binary – miscible system
14. Distillation using Sieve Plate, Bubble Cap Column
15. To determine the thermal and vaporization efficiencies in Steam Distillation
16. Single/multiple stage extraction studies
17. To prepare the ternary phase diagram.
18. Soxhlet Extraction
19. Absorption studies in packed column
20. Absorption studies in bubble column
21. Batch/ Continuous Leaching
22. Membrane separation
23. Liquid Liquid Extraction.

Subject	**: BCHT706P**	**Special Technology III (Practical)**	
Practical	: 6 Hours	No. of Credits	: 4
University	: 50 Marks	College Assessment	: 50 Marks

Duration of Examination: 6 Hours

BCHT706P/1 FOOD TECHNOLOGY PRACTICAL III
(FOOD PROCESSING)

Preparation of fruit juices, squashes, jam, jellies, concentrates, pickles, pastes, ketchup, canning of fruits & vegetables. Preparation of bakery products like bread, biscuits, cakes, crackers. Preparation of confectionary products like soft & hard boiled candies, fruit candies, chikki etc. Processing of meat, fish & poultry products & dairy products like ice cream, paneer etc.

BOOKS RECOMMENDED:

1. Practical baking by Sultan W.J., AVI publishing Co. Inc. 1969.
2. Manufacture of confectionary by an industrialist, industry publishers Ltd., 22. R.G. Kar Road, Shyam Bazaar, Calcutta.
3. Preservation of fruits &vegetabbles by Girdharilal&Sidappa, ICAR, New Delhi, 1967.

BCHT706P/2 OIL TECHNOLOGY-III
(Processing)

1. To prepare the red oxide metal primer and evaluation of its properties
2. To prepare synthetic enamel and evaluation of its properties.
3. To prepare universal strainer and evaluation of its properties.
4. To prepare cleansing creams and lotions.
5. To prepare and analyze metallic Soaps
6. To prepare lubricating grease
7. To prepare detergent powder
8. To prepare liquid detergent
9. To prepare shaving soaps
10. To prepare shampoos
11. To prepare biodiesel

BTCHT706P/3 Petroleum Refining and Petrochemical Technology - III
(Petroleum Refinery Operations)

1. To study TBP distillation of a petroleum fraction
   - 1.1 Verification of ASTM and TBP correlations
   - 1.2 Distillate blending of TBP fractions
   - 1.3 Residue blending of TBP fractions
   - 1.4 Construction of Mid-Percent curves
   - 1.5 Determination of Yield curves
2. To study Liquid-Liquid extraction
   - 2.1 Extraction of acid from kerosene fraction in a Bubble column.

2.2 Extraction of acid from kerosene fraction in a Packed column.
2.3 Extraction of acid from kerosene fraction in a Mixer-Settler.
2.4 Determination of tie line data for three component L-L system.
2.5 Determination of tie-line data in L-L extraction for a petroleum fraction.

3. Study of adsorption isotherm for a solid - liquid system
   3.1 Adsorption of acetic acid from acetic acid-water system using Granular Activated Carbon as a adsorbent.
   3.2 Adsorption of toluene from toluene-heptane system using Silica gel as a adsorbent.
4. To study the acid refining of lubricating oil stock using concentrated sulphuric acid at fixed set of parameters & observe the improvement in indices.
5. Extractive distillation
6. Azeotropic distillation
7. Merox treating
8. Vapor liquid equilibrium

BTCHT706P/4 Pulp & Paper Technology – III
(Analysis of Fibrous raw material: Pulp & Paper)

1. Determination of moisture content of pulp and paper
2. Determination ash content of pulp and paper
3. Determination of cold and hot water solubility of the a pulp and paper
4. Determination of 1%, 10%, and 18% NaOH solution solubility of a sample of pulp and paper
5. Determination of Permanganate number of a sample of pulp and paper
6. Determination of Kappa number of a sample of pulp and paper
7. Determination of Copper number of a sample of pulp and paper
8. Determination of viscosity of a pulp
9. Determination of rosin size in a sample of paper
10. Determination of hot water extractable alkalinity or acidity of paper

BTCHT706P/5 Plastics& Polymer Technology III

1. Preparation of articles by injection moulding process.
2. Preparation of Polymer strands by Hand injection moulding process.
3. To prepare fibre reinforced composites by Hand Layup technique.
4. To prepare chopped strands reinforced composites by hand layup process.
5. Determination of viscosity of polymer solution/emulsion by Brookfield viscometer.
6. To study compression moulding process.
7. To study the rotational moulding machine.
8. To study the blow moulding process.
9. To study the laboratory Extruder.
10. To study the Filament winding process.

BTCHT706P/6 **Surface Coating Technology-III**

Processing of Pigments, Paints, Enamels and Varnishes

1. Preparation and analysis of pigments.
2. Preparation and analysis of extenders
3. Preparation of Industrial paints like Stoving, Automotive, Marine and Epoxy paints and preliminary analysis of these products.
4. Preparation of primers,
5. Preparation of synthetic enamels,
6. Preparation of wall finishes.
7. Preparation of varnishes and preliminary analysis of products.

Subject	**: BCHT707P**	**Seminar and Industrial Training**	
Practical	: 3 Hours	No. of Credits	: 2
University	: -----	College Assessment	: 100 Marks
Duration of Examination: 6 Hours			

The seminar work shall consist of preferably study of certain phenomenon, system, equipment, process design in depth, review of certain research work, compilation and analysis of certain engineering/ management activity including costing, safety, administration, market study, field study, etc. on any topic which may have importance in respective technology.

Students are expected to work individually on the seminar and the report shall be a bound journal written in technical format with illustrations by graphs, charts, tables, photographs etc. about the specific work undertaken by the student.

Students are expected to undergo Industrial Training at the end of sixth semester and submit the training report in the department. The report shall be a bound journal written in technical format with the certificate provided after successful completion of training.

The number of copies of the report shall be such that the examiner, departmental library and the concerned student shall have one copy each.

SYLLABUS FOR EIGHTH SEMESTER

Subject: BCHT801T **Mathematical Methods and Computer Aided Design (Theory)**

Lecture	: 3 Hours	No. of Credits	: 3
University	: 80 Marks	College Assessment	: 20 Marks

Duration of Examination: 3 Hours

BTCHT 801T Mathematical Methods and Computer Aided Design (BTCHT)

Unit 1: Principles of modeling, mathematical formulation of the problem. Numerical methods of solution of nonlinear algebraic and transcendental equations applied to chemical process systems.

Unit 2: Methods of solution of simultaneous linear & nonlinear algebraic equations and curve fitting techniques in Chemical Technology.

Unit 3: Formulation and numerical solution of ordinary and/or partial differential equations with emphasis on chemical process systems and computer applications.

Unit 4: Strategies for computer aided balances, Steady state simulation, sequential modular approach, equation based approach, dynamic simulation, commercial CAD packages etc.

Unit 5: Computer aided application in simulation and/or design aspects of chemical process engineering systems/operations in mass transfer, fluid flow.

Unit 6: Computer aided application in simulation and/or design aspects of chemical process engineering systems/operations in reaction engineering, heat transfer.

Books recommended

1.Mathematical Methods in Chemical Engineering by V.G.Jenson, G.V. Jeffreys, Academic Press Inc, (London).
2.Applied Mathematics for Chemical Engineers by H.S.Mickley, T.S. Sherwood, C.E. Reed, McGraw Hill
3.Chemical Process Simulation byAsgharHussian, Wiley Easrern,New Delhi.
4.Numerical methods for engineers, S.C.Chapra,&R.P.Canale,Tata McGraw Hill, New Delhi.
5.Computer Aided Process Plant Design by M.E. Leesley, Editor, published by Gulf Publishing company, Houston, Texas.
6. Computer aided design of chemical process equipment, B.C.Bhattacharyya& C.M. Narayanan, New central book agency (P) Ltd. Calcutta.

Subject : BCHT802T **Project Management (Theory)**
Lecture : 3 Hours No. of Credits : 3
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

BTCHT 802T **Project Management**
(BTCHT)

Unit 1: Nature and purpose of process economics-requirement of project proposals & methods of economic analysis conceptual background for economic analysis such time value of money, description accounting, cash flow profitability. Principle of accounting analysis of financial statement- problem situations for economic decision making.

Unit 2: Developing economic data for economic analysis- estimating capital requirement or total investment for industrial projects- estimating product costs, costs, revenues,
Profits & earning for process plants, problem situation for estimation.

Unit 3: Evaluation and selection of industrial projects various modern methods of projects evaluation, economic selection of alternatives on the basis of annual costs, present worthy, rate of return and payout period etc. problem situation for selection of alternative profile, replacement problem.

Unit 4: Entrepreneurship decision about plant/company operation, plant layout, basic principle and function of management, management thought and scientific management,
Management movement, organization principle and patterns, step in building organization.

Unit 5: Material, management and control, production planning and control, manpower planning, employment and utilization, main function of person administration, financial planning and control. Inventory management.

Unit 6: Modern concept of marketing.Marketing, planning and implementation.Scales organization and sales management.Public relations.Industrial enterprises and environmental safety.

Books Recommended:
1) Handbook of Chemical Engineering J.H.Perry, Section25 on process economics, 1974
2) Fundamentals of cost engineering M.C.Bourman
3) Chemical economics Happel and Jourdon.
4) Applied project Management, Ludwig
5) Plant Design and economics for Chemical Engineers, Peter and mmerhouse

Subject: BCHT803T(BCHT)	**Special Technology- VII (Theory)**
Lecture: 3 Hours	No. of Credits: 4
Tutorial: 1 Hour	University: 80 Marks
Duration of Examination: 3 Hours	College Assessment: 20 Marks

BCHT803T/1 FOOD TECHNOLOGY VII
(BCHT) (BIOCHEMICAL ENGINEERING)

UNIT 1: Thermodynamics of biosystem. Mass & energy balance. Microbial growth Dynamics.kinetics of substrate utilisation, Biomass production & product formation in microbial cultures.

UNIT 2: Design, Preparation &sterilisation of fermentation media. Batch and continuous sterilisationSterilisation of air supply.

UNIT 3: Oxygen transfer & microbial respiration. Oxygen Transfer Coefficient, and it's determination. Oxygen transfer in gassed & agitated systems and non Newtonian fermentation broth.

UNIT 4: Classification, Design & Analysis of bioreactors. Scale up of bioreactor systems. Bioprocess simulation & control.

UNIT 5: Downstream processing &bioseparation.Modelling& design of effluent management.New trends in bioproject Engineering.

UNIT 6: Immoblilsation of cells &enzymes.Co-immobilisation of biocatalysts. Kinetics of immobilised enzymes/ Cell system. Industrial Application.

BOOKS RECOMMENDED:
Text Books:
1. Biochemical Engineering fundamentals by Bailey James E. &Ollis D.F., McGraw Hill Book Co., 1977.
2. Principles of Fermentation Technology by Whitaker

Reference Books:
1. Bioprocess Computations in Biotechnology edited by Ghose T.K., Published by Ellis Horwood Ltd. 1990.
2. Advances in biochemical Engineering vol 1 to 6 edited by Ghose T.K. &Fietcher A., Springer verlag Berlin, Heidelberg, Newyork, 1971.
3. Biochemical Engineering science vol1 & 2 edited by Blakebrough, Academic press London, 1968.
4. Immobilised enzymes, Antigens, antibodies & Peptides vol 1, 2, 3, & 4 edited by Weetal H.H., Marcel Dekkar Inc. Co., New York, 1975.

BCHT803T/2 **Oil Technology VII (Theory)**
(BCHT) **(Technology of Waxes, Drying oil, Castor oil and Misc, Uses)**

Unit 1: Natural Waxes:

Natural sources, their occurrence, composition, classification, extraction, refining and processing of waxes, general properties and uses of bees wax, shellac wax, carnauba wax, sugarcane wax, Montana wax, ceresin wax, paraffin wax, sperm-oil and spermaceti. Vegetal waxes, Animal waxes, specifications

Unit 2:Synthetic waxes:

Esters, Paraffin Wax, properties,specifications composition, properties, testing, evaluation and Industrial applications, Candle-making, Microcrystalline waxes - properties, specifications Industrial and Applications, compounded waxes.

Unit 3: Technology of Drying oils:

Chemistry, Thermal and chemical modification methods; Properties and uses, drying, semi drying oils, yellowing of oils : modified oils like heat treated oils, Malenized oils, Co-polymerized oils, dehydration, isomerised oils, segregated, reconstituted oils.

Unit 4: Castor oil Derivatives:

Processing, Formulation and Testing, DCO- Synthesis, Manufacturing and Purification of Sebacic acid and 2- octanol, use as Plasticizer. Polyester Lubricants based on Sebacic acid, Manufacturing and Applications. Hydrogenated castor oil, it’s uses, Castor oil based urethanes – synthesis and uses, Acetylated castor oil and Miscellaneous derivatives, Sulphated castor oil, Turkey red oil, Manufacturing, Derivatives, Applications.

Unit 5:Fat Based Products:

Industrial lubricants. Bio Lubricants,Lubricant additives, Plasticizers, biodiesel, Lubricating Greases, Manufacture, Properties, types, ingredients, additives, analysis.Fatty Alcohols and Amines.

Unit 6: Uses of Fats and Oils:

Leather, Textiles , linoleum, rubber, Factices, protective coatings , food , pharmaceutical, explosives, paper, cosmetics surfactants , water proofing and water repellant industries,

LIST OF REFERENCE BOOKS

1. Paint Technology Manuals. Oil and color chemists Association, Vol-I – Vol. VIII,Chapman and Hall – 1972.
2. Outline of paint technology, W.M. Morgans, Edward Arnold Publishers, London – 1990
3.Mills, M. R., "An Introduction to Drying 0il Technology,"Intersciene Publishers Inc., New York,
4. Introduction to paint chemistry – Principles of paint technology,Turner GPA, Chapman and Hall ,
5.Paint and surface coatings, theory and practice, LambourneR.EllisHorwood Ltd. Publisher – 1987.
6.American Oil Chemists' Soc. "Drying Oils," ShortCourse Lectures, American Oil Chemists' Soc. Chicago,Ill.USA.
7. Castor oil Derivatives, SBP Publications, New Delhi

BTCHT803T/3 Petroleum Refining and Petrochemical Technology- VII
(BCHT) (Petrochemical Process Design)

Unit 1: Oxidation of naphthalene to phthalic anhydride, parametric sensitivity, kinetics, thermodynamics, simple and complex models, and fluidized bed reactor vs fixed bed operations.

Unit 2: Parallel and consecutive reactions, Chlorination of paraffins and aromatics, Acetylene Manufacture, kinetic models, thermodynamics, manufacture of glycols and amines in CSTR and plug flow reactors, their comparison, effect of reactant ratio on product distribution in different reactors.

Unit 3: Oxo reaction, economic justification, kinetic models with different catalysts, control of straight chain to branched chain olefins, effect of olefin structure on reaction rate, engineering problems in reactor design, process design aspects with a flow scheme.

Unit 4: Reversible exothermic reactions, their important features, manufacture of ammonia, types of commercial reactors used for ammonia synthesis, kinetics and thermodynamics of ammonia formation, optimum temperature profiles achieved in industrial reactors.

Unit 5: Alternative energy sources, coal, biogas, biomass, alcohol. Synthetic fuels from coal by hydrogenation, solvation & coal oil processing.

Unit 6: Integrated coal-oil refinery, coal based hydrocarbons upgraded to suit as petroleum fuels; Incineration to produce energy.

The paper is to be taught with necessary mathematical treatment and numerical problems illustrating the physico chemical and chemical engineering principles, process equipment design etc, Pertaining to the topics in petrochemical industries.

Books Recommended:

1. Chemical Engineering Process Analysis, A.M.Mearns.
2. Chemistry of catalytic processes,B.C.Gates,J.R.Katzer and G.C.A.Schuit.
3. Chemical Reactor Design and Process Plants, vol I and II, H.F.Rase.
4. Equipment Design hand book for Refineries and Chemical Plants,F.L.Evans.
5. Applied Process Design for Chemical and Petrochemical Plants vol I, II and III, E.E.Ludwig.
6. Hand Book of Petroleum Refining Process, Robert. A.Meyers,2nded, Mc Graw Hill Book Co,1997.
7. Non Conventional Energy Sources, G. D. Rai.
8. Fuels, W. Francis & M. C. Peters.

BTCHT803T/4 **Pulp and Paper Technology-VII**
(BCHT) **(Paper & Board manufacture-II)**

Unit 1: Cylinder mold type paper making machine, Sheet forming mechanism, different types of vats, cylinder and Fourdrinier machines comparison, combination of cylinder and Fourdrinier machines, cylinder machine products, single cylinder wet board making machine, multicylinder paper board making machine

Unit 2: Vat stock entry, web formation, factors affecting the quality of web, drainage through cylinder mold, machine head box, cylinder vacuum, modern web forming devices

Unit 3: Process utilities in pulp and paper industry, steam, power, air, water, energy management, utilization and conservation, application of humidity saturation, paper machine drives

Unit 4: Comparison of a chemical recovery furnace with that of a standby furnace in pulp and paper mill, use of different fuels and their combustion techniques, flue gas utilization, black liquor gasification

Unit 5: Use and application of pumps, compressors, blowers ventilators, refrigerating units in pulp and paper industries. Stock chests, overall economical considerations of pulp and paper mills.

Unit 6: Process control and instrumentation in mills, maintenance, instruments specifications, on line measurement and control of parameters computer applications in pulp and paper industries, Total Quality Management

Books recommended:

1. Pulp and Paper Science & Technology Vol. I & II by C. E. Libby
2. Pulp & Paper Manufacture Vol. I, II, III by Mac Donald
3. Hand Book of Pulp and Paper Technology by K.W. Britt 2nd edition.

BTCHT 803T/5 **Plastics & Polymer Technology VII**
(BCHT)

Unit 1: Functions of packaging, advantages of plastic packaging, special requirements of polymeric materials and their selection for medical and food packaging specially for raw and processed foods, Meat, Fish, Poultry, Eggs, Milk and Dairy products, Fruits and vegetables, Cereal grains and Baked food products, Beverages, Snacks, Ready to eat food. Prevention of Food Adulteration Act (PFA)

Unit 2: Packaging legislations and regulations, distribution hazards, Economics of packaging, Specialty packages-Bottle, Strip, Skin, Blister, Shrink, Stand up pouch, Box, Tetra. Flexible packaging: Evaluation of seals in flexible packages, advantages of flexible packaging, flexible packaging products. Rigid packaging: Skin Packaging, Blister packaging, Thermoforming fill-seal.

Unit 3: Coating - definitions and general classifications, paints, varnishes and lacquers, mechanism of film formation, classification of oils, semi drying and non-drying oils, chemical properties of oils, introduction to pigments & dyes, organic and inorganic pigments, pigment volume concentration, critical pigment volume concentration, objectives of paints , basic formulations of various types of paints.

Unit 4: Additives - dispersing agent, emulsifier, anti settling agent, biocides, antifoams, corrosion inhibitors, U.V. and light stabilizers, antioxidants, driers - constitution, active & auxiliary, primary and secondary; surface & through driers, solvents - properties of solvents, solvent (cutting) power, rate of evaporation, water as coating solvent, various steps in paint manufacture, phenomenon of mixing, soaking, wetting, grinding, dispersion and stabilization.

Unit 5: Standard specifications and test methods, test on liquid paints, density, dispersion, viscosity, consistency, application of films, spreading capacity, wet opacity, dry hiding, spreading time, drying time, wet and dry film thickness, optical properties, color, gloss, haze & clarity, opacity, orange peel, transparency, hiding power, mechanical properties, electrical resistance properties, environmental resistance and ageing properties of coatings, analysis of paints and varnishes.

Unit 6: Adhesives: Theories of adhesion, wettability, pressure sensitive adhesives, hot melt adhesives, solvent & emulsion based adhesives, guidelines for good adhesion, advantages & disadvantages of using adhesive bonding over conventional joining techniques, basic principle of adhesives formulation, techniques for evaluation of adhesives, mechanical testing of adhesive bonding, chemistry and uses of adhesives, properties and testing of adhesives. (as per ASTM standards), tack, viscosity, cure time, etc.

Reference Books

1. Understanding Plastic Packaging Technology, Susan E.M. Seleke, Hanser publications – Munich, 1st Edition, 1997.
2. Plastics in Packaging, A.S. Althalye, Tata McGraw–Hill publishing Co. Ltd., New Delhi, 1st Edition, 1992.
3. Food Packaging Technology Hand Book, NIIR, Asia-Pacific publication, 1st Edition, 2012
4. Package Engineering, Honlon J F, McGraw Hill, 1st Edition, 1984
5. Plastics Packaging, Turtle Ivor, Pira International, 1st Edition, 1990.
6. Handbook of Packaging-Plastics, A.S. Altalye, multi-tech publishing co.Mumbai, 1st Edition, 2013
7. Organic Coating Technology, Volume I, by Henry Fleming Payne, John Wiley & Sons, 1954.
8. Surface Coatings, Volume I, by OCCA Australia (Prepd.), Chapman and Hall, 1983.
9. Outlines of Paint Technology, III Ed. By W. M. Morgans, Edward Arnold, 1969
10. Surface coatings: Science and Technology, by Swaraj Paul, John Wiley and Sons, 1985
11. Organic Coatings: Science and Technology, Volume I, by Z. W. Wicks, F. N. Jones and S. P. Pappas, Wiley-Interscience, 2007.
12. Basics of Paint Technology, Part I & II, by V. C. Malshe&MeenalSikchi, 2002.
13. Datta P.K. &Gray J.S. Surface Engineering Vol. I Fundamentals of coatings. Royal Society of London, 1993.
14. Datta P.K. &Gray J.S. Surface Engineering Vol. II Fundamentals of coatings. Royal Society of London, 1993.
15. Datta P.K. &Gray J.S. Surface Engineering Vol. III Fundamentals of coatings. Royal Society of London, 1993.
16. Skeist, Irving, Handbook of Adhesives, Van Nostrand, New York, 3rd edition, 1990.

BTCHT 803T/6 Surface Coating Technology – VII
(BCHT) (Technology of Powder Coatings & Industrial Paints)

Unit 1: Architecture finishes, formulation and methods for manufacture of paints for exterior and interior house design, paints for wood interior and exterior, formulation for plaster and wallboard coatings, exterior emulsion paints for masonry, interior and exterior enamels.

Unit 2: Industrial finishes, formulation and methods of manufacture for clear finishes for wood, furniture, metal goods, overprint finishes, automotive finishes, Lacquers for wood, metal and decorative finishes.

Unit 3: History of powder coatings, Comparison of powder coatings with solvent based coatings. Pretreatment equipment and power application equipments, Manufacture of powder coatings, Working of Buss Extruder.

Unit 4: Raw materials for powder coatings composition based on Epoxy, Polyester, Urathane and Acrylics, Flow agents and other additives for powder coatings, Selection of pigments and extenders for powder coatings, Causes and remedies for paint film defects.

Unit 5: Marine paints, formulation and methods of manufacture of coatings for ships, ship bottoms, seaside structures, hulls, Water thinnable coatings, Their importance and comparison with solvent based paints.

Unit 6: Speciality coatings, wrinkle finishes, hammer finishes, multicolour finishes, flock finishes, paper coatings, textile coatings, coatings for plastics, Traffic paints, formulation and method of manufacture of paints for traffic signs, bituminous coatings.

Books Recommended:

1. Payne, H.F., “Organic Coating Technology” Volume one, John Wiley & Sons, New York, 1954.
2. Payne, H.F., “Organic Coating Technology” Volume Two, John Wiley & Sons, New York, 1954.
3. Matellio, J.J., “Protective and Decorative Coatings” Volume Three, John Wiley & Sons.
4. Durrans, T.H., “Solvents” D. Van Nostrand Co., New York, 1950.
5. Oil, Colour Chemists; Association, “Paint Technology Mannuals”, Vol 2.
6. Oil, Colour Chemists; Association, “Paint Technology Mannuals”, Vol 3.
7. Oil, Colour Chemists; Association, “Paint Technology Mannuals”, Vol 4.
8. Lehr, W.D., “Powder Coating Systems”, McGraw Hill Inc., N. Y. 1991.

Subject: BCHT803T(BCHT) **Special Technology- VIII (Theory)**
Lecture: 3 Hours No. of Credits: 4
Tutorial: 1 Hour University: 80 Marks
Duration of Examination: 3 Hours College Assessment: 20 Marks

BCHT 803T/1 FOOD TECHNOLOGY VIII
(BCHT) (BIOTECHNOLOGY)

Unit1: Screening of microorganisms for biotechnological processes. Introduction to r-DNA technology, and its applications.G M foods.and biotech crops.

Unit 2: PRODUCTION OF BIOMASS: Production of bakers yeast, starter cultures, algae, mushrooms & single cell proteins from different substrates.

Unit3: PRODUCTION OF ORGANIC CHEMICALS: Production of industrial alcohol, acetic acid, citric acid, vinegar and Acetone Butanol by fermentation.

Unit 4: PRODUCTION OF SECONDARY METABOLITES: Production of antibiotics, enzymes, polysaccharides, flavours& fragrances, Introduction to tissue culture.

Unit 5: FERMENTED FOODS: Types of food fermentations.

PROCESS TECHNOLOGY OF ALCOHOLIC BEVERAGES: Types of alcoholic beverages. Raw material, fermentation & processing of alcoholic beverages. Modern brewing technology

ORIENTAL FERMENTED FOODS: Soya sauce, Tofu, Tempeh, Idli, dosa, etc.

Unit6: INDUSTRIAL WASTE MANAGEMENT: Waste utilisation& disposal in food industry. Aerobic treatment of wastewater.Biomethanation.Byproduct recovery and value addition to the food industry waste.

BOOKS RECOMMENDED:
1. Industrial Microbiolgy by Casida L.E., John Wiley & Sons Inc New york, 1964.
2. Industrial Microbiology by Presscot& Dunn, McGraw Hill Book Co. Inc. New york, 1940.
3.BiotechnologyB.D.SinghKalyani Publishers ,Ludhiana,1999

Reference
1. Industrial fermentation vol 1&2 by Underkoffler L.A., Chemical publishing Co. Inc. 212, Fifth Avenue, New york, 1954.
2. Microbial Technology vol 1 & 2 by Peppler.
3. Biotechnology : Food Fermentations Ed. VK Joshi , Ashok Pandey Educational Publishers and Distributors , New Delhi 1999

BCHT 803T/2 Oil Technology VIII (Theory)
(BCHT) (Technology of Paint, Resin and Inks)

Unit 1:Technology of Paints: Definition, ingredients, Formulation,manufacture,machinery. Principles of paint formulations and testing, varnishes and lacquers,primers, undercoats and finish coats. Manufacture, classification and types of powder coating.Sketches of the machinery used. Manufacture of different types of wall finishes.

Unit 2: Technology of Pigments and Extenders : Definition, classification ,Sources, properties, manufacture, testing and evaluation of pigments, preparation and uses of important pigments such as White,yellow,black, blue, green and red pigments, Metallic pigments, Natural organic pigments, comparison of organic pigments,Extenders:-Sources, manufacture, properties and uses,, recent developments.

Unit 3: Convertible and Non-convertible coatings: Natural Resins -Classification, composition, Rosin and shellac, properties, Processing and application in surface coatings.Oleoresins,Recovery of resin and turpen tine,

Unit 4: Convertible and Non-convertible coatings: Synthetic Resins - Chemistry and manufacture of Alkydresins , raw materials, chemistry, formulation and its application. amino resins, urea formaldehyde, epoxy resins, various epoxy modified resin and their application, water soluble epoxies, polyamide resin, amino resins, chlorinated rubber, vinyl resins with special reference to acrylics. Polyurethanes, classification, properties and application

Unit 5: Solvents and General Paint Properties: Hazards and precautions. Diluents, thinners, lacquers-Types, general properties, classification, evaluation of solvents, solubility parameters. Safety measures for coatings, ISI methods of testing of paints, specialty paints, paint film defects, recent developments. Industrial Formulation and Applications of paints

Unit 6: Technology of Printing Inks: Classification, raw materials, manufacture, machinery, formulations and evaluation.Plants and processes employed. Driers,types , functions, and mechanism.

LIST OF REFERENCE BOOKS

1. Protective and Decorative Coatings, Paint, Varnishes, Lacquers, and Inks, Mattiello, J. J., John Wiley and Sons, New York.
2. Organic Coating Technology Vol, 1 & 11 by, Payne, H.Y.
3. Paint Technology Manuals., Oil and color chemists Association, Vol-I – Vol. VIII, Chapman and Hall , London
4. Pigment Hand book Vol. 1 – Vol. VIII,. Patton, T. C., Wiley-Inter science Publications,New York.
5. The Testing of Paints, Vol – V, Paint Technology Manual,.Dunkley F.G. and Collier, C.W., Chapman and Hall.London
6. Paint film defects and their remedies, Manfred, H., Chapman and Hall Ltd. London.
7. Introduction to paint chemistry – Principles of paint technology, Turner G.P.A.,, Chapman and Hall , London
8. Outline of paint technology, Morgans, W.M. Edward Arnold Publishers, ,London
9. OCCA Surface Coating Technology Vol, 1 & 11
10. Printing inks: their chemistry and technology - Ellis, C. ,New York

BTCHT804T/3 Petroleum Refining and Petrochemical Technology- VIII
(BCHT) (Reactor Design & Catalysis)

Unit 1: Solid catalysts used in petroleum refining and petrochemical processes, methods of preparation, important properties and their evaluation, theories of heterogeneous catalysis, bifunctional and phase transfer catalysts. Role of adsorption in catalysis and its rates, development of kinetic models for rate processes.

Unit 2: Theories of deactivation, role of catalyst deactivation, the chemical nature of deactivation, deactivation of a pellet, effect on selectivity, time on stream theory, regeneration kinetics of catalyst deactivation. Performance of catalytic reactors under conditions of deactivation.

Unit 3: Heat and mass transfer effects in packed bed catalytic reactors; concept of effectiveness factor and its determination; effective thermal conductivity; role of diffusion and allied problems in catalysis.

Unit 4: Concept of fluidization, properties of fluidized bed, use of fluidized bed as a chemical reactor Design of fluidized bed reactor, basic considerations, bubble phase, emulsion phase, gas mixing in the phase, different models, heat and mass transfer effects, design of distributer and entrainment.

Unit 5: Fluidized bed reactor design for a deactivation catalyst (with complex reactions), bubble diameter and reactor internals, practical considerations and strategy for reactor design and development, variations in designs in fluidized bed reactors, multi stage, packed and fast fluidized bed reactors, transport reactors and moving bed reactors, circulating fluidized bed reactors.

Unit 6: Basic concepts and characteristics of slurry bed and trickle bed reactors, different flow regimes, Heat and mass transfer effects, catalyst ageing and fluid flow problems, applications to design of Hydrodesulphurization and Hydrocracking reactors used in Petroleum refining industry.

Books Recommended:

1. Heterogeneous Reactions, Analysis, Examples and Reactor Design, L. K. Doraiswamy and M. M. Sharma.
2. Catalysis and Chemical Processes, R. Pears and W. R. Patterson.
3. Chemical Reactor Design Practice, I.M.Rose.
4. Chemical and Catalytic Reaction Engineering, C.C.Carberry.
5. Catalyst Deactivation, Eugene E.Peterson and A.T.Bell.
6. Deactivation and Poisoning of catalysts, Jacques Oudar and Henry Wise.
7. Catalyst Poisoning, L. L. Hegedus and R.W.Mccabe.
8. Chemical Reactor Design and Process Plants, Vol I and II, H.F.Rase.

BTCHT804T/4 **Pulp and Paper Technology – VIII**
(BCHT) **(Surface treatment, finishing, Analysis, Testing, Pollution abatement)**

Unit 1: Surface treatment of paper, objective, process for surface sizing and treatment, surface sizing materials, coating, calendering, winding, reeling, wrapping and rewinding, supercalendering and embossing

Unit 2: Specialty papers, hand made papers, insulating board, hard board, recent developments in paper and board manufacture,

Unit 3: Analysis and testing, test requirements, equipments, analysis of pulp wood, wood pulp, paper and converted products,

Unit 4: Pollution abatement in Pulp and paper mills, sources of pollution, soli waste treatment and disposal

Unit 5: Water treatment in pulp and paper mills, water for process streams, boiler feed water, water from different parts of the mill, white water reclamation, physical, chemical and biochemical methods of treatment of waste water

Unit 6: Air pollution, sources, methods of treatment, control, pollution free pulping, Microbiology of wood, pulp, wet felts, water & stream pollution, slime, sulfite spent liquor, food packaging.

Books recommended:

1. Pulp and Paper Science & Technology Vol. I & II by C. E. Libby

2. Pulp & Paper Manufacture Vol. I, II, III by Mac Donald

3. Hand Book of Pulp and Paper Technology by K.W. Britt 2nd edition.

BTCHT 804T/5 **Plastics & Polymer Technology VIII**
(BCHT)

Unit 1: Polymer blends terminology, compatibility and miscibility, significances of blends over conventional polymers, difference between blends and composites, thermodynamics and characteristics of polymer blends, steps involved in designing of a blend, classification of polymer blends, compatibilizer, polymer alloys, methods of compatibilization.

Unit 2: Rheological properties of polymer blends, rheological criteria, interfacial criteria, synergy & additivity, effect of interaction parameters on properties, phase structure development in polymer blends UCST and LCST, study of factors affecting the morphology of polymer blends Introduction of IPN, Types of IPN, Methods of preparation of IPN & their Applications

Unit 3: Commercial polymer blends and their applications with case studies such as Polyolefin blends, Styrenic blends, Vinyl resin blends, Acrylic blends, Elastomeric blends, Polyamide blends, Polycarbonate blends, Polyoxymethylene blends, Polyphenyleneether (PPE) blends, Thermoplastic polyester blends, Specialty polymer blends and Thermoset blend systems.

Unit 4: Composites: Indroduction, classification, advantages & disadvantages of polymer composites, selection criteria for material, reinforcement and process. Reinforcement, glass fibre, carbon fibre, graphite fibre, aramid fibre, organic fibres, boron & silicon fibres, reinforcement/matrix interactions.

Unit 5: Manufacturing Processes: Sheet Moulding Compound (SMC), Dough Moulding Compound (DMC), Bulk Moulding Compound (BMC), Prepeg, Hand layup, Spray layup, Vacuum bagging, Filament winding, Pultrusion, Resin transfer moulding, Resin injection moulding, Sheet manufacturing, Centrifugal casting, Sandwich construction

Unit 6: Polymer Nano-Composites (PNC):Definitions, classification of nanoparticles, layered nanoparticles, (Clay), fibrillar nanoparticles (carbon nanotubes (CNTs) etc.) and other nanoparticles, polymer clay nano-composites (PCNC), preparation steps - intercalation, exfoliation**,** PNC based on CNTs for electrical conductivity, CNTs - thermoset matrix, CNTs -thermoplastic matrix, comparison of PNC with normal composites based on composition, mechanical, thermal, rheology, morphology & process parameters.

Reference books:

1. Polymer blends handbook, L. A. Utracki, Kluwer Academic Publishers, 2002.
2. Polymer Blends A Comprehensive Review; Lloyd M. Robeson; Hanser Publication, 2007.
3. Polymer Blends; D. R. Paul & Seymour Newman, Vo. 1 & 2, Academic Press, New York, 1978.
4. Advance in Polymer Blends & Alloys Technology by MalvynKohudic, Technomic® publication, 1988.
5. Plastics Materials J. A. Brydson, Butterworth Scintific, 1990.
6. Fibre Reinforced Composites, P. K. Malik, Marcel Deckar, 1988.
7. Analysis and Performance of Fiber Composites, 3rd edition, Bhagawan D. Agarwal, Lawrence J. Broutman, K. Chandrashekhara, John Wiley & Sons Inc, 2006
8. Polymer composites, Brainstrong, Sci-Tech Books.
9. Polymer Composites, Alan J. Lesser, Volume 36, 2015.

BTCHT 804T/6 **Surface Coating Technology – VIII**
(BCHT) **(Technology of Printing Inks and Other Coatings)**

Unit 1: History of printing industry, types of printing processes, introduction of printing press, lithographic process, offset and litho-offset processes, intaglio and gravuer processes, photogravure processes, single and multicolour printing processes.

Unit 2: Machinery for various printing proesses, Characteristics of inks required for various processes, types of substrate for printing, number of impressions, mode of drying, offset.

Unit 3: Manufacture of varnishes for printing inks, composition of raw materials, oils and resins used in formulation and their proportions. Additives for printing inks, driers, waxes, tack and non tack agents, solvents.Formulation of printing inks, selection of pigments and binders/vehicles, solvents, driers, resins, and additives for various process inks.

Unit 4: Formulation of letter press inks, offset press inks, lithograpghic inks, photogravure inks, screen printing inks, Flexographic inks, high gloss inks, specialty inks, inks for bank notes, Type writer and duplicating paper inks, textile inks.

Unit 5: Manufacture of Printing inks, Types of machinery used, sampling of inks for record and testing, Ink troubles and remedies, printing defects.

Unit 6: Testing of printing Inks. and Modern development in printing Inks.

Books Recommended:

1. Mertle, J.S., and Mosen, Gorden, “Photomechanics and printing”, Oxford and IEH Publishing House Calcutta 1969.
2. Woulfe H. J. “Printing and Lithographic Inks”, MacNair Dorland Co., N. Y.

Subject	**: BTCHT805P**	**Special Technology IV (Practical)**	
Practical	: 6 Hours	No. of Credits	: 4
University	: 50 Marks	College Assessment	: 50 Marks

Duration of Examination: 6 Hours

BTCHT805P/1 FOOD TECHNOLOGY PRACTICAL IV (FOOD ANALYSIS)

Analysis of wheat flour, tea, coffee, cocoa, milk, honey.Analysis of pectin, shortenings, food additives. Identification of dyes

Quality control of Bread, biscuits, cake, extruded products, protein concentrates. Fruit juices, squashes, jams, jellies, concentrates, pickles, canned fruit products. Milk products like cheeses, paneer, shreekhand. Milk powder, Confectionary products, Alcholic beverages & soft drinks.

BOOKS RECOMMENDED:

1. The analysis of foods & food products by Jacob M.R., D. Van Nostrand Co. Inc. Princeton, New jersey, New york, 1958.
2. The Chemical analysis of foods by Pearson D., J.E.A. Churchill, 104, Goucester place, London, Sixth edition, 1970.
3. Manual of analysis of fruits & vegetable products by Ranganna S., Tata McGraw Hill publishing Co. New Delhi.
4. Official Methods of Analysis of the association of Official Analytical chemists, Pub. Assoc. Office, Anal chemists, Washington D.C. 11th Edition, 1970.

BTCHT805P/2 OIL TECHNOLOGY-IV (Analysis)

1. Analysis of soaps
2. Analysis of acid oils and soap stocks
3. Analysis of metallic soaps
4. Analysis of spent bleaching earths
5. Analysis of Glycerin (sweet water)
6. Analysis of detergent powders
7. Analysis of essential oils
8. Analysis of waxes
9. Analysis of paints
10. Analysis of cosmetic products
11. Analysis of lubricating greases

BTCHT805P/3 Petroleum Refining and Petrochemical Technology – IV (Chemical Reaction Kinetics)

1. Study of thermal cracking of a petroleum fraction in a tubular flow reactor.
    1.1 Calibration of Thermocouple.
    1.2 Determination of temperature profile of tubular flow reactor.
    1.3 Calibration of a flow meter.
    1.4 Feed and product characterization.
2. To study Residence Time Distribution (RTD):
    2.1 RTD in a continuous flow stirred tank reactor
    2.2 RTD in a tubular flow reactor
3. To study Kinetics of hydrolysis:
    3.1 Methyl and ethyl acetate system in a batch reactor.
    3.2 Methyl and ethyl acetate system in a Tubular Flow Reactor (TFR).
    3.3 Energy of activation of a hydrolysis reaction
4. To study Saponification Reaction:
    4.1 In a batch reaction
    4.2 In a Continuous Stirred Tank Reactor.
    4.3 In a Tubular Flow Reactor.
5. Sulphonation of Alkyl Benzene to get acid slurry and neautralisation of acid slurry to get detergent type mixture.
6. To study Chlorination reaction:
    6.1 Chlorination of benzene by photochemical reaction to observe yield versus time for definite intensity of UV light.
    6.2 Liquid phase chlorination of petroleum oil to analyze chlorine content with the extent of reaction.
7. To study coking reaction for the comparison of yield of coke & other products.
    7.1 With additive such as Iron Oxide.
    7.2 Without any additive

BTCHT805P/4 Pulp and Paper Technology – IV (Processing)

1. Collection, grading sorting, and storage of various raw materials.
2. Proximate analysis of raw materials.
3. Pulping of different fibrous materials.
4. Washing, cleaning and bleaching of pulp.
5. Stock preparation.
6. Standard sheet making and analysis.
7. Physical, optical and chemical testing of various paper and board samples.
8. Determination of BOD, COD, SS in effluents from pulp and paper mills.
9. Analysis of cooking and spent liquors usedin pulp and paper industries

Books recommended:

1. TAPPI Standards USA
2. Pulp and Paper Science & Technology Volume I & II by C.E.Libby

3. Pulp & Paper Manufacture Volume I, II, III by Mac Donald
4. Hand Book of Pulp and Paper Technology by K.W. Britt 2nd edition

BTCHT 805P/5 Special Technology IV (Practical)
(Plastics& Polymer Technology IV)

1. Preparation of Polystyrene (PS) by suspension Polymerization.
2. Preparation of Poly butyl acrylate Emulsion.
3. Preparation of copolymer of Butyl acrylate and Methyl Methacrylate by emulsion polymerization technique.
4. Preparation of Butyl acrylate, Methyl methacrylate, Ethyl acrylate and Acrylic Acid copolymer by emulsion polymerization for coating application.
5. To prepare a high glossy architectural acrylic paint.
6. To compare the preparation of polystyrene by bulk and solution polymerisation.
7. To prepare the Polyester resin terminated with – OH group.
8. To prepare the Polyester resin terminated with – COOH group.
9. Synthesis of Epoxy resin.
10. Analysis of Epoxy resin.
11. Preparation of Polyurethane resin.

BTCHT 805P/6 SURFACE COATING TECHNOLOGY – IV

Analysis of paint and allied products

1. Analysis of resins for Acid value, Hydroxy value % solids, Viscosity, Drying, Adhesion, Hardness and resistance characteristics. Molecular weight distribution of resins.
2. Analysis of Red oxide zinc chrome primer as per the IS specification.
3. Analysis of Zinc chrome primer as per the IS specification.
4. Analysis of Aluminum paint as per the IS specification.
5. Analysis of Etch primer as per the IS specification.
6. Analysis of Synthetic enamels as per the IS specification.
7. Analysis of General purpose air-drying paint as per the specification.
8. Analysis of Emulsion paint as per the IS specification.
9. Analysis of Zinc silicate primer as per the IS specification.
10. Analysis of Powder coatings as per the IS specification.
11. Analysis of Printing Ink as per the IS specification

12. Sophisticated analysis of synthetic enamels, Industrial paints and powder coatings corrosion resistance, gloss retention, salt spray test. Crosscut adhesion test and use of modern equipment in paint analysis.

Subject	**: BTCHT806P**	**Project**	
Practical	: 6 Hours	No. of Credits	: 4
University	: 100 Marks	College Assessment	: 100 Marks
Duration of Examination: 6 Hours			

BTCHT806PProject Work/Dissertation
(BCHT)

The project work shall consist of dissertation/ experimentation, fabrication, testing of equipment; process designing in depth; review of certain research work; compilation and analysis of certain engineering/ management activities, phenomenon, designing, drawing and prototype modelling of certain equipment, instrument and testing thereof, etc. on any topic which may have importance in respective technology.

The report shall be a bound journal written in technical format with illustrations by graphs, charts, photographs, etc. about the specific work undertaken by the student. Maximum two students may work on the same project.

The number of copies of the report shall be such that the examiner, the departmental library and the concerned students shall have one copy each.

NEW SYLLABUS IMPLEMENTED FOR B.TECH CHEMICAL ENGINEERING & TECHNOLOGY

STARTING FROM ACADEMIC YEAR 2020-2021

Science and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Engineering
(First Semester)

Maths –I: CE-BS-101T **Total Credits: 02**
Teaching Scheme: Lectures: 2Hours/ Week
Examination Scheme: T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

UNIT -I : Linear Algebra-I

Matrices, Vectors,Vector Space, Rank of a Matrix, Linear Independence, Inverse of a Matrix, Linear Systems of Equations: Existence, Uniqueness,
Solutions of Linear Systems: Gauss Elimination, Cramer's Rule, Gauss-Jordan Elimination.

UNIT -II : Linear Algebra-II

Linear Algebra: Eigenvalues, Eigen vectors of Matrix, Symmetric, Skew-Symmetric, and Orthogonal Matrices, Cayley Hamilton Theorem, Sylvester Theorem, Diagonalisation.

UNIT -III: Integral Calculus

Beta, Gamma functions, Double integration : Cartesian and polar co-ordinates, Change of order of integration, Change of variables between Cartesian and polar co-ordinates, Area as a double integral, Triple integration, Volume as a triple integral.

UNIT -IV: Vector Calculus

Vectors in 2-Space and 3-Space, Inner Product (Dot Product), Vector Product (Cross Product) Vector and Scalar Functions and Fields, Derivatives Curves. Arc Length. Curvature, Gradient of a Scalar Field, Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field.
Integral Calculus. Integral Theorems, Line Integrals, Path Independence of Line Integrals, Green's Theorem in the Plane, Surfaces for Surface Integrals

Reference Books:

1. Higher Engineering Mathematics by H. K. Das, Er. Rajnish Verma
2. A text book of Engineering Mathematics by N. P. Bali, Manish Goyal
3. A text book of Engineering Mathematics (Vol- I & II) by Dr. D. T. Deshmukh
4. Higher Engineering Mathematics by B. S. Grewal

Physics CE-BS-102 T **Total Credits: 02**
Teaching Scheme: Lectures: 2Hours/ Week
Examination Scheme: T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Quantum Mechanics: Planck's Hypothesis, Properties of Photons, Compton Effect, Wave – particle duality, De-Broglie Hypothesis, Matter Waves, Davisson-Germer Experiment; Bohr's Quantization condition.
Wave Packet & Wave Equations. Heisenberg's uncertainty principle, Wave function and its probability interpretation, Schrödinger's Time dependent & time independent equations, (No derivations). Solution of Schrödinger's equation for one dimensional infinite potential well.

Unit 2: Basic Semiconductor: Qualitative idea on the formation of electron energy bands in solids, Band-theory based classification of solids into insulators, semiconductors and conductors, Intrinsic semiconductors: Germanium and silicon, Doping and Extrinsic semiconductors.
PN- junction diode; Unbiased, Forward biased & Reverse biased mode, Zener diode: Forward and reverse bias characteristics, Avalanche breakdown, Applications: Half wave rectifier & Full wave rectifier, Transistors: PNP and NPN. Configuration: - CB, CE, Bipolar Transistor action, V-I characteristics of i) Photodiode, ii) LED.

Unit 3: Lasers: Three quantum processes: Absorption, Spontaneous emission and Stimulated emission. Metastable state, Conditions for light amplification, Pumping schemes: Three level pumping scheme, Four level pumping scheme. Optical resonator, Laser beam characteristics, Ruby laser and He-Ne laser. Numericals.

Unit 4: Optical fibres: Structure, Propagation of light through a cladded fibre, Acceptance angle, acceptance cone, Fractional refractive index change, Numerical aperture, Modes of propagation; Types of Optical fibres: Single mode step index fibre, Multimode step index fibre, Graded Index fibre, V-number. Transmission Losses, Applications: Sensor, Numericals.

Books recommended:
Text Books:
Fundamentals of Physics: David Halliday, Robert Resnick and Jerle Walker, John-Wiley India(8e, extended)
A text book of Engineering Physics: M. N. Avadhanulu and Kshirsagar S. Chand & Co.
Electronic Engineering Materials and Devices: John Allision, (TMH edition, 10th reprint)
Concepts of Modern Physics: Baiser (Tata McGraw Hill).
Laser: M. N. Avadhanulu, S. Chand & Co.

Reference Books:
University Physics:Young and Freedman(Pearson Education)
Solid State Physics: C. Kittel
Solid State Physics: R.L. Singhal
Quantum Mechanics: Schiff
LASERS: Theory and Applications: Thyagarajan K and Ghatak A.K.

Chemistry-I : CE-BS-103 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week
Examination Scheme: Theory T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit I Co-ordination Chemistry and Chemical bonding: Introduction to co-ordination chemistry, explanation of terms like complex, ligands, co-ordination number, co-ordination sphere. Classification of ligands, chelates & its classification. Werner's coordination theory & its application to Co (III) and Pt (IV) ammine complexes.
Valence Bond Theory and its application to 6-coordinated complexes, Crystal Field theory and Crystal field splitting in Octahedral and tetrahedral complexes, MO theory, Structure, bonding and energy levels of bonding and shapes of many atom molecules like H2, N2, and CO.

(12)

Unit II Water: Sources, types of impurities and their effects, hardness of water & its estimation, Numerical on EDTA method, treatment of water for domestic & industrial purposes, sedimentation, coagulation, filtration, types of filters, Sterilization- chlorination, break point chlorination, Ozonization. Removal of hardness of water: Lime- soda process, Numerical on lime-soda process, Zeolite process, its advantages and disadvantages, comparison with L-S Process, Numerical based on zeolite process, Ion- exchange process, demineralization process. Boiler troubles: -Carry over- priming & foaming-causes & prevention, sludge & scales, causes of scale formation and prevention methods, Corrosion & caustic embrittlement causes & prevention. **(12)**

Unit III Cement: Raw materials, constitutional compounds& its properties, Process parameters, Manufacture of Portland cement by wet and dry process, setting and hardening of cement, Cement additives & admixtures.
Refractories: Definition, requisites of good refractory material, properties of refractory, raw materials, manufacture of refractory products, application in industries. **(10)**

Unit IV Chromatography: Introduction, Classification, General and fundamental concepts of TLC, Column, HPLC, GC, Ion Exchange and their applications. **(06)**

Books Recommended:

1. A Text Book of Engineering Chemistry, by S.S.Dara, S.Chand & Co., New Delhi.
2. A Text Book of Engineering Chemistry, by Jain & Jain, Dhanpat Rai Publishing Co., New Delhi.
3. Industrial Chemistry by B.K.Sharma Goel Pub. House, Meerut.
4. Advanced Inorganic Chemistry, Vol.II, by Satya Prakash, G.D.Tuli, S.K.Basu & R.D.Madan.
5. Text of Engineering Chemistry by Dr. Sunita Rattan, S. K. Kataria and Sons, New Delhi.
6. Analytical Chromatography by Dr. G. R. Chatwal, Himalaya Publication House.
7. Instrumental Methods Of Chemical Analysis By G. R. Chatwal, S. K. Anand, Himalaya Publication House.

Fundamentals of Reaction Mechanism: CE-BS-104 T **Total Credits: 02**
Teaching Scheme: Lectures: 02 Hours/Week
Examination Scheme: Theory T (U): 35 Marks T (I): 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Reactivity of organic molecules: factors influencing acidity, basicity and nucleophilicity of molecules with few examples. Introduction to Stereochemistry: Stereo-descriptors – R, S, E, Z. Enantiomers and Diastereomers. (**6L**)

Unit 2: Strategies for synthesis of organic compounds: Reactive intermediates, Mechanism of Addition, substitution, elimination, condensation, role of solvents. Technical preparation of bio-ethanol using molasses, enzymatic catalysis, commercial significance (**8L**)

Unit 3: **Mechanism and recent advancement (Green chemistry and catalysis etc.):** Basic principles of green chemistry, industrial significance, green catalysts. Technical preparation supported green route, Preparation of adipic acid, Acetanalide with mechanism, photo-halogenation of benzene etc (**6L**)

Unit 4: Nitration: Vant Hoffs factor for suitability of agents, Catalytic effect of sulfuric acid in industrial nitration, Mechanism of aromatic nitration process using Inductive and Mesomeric effect, examples, Equipments for nitration and safety aspects. Technical preparation of nitroglycerine (**6L**)

Books Recommended:

1. Engineering Chemistry – By Baskar, Wiley

2. Engineering Chemistry –I By D. GrourKrishana, Vikas Publishing
3. Green Chemistry: Theory and Practice by Paul T. Anastas, J.C. Warner; Oxford University Press
4. Unit Processes in Organic Synthesis- by P. H. Groggins
5. Reaction and Reagents- By O.P. Agarawal
6. Monograph on green chemistry, Green chemistry Task Force Committee, DST

Engineering and Solid Mechanics: CE-GES-105 T **Total Credits: 03**
Teaching Scheme: Lectures: 03Hours/Week
Examination Scheme: Theory T (U): 70 Marks T (I): 30 Marks
Duration of University Exam. : 03 Hours

Unit I: **Force:** Definition, Characteristics of a force, System of forces, Resolution and composition of forces. **Resultant force:** Definition, Analytical and graphical methods for resultant force in two dimensions, Moments and Couples, Varignon's theorem of moments. **Equilibrium of rigid bodies**: Principles of equilibrium, types of equilibrium, conditions of equilibrium, free body diagrams, Analytical and graphical methods for equilibrium of rigid bodies in two dimensions.

(7 Lectures)

Unit II: **Support reactions**: Types of supports and loading in beams, determination of support reactions in cantilever, simply supported and overhang beams. **Trusses and Frames**: Types of frames, Analysis of simple plane trusses in equilibrium by the method of joints and method of sections. **Friction**: Frictional forces, types, limiting friction, coefficient of friction, angle of friction, laws of friction, Equilibrium of bodies lying on rough horizontal and inclined planes, wedge friction. (8 Lectures)

Unit III: **Centroid and Moment of Inertia:** Centroid of plane standard geometric figures and composite figures, Moment of inertia (second moment of area) of plane standard geometric figures and composite figures, parallel and perpendicular axis theorems, Radius of gyration. **Simple lifting machines**: Types of machines, efficiency of a machine, ideal machine, friction in machines, law of machine, Maximum M.A. and Maximum efficiency of a machine, reversible and non reversible machines, Differential wheel & axle, single and double purchase winch crabs. (8 Lectures)

Unit IV: **Simple stresses and strains** : Types of stresses and strains, modulus of elasticity, modulus of rigidity, bulk modulus, relation between elastic constants, stress-strain diagram for mild steel, lateral strain, Poisson's ratio, volumetric strain, triaxial loading in rectangular sections, stresses in bars of varying and composite sections, Temperature stresses and strains. (7 Lectures)

Unit V: **Stresses in beams**: Theory of simple bending, simple bending equation, bending stress, moment of resistance, assumptions in theory of simple bending, section modulus. **Shear force and bending moment**: Basic concepts, Shear force and bending moment diagrams for cantilever, simply supported and overhang beams for different loading conditions. **Slope and defection of beams**: Basic concepts, slope and deflection of cantilever and simply supported beams under standard loading conditions, Macaulay's method, simple problems. (8 Lectures)

Unit VI: **Torsion**: Theory of pure torsion, torsional moment of resistance, torsion equation, assumptions in the theory of pure torsion, polar modulus, power transmitted by solid and hollow circular shafts. **Columns and struts**: Axially loaded compression members, Euler's and Rankine's formula for buckling of columns, end conditions of column, buckling load, effective length of columns, slenderness ratio. (7 Lectures)

Suggested Text Books:

1. R. S. Khurmi, A Textbook of Engineering Mechanics, S. Chand & Co., New Delhi.
2. S. N. Saluja, A Textbook of Engineering Applied Mechanics, Satya Prakashan.
3. R. S. Khurmi and N. Khurmi, Strength of Materials, S. Chand & Co., New Delhi.
4. B. C. Punmia, Mechanics of Materials, Laxmi Publications (P) Ltd.

Suggested Reference Books:

1. F. L. Singer, Engineering Mechanics, Harper & Row Publishers.
2. S. Timoshenko and D. H. Young, Engineering Mechanics, McGraw Hill Publications.
3. Andrew Pytel and F. L. Singer, Strength of Materials, Harper & Row Publishers.

HASS I Communication Skills CE-HSMC-HS-106 T **Total Credits: Audit**
Teaching Scheme: Lectures: 2Hour/ Week
Examination Scheme: Theory T (I) : 50 Marks

Unit I: Communication Skills: Introduction to Communication, Types of Communication, Barriers to communication and overcoming them **(03)**

Unit II Listening and Reading Skills: Importance of Listening, Types of listening, Listening barriers and overcoming them, Importance of reading, Sources of Reading, Skimming, Scanning and Gist Reading, Comprehending Passage, Use of Figurative Language
(03)

Unit III: Speaking Skills: Effective Speaking Skills, Components of Public Speaking, Effective Presentation Strategies, Vocabulary Acquisition **(03)**

Unit IV: Group Discussion and Interview Techniques: Importance of Group Discussion, Techniques of Group Discussion, Types of Interviews, Interview Process, Interview Techniques
(03)

Books Recommended:

1. Technical Communication by Meenakshi Raman and Sangeeta Sharma, OUP
2. Public Speaking and Influencing Men in Business by Dale Carnegie
3. Professional Communication Skills by Bhatia and Sheikh
4. Communication Skills by Dr. P. Prasad
5. Communication Skills by Sanjeev Kumar and Pushpalata, OUP

Physics Laboratory CE -BS-107 P **Total Credits: 01**
Teaching Scheme **Examination Scheme**
Lectures: 2 Hours/ Week **P (U) : 25 Marks P (I) : 25 Marks**
Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

1. To study the characteristics of a PN-junction diode in forward and reverse bias & determine its cut in voltage, static & dynamic resistance.
2. To study the characteristics of a Zener diode in forward and reverse bias & determine its

breakdown voltage.
3. To determine the Energy gap Eg of semiconductor using PN junction diode in reverse bias mode.
4. To study the V-I characteristics of a Light Emitting Diode
5. To study the V-I characteristics of a Photo Diode
6. To study PN junction diode as Half wave and Full wave rectifier and calculate ripple factor and efficiency in each case
7. To study the input and output characteristics of a transistor in Common base mode & calculate input resistance and current gain α.
8. To study the input and output characteristics of a transistor in Common emitter mode & calculate input resistance and current gain β.
9. Study of Optical Fibre kit.
10. Demonstrations of Lasers.

Chemistry-I Laboratory: CE -BS-108 P **Total Credits: 01**
Teaching Scheme: Practical: 2 Hours / Week
Examination Scheme: Practical P (U): 25 Marks, P (I): 25 Marks
Duration of University Exam: 03 Hours

LIST OF EXPERIMENTS
1. Estimation of Total Hardness by Complexometric Method in a given Sample of water.
2. Estimation of Calcium and Magnesium hardness in a given sample of water.
3. Estimation of Nickel by Complexometric Method in a given Sample of water.
4. Estimation of total alkalinity in the given water sample.
5. Estimation of percentage of Copper in the given solution of copper sulphate by Iodometry Method.
6. Estimation of Strength of Potassium Dichromate using Sodium Thiosulphate by Iodometry Method .
7. Determination of strength of Ferrous Ammonium Sulphate using Potassium Dichromate and SDS as an internal indicator.
8. Estimation of strength of NaOH using oxalic acid.
9. Estimation of strength of HCl using Borax.
10. To determine the number of components in a mixture using TLC.

Fundamentals of Reaction Mechanism Laboratory CE -BS-109 P **Total Credits: 01**
Teaching Scheme **Examination Scheme**
Lectures: 2 Hours/ Week **P (U) : 25 Marks P (I) : 25 Marks**
Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

1. Identification of unknown organic compounds using preliminary investigations such as Phase, Color, odour, solubility in various solvents.

2. Identification of unknown organic compounds on the basis of aromatic and aliphatic as well as saturated and unsaturated nature.

3. To detect the elements (N, S and Cl) present in given unknown organic compounds using sodium extract.

4. Identification of unknown organic compound using Functional group detection and confirmatory tests (Phenols and Napthols)

5. Identification of unknown organic compound using Functional group detection and confirmatory tests (Carbohydrates; aldehydes and ketones)

6. Identification of unknown organic compound using Functional group detection and confirmatory tests (mono carboxylic acids)

7. Identification of unknown organic compound using Functional group detection and confirmatory tests (di- carboxylic acids)

8. Identification of unknown organic compound using Functional group detection and confirmatory tests (Amides)

9. Identification of unknown organic compound using Functional group detection and confirmatory tests (Nitro)

10**.** Detection of Melting points of few organic compounds using melting point apparatus.

List of Books

1. A Laboratory hand bbok of Organic Qualitative analysis and separations By V. S. Kulkarni and S.P. Pathak
2. Vogels textbook of Practical Organic Chemistry

Engineering and Solid Mechanics Laboratory: CE-GES-110P Total Credits: 1.5
Teaching Scheme: Practical: 3Hours/ Week
Examination Scheme: Practical P (U): 25 Marks, P (I): 25 Marks
Duration of University Exam.: 03 Hours

List of Practicals:

Suitable number of experiments from the below list will be performed.

1. Study of forces in the members of Jib crane.
2. Reactions of a beam.
3. Law of Moments.
4. Verification of Polygon law of forces.
5. Inclined friction plane.
6. Forces in single roof truss element.
7. Graphical method of analysis of forces.
8. Differential wheel & axle.
9. Single purchase winch crab.
10. Double purchase winch crab.
11. Study of Universal testing machine.
12. Deflection in beams.

Communication Skills CE-HSMC-HS-111 P Total Credits: 01
Teaching Scheme Practical : 2Hours/ Week
Examination Scheme: P (U): 25marks, P (I): 25 Marks
Duration of University Examination. : 03 Hours

1. Barriers to Communication
2. Non-Verbal Communication
3. Listening Skills
4. Reading Skills
5. Use of Figurative Language
6. Speaking Skills
7. Presentation Skills

8. Development of Word Power
9. Group Discussion
10. Interview Techniques

Science and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Engineering
(Second Semester)

Maths –II: CE-BS-201 T **Total Credits: 03**
Teaching Scheme: Lectures: 3Hours/ Week
Examination Scheme: T (U) : 70 Marks T (I) : 30 Marks
Duration of University Exam. : 03 Hours

Unit I : Ordinary differential Equation and Higher Order Differential Equation : Differential Equations: First order first degree differential equations: Linear, reducible to linear and exact differential equations. Higher order differential equations with constant coefficient, method of variation of parameters. Cauchy's and Legendre's homogeneous differential equations, simultaneous differential equations.

Unit II : Partial Differential Equations: First order Lagrange's Linear Partial Differential Equation, Solution of higher order linear homogeneous Partial Differential Equations and linear non-homogeneous Partial Differential Equations.

Unit III : Application of Partial Differential Equations : Method of separation of variables for Partial Differential Equations, Applications of Partial Differential Equations: (i) One dimensional wave equation, (ii) One dimensional heat conduction equation in Cartesian co-ordinates and polar co-ordinates and (iii) Two dimensional steady state heat conduction equation

Unit IV : Function of Complex Variables : Basic Concepts of Complex numbers, De-Moivre's Theorem, Calculus of Functions of Complex variables : Analytic functions, Cauchy –Riemann conditions in Cartesian co-ordinates and polar co-ordinates, methods for finding conjugate functions,

Unit V: Statistics and Probability : Fitting of straight line y=a+bx, parabola and Exponential curves by method of least squares, Lines of regression and Correlation, Rank correlation.
Random variables: Discrete and Continuous random variables, Probability distribution: Binomial, Poisson, Normal Distribution.

Unit VI : Fourier Series : Fourier series, expansion of function, Even and odd function, Half range fourier series, Change of interval, Harmonic analysis.

References

1. Higher Engineering Mathematics by H. K. Das, Er. Rajnish Verma
2. A text book of Engineering Mathematics by N. P. Bali, Manish Goyal
3. Applied Engineering Mathematics (Vol- I & II) by J. N. Wartikar
4. Higher Engineering Mathematics by B. S. Grewal
5. Text book of Engineering Mathematics by Bali, Iyenger (Laxmi Prakashan)

Properties of Matter CE-BS 202 T **Total Credits: 02**
Teaching Scheme Lectures: 2 Hours/ Week Theory
Examination Scheme T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: VISCOSITY: Streamline flow, Turbulent motion, critical velocity, Viscosity, Coefficient of viscosity, Poiseulle's equation, Stokes's method, Ostwald viscometer, Numericals

Unit 2: SURFACE TENSION: Surface tension, Excess pressure inside a liquid drop and soap bubble, Angle of contact, Searl's Torsion Balance method, Quincke's method, Interfacial surface Tension, Numericals.

Unit 3: Crystal structure and X-rays : Meaning of lattice and basis, Unit cell: primitive and non primitive unit cell; Cubic crystal structure: Body and Face centered cubic structures, SC, BCC and FCC unit cells. Unit cell characteristics: Effective number of atoms per unit cell, atomic radius, nearest neighbour distance, coordination number, atomic packing fraction, void space, density; Crystal planes and Miller indices, Inter-planar distance between adjacent planes, Tetrahedral and octahedral voids, Numericals.
Production of X-Rays: Coolidge tube, Origin of X-rays, Properties of X-rays, Applications of X-Rays, Bragg's law and Bragg's X-ray spectrometer. Numericals.

Unit 4: Interference in thin film: Plane Parallel thin film, wedge shaped thin film, Newtons rings, Applications: Determination of wavelengrh and Refractive index of liquid, test of surface finish. Antireflection coating, Numericals

TEXT BOOKS

1. Brijlal and Subramaniam N., Properties of Matter , Revised Edition, S.Chand and Company,2005.
2. Murugesan R., Properties of Matter and Acoustics, Revised Edition, S.Chand and Company, 2005.
3.Thiruvadigal, J. D, Ponnusamy,S..Sudha.D and Krishnamohan M, "Physics for Technologists", Vibrant Publication, Chennai, 2013.
4. Dattu Joshi. R. "Engineering Physics",Tata McGraw- Hill,New Delhi.
5. Mathur D. S, Elements of Properties of Matter, 3rd Edition, S. Chand and Company.
6. Satyaprakash and Akash Saluja, Oscillations and Waves, Pragati Prakashan, 2002

REFERENCES

1. Landau L. D., Pitaevskii L P, Kosevich A M and Lifshitz E M, "Theory of Elasticity", Revised Edition, Butterworth-Heinemann, 2014
2. Landau L. D., Pitaevskii L P, Kosevich A M and Lifshitz E M, "Fluid Mechanics", Revised Edition, Butterworth-Heinemann, 2014.
3. "Laboratory Experiments in College Physics", C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.

Chemistry-II: CE-BS-203 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week
Examination Scheme: Theory T (U) : 35Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: A] Gaseous state: Gas laws, kinetic theory of gas, collision and gas pressure, derivation of gas laws from kinetic theory, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature. Maxwell's distribution of speeds. Kinetic energy distribution, calculations of average, root mean square and most probable velocities. Principle of equipartition of energy and its application.

B] Collision of gas molecules, Real gases: Collision diameter, collision number and mean free path; frequency of binary collisions; Deviation of gases from ideal behaviour; compressibility factor; Andrew's plots; van der Waals equation and its characteristic features. Existence of critical state. Critical constants in terms of van der Waals constants. Law of corresponding state, compressibility factor, and Joule-Thomson effect, Numericals. **[8L]**

Unit 2: Quantum mechanics: De Broglie equation, experimental verification, Compton effect, Heisenberg's uncertainty principle, Introduction of quantum mechanics, Postulates of quantum mechanics, Derivation of Schrodinger wave equation from postulates of quantum mechanics. wave function, normalized and orthogonal wave function, operators, properties of operators, eigen function and eigen values, (problems on operators, eigen values), numericals.

B] Application of Schrodinger wave equation to simple systems: Particle in a one dimensional box: derivation of energy and normalization and orthogonality of wave function. Graphical representation of Ψ and its square Ψ2. Schrodinger wave equation for 3-dimensional box(without derivation, in terms of r, and Φ), degeneracy, Numericals**.** **[8L]**

Unit 3: A] Rate expressions, order and molecularity of reaction, Integrated rate expression with examples, Factors influencing the reaction rates, Arrhenius equation, Energy of Activation, Half life, Methods for determining the order of chemical reaction, Numericals.
B] Steady state approximation, kinetics of consecutive (chain) reactions, parallel reactions, opposing reactions with examples, Mechanism of chain reactions with examples, general catalytic mechanisms, acid-base catalysis, catalysis by enzymes, Michaelis-Menten Equation, Photochemical reactions of hydrogen and bromine, hydrogen and chlorine and decomposition of HI. **[8L]**

Unit 4: A**] Chemical equilibrium:** Chemical equilibria of homogeneous systems, derivation of expression of equilibrium constants, Relation between Kp, Kc and Kx, Le Chatelier's principle of dynamic equilibrium. Effect of change of concentration, pressure, temperature and catalyst on equilibrium constant, Numericals.
B] Thermodynamics of Equilibrium: Introduction, partial molar properties, Chemical Potential, Gibbs-Duhem equation; fugacity of gases Van't Hoff Reaction isotherm – isochore & isobar, Numericals **[6L]**

Reference Books-

1. F. Daniel,Mathematical preparation for physical Chemistry, Mc. Graw Hill publication.
2. Maron and Pruton, Principles of Physical Chemistry, 4th Ed. Oxford and IBH publication.
3. I.N. Levine, Quantum Chemistry, 5th edition (2000), Pearson Educ., Inc. New Delhi
4. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8 th Ed., Oxford University Press (2006).
5. Ball, D. W., Physical Chemistry, Thomson Press, India (2007).
6. Castellan, G. W., Physical Chemistr,y 4 th Ed. Narosa (2004).
7. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
8. Laidler, K. J. Chemical Kinetics Pearson Education: New Delhi (2004).
9. A A Pearson, R G Frost, Kinetics and Mechanism.
10. House, J. E., Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
11. Lowe, J. P. & Peterson, K., Quantum Chemistry Academic Press (2005).

Text Books-

1. C.N. R. Rao, University General Chemistry. Mc. Millan Publication.
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).

Organic Process Technology : CE-BS-204 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week,
Examination Scheme: Theory T (U): 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Introduction to unit processes, e.g. Nitration, Sulfonation, sigificance of kinetics and thermodynamics, feasibility aspects of chemical process, basic concept of flowsheet, nitration and sulfonation of benzene (**6L**)

Unit 2: (Mechanisms and recent advances (green chemistry, catalysis, etc.) Basic principles of green chemistry, industrial significance. Homogeneous and hetrogeneous catalysis with examples. Alkylation of benzene, transesterification of fatty acid to bio-diesel **(7L)**

Unit 3: Mechanisms and recent advances (green chemistry, catalysis, etc.) of following processes: Hydrogenation and alkylations, e.g. hydrogenation of nitrobenzene, petroleum hydrogenation, alkylation reactions of anilines, etc. and their flow diagrams, Oxidation, e.g. oxidation of xylene etc. (**8L**)

Unit 4: Recent developments in polymerisation (reaction mechanism and catalysis) Technical preparation of biodegradable plastics such as polylactic acid, rayon using waste biomass, zeolite resins and their applications in green detergents. (**5L**)

Books Recommended:

1. Chemical and Catalytic Reaction Engineering by Carberry, J.J. Dover books on chemistry
2. Engineering Chemistry by B.L.Tembe, Kamaluddin and M.S. Krishnan(NPTEL web book)
3. Green Chemistry: Theory and Practice by Paul T. Anastas, J.C. Warner; Oxford University Press
4. Unit Processes in Organic Synthesis- by P. H. Groggins, Wiley Publication
5. Monograph on green chemistry, Green chemistry Task Force Committee, DST
6. Zeolites: Molecular sieves Textbook by D.W.Breck

Thermodynamics-I : CE-GES-205 T **Total Credits: 03**
Teaching Scheme: Lectures: 3 Hours/ Week
Examination Scheme: Theory T (U): 70 Marks T (I) : 30 Marks
Duration of University Exam. : 03 Hours

Unit 1: Introduction- Scope of thermodynamics, Dimensions and Units, Temperature, Pressure, Work, Energy, Heat. Energy conservation & first law of thermodynamics; State functions; Equilibrium; Phase Rule; Reversible process; Constant P,V, T processes; Mass and energy balances for open systems; Ideal gas law, Vander Waals.

(8L)

Unit 2: Heat effects-latent heat, sensible heat, standard heats of formation, reaction and combustion. Statements of the second law; Heat engines, Carnot's theorem,; Thermodynamic Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the second law; Entropy balance for open systems; Calculation of ideal work, Lost work.

(8L)

Unit 3: Thermodynamic property of fluids, Maxwell relations, 2-phase systems, graphs and tables of thermodynamic properties. Properties of Steam, Use of steam tables, measurement of dryness fraction, entropy of steam, temperature entropy and mollier charts.

(8L)

Unit 4: Application of thermodynamics to flow processes-pumps, compressors and turbines. (8L)

Unit 5: Thermodynamic analysis of steam power plants; Rankine cycle; Internal combustion engine, Otto engine; Diesel engine; Jet engine. (8L)

Unit 6: The Carnot refrigerator; Vapour-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes. (8L)

Suggested Text Books

1. J. M. Smith, H.C. Van Ness and M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 7th edition, McGraw-Hill International Edition, 2005.
2. P. K. Nag, Engineering Thermodynamics, Tata McGraw-Hill Publications.
3. P. L. Ballani, Thermal Engineering, Khanna Publications.
4. M. J. Moran, H. N. Shapiro, D. D. Boettner and M. B. Bailey, Principles of Engineering Thermodynamics, 8th Edition, Willey.
5. Yunus A. Cengel, Michael A. Boles, Thermodynamics and Engineering approach, Tata McGraw-Hill Publications.

Electrical & Electronics Engineering: CE-GES-206 T Total Credits: 03
Teaching Scheme: Lectures: 3Hours/ Week
Examination Scheme: Theory T (U): 70 Marks T (I): 30 Marks
Duration of University Exam. : 03 Hours

Unit 1: **DC Circuits:** Resistor, Inductor ,Capacitor, Diode, Concept of Voltage and Current sources, resistance in series and parallel, Kirchhoff's Laws, Superposition Theorem, Thevenin's theorem, Norton's theorem, Star-Delta transformation, Analysis of simple circuit with DC excitation, Node and Mesh analysis. (8L)

Unit 2: **AC Fundamentals**: Concept of AC current and voltages, difference between AC and DC, Periodic functions, Average & RMS values, Form factor and Peak factor, Steady state behaviour with sinusoidal excitation, Phosor representation, Phase and Phase difference concept. (8L)

Unit 3: **Steady State Analysis of AC circuits:** Consisting of R, L, C, RL, RC and RLC in series and parallel circuits, resonance.
Introduction to three phase AC circuits, star and delta connections, measurement of power in three phase ac circuits. (6L)

Unit 4: **Transformer modelling and analysis:** Introduction, General theory of Transformer, Basic Principles, Construction phasor diagram for transformer under no load, Transformer on load, Balance of MMF on two sides, Phasor diagrams, Equivalent Circuit, Loses in transformer, Normal and All day Efficiency, Regulation, Open- circuits and short-circuits tests. (8L)

Unit 5: Energy in Magnetic field and Principles of electromechanical Energy conversion: Working of Thermal, Hydro and Nuclear power plants. (4L)

Unit 6: Basic Electronics: BJT and its characteristics, CE and small signal model, MOSFET, SCR, Operational amplifier, Introduction to digital circuits. (8L)

Suggested Text Books

1. B.L. Thereja, A Text Book of Electrical Technology, Vol. 1, 2 and 4, S. Chand & Co., New Delhi.

2. D. P. Kothari and I. J. Nagrath, Basic Electrical Engineering, 3rd edition, Tata McGraw Hill, 2010.
3. D. C. Kulshrestha, Basic Electrical Engineering, Tata McGraw Hill, 2009.

Suggested Reference Books

1. L. S. Bobrow, Fundamentals of Electrical Engineering, Oxford University Press, 2011.
2. E. Huges, Electrical and Electronics Technology, 10th edition, PEARSON, 2010.

3. Vincent Del Toro, Electrical Engineering Fundamentals, 2nd edition, Prentice Hall India 1989.

Properties of Matter Laboratory CE-BS 207 P Total Credits: 01
Teaching Scheme Practical: 2 Hours/ Week
Examination Scheme P (U) : 25 Marks P (I) : 25 Marks
Duration of University Exam. : 03 Hours

1. Elementary analytical techniques: Method of linear least squares fit to the experimental data, error estimation, calculations involving idea of significant figures.

2. To determine the coefficient of viscosity of liquid using Stoke's method.

3. Study of Ostwald's viscometer.

4. To determine the coefficient of viscosity of liquid using Poiseulle's method.

5. To determine the surface tension of liquid using Searl's Torsion Balance method

6. To determine the surface tension of liquid using Jaeger's method.

7. To determine the surface tension of liquid using Quincke's method.

8. To determine the Interfacial surface tension between the two immiscible liquids.

9. To determine the radius of curvature of a plano convex lens using Newton's rings method.

10. Interference in thin films: Study of wedge shaped thin film.

Chemistry-II Laboratory: CE-BS-208 P Total Credits: 01
Teaching Scheme : Practical: 2 Hours / Week
Examination Scheme: Practical P (U) : 25 Marks, P (I) : 25 Marks
Duration of University Exam: 03 Hours

LIST OF EXPERIMENTS

1. Calibration of glass wares (Burette, pipette, volumetric flask etc.)

2. To determine the surface tension & Parachor value of liquid using Stalagnometer.
3. To Study the surface tension of liquids & to determine the concentration of given unknown solution using Stalagnometer.
4. To Study the viscosity of liquids & to determine the concentration of given unknown solution using Oswald's Viscometer.
5. To study the kinetics of the reaction between Potassium Persulphate and Potassium Iodide and to determine its energy of activation.
6. To study kinetics of saponification of ethyl acetate.
7. To study the relative strength of acids using method of kinetics.
8. To study the adsorption of acetic acid on charcoal and verify the Langmuir and Freundlich adsorption isotherm
9. To determine heat of ionization of weak acid by thermometric method.
10. To determine the heat of crystallization of $CuSO_4.5H_2O$ by thermometric method.
11. To determine the optical rotation of glucose / fructose /cane sugar by polarimeter.
12. To study the kinetics of inversion of cane sugar by polarimeter.
13. To study the kinetics of iodination of acetone.
14. To determine the molecular weight of a volatile substance by Victor-Mayer's apparatus.

Reference Books-

1. Experiments in general chemistry by C.N.R. Rao and Agrawal East West Press.
2. Experiments in Physical Chemistry by R.C. Das and Behere Tata Mc Graw Hill.
3. Experimental physical Chemistry by F. Daniel and others (International Student Edition)
4. B. Vishwanathan, P.S. Raghavan; Practical Physical Chemistry, Viva Books, 2010.

Organic Process Technology Laboratory CE -BS-209 P **Total Credits: 1.5**

Teaching Scheme **Examination Scheme**

Lectures: 3 Hours/ Week **P (U) : 25 Marks P (I) : 25 Marks**

Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

1. To prepare urea formaldehyde resin using bulk technique of polymerisation

2. To prepare phenol formaldehyde resin using solution technique of polymerisation.

3. To prepare Acetanilide from aniline using green route

4. To prepare p-bromo acetanilide from acetanilide.

5. To prepare 2-methoxy napthalene using unit process alkylation

6. To prepare p-nitro acetanilde from acetanilide using nitration

7. To prepare Oxalic acid from canesugar using oxidation process

8. To prepare Aspirin from salicyclic acid

9. Extraction of essential oil from biomass (demonstration)

10. Purification of organic compounds by recrystallisation. (demonstration)

List of Books

1. A Laboratory hand bbok of Organic Qualitative analysis and separations By V. S. Kulkarni and S.P. Pathak

2. Vogels textbook of Practical Organic Chemistry

3. Monograph on green chemistry, Green chemistry Task Force Committee, DST

Electrical & Electronics Engineering Laboratory: CE-GES-210 P Total Credits: 01
Teaching Scheme: Practical: 2 Hours / Week
Examination Scheme: Practical P (U) : 25 Marks, P (I) : 25 Marks
Duration of University Exam: 03 Hours

1. Introduction to Electrical engineering, safety precautions, Familiar with AC & DC measuring devices and its use, voltmeter, ammeter, wattmeter, multimeter, oscilloscope, real life resistors, capacitors and Inductors.
2. DC Circuits- Ohms law, verification of KCL & KVL, Superposition theorem, Thevenin's theorem, Norton theorem.
3. Alternating current fundamentals and single phase AC circuits.
4. Three phase circuits.
5. Magnetic materials and their characteristics.
6. Single phase Transformer.
7. Characteristics of various electronics devices- BJT, UJT, FET, SCR, UJT as relaxation oscillator, etc.
8. Demonstration of various Logic gates.

Engineering Graphics: CE-GES-211 P Total Credits: 1.5
Teaching Scheme: Practical: 3Hours / Week
Examination Scheme: Practical P (U): 25 Marks, P (I): 25 Marks
Duration of University Exam: 03 Hours

1. Introduction to graphic science, dimensioning and sheet layout.
2. Curves used in engineering practice.
3. Projections of Points and straight Lines.
4. Projections of Planes.
5. Projections of Solids.
6. Orthographic projections.
7. Missing views (or interpretation of views).

8. Isometric projections.

Suggested Text Books

1. N. D. Bhatt, V. M. Panchal, Pramod R. Ingle, Engineering Drawing [Plane and Solid Geometry], 53rd edition, Charotar Publishing House Pvt. Ltd., 2014.

2. N.H. Dubey, Engineering Drawing, 15th multicoloured edition, Nandu Printers & Publishers Pvt. Ltd., 2015.

Science and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Technology
(First Semester)

Maths –I: CT-BS-101T **Total Credits: 02**
Teaching Scheme: Lectures: 2Hours/ Week,
Examination Scheme: T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

UNIT -I : Linear Algebra-I : Matrices, Vectors,Vector Space, Rank of a Matrix, Linear Independence, Inverse of a Matrix, Linear Systems of Equations: Existence, Uniqueness,
Solutions of Linear Systems: Gauss Elimination, Cramer's Rule, Gauss-Jordan Elimination.

UNIT -II : Linear Algebra-II : Linear Algebra: Eigenvalues, Eigen vectors of Matrix, Symmetric, Skew-Symmetric, and Orthogonal Matrices, Cayley Hamilton Theorem, Sylvester Theorem, Diagonalisation.

UNIT -III: Integral Calculus : Beta, Gamma functions, Double integration : Cartesian and polar co-ordinates, Change of order of integration, Change of variables between Cartesian and polar co-ordinates, Area as a double integral, Triple integration, Volume as a triple integral.

UNIT -IV: Vector Calculus : Vectors in 2-Space and 3-Space, Inner Product (Dot Product), Vector Product (Cross Product) Vector and Scalar Functions and Fields, Derivatives Curves. Arc Length. Curvature, Gradient of a Scalar Field, Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field.
Integral Calculus. Integral Theorems, Line Integrals, Path Independence of Line Integrals, Green's Theorem in the Plane, Surfaces for Surface Integrals

References

1. Higher Engineering Mathematics by H. K. Das, Er. Rajnish Verma
2. A text book of Engineering Mathematics by N. P. Bali, Manish Goyal
3. A text book of Engineering Mathematics (Vol- I & II) by Dr. D. T. Deshmukh
4. Higher Engineering Mathematics by B. S. Grewal

Physics CT-BS-102 T **Total Credits: 02**
Teaching Scheme: Lectures: 2Hours/ Week
Examination Scheme: T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Quantum Mechanics: Planck's Hypothesis, Properties of Photons, Compton Effect, Wave – particle duality, De-Broglie Hypothesis, Matter Waves, Davisson-Germer Experiment; Bohr's Quantization condition.
Wave Packet & Wave Equations. Heisenberg's uncertainty principle, Wave function and its probability interpretation, Schrödinger's Time dependent & time independent equations, (No derivations). Solution of Schrödinger's equation for one dimensional infinite potential well.

Unit 2: Basic Semiconductor: Qualitative idea on the formation of electron energy bands in solids, Band-theory based classification of solids into insulators, semiconductors and conductors, Intrinsic semiconductors: Germanium and silicon, Doping and Extrinsic semiconductors.
PN- junction diode; Unbiased, Forward biased & Reverse biased mode, Zener diode: Forward and reverse bias characteristics, Avalanche breakdown, Applications: Half wave rectifier & Full wave rectifier, Transistors: PNP and NPN. Configuration: - CB, CE, Bipolar Transistor action, V-I

characteristics of i) Photodiode, ii) LED.

Unit 3: Lasers: Three quantum processes: Absorption, Spontaneous emission and Stimulated emission. Metastable state, Conditions for light amplification, Pumping schemes: Three level pumping scheme, Four level pumping scheme. Optical resonator, Laser beam characteristics, Ruby laser and He-Ne laser. Numericals.

Unit 4: Optical fibres: Structure, Propagation of light through a cladded fibre, Acceptance angle, acceptance cone, Fractional refractive index change, Numerical aperture, Modes of propagation; Types of Optical fibres: Single mode step index fibre, Multimode step index fibre, Graded Index fibre, V-number. Transmission Losses, Applications: Sensor, Numericals.

Books recommended:
Text Books:
1. Fundamentals of Physics: David Halliday, Robert Resnick and Jerle Walker, John-Wiley India(8e, extended)
2. A text book of Engineering Physics: M. N. Avadhanulu and Kshirsagar S. Chand & Co.
3. Electronic Engineering Materials and Devices: John Allision, (TMH edition, 10th reprint)
4. Concepts of Modern Physics: Baiser (Tata McGraw Hill).
4. Laser: M. N. Avadhanulu, S. Chand & Co.

Reference Books:
University Physics:Young and Freedman(Pearson Education)
Solid State Physics: C. Kittel
Solid State Physics: R.L. Singhal
Quantum Mechanics: Schiff
LASERS: Theory and Applications: Thyagarajan K and Ghatak A.K.

Chemistry-I : CT-BS-103 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week
Examination Scheme: Theory T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit I Co-ordination Chemistry and Chemical bonding: Introduction to co-ordination chemistry, explanation of terms like complex, ligands, co-ordination number, co-ordination sphere. Classification of ligands, chelates & its classification. Werner's coordination theory & its application to Co (III) and Pt (IV) ammine complexes.
Valence Bond Theory and its application to 6-coordinated complexes, Crystal Field theory and Crystal field splitting in Octahedral and tetrahedral complexes, MO theory, Structure, bonding and energy levels of bonding and shapes of many atom molecules like H2, N2, and CO. **(12)**

Unit II Water: Sources, types of impurities and their effects, hardness of water & its estimation, Numerical on EDTA method, treatment of water for domestic & industrial purposes, sedimentation, coagulation, filtration, types of filters, Sterilization- chlorination, break point chlorination, Ozonization. Removal of hardness of water: Lime- soda process, Numerical on lime-soda process, Zeolite process, its advantages and disadvantages, comparison with L-S Process, Numerical based on zeolite process, Ion- exchange process, demineralization process. Boiler troubles:-Carry over- priming & foaming-causes & prevention, sludge & scales, Causes of scale formation and prevention methods, Corrosion & caustic embrittlement causes & prevention. **(12)**

Unit III Cement: Raw materials, constitutional compounds& its properties, Process parameters, Manufacture of Portland cement by wet and dry process, setting and hardening of cement,

Cement additives & admixtures.
Refractories: Definition, requisites of good refractory material, properties of refractory, raw materials, manufacture of refractory products, application in industries. **(10)**

Unit IV Chromatography: Introduction, Classification, General and fundamental concepts of TLC, Column, HPLC, GC, Ion Exchange and their applications. **(06)**

Books Recommended:

1. A Text Book of Engineering Chemistry, by S.S.Dara, S.Chand & Co., New Delhi.
2. A Text Book of Engineering Chemistry, by Jain & Jain, Dhanpat Rai Publishing Co., New Delhi.
3. Industrial Chemistry by B.K.Sharma Goel Pub. House, Meerut.
4. Advanced Inorganic Chemistry, Vol.II, by Satya Prakash, G.D.Tuli, S.K.Basu & R.D.Madan.
5. Text of Engineering Chemistry by Dr. Sunita Rattan, S. K. Kataria and Sons, New Delhi.
6. Analytical Chromatography by Dr. G. R. Chatwal, Himalaya Publication House.
7. Instrumental Methods Of Chemical Analysis By G. R. Chatwal, S. K. Anand, Himalaya Publication House.

Fundamentals of Reaction Mechanism: CT-BS-104 T **Total Credits: 02**
Teaching Scheme: Lectures: 02 Hours/Week
Examination Scheme: Theory T (U): 35 Marks T (I): 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Reactivity of organic molecules: factors influencing acidity, basicity and nucleophilicity of molecules with few examples. Introduction to Stereochemistry: Stereo-descriptors – R, S, E, Z. Enantiomers and Diastereomers. (**6L**)

Unit 2: Strategies for synthesis of organic compounds: Reactive intermediates, Mechanism of Addition, substitution, elimination, condensation, role of solvents. Technical preparation of bio-ethanol using molasses, enzymatic catalysis, commercial significance (**8L**)

Unit 3: **Mechanism and recent advancement (Green chemistry and catalysis etc.):** Basic principles of green chemistry, industrial significance, green catalysts. Technical preparation supported green route, Preparation of adipic acid, Acetanalide with mechanism, photo-halogenation of benzene etc (**6L**)

Unit 4: Nitration: Vant Hoffs factor for suitability of agents, Catalytic effect of sulfuric acid in industrial nitration, Mechanism of aromatic nitration process using Inductive and Mesomeric effect, examples, Equipments for nitration and safety aspects. Technical preparation of nitroglycerine (**6L**)

Books Recommended:

1. Engineering Chemistry – By Baskar, Wiley
2. Engineering Chemistry –I By D. GrourKrishana, Vikas Publishing
3. Green Chemistry: Theory and Practice by Paul T. Anastas, J.C. Warner; Oxford University Press
4. Unit Processes in Organic Synthesis- by P. H. Groggins
5. Reaction and Reagents- By O.P. Agarawal
6. Monograph on green chemistry, Green chemistry Task Force Committee, DST

Electrical & Electronics Engineering: CT-GES-105 T **Total Credits: 03**
Teaching Scheme: Lectures: 3 Hours/ Week
Examination Scheme: Theory T (U): 70 Marks T (I): 30 Marks
Duration of University Exam. : 03 Hours

Unit 1: **DC Circuits:** Resistor, Inductor, Capacitor, Diode, Concept of Voltage and Current sources, resistance in series and parallel, Kirchhoff's Laws, Superposition Theorem, Thevenin's theorem, Norton's theorem, Star-Delta transformation, Analysis of simple circuit with DC excitation, Node and Mesh analysis. (8L)

Unit 2: **AC Fundamentals**: Concept of AC current and voltages, difference between AC and DC, Periodic functions, Average & RMS values, Form factor and Peak factor, Steady state behaviour with sinusoidal excitation, Phosor representation, Phase and Phase difference concept. (8L)

Unit 3: **Steady State Analysis of AC circuits:** Consisting of R, L, C, RL, RC and RLC in series and parallel circuits, resonance.
Introduction to three phase AC circuits, star and delta connections, measurement of power in three phase ac circuits. (6L)

Unit 4: **Transformer modelling and analysis:** Introduction, General theory of Transformer, Basic Principles, Construction phasor diagram for transformer under no load, Transformer on load, Balance of MMF on two sides, Phasor diagrams, Equivalent Circuit, Loses in transformer, Normal and All day Efficiency, Regulation, Open- circuits and short-circuits tests. (8L)

Unit 5: Energy in Magnetic field and Principles of electromechanical Energy conversion: Working of Thermal, Hydro and Nuclear power plants. (4L)

Unit 6: Basic Electronics: BJT and its characteristics, CE and small signal model, MOSFET, SCR, Operational amplifier, Introduction to digital circuits. (8L)

Suggested Text Books

1. B.L. Thereja, A Text Book of Electrical Technology, Vol. 1, 2 and 4, S. Chand & Co., New Delhi.
2. D. P. Kothari and I. J. Nagrath, Basic Electrical Engineering, 3rd edition, Tata McGraw Hill, 2010.
3. D. C. Kulshrestha, Basic Electrical Engineering, Tata McGraw Hill, 2009.

Suggested Reference Books

1. L. S. Bobrow, Fundamentals of Electrical Engineering, Oxford University Press, 2011.
2. E. Huges, Electrical and Electronics Technology, 10th edition, PEARSON, 2010.

3. Vincent Del Toro, Electrical Engineering Fundamentals, 2nd edition, Prentice Hall India 1989.

Physics Laboratory CT -BS-106 P **Total Credits: 01**
Teaching Scheme **Examination Scheme**
Lectures: 2 Hours/ Week **P (U) : 25 Marks P (I) : 25 Marks**
Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

1. To study the characteristics of a PN-junction diode in forward and reverse bias & determine its cut in voltage, static & dynamic resistance.

2. To study the characteristics of a Zener diode in forward and reverse bias & determine its breakdown voltage.
3. To determine the Energy gap Eg of semiconductor using PN junction diode in reverse bias mode.
4. To study the V-I characteristics of a Light Emitting Diode
5. To study the V-I characteristics of a Photo Diode
6. To study PN junction diode as Half wave and Full wave rectifier and calculate ripple factor and efficiency in each case
7. To study the input and output characteristics of a transistor in Common base mode & calculate input resistance and current gain α.
8. To study the input and output characteristics of a transistor in Common emitter mode & calculate input resistance and current gain β.
9. Study of Optical Fibre kit.
10. Demonstrations of Lasers.

Chemistry-I Laboratory: CT -BS-107 P **Total Credits: 01**
Teaching Scheme: Practical: 2 Hours / Week
Examination Scheme: Practical P (U) : 25 Marks, P (I) : 25 Marks
Duration of University Exam: 03 Hours

LIST OF EXPERIMENTS

1. Estimation of Total Hardness by Complexometric Method in a given Sample of water.
2. Estimation of Calcium and Magnesium hardness in a given sample of water.
3. Estimation of Nickel by Complexometric Method in a given Sample of water.
4. Estimation of total alkalinity in the given water sample.
5. Estimation of percentage of Copper in the given solution of copper sulphate by Iodometry Method.
6. Estimation of Strength of Potassium Dichromate using Sodium Thiosulphate by Iodometry Method .
7. Determination of strength of Ferrous Ammonium Sulphate using Potassium Dichromate and SDS as an internal indicator.
8. Estimation of strength of NaOH using oxalic acid.
9. Estimation of strength of HCl using Borax.
10. To determine the number of components in a mixture using TLC.

Fundamentals of Reaction Mechanism Laboratory CT -BS-108 P **Total Credits: 01**

Teaching Scheme	**Examination Scheme**
Lectures: 2 Hours/ Week	**P (U) : 25 Marks P (I) : 25 Marks**

Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

1. Identification of unknown organic compounds using preliminary investigations such as Phase, Color, odour, solubility in various solvents.

2. Identification of unknown organic compounds on the basis of aromatic and aliphatic as well as saturated and unsaturated nature.

3. To detect the elements (N, S and Cl) present in given unknown organic compounds using sodium extract.

4. Identification of unknown organic compound using Functional group detection and confirmatory tests (Phenols and Napthols)

5. Identification of unknown organic compound using Functional group detection and confirmatory tests (Carbohydrates; aldehydes and ketones)

6. Identification of unknown organic compound using Functional group detection and confirmatory tests (mono carboxylic acids)

7. Identification of unknown organic compound using Functional group detection and confirmatory tests (di- carboxylic acids)

8. Identification of unknown organic compound using Functional group detection and confirmatory tests (Amides)

9. Identification of unknown organic compound using Functional group detection and confirmatory tests (Nitro)

10**.** Detection of Melting points of few organic compounds using melting point apparatus.

List of Books

1. A Laboratory hand bbok of Organic Qualitative analysis and separations By V. S. Kulkarni and S.P. Pathak
2. Vogels textbook of Practical Organic Chemistry

Electrical & Electronics Engineering Laboratory: CT-GES-109 P   Total Credits: 01
Teaching Scheme: Practical: 2 Hours / Week
Examination Scheme: Practical P (U): 25 Marks P (I): 25 Marks
Duration of University Exam: 03 Hours

About 8 to 12 experiments to illustrate the concepts learnt in Electrical and Electronics Engineering. Suitable number of experiments should be from the following categories:

1. Introduction to Electrical engineering, safety precautions, Familiar with AC & DC measuring devices and its use, voltmeter, ammeter, wattmeter, multimeter, oscilloscope, real life resistors, capacitors and Inductors.
2. DC Circuits- Ohms law, verification of KCL & KVL, Superposition theorem, Thevenin's theorem, Norton theorem.
3. Alternating current fundamentals and single phase AC circuits.
4. Three phase circuits.
5. Magnetic materials and their characteristics.
6. Single phase Transformer.
7. Characteristics of various electronics devices- BJT, UJT, FET, SCR, UJT as relaxation oscillator, etc.
8. Demonstration of various Logic gates.

Engineering Graphics: CT-GES-110 P **Total Credits: 1.5**
Teaching Scheme: Practical: 3Hours / Week
Examination Scheme: Practical P (U) : 25 Marks, P (I) : 25 Marks
Duration of University Exam: 03 Hours

Contents

1. Introduction to graphic science, dimensioning and sheet layout.
2. Curves used in engineering practice.
3. Projections of Points and straight Lines.
4. Projections of Planes.
5. Projections of Solids.
6. Orthographic projections.
7. Missing views (or interpretation of views).
8. Isometric projections.

Suggested Text Books

1. N. D. Bhatt, V. M. Panchal, Pramod R. Ingle, Engineering Drawing [Plane and Solid Geometry], 53rd edition, Charotar Publishing House Pvt. Ltd., 2014.

2. N.H. Dubey, Engineering Drawing, 15th multicoloured edition, Nandu Printers & Publishers Pvt. Ltd., 2015.

Science and Technology,
R.T.M. Nagpur University, Nagpur.
Syllabus for B.Tech. Chemical Technology
(Second Semester)

Maths –II: CT-BS-201 T **Total Credits: 03**
Teaching Scheme: Lectures: 3Hours/ Week
Examination Scheme: T (U) : 70 Marks T (I) : 30 Marks
Duration of University Exam. : 03 Hours

Unit I : Ordinary differential Equation and Higher Order Differential Equation : Differential Equations: First order first degree differential equations: Linear, reducible to linear and exact differential equations. Higher order differential equations with constant coefficient, method of variation of parameters. Cauchy's and Legendre's homogeneous differential equations, simultaneous differential equations.

Unit II : Partial Differential Equations: First order Lagrange's Linear Partial Differential Equation, Solution of higher order linear homogeneous Partial Differential Equations and linear non-homogeneous Partial Differential Equations.

Unit III : Application of Partial Differential Equations : Method of separation of variables for Partial Differential Equations, Applications of Partial Differential Equations: (i) One dimensional wave equation, (ii) One dimensional heat conduction equation in Cartesian co-ordinates and polar co-ordinates and (iii) Two dimensional steady state heat conduction equation

Unit IV : Function of Complex Variables : Basic Concepts of Complex numbers, De-Moivre's Theorem, Calculus of Functions of Complex variables : Analytic functions, Cauchy –Riemann conditions in Cartesian co-ordinates and polar co-ordinates, methods for finding conjugate functions,

Unit V: Statistics and Probability : Fitting of straight line y=a+bx, parabola and Exponential curves by method of least squares, Lines of regression and Correlation, Rank correlation.
Random variables: Discrete and Continuous random variables, Probability distribution: Binomial, Poisson, Normal Distribution.

Unit VI : Fourier Series : Fourier series, expansion of function, Even and odd function, Half range fourier series, Change of interval, Harmonic analysis.

References

1. Higher Engineering Mathematics by H. K. Das, Er. Rajnish Verma
2. A text book of Engineering Mathematics by N. P. Bali, Manish Goyal
3. Applied Engineering Mathematics (Vol- I & II) by J. N. Wartikar
4. Higher Engineering Mathematics by B. S. Grewal
5. Text book of Engineering Mathematics by Bali, Iyenger (Laxmi Prakashan)

Properties of Matter CT-BS 202 T **Total Credits: 02**
Teaching Scheme Lectures: 2 Hours/ Week Theory
Examination Scheme T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: VISCOSITY: Streamline flow, Turbulent motion, critical velocity, Viscosity, Coefficient of viscosity, Poiseulle's equation, Stokes's method, Ostwald viscometer, Numericals

Unit 2: SURFACE TENSION: Surface tension, Excess pressure inside a liquid drop and soap bubble, Angle of contact, Searl's Torsion Balance method, Quincke's method, Interfacial surface Tension, Numericals.

Unit 3: Crystal structure and X-rays : Meaning of lattice and basis, Unit cell: primitive and non primitive unit cell; Cubic crystal structure: Body and Face centered cubic structures, SC, BCC and FCC unit cells. Unit cell characteristics: Effective number of atoms per unit cell, atomic radius, nearest neighbour distance, coordination number, atomic packing fraction, void space, density; Crystal planes and Miller indices, Inter-planar distance between adjacent planes, Tetrahedral and octahedral voids, Numericals.
Production of X-Rays: Coolidge tube, Origin of X-rays, Properties of X-rays, Applications of X-Rays, Bragg's law and Bragg's X-ray spectrometer. Numericals.

Unit 4: Interference in thin film: Plane Parallel thin film, wedge shaped thin film, Newtons rings, Applications: Determination of wavelengrh and Refractive index of liquid, test of surface finish. Antireflection coating, Numericals

TEXT BOOKS

1. Brijlal and Subramaniam N., Properties of Matter , Revised Edition, S.Chand and Company,2005.
2. Murugesan R., Properties of Matter and Acoustics, Revised Edition, S.Chand and Company, 2005.
3.Thiruvadigal,..J. D, Ponnusamy,S..Sudha.D and Krishnamohan M, "Physics for Technologists", Vibrant Publication, Chennai, 2013.
4. Dattu Joshi. R. "Engineering Physics",Tata McGraw- Hill,New Delhi.
5. Mathur D. S, Elements of Properties of Matter, 3rd Edition, S. Chand and Company.
6. Satyaprakash and Akash Saluja, Oscillations and Waves, Pragati Prakashan, 2002

REFERENCES

1. Landau L. D., Pitaevskii L P, Kosevich A M and Lifshitz E M, "Theory of Elasticity", Revised Edition, Butterworth-Heinemann, 2014
2. Landau L. D., Pitaevskii L P, Kosevich A M and Lifshitz E M, "Fluid Mechanics", Revised Edition, Butterworth-Heinemann, 2014.
3. "Laboratory Experiments in College Physics", C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.

Chemistry-II: CT-BS-203 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week
Examination Scheme: Theory T (U) : 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: A] Gaseous state: Gas laws, kinetic theory of gas, collision and gas pressure, derivation of gas laws from kinetic theory, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature. Maxwell's distribution of speeds. Kinetic energy distribution, calculations of average, root mean square and most probable velocities. Principle of equipartition of energy and its application.

B] Collision of gas molecules, Real gases: Collision diameter, collision number and mean free path; frequency of binary collisions; Deviation of gases from ideal behaviour; compressibility factor; Andrew's plots; van der Waals equation and its characteristic features. Existence of critical state. Critical constants in terms of van der Waals constants. Law of corresponding state, compressibility factor, and Joule-Thomson effect, Numericals. **[8L]**

Unit 2: Quantum mechanics: De Broglie equation, experimental verification, Compton effect, Heisenberg's uncertainty principle, Introduction of quantum mechanics, Postulates of quantum mechanics, Derivation of Schrodinger wave equation from postulates of quantum mechanics. wave function, normalized and orthogonal wave function, operators, properties of operators, eigen function and eigen values, (problems on operators, eigen values), numericals.

B] Application of Schrodinger wave equation to simple systems: Particle in a one dimensional box: derivation of energy and normalization and orthogonality of wave function. Graphical representation of Ψ and its square Ψ2. Schrodinger wave equation for 3-dimensional box(without derivation, in terms of r, θ and Φ), degeneracy, Numericals**.** **[8L]**

Unit 3: A] Rate expressions, order and molecularity of reaction, Integrated rate expression with examples, Factors influencing the reaction rates, Arrhenius equation, Energy of Activation, Half life, Methods for determining the order of chemical reaction, Numericals.
B] Steady state approximation, kinetics of consecutive (chain) reactions, parallel reactions, opposing reactions with examples, Mechanism of chain reactions with examples, general catalytic mechanisms, acid-base catalysis, catalysis by enzymes, Michaelis-Menten Equation, Photochemical reactions of hydrogen and bromine, hydrogen and chlorine and decomposition of HI. **[8L]**

Unit 4: A**] Chemical equilibrium:** Chemical equilibria of homogeneous systems, derivation of expression of equilibrium constants, Relation between Kp, Kc and Kx, Le Chatelier's principle of dynamic equilibrium. Effect of change of concentration, pressure, temperature and catalyst on equilibrium constant, Numericals.
B] Thermodynamics of Equilibrium: Introduction, partial molar properties, Chemical Potential, Gibbs-Duhem equation; fugacity of gases Van't Hoff Reaction isotherm – isochore & isobar, Numericals **[6L]**

Reference Books-

1. F. Daniel,Mathematical preparation for physical Chemistry, Mc. Graw Hill publication.
2. Maron and Pruton, Principles of Physical Chemistry, 4th Ed. Oxford and IBH publication.
3. I.N. Levine, Quantum Chemistry, 5th edition (2000), Pearson Educ., Inc. New Delhi
4. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8 th Ed., Oxford University Press (2006).
5. Ball, D. W., Physical Chemistry, Thomson Press, India (2007).
6. Castellan, G. W., Physical Chemistr,y 4 th Ed. Narosa (2004).
7. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
8. Laidler, K. J. Chemical Kinetics Pearson Education: New Delhi (2004).
9. A A Pearson, R G Frost, Kinetics and Mechanism
10. House, J. E., Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
11. Lowe, J. P. & Peterson, K., Quantum Chemistry Academic Press (2005).

Text Books-

1. C.N. R. Rao, University General Chemistry. Mc. Millan Publication.
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).

Organic Process Technology : CT-BS-204 T **Total Credits: 02**
Teaching Scheme: Lectures: 2 Hours/ Week,
Examination Scheme: Theory T (U): 35 Marks T (I) : 15 Marks
Duration of University Exam. : 02 Hours

Unit 1: Introduction to unit processes, e.g. Nitration, Sulfonation, sigificance of kinetics and thermodynamics, feasibility aspects of chemical process, basic concept of flowsheet, nitration and sulfonation of benzene (**6L**)

Unit 2: (Mechanisms and recent advances (green chemistry, catalysis, etc.) Basic principles of green chemistry, industrial significance. Homogeneous and hetrogeneous catalysis with examples. Alkylation of benzene, transesterification of fatty acid to bio-diesel **(7L)**

Unit 3: Mechanisms and recent advances (green chemistry, catalysis, etc.) of following processes: Hydrogenation and alkylations, e.g. hydrogenation of nitrobenzene, petroleum hydrogenation, alkylation reactions of anilines, etc. and their flowdiagrams, Oxidation, e.g. oxidation of xylenes etc. (**8L**)

Unit 4: Recent developments in polymerisation (reaction mechanism and catalysis) Technical preparation of biodegradable plastics such as polylactic acid, rayon using waste biomass, zeolite resins and their applications in green detergents. (**5L**)

Books Recommended:

1. Chemical and Catalytic Reaction Engineering by Carberry, J.J. Dover books on chemistry
2. Engineering Chemistry by B.L.Tembe, Kamaluddin and M.S. Krishnan(NPTEL web book)
3. Green Chemistry: Theory and Practice by Paul T. Anastas, J.C. Warner; Oxford University Press
4. Unit Processes in Organic Synthesis- by P. H. Groggins, Wiley Publication
5. Monograph on green chemistry, Green chemistry Task Force Committee, DST
6. Zeolites: Molecular sieves Textbook by D.W.Breck

Thermodynamics-I : CT-GES-205 T **Total Credits: 03**
Teaching Scheme: Lectures: 3 Hours/ Week
Examination Scheme: Theory T (U): 70 Marks T (I) : 30 Marks
Duration of University Exam. : 03 Hours

Contents

Unit 1: Introduction- Scope of thermodynamics, Dimensions and Units, Temperature, Pressure, Work, Energy, Heat. Energy conservation & first law of thermodynamics; State functions; Equilibrium; Phase Rule; Reversible process; Constant P,V, T processes; Mass and energy balances for open systems; Ideal gas law, Vander Waals.
(8L)

Unit 2: Heat effects-latent heat, sensible heat, standard heats of formation, reaction and combustion. Statements of the second law; Heat engines, Carnot's theorem,; Thermodynamic

Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the second law; Entropy balance for open systems; Calculation of ideal work, Lost work.
(8L)

Unit 3: Thermodynamic property of fluids, Maxwell relations, 2-phase systems, graphs and tables of thermodynamic properties. Properties of Steam, Use of steam tables, measurement of dryness fraction, entropy of steam, temperature entropy and mollier charts.
(8L)

Unit 4: Application of thermodynamics to flow processes-pumps, compressors and turbines.
(8L)

Unit 5: Thermodynamic analysis of steam power plants; Rankine cycle; Internal combustion engine, Otto engine; Diesel engine; Jet engine. (8L)

Unit 6: The Carnot refrigerator; Vapour-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes. (8L)

Suggested Text Books

1. J. M. Smith, H.C. Van Ness and M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 7th edition, McGraw-Hill International Edition, 2005.
2. P. K. Nag, Engineering Thermodynamics, Tata McGraw-Hill Publications.
3. P. L. Ballani, Thermal Engineering, Khanna Publications.
4. M. J. Moran, H. N. Shapiro, D. D. Boettner and M. B. Bailey, Principles of Engineering Thermodynamics, 8th Edition, Willey.
5. Yunus A. Cengel, Michael A. Boles, Thermodynamics and Engineering approach, Tata McGraw-Hill Publications.

Engineering and Solid Mechanics: CT-GES-206 T **Total Credits: 03**
Teaching Scheme: Lectures: 03Hours/Week
Examination Scheme: Theory T (U): 70 Marks T (I): 30 Marks
Duration of University Exam. : 03 Hours

Unit I: **Force:** Definition, Characteristics of a force, System of forces, Resolution and composition of forces. **Resultant force:** Definition, Analytical and graphical methods for resultant force in two dimensions, Moments and Couples, Varignon’s theorem of moments. **Equilibrium of rigid bodies**: Principles of equilibrium, types of equilibrium, conditions of equilibrium, free body diagrams, Analytical and graphical methods for equilibrium of rigid bodies in two dimensions. (7 Lectures)

Unit II: **Support reactions**: Types of supports and loading in beams, determination of support reactions in cantilever, simply supported and overhang beams. **Trusses and Frames**: Types of frames, Analysis of simple plane trusses in equilibrium by the method of joints and method of sections. **Friction**: Frictional forces, types, limiting friction, coefficient of friction, angle of friction, laws of friction, Equilibrium of bodies lying on rough horizontal and inclined planes, wedge friction. (8 Lectures)

Unit III: **Centroid and Moment of Inertia:** Centroid of plane standard geometric figures and composite figures, Moment of inertia (second moment of area) of plane standard geometric figures and composite figures, parallel and perpendicular axis theorems, Radius of gyration. **Simple lifting**

machines: Types of machines, efficiency of a machine, ideal machine, friction in machines, law of machine, Maximum M.A. and Maximum efficiency of a machine, reversible and non reversible machines, Differential wheel & axle, single and double purchase winch crabs. (8 Lectures)

Unit IV: **Simple stresses and strains** : Types of stresses and strains, modulus of elasticity, modulus of rigidity, bulk modulus, relation between elastic constants, stress-strain diagram for mild steel, lateral strain, Poisson's ratio, volumetric strain, triaxial loading in rectangular sections, stresses in bars of varying and composite sections, Temperature stresses and strains. (7 Lectures)

Unit V: **Stresses in beams**: Theory of simple bending, simple bending equation, bending stress, moment of resistance, assumptions in theory of simple bending, section modulus. **Shear force and bending moment**: Basic concepts, Shear force and bending moment diagrams for cantilever, simply supported and overhang beams for different loading conditions. **Slope and defection of beams**: Basic concepts, slope and deflection of cantilever and simply supported beams under standard loading conditions, Macaulay's method, simple problems. (8 Lectures)

Unit VI: **Torsion**: Theory of pure torsion, torsional moment of resistance, torsion equation, assumptions in the theory of pure torsion, polar modulus, power transmitted by solid and hollow circular shafts. **Columns and struts**: Axially loaded compression members, Euler's and Rankine's formula for buckling of columns, end conditions of column, buckling load, effective length of columns, slenderness ratio. (7 Lectures)

Suggested Text Books:

1. R. S. Khurmi, A Textbook of Engineering Mechanics, S. Chand & Co., New Delhi.
2. S. N. Saluja, A Textbook of Engineering Applied Mechanics, Satya Prakashan.
3. R. S. Khurmi and N. Khurmi, Strength of Materials, S. Chand & Co., New Delhi.
4. B. C. Punmia, Mechanics of Materials, Laxmi Publications (P) Ltd.

Suggested Reference Books:

1. F. L. Singer, Engineering Mechanics, Harper & Row Publishers.
2. S. Timoshenko and D. H. Young, Engineering Mechanics, McGraw Hill Publications.
3. Andrew Pytel and F. L. Singer, Strength of Materials, Harper & Row Publishers.

HASS I Communication Skills CT-HSMC-HS-207 T **Total Credits: Audit**
Teaching Scheme: Lectures: 2Hour/ Week
Examination Scheme: Theory T (I): 50 Marks

Unit I: Communication Skills: Introduction to Communication, Types of Communication, Barriers to communication and overcoming them **(03)**

Unit II: Listening and Reading Skills: Importance of Listening, Types of listening, Listening barriers and overcoming them, Importance of reading, Sources of Reading, Skimming, Scanning and Gist Reading, Comprehending Passage, Use of Figurative Language

Unit III: Speaking Skills: Effective Speaking Skills, Components of Public Speaking, Effective Presentation Strategies, Vocabulary Acquisition **(03)**

Unit IV: Group Discussion and Interview Techniques: Importance of Group Discussion, Techniques of Group Discussion, Types of Interviews, Interview Process, Interview Techniques **(03)**

Books Recommended:

1. Technical Communication by Meenakshi Raman and Sangeeta Sharma, OUP
2. Public Speaking and Influencing Men in Business by Dale Carnegie
3. Professional Communication Skills by Bhatia and Sheikh

4. Communication Skills by Dr. P. Prasad
5. Communication Skills by Sanjeev Kumar and Pushpalata, OUP

Properties of Matter Laboratory CT-BS 208 P **Total Credits: 01**
Teaching Scheme Practical: 2 Hours/ Week
Examination Scheme P (U) : 25 Marks P (I) : 25 Marks
Duration of University Exam. : 03 Hours

1. Elementary analytical techniques: Method of linear least squares fit to the experimental data, error estimation, calculations involving idea of significant figures.

2. To determine the coefficient of viscosity of liquid using Stoke's method.

3. Study of Ostwald's viscometer.

4. To determine the coefficient of viscosity of liquid using Poiseulle's method.

5. To determine the surface tension of liquid using Searl's Torsion Balance method

6. To determine the surface tension of liquid using Jaeger's method.

7. To determine the surface tension of liquid using Quincke's method.

8. To determine the Interfacial surface tension between the two immiscible liquids.

9. To determine the radius of curvature of a plano convex lens using Newton's rings method.

10. Interference in thin films: Study of wedge-shaped thin film.

Chemistry-II Laboratory: CT-BS-209 P **Total Credits: 01**
Teaching Scheme: Practical: 2 Hours / Week
Examination Scheme: Practical P (U) : 25 Marks, P (I) : 25 Marks
Duration of University Exam: 03 Hours

LIST OF EXPERIMENTS

1. Calibration of glass wares (Burette, pipette, volumetric flask etc.)
2. To determine the surface tension & Parachor value of liquid using Stalagnometer.
3. To Study the surface tension of liquids & to determine the concentration of given unknown solution using Stalagnometer.

4. To Study the viscosity of liquids & to determine the concentration of given unknown solution using Oswald's Viscometer.

5. To study the kinetics of the reaction between Potassium Persulphate and Potassium Iodide and to determine its energy of activation.
6. To study kinetics of saponification of ethyl acetate.
7. To study the relative strength of acids using method of kinetics.
8. To study the adsorption of acetic acid on charcoal and verify the Langmuir and Freundlich adsorption isotherm
9. To determine heat of ionization of weak acid by thermometric method.
10. To determine the heat of crystallization of $CuSO_4.5H_2O$ by thermometric method.
11. To determine the optical rotation of glucose / fructose /cane sugar by polarimeter.
12. To study the kinetics of inversion of cane sugar by polarimeter.
13. To study the kinetics of iodination of acetone.
14. To determine the molecular weight of a volatile substance by Victor-Mayer's apparatus.

Reference Books-

1. Experiments in general chemistry by C.N.R. Rao and Agrawal East West Press.
2. Experiments in Physical Chemistry by R.C. Das and Behere Tata Mc Graw Hill.
3. Experimental physical Chemistry by F. Daniel and others (International Student Edition)
4. B. Vishwanathan, P.S. Raghavan; Practical Physical Chemistry, Viva Books, 2010.

Organic Process Technology Laboratory CT -BS-210 P **Total Credits: 1.5**
Teaching Scheme **Examination Scheme**
Lectures: 3 Hours/ Week **P (U) : 25 Marks P (I) : 25 Marks**
Duration of University Exam. : 03 Hours

LIST OF EXPERIMENTS

1. To prepare urea formaldehyde resin using bulk technique of polymerisation
2. To prepare phenol formaldehyde resin using solution technique of polymerisation.
3. To prepare Acetanilide from aniline using green route
4. To prepare p-bromo acetanilide from acetanilide.
5. To prepare 2-methoxy napthalene using unit process alkylation
6. To prepare p-nitro acetanilde from acetanilide using nitration
7. To prepare Oxalic acid from canesugar using oxidation process
8. To prepare Aspirin from salicyclic acid
9. Extraction of essential oil from biomass (demonstration)
10. Purification of organic compounds by recrystallisation.(demonstration)

List of Books

1. A Laboratory hand bbok of Organic Qualitative analysis and separations By V. S. Kulkarni and S.P. Pathak
2. Vogels textbook of Practical Organic Chemistry
3. Monograph on green chemistry, Green chemistry Task Force Committee, DST

Engineering and Solid Mechanics Laboratory: CT-GES-211 P   Total Credits: 1.5
Teaching Scheme: Practical: 3Hours/ Week
Examination Scheme: Practical   P (U): 25 Marks, P (I): 25 Marks
Duration of University Exam.: 03 Hours

LIST OF EXPERIMENTS

1. Study of forces in the members of Jib crane.
2. Reactions of a beam.
3. Law of Moments.
4. Verification of Polygon law of forces.
5. Inclined friction plane.
6. Forces in single roof truss element.
7. Graphical method of analysis of forces.
8. Differential wheel & axle.
9. Single purchase winch crab.
10. Double purchase winch crab.
11. Study of Universal testing machine.
12. Deflection in beams.

HASS I Communication Skills CT-HSMC-HS-212 P   Total Credits: 01
Teaching Scheme Practical   : 2Hours/ Week
Examination Scheme: P (U): 25marks, P (I): 25 Marks
Duration of University Examination. : 03 Hours

1. Barriers to Communication
2. Non-Verbal Communication
3. Listening Skills
4. Reading Skills
5. Use of Figurative Language
6. Speaking Skills
7. Presentation Skills
8. Development of Word Power
9. Group Discussion
10. Interview Techniques

M.TECH CHEMICAL ENGINEERING & TECHNOLOGY

SYLLABUS – ALL SEMESTERS

COURSE SCHEME
EXAMINATION SCHEME
ABSORPTION SCHEME
&
SYLLABUS

Of

First, Second, Third & Fourth Semester
Choice Base Credit System (CBCS)

Of

Master of Technology (M.Tech)
In

CHEMICAL ENGINEERING

Of
RASHTRASANT TUKDOJI MAHARAJ
NAGPUR UNIVERSITY, NAGPUR

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIRST SEMESTER M.TECH (C.B.C.S.) (CHEMICAL ENGINEERING)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHE 101T	Modeling & Simulation in Chemical Engineering	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHE 102T	Advanced Transport Phenomena	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHE 103T	Advanced Reactor Design	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHE 104T	Elective-I	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGOPEN 105T	Elective-II	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHE 106P	Modeling & Simulation of Chemical Processes	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective	Subject Name			
	BOARD			
	BTCHE			
Elective-I (Discipline Specific)	1. Process Design, Integration and Intensification	2. Advanced Optimization Techniques	3. Fluidization Engineering	4. Computational Fluid Dynamics
Elective-II (Open)	1. Chemical Engineering Mathematics	2. Modern Chemical Instrumentation		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SECOND SEMESTER M.TECH (C.B.C.S.) (CHEMICAL ENGINEERING)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHE 201T	Advanced Separation Processes	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHE 202T	Advanced Process Dynamics & Control	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHE 203T	Advanced Biochemical Engineering	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHE 204T	Elective-III	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGFD 205T	Research Methodology	4	-	-	4	4	-	-	4	30	70	-	-	100
Total			20	-	-	20	20	-	-	20	150	350	-	-	500

Elective	Subject Name			
	BOARD			
	BTCHE			
Elective-III (Discipline Specific)	1. Energy Conservation & Planning	2. Artificial Neural Network and Evolutionary Algorithms	3. Multiphase Flow	4. Fuel Cell Technology

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
THIRD SEMESTER M.TECH (C.B.C.S.) (CHEMICAL ENGINEERING)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGOPEN 301T	Elective IV	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGFD 302T	Project Planning and Management	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHE 303P	*Project Seminar	-	3	-	3	-	8	-	8	-	-	100	100	200
Total			8	3	-	11	8	8	-	16	60	140	100	100	400

Elective-IV (Open)	1. Advanced Petroleum Refining	2. Nanotechnology		

*For Work Load: 2 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FOURTH SEMESTER M.TECH (C.B.C.S.) (CHEMICAL ENGINEERING)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHE 401P	*Project	-	6	-	6	-	16	-	16	-	-	200	200	400
Total			-	6	-	6	-	16	-	16	-	-	200	200	400

* For Work Load: 3 Hours/week/faculty

Scheme of Absorption for 1st semester M.Tech. Old Pattern to CBCS Pattern of 1st Semester M. Tech. (Chemical Engineering)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Semester Pattern)				As Per Rashtrasant Tukadoji Maharaj Nagpur University (CBCS Pattern Scheme)		
1st Semester M. Tech (Chemical Engineering)				1st Semester M. Tech (Chemical Engineering)		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	CT 1.01	Modern Chemical Instrumentation	Theory	PGOPEN 105T	Elective-II- Modern Chemical Instrumentation	Theory
2	----	---		PGCHE 101T	Modeling & Simulation in Chemical Engineering #	Theory
3	CE 1.02	Science & Technology of Materials	Theory	----	---	
4.	CE 1.03	Momentum and heat Transfer		PGCHE 102T	Advanced Transport Phenomena	Theory
5.	CE 1.04	Advanced Chemical Reaction Engineering	Theory	PGCHE 103T	Advanced Reactor Design	Theory
6.	CE 1.05	Plant Design	Theory	----	---	
7	----	---		PGCHE 104T	Elective-I	Theory
8	----	---		PGOPEN 105T	Elective-II	Theory
9	----	---		PGCHE 106P	Modeling & Simulation of Chemical Processes	Practical

Students will have to appear in University theory and practical examination as per the new scheme.

Scheme of Absorption for 2nd semester M.Tech. Old Pattern to CBCS Pattern of 2nd Semester M. Tech. (Chemical Engineering)							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Semester Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University (CBCS Pattern Scheme)**		
2nd Semester M. Tech (Chemical Engineering)					**2nd Semester M. Tech (Chemical Engineering)**		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	CT 2.01	Biotechnology	Theory		PGCHE 203T	Advanced Biochemical Engineering	Theory
2	CE 2.02	Environmental Engineering	Theory		---	----	
	CE 2.05	Process Dynamics and Control	Theory		PGCHE 202T	Advanced Process Dynamics & Control	Theory
3	CE 2.03	Mass Transfer	Theory		PGCHE 201T	Advanced Separation Processes	Theory
4.	CE 2.04	Optimization and Mathematical Modeling #	Theory		----	---	
5.	----	---			PGCHE 204T	Elective-III	Theory
6.	----	---			PGFD 205T	Research Methodology	Theory

Students will have to appear in University theory and practical examination as per the new scheme.

 # Students have to attend the classes and appear in University examination (Theory) of the subject Modeling & Simulation in Chemical Engineering **of First semester M. Tech (Chemical Engineering) (CBCS) which is equivalent to** Optimization and Mathematical Modeling **(Theory) of Second Semester M.Tech (Chemical Engineering) old Semester pattern respectively.**

Scheme of Absorption for 3rd semester M.Tech. Old Pattern to CBCS Pattern of 3rd Semester M. Tech. (Chemical Engineering)

As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Semester Pattern)				As Per Rashtrasant Tukadoji Maharaj Nagpur University (CBCS Pattern Scheme)		
3rd Semester M. Tech (Chemical Engineering)				3rd Semester M. Tech (Chemical Engineering)		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	CE 3.01	Elective	Theory	PGOPEN 301T	Elective IV	Theory
2	----	---		PGFD 302T	Project Planning and Management	Theory
3	CE 3.02	Seminar	Practical	PGCHE 303P	Project Seminar	Practical
4.	CE 3.03	Minor Project Sessional Practical	Practical	PGCHE 303P	Project Seminar	Practical

Students will have to appear in University theory and practical examination as per the new scheme.

Scheme of Absorption for 4th semester M.Tech. Old Pattern to CBCS Pattern of 4th Semester M. Tech. (Chemical Engineering)

As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Semester Pattern)				As Per Rashtrasant Tukadoji Maharaj Nagpur University (CBCS Pattern Scheme)		
4th Semester M. Tech (Chemical Engineering)				4th Semester M. Tech (Chemical Engineering)		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	CE 4.01	Major Project Viva-Voice	Practical	PGCHE 401P	Project	Practical

Students will have to appear in University theory and practical examination as per the new scheme.

FIRST SEMESTER M. Tech Chemical Engineering

Subject	**: PGCHE 101T** (BCHE)	**Modeling & Simulation in Chemical Engineering (Theory)**	
Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction to process modeling, Applications of models, classification of models, Principles of Formulation, fundamental laws, general modeling procedure, industrial usage of process modelling and simulation; Macroscopic and microscopic mass, energy and momentum balances

Unit 2: Parameter estimation techniques in theoretical as well as numerical models, population balance, stochastic, and empirical models

Unit 3: Modeling of various mass and heat transfer equipment: distillation, absorption, extraction columns; evaporators; furnaces; heat exchangers; flash vessels etc.

Unit 4: Modeling of Chemical Reactors: single phase and multiphase reactors

Unit 5: Numerical Methods for chemical engineering applications. Introduction and use of different softwares for modeling and simulation

Recommended Books:

1. W. L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.
2. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
3. R.E.G. Franks, Modeling and Simulation in Chemical Engineering, Wiely Intrscience, NY, 1972.
4. J. Ingam, I. J. Dunn, Chemical Engineering Dynamic Modeling with PC simulation, VCH Publishers, 2008.
5. D. Himmelblau, K.B. Bischoff, Process Analysis and Simulation, John Wiley & Sons, 1968.

Subject **: PGCHE 102T** (BCHE) **Advanced Transport Phenomena (Theory)**

Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Review of mathematics: Scalar, Vectors, Tensors, divergence, relation between rectangular coordinates and cylindrical coordinates, relation between rectangular coordinates and spherical coordinates, partial derivative, substantial derivative, total derivative, line integral, surface integral, integral theorems.

Unit 2: Equations of continuity, equation of motion, the equation of mechanical energy, application of Navier-Stokes equation to solve problems, the equations of change for incompressible non- Newtonian fluids.

Unit 3: Developing equations for obtaining velocity & shear stress distribution for flow of Newtonian, Bingham plastic & power law fluids in spheres etc. from Ist principle, Introduction to 2 dimensional & turbulent momentum transfers

Unit 4: Equations of energy, the energy equation in curvilinear coordinates, use of equations of change to set up steady state heat transfer for problems.

Unit 5: Unsteady state heat conduction expression for rectangular, spherical and cylindrical co-ordinate system from Ist principles, Numerical methods for 2 dimensional steady state conduction and Schmidt method for unsteady state heat conduction with / without surface resistance for obtaining temperature profiles

Recommended Books:

1. R.B. Bird, W. E. Stewart and E. N. Light foot Transport Phenomena Wiley international Edition, New York 2002.
2. James R. Welty, Charles E. Wicks and Robert E. Wilson, Fundamentals of momentum, heat and mass transfer, John Wiley & sons, Inc, New York, 2008.

Subject **: PGCHE 103T** (BCHE) **Advanced Reactor Design (Theory)**

Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Non ideal flow, RTD function, characteristics of RTD, Zero-parameter models, one-parameter models, two-parameter models

Unit 2: Heterogeneous catalysis: Diffusion with reaction in porous catalyst, Mechanism of catalytic reactions. Langmuir - Hinshelwood model, Rideal - Eiley Mechanism, Rate controlling steps**,** Development of rate equations for solid catalysed fluid phase reactions; External/internal mass and heat transfer resistances in catalyst particles, catalyst deactivation.

Unit 3: Heterogeneous Catalytic Reactors: Isothermal and adiabatic fixed bed reactors, Non-isothermal and non-adiabatic fixed bed reactors.

Unit 4: Introduction to multiphase reactor design, fluidized bed reactor, slurry reactor, Trickle bed reactor, Photocatalytic reactor, Sonochemical reactors

Unit 5: Theory of mass transfer with chemical reaction (regimes and examples), model contactors

Recommended Books:

1. H.S. Fogler, Elements of Chemical Reaction Engineering, Prentice – Hall, 1986.
2. O. Levenspeil, Chemical Reaction Engineering, 3rd Edition, Wiley, 1999.
3. J.M. Smith, Chemical Engineering Kinetics, McGraw-Hill, 1981.
4. G.F. Froment, K.B. Bischoff, Chemical Reactor Design and Analysis, Addision -Wesley, 1982.
5. L.K. Doraiswamy, M.M. Sharma, Heterogeneous Reactions vol. I and II, John Wiley & Sons Inc.
6. P.V. Danckwerts, Gas Liquid Reactions, McGraw-Hill Book Co., New York, 1970.

Subject **: PGCHE 104T** (BCHE) **Elective I- Process Design, Integration and Intensification (Theory)**

Lecture : 4 Hours No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction to chemical process design, integration and intensification. Hierarchy and approach of chemical process design and integration

Unit 2: Choice of reactors: Performance, conditions, configurations, heat integration of reactors etc.

Unit 3: Distillation sequencing: multicomponent, extractive, azeotropic distillation systems etc. with and without heat integration.

Unit 4: Heat exchanger networks: Energy Target and network design, trade-off & utilities, Heat & power integration.

Unit 5: Case studies on chemical process design, integration and intensification.

Recommended Books:

1. R. Smith, Chemical Process Design and Integration, John Wiley and Sons. Ltd., New Delhi, 2005.
2. J. Douglas, Conceptual Design of Chemical Processes. New York, NY: McGraw-Hill Science/Engineering/Math, 1988.
3. W. D. Seider, J. D. Seader, D. R. Lewin. Product and Process Design Principles: Synthesis, Analysis, and Evaluation. 2nd ed. New York, Wiley, 2004.
4. R. Turton, R. C. Bailie, W. B. Whiting, J. A. Shaeiwitz. Analysis, Synthesis, and Design of Chemical Processes, 2nd Edition, Prentice Hall, 2002.
5. L.T. Biegler, I.E. Grossmann, A.W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall, 1997.

Subject **: PGCHE 104T** (BCHE) **Elective I - Advanced Optimization Techniques (Theory)**

Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction to process optimization; formulation of various process optimization problems and their classification. Basic concepts of optimization-convex and concave functions, necessary and sufficient conditions for stationary points.

Unit 2: Optimization of one dimensional functions, unconstrained multivariable optimization direct search methods.

Unit 3: Indirect first order and second order method. Gradient-based methods

Unit 4: Constrained Optimization Algorithms: Kuhn-Tucker conditions, Transformation methods: Penalty function method, method of multipliers.

Unit 5: Multivariable Optimization Algorithms: Optimality criteria, Unidirectional search, direct search methods: Evolutionary optimization method, simplex search method, Powell's conjugate direction method. Gradient-based methods: Cauchy's (steepest descent) method, Newton's method.

Recommended Books:

1. S.S. Rao, Optimization Theory and Applications, Wiley Eastern Ltd., 1979.
2. T.F. Edgar, D.M. Himmelblau, optimization of chemical processes, McGraw Hill International editions, Chemical Engineering Series, 1989.
3. G.S. Beveridge, R.S. Schechter, Optimization theory and practice, McGraw Hill, New York, 1970.
4. G.V. Rekllitis, A. Ravindran, K.M. Ragdell, Engineering Optimization-Methods and Applications, John Wiley, New York, 1983.

Subject : **PGCHE 104T** (BCHE) **Elective I- Fluidization Engineering (Theory)**

Lecture : 4 Hours
No. of Credits : 4
University : 70 Marks
College Assessment : 30 Marks
Duration of Examination: 3 Hours

Unit 1: Introduction: Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode

Unit 2: Mapping of fluidization regimes: Characterization of particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption

Unit 3: Bubbles in dense bed: Davidson model for gas flow, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow. **Bubbling fluidized beds:** Emulsion movement, estimation of bed properties, bubble rise velocity, scale up aspects, flow models, two phase model, K-L model

Unit 4: Entrainment and elutriation: Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization. **Solids movement:** Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds. **Gas dispersion:** Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient

Unit 5: Design of fluidized bed reactors: Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts, Design of noncatalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size

Recommended Books:

1. O. Levenspiel, D. Kunnii, Fluidization Engineering, John Wiley, 1972.
2. Liang-Shih Fan, Gas-Liquid-Solid Fluidization Engineering, Butterworths, 1989.

Subject **: PGCHE 104T** (BCHE) **Elective I- Computational Fluid Dynamics (Theory)**

Lecture : 4 Hours No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Conservation Laws of Fluid Motion and Boundary Conditions: Governing equations of fluid flow and heat transfer, Equations of state, Navier-Stokes equations for a Newtonian fluid, Classification of physical behaviour, Classification of fluid flow equations, Auxiliary conditions for viscous fluid flow equations

Unit 2: Turbulence and its Modelling: Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model,The k-e model, Reynolds stress equation models, Algebraic stress equation models

Unit 3: The Finite Volume Method for Diffusion Problems: Introduction, one dimensional steady state diffusion, two-dimensional diffusion problems, three dimensional diffusion problems, discretised equations for diffusion problems

Unit 4: The Finite Volume Method for Convection-Diffusion Problems: Steady one dimensional convection and diffusion, The central differencing scheme, Properties of discretisation schemes-Conservativeness, Boundedness, Transportiveness, Assessment of the central differencing scheme for convection-diffusion problems, The upwind differencing scheme, The hybrid differencing scheme, The power-law scheme, Higher order differencing schemes for convection-diffusion, Quadratic upwind differencing scheme

Unit 5: The Finite Volume Method for Unsteady Flows and Implementation of Boundary Conditions: One-dimensional unsteady heat conduction, Discretisation of transient convection-diffusion equation, Solution procedures for unsteady flow calculations, Implementation of Inlet, outlet and wall boundary conditions, constant pressure boundary condition.

Recommended Books:

1. H. K. Versteeg, W. Malalasekera, An introduction to computational fluid dynamics: the finite volume method , Longman scientific & technical publishers, 2007
2. John D. Anderson, Computational fluid dynamics: The Basics with Applications McGraw-Hill, .New York, 1995.
3. Vivek V. Ranade, Computational flow modeling for chemical reactor engineering, Academic Press, San Diego, 2002

Subject : **PGOPEN 105T** (BCHE) **Elective II- Chemical Engineering Mathematics (Theory)**

Lecture : 4 Hours   No. of Credits : 4

University : 70 Marks   College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Algebraic Equations: Systems of linear equations – Jacabi, Gauss Seidel, Successive over Relaxation methods, Thomas algorithm for tridiagonal systems; Systems of non-linear equations –Successive approximation method, methods for improved convergence, Muller method, Chebyshev third order method, Newton method and its variants, Continuation methods for multiple solutions.

Unit 2: Ordinary Differential Equations: Runge Kutta methods, step size control and estimates of error, stability of the steady state of a linear system, solution of stiff ODEs, ODE-IVPs coupled with algebraic equations.

Unit 3: Ordinary Differential Equations (BVPs): Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method, stability analysis, shooting methods.

Unit 4: Partial Differential Equations – Finite Difference Method: Parabolic equations – Explicit and implicit methods – Alternating direction explicit and implicit methods; Chemical reaction and diffusion in a spherical catalyst pellet – Elliptic equations – Point iterative methods – Finite difference solution of a Poisson BVP – First order hypabolic equations – methods of characteristics – explicit and implicit methods – numerical stability analysis, method of lines.

Unit 5: Partial Differential Equations – Finite Element Method: Partial differential equations – Finite element method – Orthogonal collocation method, Orthogonal collocation with finite element method, Galerkin finite element method – Function approximation.

Recommended Books:

1. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
2. K. J. Beers, Numerical methods for Chemical Engineering, Cambridge University Press, New York, 2007.
3. S.K. Gupta, Numerical methods for Engineers, New age publishers 2003.
4. M.K. Jain. S.R.K. Iyengar, R.K. Jain, Numerical methods: Problems and solutions, Wiley Eastern Limited, 2008
5. M.K. Jain, S.R. Iyenkar, M.B. Kanchi, R.K. Jain, Computational methods for partial differential equations, New Age publishers, 2007.

Subject **: PGOPEN 105T** (BCHE) **Elective II- Modern Chemical Instrumentation (Theory)**

Lecture : 4 Hours No. of Credits : 4
University : 70 Marks College Assessment : 30 Marks
Duration of Examination: 3 Hours

Unit 1: UV & IR spectroscopy, basic principles of UV & IR, Microwave spectroscopy, radiation sources, monochromators, detectors, instrumentation & Application of qualitative & Quantitative chemical analysis, Raman spectroscopy, sample handling & illumination & applications

Unit 2: Atomic absorption & Atomic emission spectroscopy, flame & flame temperatures, instrumentation & Application, in chemical analysis, fluorescence & phosphoresce, spectrophotometry

Unit 3: Mass spectrometry, basic principles, commercial mass spectrometers, correlation of mass spectra with molecular structure for a few typical cases, application of mass spectral data

Unit 4 : NMR spectroscopy, NMR phenomena, principle & Instrumentation, chemical shift , its measurement, spin – spin coupling, spin – spin splitting, application of NMR in structural diagnosis & Quantitative analysis, electron spin resonance spectroscopy, principle & application in chemical analysis,

Unit 5: Gas chromatography, HPLC, GCMS, SEM, Basic principal of XRD & XRF techniques, Differential Thermal Analysis & Differential scanning calorimeter, thermogravimetry, thermometric titrimetry, electrogravimetry, colorometry, principles applications of colorometry, colorometric titration stripping analysis

Recommended Books:

1. V.M. Parikh, Absorption Spectroscopy of Organic Molecules, Addison - Wesley Publishing Company, 1974.
2. H.H. Willard, I.I. Merritt, J.A. Dean, F.A. Settle, Instrumental Methods of Analysis, Sixth edition, CBS publishers, 1986.
3. D.A. Skoog, D.M. West, Fundamentals of Analytical Chemistry, Saunders-College Publishing, 1982.
4. G.C. Banwell, Fundamentals of Molecular Spectroscopy, TMH, 1992.

Subject	**: PGCHE 106P** (BCHE)	**Modeling & Simulation of Chemical Processes (Practical)**	
Practical	: 4 Hours	No. of Credits	: 2
University	: 100 Marks	College Assessment	: 100 Marks

Modeling and Simulations should be performed based on but not limited to the following List of examples

1. Dynamics of a Stirred Tank Heater with variable Volume
2. Modeling and Dynamics of a Quadruple Tank System.
3. Decoupled SISO control of the Quadruple Tank System.
4. Multi-variable Control of the Quadruple Tank System.
5. Dynamic Matrix Control of the Stirred Tank System.
6. Experiment on Programmed Adaptive Control System
7. Experiment on Time-delay compensation (Smith-Predictor)
8. Experiment on Inverse Response compensation
9. Experiment on multiple outputs controlled by a single input
10. Experiment on a single output controlled by multiple input
11. Introduction to process simulators and CFD software- ASPEN PLUS, HYSYS.
12. Simulation of steady state and Dynamic processes using ASPEN PLUS
13. Simulation of a batch reactor, CSTR, Tubular Reactor, multiphase reactor systems
14. Simulation of a shell and tube heat exchanger
15. Simulation of a condenser
16. Simulation of a pump/compressor
17. Simulation of a fixed bed absorber
18. Simulation of a staged distillation column
19. Simulation of flow in channels and pipes
20. Simulation of flow in sudden expansion/contraction systems
21. Simulation of flow in a square cavity, cylindrical venturi, slit venturi and orifice plate.
22. Process simulation study (flow sheeting)- Production of hydrogen by stream reforming
23. Process simulation study (flow sheeting)- Production of vinyl chloride monomer flowsheet
24. Process simulation study (flow sheeting)- Production of nitric acid from anhydrous ammonia

For the simulation of the above Processes/Process Equipment using Computer Programs or Simulation Packages such as ASPEN PLUS/CHEMCAD/HYSYS (UNISIM)/gPROMS etc. can be used.

SECOND SEMESTER M. Tech Chemical Engineering

Subject	**: PGCHE 201T** (BCHE)	**Advanced Separation Processes (Theory)**	
Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Flux Definition, Differential Equations of Mass transfer, Molecular diffusivities, Molecular diffusion, Mass Transfer coefficients

Unit 2: Multicomponent distillation: Bubble point and dew point calculations, Lewis and Matheson calculation, Method of Thiele and Geddes; Azeotropic distillation; Extractive distillation; Molecular distillation; Reactive distillation

Unit 3: Azeotropic and extractive fractional distillation: Separation of homogeneous azeotropes, separation of heterogeneous azeotropes, quantitative treatment of separation of binary heterogeneous azeotropes, selection of addition agents, selectivity, factors affecting selectivity, methods for prediction, mechanism of relative volatility change, choice of entrainer or solvent, design of an azeotropic distillation process, design of an extractive distillation process, methods of solvent recovery

Unit 4: Membrane separation processes: Fundamentals, mechanism and equilibrium relationships, types and structure of membranes, membrane permeation of liquids and gases, effects of concentration, pressure and temperature, dialysis: mechanism, basic idea on dialyser design, industrial application, reverse osmosis, definitions and theory, design considerations, applications, ultra filtration.

Unit 5: Adsorption and Ion Exchange Processes: Adsorption and ion exchange equilibria. Various isotherms. Contact filtration, design of fixed bed adsorber including breakthrough curve.

Recommended Books:

1. R.E. Lacey, S. Loaeb, Industrial Processing with Membranes, Wiley –Inter Science, New York, 1972.
2. C.J. King, Separation Processes, Tata McGraw - Hill Publishing Co., Ltd., 1982.
3. C.J. Geankoplis, Transport Processes and Unit Operations, Prentice-Hall of India Pvt. Ltd., New Delhi, 2000.
4. R.E. Treybal, Mass-Transfer Operations, McGraw-Hill, New York, 1980.
5. J.D. Seader, E.J. Henley, Separation Process Principles, Wiley, 2011.
6. B.K. Dutta, Principles of Mass Transfer and Separation Processes, PHI, 2006
7. T.K. Sherwood, R.L. Pigford, C.R. Wilke, Mass Transfer, McGraw-Hill, New York, 1975.
8. H.M. Schoew, New Chemical Engineering Separation Techniques, Interscience Publishers, 1972.
9. Osadar, Varid Nakagawa, Membrance Science and Technology, Marcel Dekkar, 1992.

Subject : **PGCHE 202T** (BCHE) **Advanced Process Dynamics & Control (Theory)**

Lecture : 4 Hours No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Process Identification and Non-Linear Systems. Introduction and analysis of Non-liner control system. Phase plane analysis of second order control system, Analysis of critical points. Method of isoclines for non linear system.

Unit 2: Control of complex processes Process modeling and dynamic response of gas absorber, steam jacketed kettle, heat exchanger, distributed parameter model, non-interacting continuous stirred tank reactors, non-interacting stirred tank heaters.

Unit 3: Feedforward-feedback control configuration. Industrial examples of feedforward-feedback control of heat exchanger, jacketed continuous stirred tank reactor for exothermic and endothermic reactions, stirred tank heater, distillation column, drum boiler, level control, extraction column.

Unit 4: Industrial control system. Control configuration of Supervisory control and data acquisition SCADA, Working control components and network communication of SCADA. Industrial examples of SCADA. Control configuration of distributed control system DCS. Working of Programmable logic controller PLC. Real time monitoring control.

Unit 5: Programmed adaptive control, Gain programmed adaptive control. Reference model adaptive control, Inferential control. Industrial examples of adaptive and inferential control. Reaction curve method.

Recommended Books:

1. B. A. Ogunaike, W. H. Ray, Process Dynamics, Modeling and Control, Oxford University Press, NY, 1994
2. B. W. Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall International Series, 1998
3. D. E. Seborg, D. A. Mellichamp, T. F. Edgar, F. J. Doyle III, Process Dynamics and Control, 3rd Edition, Wiley.
4. G. Stephanopoulos, Chemical Process Control, Prentice-Hall, Englewood Cliffs, NJ, 1984
5. T. Marlin, Process Control, 2nd Edition, McGraw Hill Inc, US, 2000.
6. R.P. Vyas, Process control and Instrumentation, Seventh Edition, Denett& Co. publication, 2015.
7. R.P. Vyas, Measurement and Control, Denett& Co. Publication 2010.

Subject	**: PGCHE 203T** (BCHE)	**Advanced Biochemical Engineering (Theory)**	
Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Enzyme Kinetics: Models for complex enzyme kinetics, modeling of effect of pH and temperature, models for insoluble substrate, models for immobilized enzyme systems, diffusion limitations in immobilized enzyme system, electrostatic and steric effects.

Unit 2: Major metabolic pathways, bioenergetics, Glucose metabolism, metabolism of nitrogenous compounds, respiration, metabolism of hydrocarbons, anaerobic metabolism, autotrophic metabolism.

Unit 3: Bioreactors: Sterilization techniques, Modifications of batch and continuous reactors, chemostat with recycle, multistage chemostat, fed-batch operation, perfusion system, active and passive immobilization of cells, diffusional limitations in the immobilized system, fermenters.

Unit 4: Homogeneous and heterogeneous reactions in bioprocesses: Reaction thermodynamics, growth kinetics with Plasmid instability, The Thiele Modulus and effectiveness factor, diffusion and reaction in waste treatment lagoon. Reactors and choice of reactors.

Unit 5: Biological waste water treatment: Microbial participation in natural cycle of matter, activated sludge process, design and modeling of activated sludge process, Nitrification, anaerobic digestion, mathematical modeling of anaerobic digester, anaerobic denitrification, phosphate removal.

Recommended Books:

1) Michael L. Shuler, Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, 2001.
2) J. E. Bailey, D. F. Ollis, Biochemical Engineering Fundamentals, McGraw- Hill, 1986.
3) P. M. Doran, Bioprocess Engineering Principles, Academic Press, 2nd Edition, 2012.
4) J. M. Lee, Biochemical Engineering, Prentice Hall, Englewood Cliffs, New Jersey, 1992.

Subject **: PGCHE 204T** (BCHE) **Elective III- Energy Conservation & Planning (Theory)**

Lecture : 4 Hours No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Energy Outlook, Energy conservation and its importance, Energy intensive industries

Unit 2: Global industrial energy efficiency benchmarking, Engineering fundamentals related to energy efficiency

Unit 3: Principles on energy management, Energy Audit, Detailed thermodynamic analyses of common unit operations

Unit 4: Opportunities and techniques/methods for energy conservation in equipment and utility systems in process industries, Process synthesis, Thermo-economics, Energy Management Information Systems (EMIS).

Unit 5: Software tools for industrial energy efficiency and savings, Case studies on energy conservation and management in process industries

Recommended Books:

1. W.F. Kenney, Energy Conservation in the Process Industries. Academic Press Inc., 1984.
2. Vladimir S. Stepanov, Analysis of Energy Efficiency of Industrial Processes. 1st Edition, Springer-Verlag, 1993.
3. Jakob de Swaan Arons, Hedzer van der Kooi, Krishnan Sankaranarayanan, Efficiency and Sustainability in the Energy and Chemical Industries, 1st Edition, Marcel Dekker, Inc., 2004.

Subject **: PGCHE 204T** (BCHE) **Elective III- Artificial Neural Network and Evolutionary Algorithms (Theory)**

Lecture : 4 Hours No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Biological Neuron and neural network, McCulloch-Pitts Neuron, Thresholds logic unit (TLU), simple net with bias, Hebb craining algoritm

Unit 2: Feed forward error back propagation network, flow chart algorithm, topology, architecture, learning principals, applications to chemical process modeling, advantages , limitations.

Unit 3: Fuzzy logic: Introduction, examples, principal fuzzy logic controller applications including chemical processes

Unit 4: Evolutionary algorithm I: Genetic algorithm, natural genetics, advantages applications and algorithm.

Unit 5: Evolutionary algorithm II: Bee algorithm principle, flow chart, algorithm, chemical reactor optimization, swarm particle optimization, case based reasoning system

Recommended Books:

1. James A. Anderson, An introduction to neural networks, MIT Press, 1995.
2. S. L. Pandharipande, Artificial neural networks with free software CD, Dennet and Co. 2004.
3. S. N. Shivanandan, S. N. Deepa, Principles of soft computing, Wiley International, 2nd Edition, 2011.
4. Lan Cloete, J.M. Zurada, Knowledge based neuro computing, University Press (India) Ltd. 2002.

Subject	**: PGCHE 204T** (BCHE)	**Elective III- Multiphase Flow (Theory)**	
Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Two phase flow: Gas/Liquid and Liquid/liquid systems: Flow patterns in pipes, analysis of two phase flow situations

Unit 2: Prediction of holdup and pressure drop or volume fraction, Bubble size in pipe flow, Lockchart-Martinelli parameters, Bubble column and its design aspects, Minimum carryover velocity. holdup ratios, pressure drop and transport velocities and their prediction.

Unit 3: Flow patterns - identification and classification - flow pattern maps and transition - momentum and energy balance - homogeneous and separated flow models -correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two phase flow - drift flux model - correlations for bubble, slug and annular flows

Unit 4: Introduction to three phase flow, Dynamics of gas-solid liquid contactors (agitated vessels, packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds), Flow regimes, pressure drop, holdup, distributions, mass and heat transfer, reactions, Applications of these contactors

Unit 5: Measurement techniques in multiphase flow: Conventional and novel measurement techniques for multiphase systems (Laser Doppler anemometry, Particle Image Velocimetry)

Recommended Books:

1. R. Clift, M.E. Weber, J.R. Grace, Bubbles, Drops, and Particles, Academic Press, New York, 1978.
2. Y. T. Shah, Gas-Liquid-Solid reactors design, McGraw Hill Inc, 1979
3. L. S. Fan, C. Zhu, Principles of Gas-solid Flows, Cambridge University Press, 1998
4. G. W. Govier, K. Aziz, The Flow of Complex Mixture in Pipes, Van Nostrand Reinhold, New York, 1972.
5. G.B. Wallis, One Dimensional Two Phase Flow, McGraw Hill Book Co., New York, 1969.
6. C. T. Crowe, M. Sommerfeld, Y. Tsuji, Multiphase Flows with Droplets and Particles, CRC Press, 1998
7. C. Kleinstreuer, Two-phase Flow: Theory and Applications, Taylor & Francis, 2003
8. M. Rhodes, Introduction to Particle Technology, John Wiley & Sons, New York. 1998.

Subject : **PGCHE 204T** (BCHE) **Elective III- Fuel Cell Technology (Theory)**
Lecture : 4 Hours No. of Credits : 4
University : 70 Marks College Assessment : 30 Marks
Duration of Examination: 3 Hours

Unit 1: Hydrogen Production Methods Production: from fossil fuels, electrolysis, thermal decomposition, photochemical, photocatalytic, hybrid; Hydrogen Storage Methods Storage: Metal hydrides, Metallic alloy hydrides, Carbon nano-tubes; Sea as the source of Deuterium.

Introduction and overview of fuel cells technology: low and high temperature fuelcells.

Unit 2: Fuel cell thermodynamics. Fuel cell reaction kinetics: Introduction to electrode kinetics. Exchange current and electrocatalysis, Simplified activation kinetics, Catalyst electrode design. Fuel cell thermodynamics - second law analysis of fuel cells, efficiency of fuel cells fuel cell electrochemistry - Nernst equation, Electrochemical kinetics,Butler-Volmer equation

Unit 3: Fuel cell types Classification by operating temperature/electrolyte type, Fuel Cell Performance, Activation, Ohmic and Concentration over potential Fuel cell charge and mass transport. Fuel cell characterization.

Unit 4: Fuel cell modeling and system integration: Balance of plant.

Unit 5: Safety issues and cost expectation and life cycle analysis of fuel cells. Description of some commercially available fuel cell stacks, overview on research activities on fuel cells in world, Research and development related to fuel cell development in India

Recommended Books:

1. R.P. O'Hayre, S. Cha, W. Colella, F.B. Prinz, Fuel Cell Fundamentals, Wiley, NY, 2006.
2. A. J. Bard, L. R. Faulkner, Electrochemical Methods, Wiley, N.Y. 2004.
3. S.(Ed) Basu, Fuel Cell Science and Technology, Springer, N.Y. 2007.
4. H. Liu, Principles of fuel cells, Taylor & Francis, N.Y. 2006.

Subject **: PGFD 205T** (BCHE) **Research Methodology (Theory)**

Lecture	: 4 Hours	No. of Credits	: 4
University	: 80 Marks	College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit 1 Research Foundation

What is Research, Objectives of Research, Types of Research, Scientific Research, Research and Theory, Conceptual and theoretical Models, Importance of research methodology in scientific research

Unit 2 Review of Literature

Need for Reviewing Literature, What to Review and for what purpose, Literature Search Procedure, Sources of Literature, Planning of Review work, Note Taking, Library and documentation

Unit 3 Planning of Research

The planning process, Selection of a Problem for Research, Formulation of the Selected Problems, Hypothesis formation, Measurement, Research Design/Plan

Unit 4 Processing of Data and Statistical Analysis of Data

Introduction to Statistical Software, MINITAB, SPSS, Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, MATLAB and Neural Network based optimization, Optimization of fuzzy systems, Error Analysis, Results and their discussions

Unit 5 Report and Thesis writing

Types of Reports, Planning of Report Writing, Research Report Format, Principles of Writing, Data and Data Analysis Reporting in a Thesis, Use of Endnote, Bibliography, API , appendix, table, Observations arrangement, Preparation of type script and lay-out of thesis, Use of LATEX Indexing of Journals, Impact factor and social Media for Researchers.

Recommended Books:

1. Research Methodology: Methods and Techniques by C. R. Kothari, New Age International Publishers, ISBN:81-224-1522-9
2. Statistical Methods for Research Workers by Fisher R. A., Cosmo Publications, New Delhi ISBN:81-307-0128-6
3. Design and Analysis of Experiments by Montogomery D.C. (2001), John Wiley, ISBN: 0471260088
4. MINITAB online manual
5. Methodology of Research in Social Sciences by O. R. Krishnaswamy and M. Rangnatham Himalaya publication House, 2005, ISBN: 8184880936
6. SPSS online manual

THIRD SEMESTER M. Tech Chemical Engineering

Subject	**: PGOPEN 301T** (BCHE)	**Elective IV- Advanced Petroleum Refining (Theory)**	
Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: History and development of Refining, Composition of Petroleum, Refinery products and Test methods, Evaluation of Oil stocks, Physical properties of Petroleum Oil.

Unit 2: Introduction to Processing, Refinery and Distillation Process, Auxillary processes and operations, Refinary metals and Corrosion

Unit 3: Vaporization and Condensation, Fractionation and Towers

Unit 4: Heat transfer and Exchangers, Tube-still Heaters.

Unit 5: Thermal Cracking and Decomposition Processes, Rebuilding Hydrocarbons, Catalytic Cracking and Reforming, Natural and Refinery gases

References

1. W.L. Nelson, Petroleum Refinery Engineering, McGraw Hill Publishing Company Limited, 1958.
2. G.D. Hobson, Modern petroleum Refining Technology, 4th Edition, Institute of Petroleum U.K, 1973.
3. J.H. Gary, G.E. Handwerk, M. J. Kaiser, Petroleum Refining: Technology and Economics, Fifth Edition, CRC Press, 2007.

Subject	**: PGOPEN 301T** (BCHE)	**Elective IV- Nanotechnology (Theory)**	
Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: **Introduction to nanotechnology:** The nanoscale dimension and paradigm, definitions, history and current practice, Overview of current industry applications, Nanoscale science and engineering principles, Self-assembly of nano particles and nano structural molecular materials, Different structures anisotropic, asymmetric, symmetric particles, clay materials platelets structures, dendrimers, colloid structures

Unit 2: **Approach of synthesis of nanomaterials**: Methods of synthesis of nanomaterials Top down approach, Bottom up approaches, Bottom-up vs. top-down, Insitu Deposition Method, Colloidal Methods, Plasma Technique, Layer by Layer technique, Self-assembly, Nanotubes Carbon arc bulk synthesis in presence and absence of catalysts graphite, Chemical Vapor Deposition (CVD), Micro fluidics and Micro reactors Focus on emerging applications. Mini emulsion synthesis

Unit 3: **Instrumentation for nanoscale characterization**: Instrumentation required for characterization of properties on the nanometer scale. The measurable properties and resolution limits of each technique, with an emphasis on measurements in the nanometer range. Zeta Potential, XRD, TEM, SEM, XPS, DSC, Particle size distribution analysis methods and applications, Cryo TEM for material analysis. Contact angle, surface tension. Gel Permission Chromatography Atomic Force Microscopy, Focus on emerging applications.

Unit 4: **Properties of nanomaterials:** Mechanical properties: Strength of nano crystalline, Preparation for strength measurements, Mechanical properties, Magnetic properties, Electrical properties: electronic conduction with nano particles Optical properties: Optical properties. Polymer nanocomposites. Hiding powder improvement coating. New advancement reported in current literature. Population balance Quantum dots properties, dendrimer properties

Unit 5: **Applications of nanomaterials :** Catalysis : Using nanometal colloids as catalysts, Catalysts, Using, Other Types of Catalysts Made From Nanomaterials, Separations nanofiltration membranes, Magnetic Fluids - Processing Methods and Potential Applications Remediation : TiO_2 photocatalysis, disinfections, advance waste water treatments using metal oxides Drug delivery system, Introduction to industries which produces commercial nanomaterials.

Recommended Books:

1. G. Louis Hornyak, Joydeep Dutta, Harry F. Tibbals, Anil K. Rao, Introduction to Nano Science, CRC Press of Taylor and Francis Group LLC, 2008, 856pp, ISBN-13: 9781420048056
2. M. Di Ventra, S. Evoy, J. R. Heflin, Jr. (Eds.), Introduction to Nanoscale Science and Technology, Springer, 2004.
3. Ping Sheng, Zikang Tang, Nano science and technology: novel structures and phenomena, Taylor and Francis, 2003
4. Michael Rieth**,** Nano-Engineering in Science and Technology: An Introduction to the World of Nano design, World Scientific, 2003

5. R. Kelsall, I. Hamley, M. Geoghegan (Eds.), Nanoscale Science and Technology, Wiley, 2005.
6. C. P. Poole, Jr., F. J. Owens, Introduction to Nanotechnology, Wiley, 2003.
7. S. A. Campbell, The Science and Engineering of Microelectronic Fabrication, Oxford, 2001.

Subject : **PGFD 302T** (BCHE) **Project Planning and Management (Theory)**
Lecture : 4 Hours No. of Credits : 4
University : 70 Marks College Assessment : 30 Marks
Duration of Examination: 3 Hours

Unit 1 : ***Basics of Project Management:*** Introduction, Need for Project Management, Project Management Knowledge Areas and Processes, The Project Life Cycle, The Project Manager (PM), Phases of Project Management Life Cycle, Project Management Processes, Impact of Delays in Project Completions, Essentials of Project Management Philosophy, Project Management Principles

Unit 2 : ***Project Identification and Selection:*** Introduction, Project Identification Process, Project Initiation, Pre-Feasibility Study, Feasibility Studies, Project Break-even point
Project Planning: Introduction, Project Planning, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS)
Organisational Structure and Organisational Issues: Introduction, Concept of Organisational Structure, Roles and Responsibilities of Project Leader, Relationship between Project Manager and Line Manager, Leadership Styles for Project Managers, Conflict Resolution, Team

Unit 3: ***Resources Considerations in Projects:*** Introduction, Resource Allocation, Scheduling, Project Cost Estimate and Budgets, Cost Forecasts
Project Risk Management: Introduction, Risk, Risk Management, Role of Risk Management in Overall Project Management, Steps in Risk Management, Risk Identification, Risk Analysis, Reducing Risks

Unit 4: ***Project Quality Management and Value Engineering:*** Introduction, Quality, Quality Concepts, Value Engineering
Project Management Information System: Introduction, Project Management Information System (PMIS), Planning of PMIS, Design of PMIS
Purchasing and Contracting for Projects: Introduction, Purchase Cycle, Contract Management, Procurement Process

Unit 5: ***Project Performance Measurement and Evaluation:*** Introduction, Performance Measurement, Productivity, Project Performance Evaluation, Benefits and Challenges of Performance Measurement and Evaluation, Controlling the Projects
Project Execution and Control: Introduction, Project Execution, Project Control Process, Purpose of Project Execution and Control
Project Close-out, Termination and Follow-up: Introduction, Project Close-out, Steps for Closing the Project, Project Termination, Project Follow-up
Project Management Software: Introduction, Advantages of Using Project Management Software, Common Features Available In Most of the Project Management Software, Project 2000.

Reference Books:

1. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, by John W. Creswell, 2nd Edition , Sage Publication, 2003
2. Qualitative Inquiry and Research Design: Choosing among Five Approaches, by John W. Creswell, 3rd Edition, Sage publication, 2013.
3. Evaluation: A Systematic Approach, Peter H. Rossi, Mark W. Lipsey, and Howard E. Freeman, 7th edition , Sage publications, 2007.
4. Handbook of Practical Program Evaluation, Joseph S. Wholey, Harry P. Hatry, Kathryn E. Newcomer. 4th edition, Wiley, 2015
5. Program Evaluation and Performance Measurement: An Introduction to Practice, James C. McDavid and Laura R. L. Hawthorn, Sage Publication, 2013.
6. Evaluation, Carol H. Weiss, 2nd Edition, ABE books, 1997.
7. Case Study Research: Design and Methods, Robert K. Yin, 3rd Edition, Sage Publications, 2011

Subject	**: PGCHE 303P** (BCHE)	**Project Seminar**	
Practical	: 3 Hours	No. of Credits	: 8
University	: 100 Marks	College Assessment	: 100 Marks

Each student will undertake an independent project seminar. The student is required to select the topic in consultation with his/her Guide. Student should undertake project concerning Chemical Engineering applications such as design and development, experimental work, industry based problems, generation of new ideas and concept, modification in the existing process/system, development of computer programs, modelling and simulation etc. A preliminary work is to be carried out in this stage of the project. Two neatly typed copies of the Report on the completed work at this stage include comprehensive report on literature survey, design and fabrication of experimental set up and/or development of model, relevant computer programs and the plan for stage II should be submitted at end on the 3rd semester. University and college assessment would be made on the basis of the submitted report and the presentation cum viva-voce examination conducted by the board of examiners.

FOUTH SEMESTER M. Tech Chemical Engineering

Subject	**: PGCHE 303P** (BCHE)	**Project**	
Practical	: 6 Hours	No. of Credits	: 16
University	: 200 Marks	College Assessment	: 200 Marks

Project work undertaken in the 3rd semester will be continued and completed at the end of fourth semester. This stage will include comprehensive report on the work carried out at this stage and relevant portions from project seminar stage, including experimental studies, analysis and/or verification of theoretical model, conclusions. Two neatly typed and bound copies of the report consisting of project seminar stage of 3rd semester and project stage from 4th semester combined together along with its soft copy should be submitted at the end of fourth semester. The student are expected to publish at least one national/international paper based on the project work. The publication/accepted paper for publication shall be included in the report. University and college assessment would be made on the basis of the submitted report and the presentation cum viva-voce examination conducted by the board of examiners.

COURSE SCHEME
EXAMINATION SCHEME
ABSORPTION SCHEME
&
SYLLABUS

Of

First, Second, Third & Fourth Semester
Choice Base Credit System (CBCS)

Of
Master of Technology (M.Tech)

In
CHEMICAL TECHNOLOGY

Of
RASHTRASANT TUKDOJI MAHARAJ
NAGPUR UNIVERSITY, NAGPUR

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIRST SEMESTER M.TECH (C.B.C.S.) (FOOD TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 101T/1	Chemistry & Biochemistry of Food Components	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 102T/1	Food Product Development & Packaging	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 103T/1	Bioprocess Engineering	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 104T/1	Elective-I	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGOPEN 105T	Elective-II	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT 106P/1	Food Technology Practical	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective				
Elective-I (Discipline Specific)	1. Advances in Food Engineering	2. Molecular Biology	3. Advances in Nutrition	
Elective-II (Open)	1. Chemical Engineering Mathematics	2. Modern Chemical Instrumentation		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SECOND SEMESTER M.TECH (C.B.C.S.) (FOOD TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 201T/1	Advances in Food Science & Technology	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 202T/1	Food Biotechnology	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 203T/1	Food Safety & Food Regulations	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 204T/1	Elective III	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGFD205T	Research Methodology	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT206P	Seminar	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective	Subject Name			
Elective-III (Discipline Specific)	1. Food Industry Waste Management	2. Enzyme Technology		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
THIRD SEMESTER M.TECH (C.B.C.S.) (FOOD TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGOPEN 301T	Elective IV	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGFD 302T	Project Planning and Management	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 303P	*Project Seminar	-	3	-	3	-	8	-	8	-	-	100	100	200
Total			8	3	-	11	8	8	-	16	60	140	100	100	400

Elective-IV (Open)	1. Advanced Petroleum Refining	2. Nanotechnology		

*For Work Load: 2 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FOURTH SEMESTER M.TECH (C.B.C.S.) (FOOD TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 401P	*Project	-	6	-	6	-	16	-	16	-	-	200	200	400
Total			-	6	-	6	-	16	-	16	-	-	200	200	400

* For Work Load: 3 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIRST SEMESTER M.TECH (C.B.C.S.) (PETROCHEMICAL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 101T/2	Catalyst Science and Technology	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 102T/2	Petroleum Refinery Engineering	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 103T/2	Petrochemical Process Design	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 104T/2	Elective-I	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGOPEN 105T	Elective-II	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT 106P/2	Process Simulation Laboratory	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective				
Elective-I (Discipline Specific)	1. Oil & Natural Gas Processing	2. Modelling & Simulation in Chemical Engineering	3. Advanced Transport Phenomena	4. Advanced Thermodynamics
Elective-II (Open)	1. Chemical Engineering Mathematics	2. Modern Chemical Instrumentation		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SECOND SEMESTER M.TECH (C.B.C.S.) (PETROCHEMICAL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 201T/2	Multicomponent Distillation	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 202T/2	Process Equipment and Piping Design	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 203T/2	Petroleum Specialty Products	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 204T/2	Elective III	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGFD205T	Research Methodology	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT206P	Seminar	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective	Subject Name			
Elective-III (Discipline Specific)	1. Advanced Separation Processes	2. Advanced Process Dynamics & Control	3. Advanced Chemical Reaction Engineering	4. Environment, Health and Safety in Industries

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
THIRD SEMESTER M.TECH (C.B.C.S.) (PETROCHEMICAL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGOPEN 301T	Elective IV	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGFD 302T	Project Planning and Management	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 303P	*Project Seminar	-	3	-	3	-	8	-	8	-	-	100	100	200
Total			8	3	-	11	8	8	-	16	60	140	100	100	400

Elective-IV (Open)	1. Advanced Petroleum Refining	2. Nanotechnology		

*For Work Load: 2 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FOURTH SEMESTER M.TECH (C.B.C.S.) (PETROCHEMICAL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 401P	*Project	-	6	-	6	-	16	-	16	-	-	200	200	400
Total			-	6	-	6	-	16	-	16	-	-	200	200	400

* For Work Load: 3 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIRST SEMESTER M.TECH (C.B.C.S.) (OIL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 101T/3	Advanced Oil Chemistry and Oleochemicals	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 102T/3	Advanced Quality Control Techniques	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 103T/3	Technology of Expression, Extraction and Refining of Oil Bearing Materials	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 104T/3	Elective-I	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGOPEN 105T	Elective-II	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT 106P/3	Oil Technology Practical	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective				
Elective-I (Discipline Specific)	1. Technological Advancement in Oleochemicals	2. Process Economics, Utilities and Byproducts of Oil Industry		
Elective-II (Open)	1. Chemical Engineering Mathematics	2. Modern Chemical Instrumentation		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SECOND SEMESTER M.TECH (C.B.C.S.) (OIL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 201T/3	Technology of Soaps, Detergents & Surfactants	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 202T/3	Technological Advancement of Cosmetics and Allied Products	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 203T/3	Modification of Oil and Fat Products including Surface Coatings	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 204T/3	Elective III	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGFD205T	Research Methodology	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT206P	Seminar	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective	Subject Name			
Elective-III (Discipline Specific)	1. Environmental Aspects of Oil and Allied Industries	2. Polymeric Surfactants		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
THIRD SEMESTER M.TECH (C.B.C.S.) (OIL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGOPEN 301T	Elective IV	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGFD 302T	Project Planning and Management	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 303P	*Project Seminar	-	3	-	3	-	8	-	8	-	-	100	100	200
Total			8	3	-	11	8	8	-	16	60	140	100	100	400

Elective-IV (Open)	1. Advanced Petroleum Refining	2. Nanotechnology		

*For Work Load: 2 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FOURTH SEMESTER M.TECH (C.B.C.S.) (OIL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 401P	*Project	-	6	-	6	-	16	-	16	-	-	200	200	400
Total			-	6	-	6	-	16	-	16	-	-	200	200	400

* For Work Load: 3 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIRST SEMESTER M.TECH (C.B.C.S.) (PAINT TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 101T/4	Chemistry of Film Forming Materials & Polymerization Techniques	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 102T/4	Technology of Pigment Extenders and Additives	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 103T/4	Principle and Formulation of Surface Coatings	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 104T/4	Elective-I	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGOPEN 105T	Elective-II	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT 106P/4	Paint Technology Practical	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective				
Elective-I (Discipline Specific)	1. Automotive and Coil Coatings	2. Technology of Cosmetics and Polishes	3. Bio-Polymers in Coatings	
Elective-II (Open)	1. Chemical Engineering Mathematics	2. Modern Chemical Instrumentation		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SECOND SEMESTER M.TECH (C.B.C.S.) (PAINT TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 201T/4	Manufacturing Methods, machinery & Planning	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 202T/4	Processing, Application & Technology of Inks	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 203T/4	Application, Evaluation of Surface Coating & Industrial Waste Treatment	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 204T/4	Elective III	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGFD205T	Research Methodology	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT206P	Seminar	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective	Subject Name			
Elective-III (Discipline Specific)	1. Functional Coatings (Super Hydrophobic and Self Healing Coatings)	2. Chemistry and Technology of Nano-Pigments		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
THIRD SEMESTER M.TECH (C.B.C.S.) (PAINT TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGOPEN 301T	Elective IV	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGFD 302T	Project Planning and Management	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 303P	*Project Seminar	-	3	-	3	-	8	-	8	-	-	100	100	200
Total			8	3	-	11	8	8	-	16	60	140	100	100	400

Elective-IV (Open)	1. Advanced Petroleum Refining	2. Nanotechnology		

*For Work Load: 2 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FOURTH SEMESTER M.TECH (C.B.C.S.) (PAINT TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 401P	*Project	-	6	-	6	-	16	-	16	-	-	200	200	400
Total			-	6	-	6	-	16	-	16	-	-	200	200	400

* For Work Load: 3 Hours/week/faculty

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Food Technology) FIRST SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT1.03-4	Special Technology I (Biochemistry and Analysis of Food Components)	Theory		PGCHT 101T/1	Chemistry & Biochemistry of Food Components	Theory
2.	CT 1.04-4	Special Technology II (Molecular Biology)	Theory		PGCHT 104T/1	Elective-I (Molecular Biology)	Theory
3.	CT 1.05-4	Special Technology III (Bioprocess Engineering)	Theory		PGCHT 103T/1	Bioprocess Engineering	Theory
4.	----	----	----				Theory
5.	CT1.01	Modern Chemical Instrumentation	Theory		PGOPEN 105T	Elective-II(Modern Chemical Instrumentation)	Theory
6.	----	----	----		*PGCHT 106P/1	Food Technology Practical	Practical
7.	CE 1.02	Science and Technology of Materials	Theory		----	----	----

*Subject is covered in Second Semester for Old Pattern according to subject CT 2.06. They may be exempted.

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Food Technology) SECOND SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT2.03-4	Special Technology IV (Modern Trends in Food Science and Technology)	Theory		PGCHT 201T/1	Advances in Food Science & Technology	Theory
2.	CT2.04-4	Special Technology V (Food Biotechnology)	Theory		PGCHT 202T/1	Food Biotechnology	Theory
3.	CT2.05-4	Special Technology VI (Biotechnology Applications)	Theory		PGCHT 204T/1	Elective III (Food Industry Waste Management)	Theory
4.	----	----	----				Theory
5.	----	----	----		PGFD205T	Research Methodology	Theory
6.	----	----	----		PGCHT206P	Seminar	Practical
7.	CT2.01	Industrial Fermentations	Theory		----	----	----
8.	CE2.02	Environmental Engineering	Theory		----	----	----
9.	CT 2.06	Practical: Food Technology	Practical		----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Food Technology) THIRD SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	----	----	----		PGOPEN 301T	Elective IV	Theory
2.	----	----	----		PGFD 302T	Project Planning and Management	Theory
3.	----	----	----		PGCHT 303P	Project Seminar	Practical
4.	CT3.01	Seminar	Practical		----	----	----
5.	CT3.02	Training Report/Minor Project/Home Assignment	Practical		----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Food Technology) FOURTH SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT 4.01	Project and Viva-voce	Practical		PGCHT 401P	Project	Practical

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Petrochemical Technology) FIRST SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT1.03-3	Special Technology-I (Science & Technology of Polymerisation)	Theory		PGCHT 101T/2	Catalyst Science and Technology	Theory
2.	CT1.04-3	Special Technology II (Natural gas technology)	Theory		PGCHT 104T/2	Elective I (Oil & Natural Gas Processing)	Theory
3.	CT1.05-3	Special Technology III (Lubricant waxes and Petroleum Special Product)	Theory		PGCHT 103T/2	Petroleum Specialty Products	Theory
4.	----	----	----		PGCHT 104T/2	Elective-I	Theory
5.	CT 1.01	Modern Chemical Instrumentation	Theory		PGOPEN 105T	Elective-II (Modern Chemical Instrumentation)	Theory
6.	----	----	----		*PGCHT 106P/2	Process Simulation Laboratory	Practical
7.	CE 1.02	Science and Technology of Materials	Theory		----	----	----

*Subject is covered in Second Semester for Old Pattern according to subject CT 2.06. They may be exempted.

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Petrochemical Technology)
SECOND SEMESTER

As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT2.03-3	Special Technology IV (Project Engineering of Petroleum and Petrochemical Plants)	Theory	PGCHT 201T/2	Process Equipment and Piping Design	Theory
2.	CT2.04-3	Special Technology V (Petroleum Refinery Processing)	Theory	PGCHT 202T/2	Multi Component Distillation	Theory
3.	CT2.05-3	Special Technology VI (Petrochemical Process Engineering)	Theory	PGCHT 203T/2	Petrochemical Process Design	Theory
4.	----	----	----	PGCHT 204T/2	Elective III	Theory
5.	----	----	----	PGFD205T	Research Methodology	Theory
6.				PGCHT206P	Seminar	Practical
7.	CT2.01	Biotechnology	Theory	----	----	----
8.	CE2.02	Environmental Engineering	Theory	----	----	----
9.	CT 2.06	Practical: Petrochemical Technology	Practical	----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Petrochemical Technology) THIRD SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	----	----	----		PGOPEN 301T	Elective IV	Theory
2.	----	----	----		PGFD 302T	Project Planning and Management	Theory
3.	----	----	----		PGCHT 303P	*Project Seminar	Practical
4.	CT3.01	Seminar	Practical		----	----	----
5.	CT3.02	Training Report /Minor Project/Home Assignment	Practical		----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Petrochemical Technology) FOURTH SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT 4.01	Project and Viva-voce	Practical		PGCHT 401P	Project	Practical

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Oil Technology) FIRST SEMESTER						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT1.03-1	Special Technology I (Chemistry and Biochemistry of lipids and fatty materials)	Theory	PGCHT 101T/3	Advanced Oil Chemistry and Oleochemicals	Theory
2.	CT1.04-1	Special Technology II (Analytical Techniques and Quality Control)	Theory	PGCHT 102T/3	Advanced Quality Control Techniques	Theory
3.	CT1.05-1	Special Technology III (Technology of oil bearing materials and processing of oils)	Theory	PGCHT 103T/3	Technology of Expression, Extraction and Refining of Oil Bearing Materials	Theory
4.	----	----	----	PGCHT 104T/3	Elective-I	Theory
5.	CT 1.01	Modern Chemical Instrumentation	Theory	PGOPEN 105T	Elective-II(Modern Chemical Instrumentation)	Theory
6.	----	----	----	*PGCHT 106P/3	Oil Technology Practical	Practical
7.	CE 1.02	Science and Technology of Materials	Theory	----	----	----

*Subject is covered in Second Semester for Old Pattern according to subject CT 2.06. They may be exempted.

<table>
<tr><th colspan="9">Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Oil Technology)
SECOND SEMESTER</th></tr>
<tr><th colspan="4">As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)</th><th></th><th colspan="4">As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme</th></tr>
<tr><th>Sr. No.</th><th>Sub. Code Theory/ Practical</th><th>Subject</th><th>Theory/ Practical</th><th></th><th>Sub. Code Theory/ Practical</th><th>Subject</th><th>Theory/ Practical</th></tr>
<tr><td>1.</td><td>CT2.03-1</td><td>Special Technology IV (Technology of Soaps, detergents and Surfactants)</td><td>Theory</td><td></td><td>PGCHT 201T/3</td><td>Technology of Soaps, Detergents & Surfactants</td><td>Theory</td></tr>
<tr><td>2.</td><td>CT2.04-1</td><td>Special Technology V (Technology of Cosmetics and allied products)</td><td>Theory</td><td></td><td>PGCHT 202T/3</td><td>Technological Advancement of Cosmetics and Allied Products</td><td>Theory</td></tr>
<tr><td>3.</td><td>CT2.05-1</td><td>Special Technology VI (Technology of Miscellaneous Oil and Fat Products, including Surface Coatings)</td><td>Theory</td><td></td><td>PGCHT 203T/3</td><td>Modification of Oil and Fat Products including Surface Coatings</td><td>Theory</td></tr>
<tr><td>4.</td><td>----</td><td>----</td><td>----</td><td></td><td>PGCHT 204T/3</td><td>Elective III</td><td>Theory</td></tr>
<tr><td>5.</td><td>----</td><td>----</td><td>----</td><td></td><td>PGFD205T</td><td>Research Methodology</td><td>Theory</td></tr>
<tr><td>6.</td><td>----</td><td>----</td><td>----</td><td></td><td>PGCHT206P</td><td>Seminar</td><td>Practical</td></tr>
<tr><td>7.</td><td>CT2.01</td><td>Biotechnology</td><td>Theory</td><td></td><td>----</td><td>----</td><td>----</td></tr>
<tr><td>8.</td><td>CE2.02</td><td>Environmental Engineering</td><td>Theory</td><td></td><td>----</td><td>----</td><td>----</td></tr>
<tr><td>9.</td><td>CT 2.06</td><td>Oil Technology : Practical</td><td>Practical</td><td></td><td>----</td><td>----</td><td>----</td></tr>
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Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Oil Technology) THIRD SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	----	----	----		PGOPEN 301T	Elective IV	Theory
2.	----	----	----		PGFD 302T	Project Planning and Management	Theory
3.	----	----	----		PGCHT 303P	*Project Seminar	Practical
4.	CT3.01	Seminar	Practical		----	----	----
5.	CT3.02	Training Report /Minor Project/Home Assignment	Practical		----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Oil Technology) FOURTH SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT 4.01	Project and Viva-voce	Practical		PGCHT 401P	Project	Practical

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Paint Technology) FIRST SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT1.03-2	Special Technology I (Chemistry of film forming materials and polymerization techniques)	Theory		PGCHT 101T/4	Chemistry of Film Forming Materials & Polymerization Techniques	Theory
2.	CT1.04-2	Special Technology II (Technology of pigments extenders and additives)	Theory		PGCHT 102T/4	Technology of Pigment Extenders and Additives	Theory
3.	CT1.05-2	Special Technology III (Principles of formulations of surface coatings)	Theory		PGCHT 103T/4	Principle and Formulation of Surface Coatings	Theory
4.	----	----	----		PGCHT 104T/4	Elective-I	Theory
5.	CE 1.01	Modern Chemical Instrumentation	Theory		PGOPEN 105T	Elective-II	Theory
6.	----	----	----		*PGCHT 106P/4	Paint Technology Practical	Practical
7.	CE 1.02	Science and Technology of Materials	Theory		----	----	----

*Subject is covered in Second Semester for Old Pattern according to subject CT 2.06. They may be exempted.

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Paint Technology) SECOND SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT2.03-2	Special Technology IV (Manufacturing methods, machinery and planning)	Theory		PGCHT 201T/4	Manufacturing Methods, machinery & Planning	Theory
2.	CT2.04-2	Special Technology - V (Processing applications and Technology of inks)	Theory		PGCHT 202T/4	Processing, Application & Technology of Inks	Theory
3.	CT2.05-2	Special Technology - VI (Application, evaluation of surface coatings and industrial waste treatment)	Theory		PGCHT 203T/4	Application, Evaluation of Surface Coating & Industrial Waste Treatment	Theory
4.	----	----	----		PGCHT 204T/4	Elective III	Theory
5.	----	----	----		PGFD205T	Research Methodology	Theory
6.	CT2.01	Biotechnology	Theory		PGCHT206P	Seminar	Practical
7.	CE2.02	Environmental Engineering	Theory		----	----	----
8.	CT 2.06	Practical : Paint Technology	Practical		----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Paint Technology) THIRD SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	----	----	----		PGOPEN 301T	Elective IV	Theory
2.	----	----	----		PGFD 302T	Project Planning and Management	Theory
3.	----	----	----		PGCHT 303P	*Project Seminar	Practical
4.	CT3.01	Seminar	Practical		----	----	----
5.	CT3.02	Training Report /Minor Project/Home Assignment	Practical		----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Paint Technology) FOURTH SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT 4.01	Project and Viva-voce	Practical		PGCHT 401P	Project	Practical

SYLLABUS FOR FIRST SEMESTER M. TECH. (C.B.C.S.)

PGCHT101T/1 **Credit: 4**

Chemistry and Biochemistry of Food Components

Unit 1: Chemistry of carbohydrates, fats and proteins. Colloidal properties of foods. Browning Reaction

Unit 2: Structure and Composition of Plant tissues. Physiology of plant tissues. Post harvest biochemical changes of fruits & vegetables. Transpiration and respiration of plant tissues. Changes during ripening of climacteric and non climacteric fruits. Controlled Atmospheric and Modified Atmospheric storage. Post harvest management of fruits & vegetables. Natural plant pigments. Effect of processing on plant pigments.

Unit 3: Structure and composition of animal muscle tissues. Biochemical changes in animal muscle. Conversion of animal muscle tissue into meat. Rigor mortice. Post mortem biochemical changes in animal muscle. Preservation techniques. Effect of cooking & processing. Tenderness in meat.

Unit 4: Natural and developed toxins in foods of plant and animal origin. Types of food additives and their role in food products. Non nutritive sweeteners. Intentional and non intentional food additives,

Unit 5: Assessment of food safety. Modern methods of food analysis such as spectrophotometry, chromatography, electrophoresis, Immuno assay techniques, Biosensors, etc.

PGCHT 101T/2 **Credit: 4**

Catalyst Science and Technology

Unit 1: Heterogeneous Catalytic Processes, Types of Heterogeneous Reactions, Absorption, Absorption Isotherms, Rates of Absorption, Physisorption and Chemisorptions.

Unit 2: Solid Catalysis, Types of Catalysts, Catalyst Formulations and Preparation Methods, Catalysts Characterization Methods: Surface Area and Pore Volume Determinations, XRD, Various Spectroscopic Techniques, Temperature Programmed Reduction & Oxidation, Electron Microscopy.

Unit 3: Testing of Catalysts, Various Types of Reactors, Activity and Selectivity Studies, Effect of External Transport Processes on observed rate of reactions.

Unit 4: Effect of Internal Transport Processes: Reactions and Diffusion in Porous Catalysts, Mechanism of Catalytic Reactions, Rates of Adsorption, Desorption, Surface Reactions, Rate Determining Steps.

Unit 5: Kinetic Modelling and Parameter Estimations, Model Discriminations, Catalysts Promoters, Inhibitors, Catalyst Deactivations, Kinetics of Catalyst Deactivations.

Unit 6: Industrial Processes involving Heterogeneous Solid Catalysts, New Development in Solid Catalysis, Monolith Catalysts , Nano-catalysts, Fuel Cell Catalysts, Environmental Catalysts, Insitu Characterization, Design of Catalysts ; Simulation Techniques.

References:

1. G. Ertl, H. Knozinger and J. Weitkamp, "Handbook of Heterogeneous Catalysis" Vol 1-5, Wiley - VCH.
2. B. Viswanathan, S. Sivasanker , A.V. Ramaswamy, "Catalysis : Principles & Applications" CRC Press.
3. J. M. Smith, "Chemical Engineering Kinetics" McGraw-Hill Book Company.
4. J. M. Thomas and W. J. Thomas, "Principles and Practice of Heterogeneous Catalysis", Wiley-VCH.
5. H. S. Fogler, "Elements of Chemical reaction engineering" Prentice – Hall of India.
6. J.J. Carberry , "Chemical and catalytic reaction Engineering", Dover Publications.
7. C. H. Bartholomew and R. J. Farrauto "Fundamentals of Industrial catalytic Processes", Wiley-VCH.

PGCHT 101T/3 **Credit: 4**

ADVANCED OIL CHEMISTRY AND OLEO CHEMICALS

Unit-1 Natural sources of fats and oils, their geographic distribution. Fatty acid and triglyceride composition of fats, its types, nomenclature, structure. Theories of tri glyceride composition. Classification of fat, various types of classification and their basis, constituent of fats and fatty acids

Unit-2 Mechanism related to chemical and biochemical reactions of fats and fatty acids; Hydrolysis, Acidolysis, Saponification, Esterification, Inter-esterification, Trans-esterification, Isomerisation, polymerization, Hydrogenation, Dehydration, Pyrolysis and Oxidation. Polymorphism of fats and fatty acids. Chemical synthesis of fatty acids and their derivatives

Unit-3 Elementary chemical analytical constants of oils and fats like Acid value, Iodine value, Acetyl Value, Hydroxyl value, Ester value, HBr Value, Peroxide value, RM, Krischner and Polenske values. Elementary physical analytical constants of oils and fats like Refractive index, specific gravity, titer, smoke point, flash point, Cloud Point.

Unit-4 Non glyceride components of oils & fats phospholipids, glycol lipids, neutral lipids, sterols, etc. Toxic constituents & Detoxification Biosynthesis of oils & fatty acids. Role of fat in human metabolism. Nutritional functions of fats and oils

Unit-5 Fatty acids, distillation, crystallization, Fractionation, High purity fatty acid products blend distillation.

Reference Book

1. The Chemical Constitution of Natural Fats, Hilditch T.P., Chapman and Hall Ltd., London.
2. Fatty acids: Their chemistry, properties, production, and uses, Markley K.S., Interscience Publishers, New York

3. An introduction to the chemistry and biochemistry of fatty acids and their triglycerides, Gunstone F.D.. Chapman & Hall Ltd., London.
4. Bailey's Industrial Oil and Fat Products, 6th Edition, Wiley-Interscience Publication, New York .
5. The Analysis of Fats and Oils, Mehlenbacher, V. C., The Garrard Press, Champaign, Illinois.
6. AOCS Official and Tentative Methods for Analysis of Oils and fats, Vol. 1and 2,, Third Edition, AOCS, Champaign IL,USA.
7. Modern Technology Of Oils, Fats & Its Derivatives,National Institute of Industrial Research, New Delhi.

PGCHT 101T/4 **Credit: 4**
Chemistry of film forming materials and polymerization techniques

Unit 1: Natural Resins and Chemistry of drying oils

Natural resins, Composition of major natural resins: Rosin, Copals, Shellac, Damar, etc. used in coatings, Recovery and purification, Modification of natural resins. Applications of natural resins in coatings.

Drying oils and their modificationsModifications of drying and semidrying oils for surface coatings. Synthetic drying oils

Unit 2: Synthetic Resins-I Chemistry and Technology of synthetic resins: Alkyd resins, Polyester, Amino resins, Phenolic resins and Polyamide resins. Recent trends in the alkyd, polyester, amino, phenolic and polyamide resins technology.

Unit 3: Synthetic Resins-II

Chemistry and Technology of synthetic resins: Epoxy resins, polyurethane resins, silicone resins, Recent trends in the epoxy resin, polyurethane resins. Modification of epoxy resins. Inorganic binders.

Unit 4: Synthetic Resins-III Techniques of polymerization, manufacture of film forming materials such as acrylic and vinyl resins for use in surface coating. Cellulose and rubber derivatives for coatings.

Unit:5: Development and evaluations of binders:Recent developments in the formulation of vehicles, Evaluation of film forming materials for surface coating.

PGCHT102T/1 **Credit: 4**
Food product Development and Packaging

Unit 1: Concept of new product development, principles of product development, product development strategic orientation, process tools for NPD, product planning, PD process flow, protecting new product, new product failure and considerations during NPD. Acceptance sampling: operational characteristics, risks, attribute sampling plans, administration of attribute sampling plans, sampling error; Physical, chemical and rheological properties of food; Principles of analysis of various food constituents and subsequent changes on packaging;

Unit 2: Sensory attributes of foods: mechanisms of sensation and perception of colour, taste, odour, and flavour; importance and use of sensory evaluation methods; facilities required for sensory evaluation; selection of trained panelists: type of panelists suitable for different tasks and methods; conditions for sensory analysis: room, serving and preparation of samples; application of consumer tests;

Unit 3: affective and analytical methods: discrimination methods, preference and ranking; rating with use of scales, magnitude determination, sensory profiling, flavour profile; descriptive analysis: Quantitative

Descriptive Analysis and Spectrum techniques; texture profile; control of factors affecting accuracy and precision of sensory data; analysis of sensory data; statistical testing; correlating instrumental and sensory measurements.

Unit 4: Packaging as a method for conservation of foods Packaging materials and their physico-chemical characteristics Evaluation of quality of packaging materials; Package design; Test procedures for packages; Cushioning materials; Selection of packaging materials

Unit 5: package design for food products; Prepackaging. Packaging materials for newer techniques like radiation processing, microwave and radiowave processing, high pressure processing, modified atmosphere and thermal processing as retortable pouches; Biodegradable packaging, Edible packaging, smart packaging.

Reference Books:

A. V. Sathe, *A First Course in Food Analysis*, New Age International Pvt. Ltd. 1999

S. S. Nielsen, *Food Analysis, 3rd ed*., Kluwer Academic Publishers, 2003

S. S. Nielsen, *Food Analysis Laboratory Manual*, Kluwer Academic Publishers, 2003

R.Wood, L.Foster, A.Damant and P.Key, *Analytical Methods for Food Additives*, Woodhead Publishing, 2004

Y. Pomeranz and C.E.Meloan, *Food Analysis: Theory and Practice*, *3rd ed*., Chapman & Hall, 1994

AOAC, *Official Methods of Analysis and AOAC International*, 2005

R.E.Wrolstad, T.E. Acree, E.A.Decker, M.H.Penner and D.S.Reid, *Handbook of Food Analytical Chemistry*, John Wiley & Sons, 2004

Modern food packaging, Indian Institute of Packaging, 1998

Profile on food packaging/C.F.T.R.I and Indian Institute of packaging, 1995.

Food packaging and preservation by M.Malthlouthi, 1994

Food and Packaging Interactions by Risch.S.H. 1991

Handbook of Food Packaging by F.A. Paine and H.Y. Paine 1983

Food Packaging Technology (Vol.1 & 2) by G. Bureau and J.L.Multon, 1996

PGCHT 102T/2 **Credit: 4**

Petroleum Refinery Engineering

Unit 1: History and development of Refining, Composition of Petroleum, Refinery products and Test methods, Evaluation of Oil stocks, Physical properties of Petroleum Oil.

Unit 2: Introduction to Processing, Refinery and Distillation Process, Auxillary processes and operations, Refinary metals and Corrosion

Unit 3: Vaporization and Condensation, Fractionation and Towers;

Unit 4: Heat transfer and Exchangers, Tube-still Heaters.

Unit 5: Thermal Cracking and Decomposition Processes, Rebuilding Hydrocarbons.

Unit 6: Catalytic Cracking and Reforming, Natural and Refinery gases

References

1. Nelson, W.L “Petroleum Refinery Engineering” McGraw Hill Publishing Company Limited.
2. Hobson, G.D. – Modern petroleum Refining Technology, 4th Edition, Institute of Petroleum U.K.
3. J.H. Gary And G.E. Handwerk " Petrolem Refinery Technologies And Economics ".

PGCHT 102T/3 **Credit: 4**

ADVANCED QUALITY CONTROL TECHNIQUES

Unit -1: Importance of Quality control, Techniques of separation of glyceride and fatty acids: Liquid – liquid extraction; fractional distillation; low temperature crystallization. Testing of DOC and Oil beyond conventional testing for export. Detection of adulteration in oils and fats

Unit -2

Chromatography: History, theoretical developments and various techniques e.g., thin layer chromatography,, gas-liquid chromatography, HPLC and Super critical Chromatography; their principles, practices and applications to the analysis of oils and allied products. Application of chromatographic techniques in the quality control and quality assurance of oils, fats and products

Unit –3

Spectral methods of application; Ultra-violet, visible, infrared infra red spectroscopy techniques: principles, practices and application to the analysis of oils and allied products. Nuclear magnetic resonance spectroscopy: principle, analysis of spectra and quantitative applications.

Unit –4

Special quality control methods like iron, sulphur and phosphatide content of crude and refined vegetable oils; wax content of vegetable oils; amino acid analysis by chemical and instrumental methods.

Unit –5

Lipase hydrolysis, Dilatometry measurements and their significance, Determination of color and viscosity of oils and fats, solid fat index of oils and fats. Essential Fatty acids and Trans fats.

Reference Books:

1. Fatty acids; Their chemistry, properties, production and uses Part – III Edited by K.S. Markley
2. Principles of Instrumentation analysis, Edition- III (1985) Edited by Douglas A. Skog
3. Sharma Y.R. Vig O.P., “Elementary Organic spectroscopy” S. Chand & Company Ltd, 1994, P. No. 63-127, 133-199.
4. Silverstein R. M., Webster F.X., “Spectroscopc identfication of organic compound”, 6^{th} edition to John Willey & sons, Inc, New York, 1998, P. No. 71-143, 217-250.
5. Puri B.R, Sharma I.R, “Principles of physical chemistry”, S. Chand & co. New Delhi, 1997.

PGCHT 102T/4 **Credit: 4**

Technology of Pigments, Extenders and Additives

Unit I1: General properties of pigments, Classification of pigments, extender, lakes and toners. General methods of manufacture of pigments. General properties of pigments and extenders. Metal pigments and metallic stearates: Composition, manufacture, properties and applications. Extenders: Composition and properties, occurrence and manufacture of extenders.

Unit 2: White and black Pigments

White pigments, composition and comparison of properties, occurrence and manufacture of white pigments.Black pigments, comparison of various black pigments and their composition.

Unit 3: Coloured Pigments:

Coloured inorganic pigments, comparison of properties and their composition, methods of manufacture of red, organic, yellow, green and blue pigments.

Unit 4: Organic Pigments:

Organic pigments, methods of manufacture, important class and properties of organic pigments, production of lakes and toners.

Unit 5: Specialty pigments, additives and solvents

Introduction of important pigments and their evaluation, special purpose pigments.

Classification, properties of various types of driers, manufacture of driers. Additives for surface coatings.

Solvents for surface-coatings, classification, selection and evaluation,

PGCHT 103T/1 **Credit: 4**

Bioprocess Engineering

Unit 1: Thermodynamics of biosystem. Material and energy balances. Microbial growth dynamics. Kinetics of substrate utilization, biomass production and product formation in cell cultures.

Unit 2: Design, Preparation and sterilization of fermentation media and bioreactor. Air sterilization and asepsis.

Unit 3: Bioreactor configuration. Practical considerations for bioreactor construction. Monitoring and control of Bioreactors. Ideal reactor operation.

Unit 4: Rheological properties of fermentation broths, factors affecting broth viscosity. Mixing power requirement for mixing, scale up of mixing systems, improving in mixing in fermenters. Design equation for heat transfer systems in fermenter.Development and applications of Biosensors

Unit 5: Role of diffusion in bioprocessing. Mass transfer and microbial respiration. Oxygen uptake in cell cultures. Oxygen transfer in fermenters. Measuring dissolved oxygen concentrations. Mass transfer correlations. Measurement of K_La. Oxygen transfer in Large Vessels.

Reference Books:

1. J. E. Bailey, D F Ollis, Biochemical Engineering Fundamentals, McGraw- Hill 1986
2. P. M. Doran, Bioprocess Engineering Principles, Academic Press
3. J. M. Lee, Biochemical Engineering , Prentice Hall, Englewood Cliffs, New Jersey
4. Michael L. Shuler and Fikret Kargi, Bioprocess Engineering- Basic Concept, Second edition, Prentice Hall.

PGCHT 103T/2 **Credit: 4**

Petrochemical Process Design

Unit-1: Complex reaction, consecutive reaction, parallel reaction and parallel and consecutive reactions, acetylene production from hydrocarbons, kinetics and thermodynamics, different process details, parallel-consecutive reaction in a batch and flow reaction(TFR and CSTR), kinetics, derivation, industrial processes of chlorination of hydrocarbon, amines and glycols, effect of reactant ratio on distribution of products in different types of reactors.

Unit-2: Pyrolysis of hydrocarbon for production of olefins, thermodynamics and kinetics, thermal cracking mechanism, role of self inhibition, surface reactions and isomerisation of radicals in mechanism product distribution in cracking processes, condition of operation of pyrolysis reactors, concept of equilibrium approach and its influence on conversion, selectivity, steam dilution and yield of products desirable condition for ethylene productions use of kinetics models in the design, kinetics of petroleum fractions for olefin production. Effect of various process design parameters like tube diameter, hydrocarbon to steam ratio, pressure drop etc on conversion and yields.

Unit-3: Exothermic catalytic reactions – some industrially important reactions like production of phthalic anhydride, ethylene oxide, vinyl chloride and cyclohexane. Reactor operating condition. Kinetics of phthalic anhydride, simple and complex models operating features of different reactors used, factors influencing the choice of conditions of fluidized beds, mathematical derivations involved , analysis of naphthalene oxidation in fixed beds, one dimensional and two dimensional models, their derivation.

Unit-4: Ethylene oxide manufacture, its status among ethylene derivatives, direct oxidation process, chemistry and mechanism, side reaction, process design aspects such as thermal factors, exothermicity on selectivity, ethylene conversion, feed stock preparation, inhibitors, plant safety, catalyst details manufacturing process details, reversible exothermic reactions, important features , manufacture of ammonia.

Unit -5: Production of styrene from ethylene benzene, theoretical considerations, variables effecting styrene yields, such as pressure, temperature, steam to ethyl benzene ratio, catalyst particle size, purity of feed catalyst to ethyl benzene ratio, different reactor systems employed in styrene production, practical considerations, process details and styrene purification.

Unit-6: Mass transfer influence on kinetics of Ziegler-Natta ethylene polymerization, types of polymerization, fundamentals of polymerization, design aspects of polymer reactors. Mass transfer influence on hydroformylation reaction, reactor design process details, kinetic models, effect of olefin structure on reactivity, engineering problem in reactor design with a flow scheme.

References:

1. Chemical Engineering process analysis, A.M. Mearns
2. Chemistry of Catalytic processes, B.C. Gats, J.R. Katzer and G.C.A. Schuit
3. Chemical reactor design and process plants, vol 1 and 2, H.A. Rase.

4. Equipment Design Handbook for Refineries and Chemical Plants, F.L. Evans.
5. Applied Process Design For Chemical and Petrochemical Plants Vol I, II, and III, E.E. Ludwig.

PGCHT 103T/3 **Credit: 4**

TECHNOLOGY OF EXPRESSION, EXTRACTION AND REFINING OF OIL BEARING MATERIALS

Unit-1 Domestic and world production of oil seeds and oils. Processing of oil-bearing materials: Storage of raw materials, handling, sampling, pretreatments prior to storage, methods of cleaning, and milling, crushing, cooking and mechanical expression of oil. Newer Methods in of oil extraction. Rendering of animal fats. Utilization of oil cakes.

Unit-2 Plant and Machinery employed for expression of oils viz. Mechanical expression of oil in Ghanis, hydraulic presses, screw presses, low pressure and high pressure expellers' expander- extruder system

Unit-3 Pre-treatments of oil bearing materials prior to solvent extraction: cleaning, size reduction, pre-pressing, flaking, extrusion, pelletization, stabilization (for rice bran), dehulling etc. Plants & Processes and the machinery and equipments used.

Unit-4 Solvent extraction: Theory, solvents and their availability, selection of solvents, advantages and limitations, properties of different solvents. Solvent extraction techniques: Batch and continuous plants and processes employed for solvent extraction of low and high oil bearing materials. Recent trends in solvent extraction.

Unit-5 Refining of fats: Various physical and chemical methods of refining such as degumming, Neutralization, bleaching & deodorization. Plants and equipment used in batch and continuous refining. Quality control in processing

Reference Books:

1. Refining of Oils& Fats, Anderson, A. J. C, The MacMillan Co., New York.
2. Fats and Oils, D O'Brien, Third Edition, CRC Press,London
3. Bailey's Industrial Oil and Fat Products, 6 Volumes, Wiley-Interscience Publication,New York 4. Confectionary fats Handbook, Timms, R. E. The Oily Press Lipid Library, UK
5. Practical Short Course on Processing and Products of Vegetable Oil / Biodiesel ,College Station, Texas, Held on October 18-22, 2009
6. Vegetable Oils in Food Technology (Chemistry and Technology of Oils and Fats), Frank Gunstone, Wiley Blackwell; USA
7. Edible Oils and Fats--A Global Overview of Technological Developments, Guinness Centre, Taylors Lane,, Ireland.

PGCHT 103T/4 **Credit: 4**

Principles and Formulations of Surface Coatings

Unit 1: Concept of Formulations

Principles of formulations of surface coating with special reference to paints, varnishes, lacquer.

Unit 2: Protective and Decorative coatings

Selection of raw materials for its specific applications, viz. Protective, decorative and their types. Architectural finishes,.

Unit 3: Industrial and Specialty Finishes

Industrial and Specialty coatings like, heat resistant, marine, traffic & fluorescent. Recent trends in industrial and specialty coatings.

Unit 4: Rheology of paints

Rheology of paint systems and its importance in coatins. Film formation, film structure and its correlation to formulation. PVC and CPVC, Thioxtropy.

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Unit 5: Powder Coatings

Solvents less and powder coatings. Binder for powder coatings and their classification. Selection of pigments, extenders and additives. Manufacture of coating powders: Methods and equipments. Application techniques in powder coatings.

Recent developments in powder coatings

PGCHT 104T/1 **Credit: 4**

ELECTIVE - I (Discipline Specific BCHT)

1. **Advances in Food Engineering**

Unit 1: Application of Transport Phenomena for food systems. Flow behaviour of non Newtonian fluids. Unsteady state Heat Transfer with phase change. Heat transfer during freezing and thawing. Rheology of dough with reference to wheat and bakery products.

Unit 2: Design of autoclave, Pasteurizer, Continuous Sterilizer, Steam Jacketed Pan and

Vacuum Concentrator. Materials used for food processing equipment and corrosion control.

Unit 3: Design of Basket Press, Screw type Juice Extractor, Solid Mixer, Kneader; Oil Expeller, filters and extruder.

Unit 4: Design of Tray Drier, Drum Drier, Spray Drier, Fluidized Bed Drier and Rotary Roaster, solar dryers.

Unit 5: Design of Homogenizer, Pulping Machine, Plate Type Freezer and Freeze Drier.

Reference Books:

Food Engineering Operations by Brennan J.G, 1976

Fundamentals of food process engineering by Romeo Toledo, 1999

Engineering Properties of Foods by Rao MA and Rizvi SSH, 1986

Elements of Food Engineering by Watson EL and Harper JC, 1989

Food Process Engineering by Heldman DR and Singh RP, 1984

Food Engg. Fundamentals by J. Clair Batty, 1983

Chemical Engineer's Handbook; Perry, Chilton & Green; MGH.

Fundamentals of Food Process Engineering, 2nd ed; Toledo Romeo T; CBS Publishers.

Preservation of Fruits & Vegetables; Lal G, Sidhapa GS & Tandon GL; ICAR.

Introduction to Chemical Equipment Design – Mechanical Aspects; Bhattacharyya BC; CBS Publishers.

Process Equipment Design; Hesse HC & Rushton JH; Van Nostrand, East West Press Selection of Material and Fabrication for Chemical Process Equipment; Bhattacharyya BC; Chemical engineering Education Development Centre, IIT Madras.

Process Equipment Design; Brownell LE & Young EH; John Wiley and Sons, Inc.

Computer Aided Design of Chemical Process Equipment; Bhattacharyya BC & Narayanan CM; New Central Book Agency.

Mechanical Design and Fabrication of Process Equipment; Bhattacharyya BC; sKhanna Publishers.

PGCHT 104T/1 **Credit: 4**

ELECTIVE - I (Discipline Specific BCHT)

2. **Molecular Biology**

Unit 1: Chemical structure and base composition of nucleic acid. Double helical structures, triple helical structures. Properties of DNA. DNA denaturation and renaturation.
DNA replication and repair mechanisms in eukaryots, bacteria and phages.

Unit 2: Transcription: RNA polymerases in prokaryots and eukaryots. Process of transcription. Concept of promoters and promoters types. Post transcriptional processing of RNA, Translation: Genetic Code. Post translational modifications. Protein targeting. Non ribosomal polypeptide synthesis.

Unit 3: Regulation of gene expression: Constitutive and inducible enzymes Gene regulation, operon concept (Lac operon and trp operon). Induction of genes under stress conditions in plants. Differential processing of mRNA.

Unit 4: Mutation: Spontaneous and induced mutations. Insertion, deletion, point, frame shift and suppressor mutation. Chemical & physical mutagens. Selection and isolation of mutants.

Unit 5: Genetic Engineering: Recombinant DNA technology. Isolation and amplification of gene cloning vectors. Application of recombinant DNA technology.

PGCHT 104T/1 **Credit: 4**

ELECTIVE - I (Discipline Specific BCHT)

3. **Advances in Nutrition**

Unit 1: Recent advances in metabolism and nutritional aspects of foods; Nutritional requirements of special target groups such as aged, infants, pregnant & lactating mothers, etc.

Unit 2: Therapeutic nutrition & formulation of special dietary foods; Relation of food and diseases; Nutrition related diseases. Assessment of nutritional status & RDA; Effect of processing on nutrients;

Unit 3: Functional foods and nutraceuticals for lifestyle disorders such as cardiovascular diseases, obesity, diabetics, etc. Glycemic Index and Glycemic load of composite foods.

Unit 4: Protective foods: Role of food ingredients in aging, cancer and immunomodulation. Food components and nutrients affecting immune systems, phytosterols, polyphenols, flavonoids and antioxidants.

Unit 5: Functional aspects of dietary fibre, amino acids & peptides, probiotic foods, antioxidants, vitamins, fatty acids etc. Regulatory aspects for functional foods and nutraceuticals.

Reference Books:

Advances in food and nutrition research by Steve L. Taylor
Human nutrition by Alfin-Slater, 1979,
Human nutrition by Burton, BT, 1976,
Food, Nutrition and Diet Therapy by Krause and Mahan 1996,
Modern Nutrition in Health & Disease by Young & Shils.

PGCHT 104T/2 **Credit: 4**

ELECTIVE I (Discipline Specific BCHT)

1. **Oil & Natural Gas Processing**

Unit 1: Introduction

Brief history of natural gas industry, characteristics of various utility and industrial gases, sources of natural gas, occurrence, composition, chemical properties and characteristics of natural gas

Unit 2: Phase Behaviour

Phase behavior of natural gas, pressure-volume-temperature diagram for pure hydrocarbons. Phase rule, solubility of gases in liquids, binary mixtures.

Unit 3: Properties

Properties of natural gases and volatile hydrocarbon liquids, diffusion coefficient, compressibility factors, density of gases and liquids, surface tension, thermodynamic properties, heating value, flammability limits, critical properties, viscosity and thermal conductivity.

Unit 4: Gas Hydrates

Water-hydrocarbon system, general phase relations for water-hydrocarbon system, measurement of water contents of natural gas, gas hydrates, conditions of formation, prediction of hydrate formation condition, prevention of hydrate formation.

Unit 5: Gas Flow Measurement

Gas flow measurement, flow and compressor calculations, flow equation, pipeline flow calculations, calculations of work required to compress natural gas.

Unit 6: Gas Processing

Low temperatures processing of natural gas, natural gas liquefaction, dehydration and sweetening of natural gas, methods of dehydration and sweetening.

References:

1. Donald L.Katz and Robert L.Lee, Natural Gas Engineering, McGraw – Hill Publishing Company, NY.
2. Speight, J.G Fuel Science and Technology Handbook, Marcel Decker Inc.
3. Dring, M.M – The Natural Gas Industry – A review of World Resources and Industrial Applications, Butterworth, London.
4. Lom. W.L and A.F. Williams, Substitute Natural Gas, Kalstod Willey, New York.
5. Dermott, M.C. Liquified Natural Gas Technology, NeysosPark Ridge, N.J.
6. M.J. EcononidesA.Daniel "Petroleum Production Systems", Prentice Hall Petroleum Engineering series.
7. Michael J.Economides, A.Daniel Hill and Christine Ehlig – Economides, Petroleum Production Systems, PTR Prantice Hall, NJ.
8. Guide to Natural Gas Utilization Technologies, Fairmount Press Inc.

PGCHT 104T/2 **Credit: 4**

ELECTIVE I (Discipline Specific BCHT)

2. Modeling & Simulation in Chemical Engineering

Unit 1: Introduction to process modeling, Applications of models, classification of models,Principles of Formulation, fundamental laws, general modeling procedure, industrial usage of processmodelling and simulation; Macroscopic and microscopic mass, energy and momentum balances

Unit 2: Parameter estimation techniques in theoretical as well as numerical models, population balance, stochastic, and empirical models

Unit 3: Modeling of various mass and heat transfer equipment: distillation,absorption, extraction columns; evaporators; furnaces; heat exchangers; flash vessels etc.

Unit 4: Modeling of Chemical Reactors: single phase and multiphase reactors

Unit 5: Numerical Methods for chemical engineering applications. Introduction and use of different softwares for modeling and simulation

Recommended Books:

1. W. L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.
2. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
3. R.E.G. Franks, Modeling and Simulation in Chemical Engineering, WielyIntrscience, NY, 1972.
4. J. Ingam, I. J. Dunn, Chemical Engineering Dynamic Modeling with PC simulation, VCH Publishers, 2008.
5. D. Himmelblau, K.B. Bischoff, Process Analysis and Simulation, John Wiley & Sons, 1968.

PGCHT 104T/2 **Credit: 4**

ELECTIVE I (Discipline Specific BCHT)

3. Advanced Transport Phenomena

Unit 1: Review of mathematics: Scalar, Vectors, Tensors, divergence, relation between rectangular coordinates and cylindrical coordinates, relation between rectangular coordinates and spherical coordinates, partial derivative, substantial derivative, total derivative, line integral, surface integral, integral theorems.

Unit 2: Equations of continuity, equation of motion, the equation of mechanical energy, application of Navier-Stokes equation to solve problems, the equations of change for incompressible non-Newtonian fluids.

Unit 3: Developing equations for obtaining velocity & shear stress distribution for flow of Newtonian, Bingham plastic & power law fluids in spheres etc. from I^{st} principle, Introduction to 2 dimensional & turbulent momentum transfers

Unit 4: Equations of energy, the energy equation in curvilinear coordinates, use of equations of change to set up steady state heat transfer for problems.

Unit 5: Unsteady state heat conduction expression for rectangular, spherical and cylindrical co-ordinate system from I^{st} principles, Numerical methods for 2 dimensional steady state conduction and Schmidt method for unsteady state heat conduction with / without surface resistance for obtaining temperature profiles

Recommended Books:

1. R.B. Bird, W. E. Stewart and E. N. Light foot Transport Phenomena Wiley international Edition, New York 2002.
2. James R. Welty, Charles E. Wicks and Robert E. Wilson, Fundamentals of momentum, heat and mass transfer, John Wiley & sons, Inc, New York, 2008.

PGCHT 104T/2 **Credit: 4**

ELECTIVE I (Discipline Specific BCHT)

4. Advanced Thermodynamics

Unit 1: Quantum Considerations: Introduction, Internal energy levels, Microstates, Macrostates and Probability, Case or repeated trials, Phase space, combinatorial problems with respects to particles and energy states.

Unit 2: Entropy and Probability: Thermodynamic probability, State of maximum Thermodynamic probability, Microscopic meaning of entroy, Use of Lagrangion multipliers, Stirling's approximation.

Unit 3: Statistical Mechanics: The statistical distribution laws, Maxwell – Boltzmann statistics, The Fermi-Dirac and Bose -Einstein Statistics, Partition functions, Transnational, Rotational etc., Applications of physical models.

Unit 4: Statistical Evaluation Of Thermodynamic Properties: Ideal Monatomic gas, Partition function, Calculation of the translational properties of an ideal monatomic gas, Sector - Tetrode equation, Potential energy function for a diatomic molecule, Rigid rotor harmonic – oscillator approximation, Rotational and vibrational partition functions of ideal polyatomic gases.

Unit 5: Thermodynamic of Irreversible Processes: Irreversible processes, Phenomenological laws, Application of onsager - reciprocal relations, Seebeek effect, Peltier effect, Thompson effect.

Recommended Books:

1. R.E. Sonntag, G.I. Van wylen, Fundamental of Statistical Thermodynamics, John wiley and Sons, New York, 1966.

2. D.A. McQuarric, Statistical Thermodynamics, Harper and row Pub. New York, 1973.

3. M.T. Howerton, Engineering Thermodynamics, D. Van Nostrand Co., Inc., New York, 1962.

4. C.L. Tien, J.H. Lienhard, Statistical Thermodynamics, Halt Rinhart and Winston Inc., New York, 1971.

5. J. Otto Beran, Juliana Boerio, Gates Vol I & II, Chemical Thermodynamics: Advanced Applications", Academic press, 2000.

6. Reid, Prausnitz, Poling, The Properties of Gases and Liquids, McGraw Hill Publication

PGCHT 104T/3 **Credit: 4**

ELECTIVE - I (Discipline Specific BCHT)

1. <u>TECHNOLOGICAL ADVANCEMENT IN OLEOCHEMICALS</u>

Unit- 1

Hydrogenation of oils and fats, Types of processes, methods of manufacture of hydrogen (pure), Types of catalysts and their production, hydrogenation plant. Selective hydrogenation. quality control in hydrogenation plant.

Unit 2

Manufacture of butter, ghee, margarine, and vanaspati, Trans esterified oils and fats, cooking oils, salad oils and their fatty edible products. Plastic shortening agents and confectionary fats. Causes of rancidity and prevention. Detection of adulteration, winterization of oils and fats.

Unit- 3

Sources, properties, grades, and types of glycerol, recovery and purification of glycerin from fat splitting crudes and waste soap lye’s, analysis and industrial uses of glycerol. Synthetic glycerin

Unit-4

Lipid Associates and Applications of non-traditional oils such as Karanja, Neem, Mahua, Sal, Rubber seed, Jojoba, Jatropha, Kokum etc., Fish Oils, Rendering of Animal Fats. Membrane Processing of Fats and Oils, Utilization of waste products from oil processing industries.

Unit- 5

Detoxification of oil cakes, Manufacture of value added products from oil meals. Utilization of deteriorated deep fried oil for industrial utilization.

Reference Book

1. The Chemical Constitution of Natural Fats, Hilditch T.P., Chapman and Hall Ltd., London.
2. Bailey's Industrial Oil and Fat Products, 6th Edition, Wiley-Interscience Publication, New York .
3. Modern Technology Of Oils, Fats & Its Derivatives,National Institute of Industrial Research, New Delhi.
4. Edible Oils and Fats--A Global Overview of Technological Developments, Guinness Centre, Taylors Lane,, Ireland.

PGCHT 104T/3 **Credit: 4**

ELECTIVE - I (Discipline Specific BCHT)

2. PROCESS ECONOMICS, UTILITIES AND BYPRODUCTS OF OIL INDUSTRY

Unit- 1
Industrial pollution and its impact . Magnitude of industrial waste , Legislative regulations. Recycle and reuse of waste water , recovery of by/c0-product from industrial effluents.
Unit 2
Components of Costing; Utilities, power , steam, air, water; Cost and analysis of plant e.g. Break Even Point, Rate of Return, Pay Back Period, Depreciation etc

Unit- 3
Utilities in expression, solvent extraction refining plant, hydrogenation plant, a typical other oleo chemical unit. A working layout and calculation of cost of production for above plants
Unit-4
Introduction to by- products of refining industry; Phospholipids, production of industrial and edible grade Lecithin, gums. Manufacture of compound cattle feed; production of protein concentrates and isolates. Re-esterification of fatty acid with glycerin and its trans-esterification for production of biodiesel

Unit- 5
Segregation of deodorizer distillate and isolation of value added products by conventional and molecular distillation and other plants and machinery involved. Classification of effluents of oil and allied industries, GOI specifications of effluents and various treatment techniques

Reference Books:

1. Bailey's Industrial Oil and Fat Products, Edible Oil and Fat Products: Chemistry, Properties, and Health Effects, 6th Edition, John Wiley & Sons, USA.
2. Hand Book of Oils, Fats and Derivatives with Refining and Packaging Technology, Published by Indian Institute of Consultants, Engineers India Research Institute, New Delhi
3. Essential Oils and Culinary Herbs*James E. Simon
4. Industrial Fatty Acids and their Applications," edited by E. Scott Pattison, Reinhold Publ. Corp. New York.
5. Fatty acids; Their chemistry, properties, production and uses Part – III Edited by K.S. Markley

PGCHT 104T/4 **Credit: 4**

ELECTIVE –I (Discipline Specific)

1. **Automotive and Coil Coatings)**

Unit 1: Introduction

Introduction, Automotive and automotive paint market. Materials and Concept in body construction. Surface Treatments of multimetals in automotives.

Polymeric materials in automotive coatings

Unit 2: Coating systems for automotives

Primers for automotives, Surfacers, Topcoats for automotive industry. Paint for plastics (non-metals). Paint shops and quality control in automotive coatings, Coatings for rail-road engines, passenger cars, fright carrier, truck, bus, etc.

Recent advances in automotive coatings.

Unit 3: Applications and quality control

Application techniques in automotive coatings. Electro-deposition techniques. Defects and their remedies in automotive coatings. Evaluation of automotive coatings.

Unit 4: Coil Coatings

Introduction to coil coatings, requirements of coil coatings, metal pre-treament processes,

Detail study of binders, pigments and additives for coil coatings.

Unit 5: Coil coating systems:

Primers, Surfacers, and top coat formulation for coil coatings. Application techniques.

Recent advances in coil coatings.

PGCHT 104T/4 **Credit: 4**

ELECTIVE –I (Discipline Specific)

2. **Technology of Cosmetics and polishes)**

Unit 1:

Nature of human skins and other parts of body. Classification of cosmetics.

Unit 2:

Creams, lotions and face powders, Functions of cream, lotions and face powderRaw materials for cream, lotions and face powders, formulations and evaluations of cream, lotions and face powders.

Unit 3 :

Lipsticks: Functions of lipstick, raw materials, manufacture and evaluations.

Unit 4:

Cosmetic preparation such as eye-make up, Nail lacquers, and polishes.

Unit 5:

Hair dyes. Raw materials, preparation, and properties. Evaluation of hair colours.Recent trends and other miscellaneous cosmetic preparations.

PGCHT 106P/1 **Credit: 2**

FOOD TECHNOLOGY PRACTICAL (P)

Estimation of Reducing and non Reducing sugars by Lane Eynon Method

Proximate analysis of Food Product

Estimation of Protein Content By Folin –Lowry Method

Estimation of Protein Content By Biurett Method

Estimation of Iron Content

Estimation of Phosphorus Content

Estimation of Reducing Sugar By Nelson-Semogyi Method

Estimation of Reducing Sugar By DNS Method

To Determine Ascorbic Acid By 2,6 Dichloroendophenol

Estimation of Starch By Anthrone Method.

Estimation of Amylose & Amylosepectin Content

Immobilization of Invertase Enzyme from Yeast

PGCHT 106P/2

Process Simulation Laboratory (Petrochemical Technology)

Credit : 2

Softwares

Simulation exercises using

A) ASPEN software

B) Fluent code software

C) Prosim software (steady and unsteady state processes) and

D) Response Surface Methodology.

List of experiments

Group A

Simulation exercises using aspen

1. Physical property estimations;
2. Mass and energy balances; handling user specifications on output streams;
3. Simulation of individual units like,
   - I. Mixers
   - II. Splitters,
   - III. Heat Exchangers,
   - IV. Flash Columns,
   - V. Reactors,
   - VI. Distillation Columns Etc.
4. Heat Exchanger Networks
5. Distillation Trains

6. Pipeline Networks
7. Dynamic Simulation
8. Costing and Economic Analysis

Group B

Simulation Exercises Using Prosim Software

9. Steady State Simulation of Unit Operations
    - A. Evaporator
    - B. Plug Flow Reactor
    - C. Cyclone Separator
    - D. Continuous Stirred Tank Reactor
10. Dynamic Simulation of Chemical Processes
    - A. Cascade Control System
    - B. Feed Forward Control
    - C. Ratio Control
    - D. On-Off Control

Group C

Simulation Exercises Using Fluent Code Software

11. To Study Flow Pattern Inside the Various Unit Operation & Processes using Fluent and Work Bench for Grid Generation.
    - A. Heat Exchanger
    - B. Rotating Disc Contactor
    - C. Atmospheric flow simulation
    - D. Flow through pipe viz., bends, elbow, valves etc.
    - E. Evaporators
    - F. Dispersion study

Minimum experiments of 5 from group A, 3 from group B and 3 from group C

List of softwares needed

A) Aspen Software
B) Fluent Code Software.
C) Prosim Software (Steady And Unsteady State Processes).

PGCHT 106P/3 **Credit: 2**

OIL TECHNOLOGY – PRACTICAL I (P)

1. Estimation of Physico – Chemical properties of Oils and Fats
2. Beliers Test (Turbidity Temp.) Acetic Acid Method
3. Detection of Colour by Tintometer Method
4. Estimation of RM and Polenske Value
5. Extraction of oil by Soxhlet Method
6. Extraction of essential oil by Clevenger's Assembly
7. Isolation and detection of Protein Content from de oiled cake
8. Preparation of Mixed Fatty Acids and its analysis
9. Preparation of Bio-diesel and its analysis
10. Preparation of Malenized oil and its analysis
11. Analysis of Mono and Di glycerides in oil and fats.

12. To prepare the red oxide metal primer and evaluation of its properties
13. To prepare synthetic enamel and evaluation of its properties.
14. To prepare universal strainer and evaluation of its properties.
15. To prepare cleansing creams, lotions and metallic Soaps
16. To prepare lubricating grease
17. To prepare detergent and liquid detergent
18. Analysis of soaps and soap stocks
19. Analysis of detergent, metallic soaps and cosmetics.
20. Analysis of waxes and paints

Reference Books

1. Analysis of Oil and Soaps by R.N.Mathur
2. AOCS, official and tentative methods Da 2a-48, (For moisture and volatile matter of soap and soap products) 1973.
3. Bailey's Industrial Oil and Fat Products, 6th Edition, Wiley-Interscience Publication,New York .
4. The Analysis of Fats and Oils, Mehlenbacher, V. C., The Garrard Press, Champaign, Illinois.
5. AOCS Official and Tentative Methods forAnalysis ofOils and fats, Vol. 1and 2,, Third Edition, AOCS, Champaign IL,USA.

<u>SYLLABUS FOR SECOND SEMESTER M. TECH. (C.B.C.S.)</u>

PGCHT 201T/1 **Credit: 4**

Advances in Food Science and Technology

Unit 1: Functional properties of food macromolecules, their evaluation and modifications,
Protein Technology: Protein concentrates, isolates and hydrolysates. Methods of manufacturing protein hydrolysates; Factors affecting quality of hydrolysates; Food uses of hydrolysates; Carbohydrate technology: Functional properties of starch and other polysaccharides, Process technology and food application of dextrins, chemical and enzymatic modification of starch, high fructose corn syrup.

Unit 2 : Recent trends in processing of foods such as application of high pressure, low temperature, ohmic heating, and microwave heating, supercritical fluid extraction and membrane separation in food processing Minimal processing of foods, Ohmic heating, pulsed electric field, high-intensity light pulses, radio-frequency heating, microwave, thermo-sonication,

Unit 3: Applications of high pressure extrusion in food processing. High hydrostatic processing of foods. Effect on enzymes, microorganisms in various food systems Equipment for batch and continuous processing. Other applications of HPP including thawing

Unit 4: Speciality foods such as simulated and restructured foods, functional and health foods, fast foods, space foods, Textured protein gels and expanded products; Simulated milk products; Restructured protein; Nonconventional sources of protein and its Utilizations.

Unit 5: Hybrid drying technologies: combined microwave vacuum drying, combining microwave vacuum drying with other processes, equipment for microwave vacuum drying, product quality degradation during dehydration. Advanced Membrane Technology for water and liquid foods. RTE frozen foods with reference to packaging and Recent developments in Food Processing with focus on Indian Industry

Reference Books:

Advances in food and nutrition research by Steve L. Taylor, 2009

Advances in food research by C.O.Chichester, 1986

Handbook of food and bioprocess modeling by Sablani S., Rahman M, 2007

Advances in food processing and technology by Peter Fellows

Food processing and technology: Principle and practice by P Fellows, taylor and Francis, 2009

PGCHT 201T/2 **Credit: 4**

Multicomponent Distillation

Unit 1: Multicomponent Vapor Liquid Equilibria

Rules and Law describing Equilibrium, Vapor Liquid Equilibria – Binary system, Prediction of Binary Vapor Liquid Equilibrium Data from pure component properties, Consistency tests for Binary Vapor Liquid Equilibrium, Ideal Multicomponent systems, Ideal Ternary systems, Non Ideal Vapor Liquid Equilibria – Multicomponent systems, Relationship between Li and Coull and Bonham Vapor Liquid Equlibrium Relations.

Unit 2: Phase Equilibrium for Petroleum Fractions at Super Atmospheric Pressure

Data resources, Analytical Distillation, Equilibrium Flash Vaporisation, Empirical Correlations, EFV Correlations, ASTM – TBP – EFV Relationships, Pressure effect on EFV curves, EFV Vapor and Liquid Properties.

Unit 3: Phase Equilibrium for Petroleum Fractions at Sub - Atmospheric Pressure

Conversion of ASTM Distillation Assays, Phase Equilibrium for Sub – Atmospheric Pressure, Pressure effect on 30% and 50% Points, Vacuum Phase Diagram Constructions, Consistency between Atmospheric and Vacuum EFV Correlations.

Unit 4: Atmospheric tower

Analysis of crude petroleum and its fraction, Basic processes for Atmospheric Crude Distillation, Separation criteria in petroleum fractionation, atmospheric charge data, Estimate of material balance, Heat and mass transfer balance calculations for type U tower, Heat and Mass Balance calculation for Type R Towers, Heat and Mass Balance calculation for Type A tower, Alternate Procedure for Type A tower calculations.

Unit 5: Vacuum Tower

Types of operations in Vacuum Distillation, Lube or Speciality Vacuum Distillate Operations, Fuels operation, Economic consideration in Vacuum Tower Design, Vacuum Unit Charge Data, Estimate of Material Balance, Lube-Asphalt Operation, Fuels-Pitch Operation, Flash zone and Tower Base Calaculations, Flash Zone Pressure, Steam Requirement, Heat Quantities, Heat and mass balance Calculation for Lube-Type Towers, Steam to Product Strippers , Tower Top Condition, Estimate Tower Temprature Profile, Overflash Liquid Condensation section, First sidestream Product Draw Tray, Second Sidestram Product Draw Tray Tower, Top Sidestream Product Draw Tray, Vapor-Liquid Traffic, Fractionation Analysis, Heat and Material Balance Calculation for Fuels-Type Towers, Temperature Profiles, Overflash Liquid Condensation Section, Sidestream Products condensing Section.

Unit 6: Refinary Light Ends Fractionation

Introduction, Process Design Consideration, Example Design Calculation, Reboiled Absorber.

References:

1. Matthew Van Winkle, Distillation, McGraw Hill Book Company, New York.
2. Wayne C. Edmister, Applied Hydrocarbon Thermodynamics Vol.2, Gulf Publishing Company, Houston.
3. Watkins, R.N "Petroleum Refinery Distillation", 2nd Edition, Gulf Publishing Company, Texas.

PGCHT 201T/3 **Credit: 4**

TECHNOLOGY OF SOAPS, DETERGENT AND SURFACTANTS

Unit- 1

Types of soaps, selection of raw materials, physical chemistry of soaps in boiling pan, manufacturing process batch and continuous and the sequences of operations, recent advances in the manufacturing methods. Metallic, transparent & herbal soaps. Analysis of soaps. Quality control during manufacture

Unit 2

Plants and process employed in soap manufacture of household and toilet soaps by age old and newer techniques, details of machinery employed and quality specifications, , Continuous processes of soap manufacture. Modern process and plants for the production of house hold and toilet soaps from Fatty acid based soaps,

Unit 3

Surfactants: Classification, chemistry and preparation. Hydrophilic lypophilic balance. Correlation of structure of the surfactant and its performance, manufacture of detergents. Formulation of detergents, wetting agents, foam boosters, dispersing agents.

Unit- 4

Modern developments in the detergent industry. Recent trends and modern developments in the Detergent industry. Biodegradation of detergents, pollution control in soap and detergent utilization

Unit-5

Analysis of soaps and detergents, BIS methods of testing, Properties of soaps and soap solutions, phase separation in soap boiling, various types of soaps andcleaning Preparations,

Reference Books:

1. The Handbook Of Soap Manufacture, Simmons ,W. H. and Appleton ,H. A. Kindle Books, USA.
2. Soap, Detergent & Perfume Industry,Srivastava S.B ,Small Industry Research Institute,New Delhi.
3 . Sulphonation Technology In The Detergent Industry, Herman W. and De Groot, Springer-Verlag New York.
4. Surface Active Agents , Goliath Company,The Gale Group, USA
5. Powdered Detergents , Showell, M. The Procter & Gamble Company, Cincinnati, Ohio, USA.
6. The manufacture of glycerol,by Martin, G. Technical Press, London

7. Soap-Chemistry and Technology, Kane,J. G.,
9. The Manufacture of Soaps, Other Detergents, and Glycerine,Woollatt, Edgar, Mountainview Books, PA, U.S.A.

PGCHT 201T/4 **Credit: 4**

Manufacturing methods, Machinery, and Planning

Unit 1:

Manufacture of modified drying oils, plants and equipments for varnishes lacquer manufacture.

Unit 2:

General principles of grinding, mixing, dispersion of surface coating. Equipment and machinery for grinding, mixing and dispersion.

Unit 3:

Ball mills, Roll mills, Attritors, Kady mills, Sand mills, Cone mills, Age runners, Amalgamator, planetary and impellor mixing.

Unit 4:

Selection of machinery for manufacture of surface coating including printing inks.

Unit 5:

Project planning. Plant location, planning and layout. Planning of disposal of waste.

Preparation of project for manufacture of paint, varnish, lacquer, printing inks.

PGCHT 202T/1 **Credit: 4**

Food Biotechnology

Unit 1: Production of baker's yeast; Lactic starter cultures, Physiology and biochemistry of starters, Propagation and management of starters; Production of mushrooms, Spawn production, mushroom harvesting; Production of single cell proteins from algae and bacteria, Product quality and safety, Merits and demerits.

Unit 2: Microbiology and Biochemistry of fermented Foods; Fermented Dairy products such as cheese, yoghurt, sweet curd, paneer, sheekhand; Fermented Cereal/legume products, including bread; Traditional fermented foods like idli, dosa, dhokla,

Unit 3: Raw materials, fermentation and processing of alcoholic beverages; Fruit based alcoholic beverage like wine; Cereal based alcoholic beverage like Beer, distilled beverages gen and whisky. soya based oriental fermented foods soya sauce, Tofu, Tempeh; Fermented pickles.

Unit 4: Production of industrial alcohol, microrganism used, fermentation condition, recovery; lactic acid production, Production of citric acid by surface and submerged culture process; acetic acid, glycerol and acetone butanol by fermentation.

Unit 5: Process technology for Microbial production of Vitamins, Production of Microbial polysaccharides such as Xanthan and Dextran gum production and their application, flavors and fragnances, Industrially produced enzymes from microbial sources and their applications; antibiotics e.g. Penicillin and Streptomycin.

Reference Books:

1. Industrial Microbiology by Casida L. E., John Wiley & Sons Inc New York, 1964
2. Industrail Microbiology by Presscot & Dunn, McGraw Hill Book Co. Inc. New York, 1940
3. Biotechnology B. D. Singh Kalyani Publishers, Ludhiana, 1999.

PGCHT 202T/2 **Credit: 4**

Process Equipment and Piping Design

Unit 1: Fundamentals of Piping Engineering

Definitions, Piping Components, Their Introduction, Applications. Piping Moc, Budget Codes and Standards, Fabrication and Installations of Piping.

Unit 2: Pipe Hydraulics and Sizing

Pipe Sizing Based on Velocity and Pressure Drop Consideration Cost, Least Annual Cost Approach, Pipe Drawing Basics, Development of Piping General Arrangement Drawing, Dimensions and Drawing of Piping.

Unit 3: Plot Plan

Development of Plot Plan for Different Types of Fluid Storage, Equipment Layout, Process Piping Layout, Utility Piping Layout. Stress Analysis -Different Types of Stresses and its Impact on Piping, Methods of Calculation, Dynamic Analysis, Flexibility Analysis.

Unit 4: Piping Support

Different Types of Support Based on Requirement and its Calculation.

Unit 5: Instrumentation

Final Control Elements; Measuring Devices, Instrumentation Symbols Introduction to Process Flow Diagram (PFD) and Piping & Instrumentation Diagram (P&I)

References:

1. Piping Handbook, 6 Th Edition, M.L. Nayyar, P.E., Mc Graw-Hill, Inc
2. Piping Design Handbook Edited By Johan J Mcketta, Crc Press.
3. Process Modeling Simulation And Control For Chemical Engineers, Luyben, W. L., Mcgraw Hill.

PGCHT 202T/3 **Credit: 4**

TECHNOLOGICAL ADVANCEMENT OF COSMETICS AND ALLIED PRODUCTS

Unit- 1

Classification of cosmetics and cosmetic preparations:- Cosmetic preparations such as Shampoos and Conditioners, their Ingredients , types, Functions, formulation, Production techniques, evaluation and safety considerations,

Unit 2

Face care products: Beauty Masks , face creams, Cleansing and Emollient Creams and Lotions, Vanishing Creams, Foundation Makeup., face/body Formulation, Hand Creams and Lotions , Skin Lighteners and Bleach Creams ,sun care cosmetics, Rouge, Moisturizing Creams etc.

Unit 3

Face care products: Lipsticks, face powders, talcum powders, Eye makeup cosmetics, Hormone Creams, Bath and shower products Shaving soaps and creams: After shave products, hair oils, hair dyes, Hair Conditioners, brilliantine's.

Unit 4

Dentifrices: Toothpaste, tooth powders, Mouthwashes, teeth whiteners, evaluation of cosmetic preparations, Plant and Machinery used in cosmetic manufacture. Lay out and Hygiene aspect of cosmetic. Miscellaneous Cosmetics, Anti per spirants and deodorants, depilatories, Baby Toiletries, nail lacquers and polishes, recent trends and other miscellaneous cosmetic preparations

Unit- 5

Herbal Cosmetic preparations; Chemical components of herbs & its extraction, Application of herbs & its extracts, Application of herbs in cosmetics application, preservation; Advantages in perfumery: Notes of perfume, compatibility of perfume , fixation and stability of perfume ; analysis of perfumes, Medicinal applications of herbal and other essential oils & perfumes.

Reference Books:

1. Handbook of Cosmetic Science and Technology, Barel,A.. Paye,M.,Howard I. and Maibach,H. I. Marcel Dekker, Inc.270 Madison Avenue, New York.
2.Cosmetics Formulations, Technology & Project Estimations, Institute of Natural & Modern Cosmetech,USA.
3. Cosmetic Formulation of Skin Care Products, Series EditorEricJungermann ,Jungermann Associates, Inc. New York.
4. Cosmetics-Science and Technology, Vol-2, 2nd Ed,Sagarin, E. andBalsam, M,Wiley India Pvt. Ltd,New Delhi.
5.Analysis of Cosmetic Products,Salvador,E.,Elsevier, New York.

PGCHT 202T/4 **Credit: 4**

Processing, Application and Technology of Printing Inks

Unit 1:

Development of printing ink Industry. Nature of various printing process.

Unit 2:

Requirements for topographic, Plano graphic, intaglio, flexographic and silkscreen printing process.

Unit 3:

Relation of rheological and their properties of printing ink with substrate to be printed. Natural of stock of paper.

Unit 4:

Formulations of printing ink, special additives. Nature of additives and its effects on the final performance, special pigments for printing inks.

Unit 5:

Standard of printing inks. Evaluation printing inks. Methods of test.

Special purpose inks, UV-cured inks & modern developments in inks.

PGCHT 203T/1 **Credit: 4**

Food Safety and Food Regulation

Unit 1: Types of food hazards: biological, chemical and physical; Risk assessment; Newer systems of safety evaluation such as HACCP. Salient features of Food Safety & Standards Act, 2006, Structure of FSSAI, Administrative set up at the State level. Roles and Responsibilities of diff. Food safety Regulators, Licensing and registration, Documents/ Format required for Registration/ Licensing

Unit 2: Introduction to Food Safety, Food Contaminants (Microbial, Chemical, Physical), Food Adulteration (Common adulterants), Food Additives (functional role, safety issues), Food Packaging & labelling (Packaging types, understanding labelling rules & Regulations, Nutritional labelling, labelling requirements for pre-packaged food as per CODEX)

Unit 3: Organic food, Identifying Organic foods, Advantages, The Organic Certification Process, Organic Food labeling, GM food, Why are GM food produced, Main issues of concern for Human Health, How are GM Food regulated Internationally, Regulation in India.

Role of WHO to improve evaluation of GM food, Benefits & Controversies, Irradiated Food, Labelling of Irradiated Food. Freeze dried food, Functional Foods & Nutraceuticals, Functional foods from plant sources, animal sources, dietary supplements, Regulation.

Unit 4: Food & Agriculture Organization (FAO)in India, Technical Cooperation programmes, Bio-security in Food and Agriculture, World Health Organization (WHO), World Animal Health Organization (OIE), International Plant Protection Convention (IPPC) Codex Alimentarius Commission - Codex India – Role of Codex Contact point, National Codex contact point (NCCP), National Codex Committee of India – ToR, Functions, Shadow Committees etc.

Unit 5: Good Hygienic Practices (GHP), Good Manufacturing Practices (GMP), HACCP, ISO 9001 (Quality Management System), ISO 22000 (Food Safety Management System), Traceability, Food Recall Need for Food analysis, Accreditation of Food Laboratory, Referral labs. Risk analysis and management in food safety, What is food surveillance, Steps to be taken for reporting and dealing with food incidents. Food alerts. Offences in food, Trials (Case Study) and procedure to launch prosecution

Reference Books:

Environmental regulation and food safety by Veena Jha.

Microbiological safety of food by Hobbs, 1973

Emerging technologies; food process by Da-wen, 2005

Food safety by Laura K Egendorf, 2000

International standards of food safety by Naomi Rees, David Watson, 2000

Codex alimentarius by FAO & WHO, 2007

Nutritional and safety aspects of food processing by Tannenbaum SR

The food safety information handbook by Cynthia A. Robert, 2009

PGCHT 203T/2 **Credit: 4**

Petroleum Specialty Products

Unit 1: Lubricating Oil Base Stocks and their Blending:

Conventional Processes, Catalytic Dewaxing, API Classification of Base Oils.

Classification of Lube Oils by Viscosity, additive Types, International Standards, Automotive Engine Oils and their additives, Effect of Viscosity on Fuel Economy, Additive Depletion, Engine Oil Formulation, Effect of Base Stock Quality, API Service Classifications.

Unit 2: Metal Working Fluids:

Types & Functions of MWF's, Cutting Oil Formulation, Maintenance & Disposal.

Quenchants: Heat Treating Processes, Quenching, Types of Quenchants, three stages of Heat Removal, Quench System Design, Other HeatTreating Processes.

Unit 3: Turbine Oils, Gear Oils & Hydraulic Fluids:

Base oils, formulation, life, Test methods.

SAE Gear oil Calssification, Automotive lubricant Test Methods, Cold Crank Simulator (ASTM D 5293) and Four Ball Wear Test (ASTM D 4172).

Physical Properties of Hydraulic Fluids, Biodegradability, base oils for Hydraulic Fluids, Brake Fluids.

Unit 4: Lubricating Greases & Waxes:

Grease Composition, Base Oil, Thickeners, Additives, Grease manufacture, Grease Quality, Automotive Greases, Aircraft Greases, Heavy Machinery Greases, Marine Greases, High-Temperature Greases.

Paraffin Waxes, Classification, Properties, Test Methods, Petroleum Wax Manufacture, Non Petroleum Waxes and Petrolatums.

Unit 5: Transformer/ Electrical Insulating Oils & White Mineral Oils:

Properties, Specifications, Transformer Oil Manufacture.

Properties, Uses, Manufacturing of White Oils, Process description, Intermediate Product Nomenclature and Storage, Sulfonate Blending, petroleum Sulfonates,

Unit 6: Bitumen & Carbon Black:

Composition of Bitumen, Bitumen for Pavement, Evaluation, Grading Systems, Hot- Mix Asphalt, Test Methods, Types of Bitumen, Air Blowing Process, Industrial Uses, Storage and Handling.

Manufacturing Processes for Carbon Black viz.Channel Black Process, Gas Black Process, Thermal Black Process, Acetylene Black Process, Lamp Black Process, Furnace Black Process, Reactor, Oxidised Carbon Black, Properties, Secondary Properties, Test Methods, Application and Uses, Printing Inks, Cosmetics Usage.

References:

1. Petroleum Fuels Manufacturing Handbook, Surinder Prakash, Mc Graw Hill.
2. Modern Petroleum Technology, G. D. Hobson & Pohl., Applied Science Publications.
3. Asphalts and Road Materials, Modern Technology, J. E. Parson, Noyes Data Corporation.
4. Lubricant Additives, M. W. Ranney, Noyes Data Corporation.

PGCHT 203T/3 **Credit: 4**

MODIFICATION OF OIL AND FAT PRODUCTS INCLUDING SURFACE COATINGS

Unit- 1

Fat Based Products, Industrial lubricants. Bio Lubricants, Lubricant additives, Plasticizers, biodiesel, Lubricating Greases, Manufacture, Properties, types, ingredients, additives, analysis. Fatty Alcohols and Amines

Unit 2

Technology of Drying oils, Chemistry, Thermal and chemical modification methods; Properties and uses, drying, semi drying oils, yellowing of oils : modified oils like heat treated oils, Malenized oils, Co-polymerized oils, dehydration, isomerised oils, segregated, reconstituted oils.

Unit 3

Principles of paint formulations and testing, varnishes and lacquers ,primers, undercoats and finish coats. Manufacture, classification and types of powder coating. Sketches of the machinery used. Manufacture of different types of wall finishes. Convertible and Non-convertible coatings

Unit 4

Technology of Pigments and Extenders, Definition, classification ,Sources, properties, manufacture, testing and evaluation of pigments, preparation and uses of important pigments such as White, yellow, black, blue, green and red pigments, Metallic pigments, Natural organic pigments, comparison of organic pigments, Extenders:- Sources, manufacture, properties and uses,, recent developments.

Unit 5

Solvents and General Paint Properties Hazards and precautions. Diluents, thinners, lacquers-Types, general properties, classification, evaluation of solvents, solubility parameters. Safety measures for coatings, ISI methods of testing of paints, specialty paints, paint film defects, recent developments. Industrial Formulation and Applications of paints

Reference Books:

1. Protective and Decorative Coatings, Paint, Varnishes, Lacquers, and Inks, Mattiello, J. J., John Wiley and Sons, New York.
2. Organic Coating Technology Vol, 1 & 11 by, Payne, H.Y.
3. Paint Technology Manuals., Oil and color chemists Association, Vol-I – Vol. VIII, Chapman and Hall , London
4. Pigment Hand book Vol. 1 – Vol. VIII,. Patton, T. C., Wiley-Inter science Publications, New York.
5. The Testing of Paints, Vol – V, Paint Technology Manual,. Dunkley F.G. and Collier, C.W., Chapman and Hall. London
6. Paint film defects and their remedies, Manfred, H., Chapman and Hall Ltd. London.
7. Introduction to paint chemistry – Principles of paint technology, Turner G.P.A.,, Chapman and Hall , London
8. Outline of paint technology, Morgans, W.M. Edward Arnold Publishers, London

PGCHT 203T/4 **Credit: 4**

Applications, Evaluation of Surface Coating and Industrial Waste Treatment

Unit1:

Study of metal and nonmetal surfaces for coatings. Surface preparation and treatment.

Unit 2:

Methods of application of paints and the coatings, their advantages and disadvantages.

Plant and equipment used for application. Maintenances of equipments.

Unit 3:

Drying of coating. Analysis and evaluation of paints, varnishes, lacquer, and other coating. Accelerated and exposer tests for coating .I.S.I. standards for coatings.

Unit 4:

Electrodeposition technique anodic & cathodic deposition. Plant for electrodeposition.

Unit 5:

Paint film defects. Methods of improving performance, removal of defects, and correlation of formulation and defect of paint and films.

Safety in paint industry hazard and pollution control.

PGCHT 204T/1 **Credit: 4**

ELECTIVE - III (Discipline Specific BCHT)

1. **Food Industry Waste Management**

Unit 1: Standards for disposal of water, physical, chemical and biological characteristics of waste water; measurement of organic content in waste water; Physical unit operations in waste water treatment - screening; racks, mixing, flocculation, sedimentation, floatation, elutriation, vacuum filtration, incineration;

Unit 2: Chemical unit operations in waste water treatment-chemical precipitation, aeration and gas transfer process, rate of gas transfer, adsorption, disinfection; Alternative techniques to reduce the use of chlorine for water treatment, zero-discharge system, zero-emission system , Ion exchange treatment of waste water, Drinking-Water treatment

Unit 3: Biological unit operations - Aerobic and anaerobic treatment of effluents from food processing industry [Trickling filters, rotating biological contractor, Activated sludge, sludge treatment, oxidation ponds].

Unit 4: Waste management of fruits and vegetable such as production of pectin, ethanol, natural gas, citric acid, activated charcoal, fibre extract from apple pomace, vitamins , Production of citrus oil from peels of citrus fruits; Manufacture of candied peel. Recovery of Protein from potato starch plant waste. Waste management of cereals such as Feed for livestock from wheat and corn bran and germ. Extraction of oil & wax from rice bran, Puffed cereals from broken rice; Starch, modified starch and industrial alcohol from nonusable cereals; Silica from rice husk; Extraction of plolamin (Zein & katirin); Protein from sorghum; Beer spent graining.

Unit 5: Waste management of fish, meat, poultry such as Production of fish meal; Fish protein concentrate; Animal feed; Shell product;Glue from seafood processing waste. Texturised fish protein concentrate (marine beef); Utilization of organs and glands of animal as human food. Production of human food from animal blood and blood protein; Marketable products like chitin, chitosan, fertilizer, nutritional enhancer animal feed from shells. Waste management of Dairy, tea and coffee industry such as Fermentation products from whey. Condensed & dried products from whey; Production of lactose and protein from whey; Utilization of tea waste as feed for livestock & poultry.

Reference Books:

1. The potato in the human diet-Jennifer A Woolfe

2. Edible meat by products- A M Pearson & T R Dutson

3. By products from milk- Webb & Whitier.

4. Fish & Krill protein processing technology- Taneko Suzuki.

5. Processed apple products-Downing

6. Citrus fruits and their products- Ting & Rouseft.

7. Cocoa- Wood & Lass

8. Wheat- Peterson

9. Sweetness & Sweetener- Birch, Green & Coulson.

10. Outlines of Food Technology- Hanx W. VonLoesecke (ab)- Agrabios (India) 2nd

Edition, 200 1.

Food Industry Wastes: Disposal and Recovery; Herzka A & Booth RG; 1981, Applied Science Pub Ltd.

Water & Wastewater Engineering; Fair GM, Geyer JC & Okun DA; 1986, John Wiley & Sons, Inc.

Wastewater Treatment; Bartlett RE; Applied Science Pub Ltd.

Symposium: Processing Agricultural & Municipal Wastes; Inglett GE; 1973, AVI.

Food Processing Waste Management; Green JH & Kramer A; 1979, AVI.

Environmental Biotechnology: Principles and Applications; Rittmann BE & McCarty PL; 2001, Mc-Grow-Hill International editions.

Environmental Biotechnology; Bhattacharyya B C & Banerjee R; Oxford University Press.

PGCHT 204T/1 **Credit: 4**

ELECTIVE - III (Discipline Specific BCHT)

2. **Enzyme Technology**

Unit 1: Enzymes: classification, properties, coenzymes and cofactors, enzyme kinetics, regulatory enzymes, isoenzymes. Introduction to enzyme technology; Industrial enzymes – present status and opportunities with special reference to food industries;

Unit 2: enzyme inhibition and kinetics of enzyme inhibition, enzyme purification;

Types of enzyme reactions. Catalytic properties of enzymes; Intracellular and extra-cellular enzymes.

Unit 3: Enzyme production technology; Enzyme reactors and process design; Isolation of enzymes from various sources like plant, animals and microbiological.

Unit 4: Cell disintegration by physical, chemical and biological methods; Enzyme purification methods.

Unit 5: Enzyme applications in industry. Application of enzymes for production in biochemical and food processing industries; Application of immobilized enzymes and cells. Advantages and constraints of immobilized enzymes and microbial cells.

Reference Books:

1.Methods of Enzymology

2. Biochemical Engg Fundamentals-Baily, Ollis. MGH

3. Prescott & Dunn’s Industrial Microbiology Macmiller

4. Principles of Fermentation Technology-Wittaker and Stanby

PGCHT 204T/2 **Credit: 4**

ELECTIVE III (Discipline Specific BCHT)

1. **Advanced Separation Processes**

Unit 1: Flux Definition, Differential Equations of Mass transfer, Molecular diffusivities, Molecular diffusion, Mass Transfer coefficients

Unit 2: Multicomponent distillation: Bubble point and dew point calculations, Lewis and Matheson calculation, Method of Thiele and Geddes; Azeotropic distillation; Extractive distillation; Molecular distillation; Reactive distillation

Unit 3: Azeotropic and extractive fractional distillation:Separation of homogeneous azeotropes, separation of heterogeneous azeotropes, quantitative treatment of separation of binary heterogeneous azeotropes, selection of addition agents, selectivity, factors affecting selectivity, methods for prediction, mechanism of relative volatility change, choice of entrainer or solvent, design of an azeotropic distillation process, design of an extractive distillation process, methods of solvent recovery

Unit 4: Membrane separation processes:Fundamentals, mechanism and equilibrium relationships, types and structure of membranes, membrane permeation of liquids and gases, effects of concentration, pressure and temperature, dialysis: mechanism, basic idea on dialyser design, industrial application, reverse osmosis, definitions and theory, design considerations, applications, ultra filtration.

Unit 5: Adsorption and Ion Exchange Processes: Adsorption and ion exchange equilibria. Various isotherms. Contact filtration, design of fixed bed adsorber including breakthrough curve.

Recommended Books:

1. R.E. Lacey, S. Loaeb, Industrial Processing with Membranes, Wiley –Inter Science, New York, 1972.
2. C.J. King, Separation Processes, Tata McGraw - Hill Publishing Co., Ltd., 1982.
3. C.J. Geankoplis, Transport Processes and Unit Operations, Prentice-Hall of India Pvt. Ltd., New Delhi, 2000.
4. R.E. Treybal, Mass-Transfer Operations, McGraw-Hill, New York, 1980.
5. J.D. Seader, E.J. Henley, Separation Process Principles, Wiley, 2011.
6. B.K. Dutta, Principles of Mass Transfer and Separation Processes, PHI, 2006
7. T.K. Sherwood, R.L. Pigford, C.R. Wilke, Mass Transfer, McGraw-Hill, New York, 1975.
8. H.M. Schoew, New Chemical Engineering Separation Techniques, Interscience Publishers, 1972.
9. Osadar, Varid Nakagawa, Membrance Science and Technology, Marcel Dekkar, 1992.

2. Advanced Process Dynamics & Control

Unit 1: Process Identification and Non-Linear Systems. Introduction and analysis of Non-liner control system. Phase plane analysis of second order control system, Analysis of critical points. Method of isoclines for non linear system.

Unit 2: Control of complex processes Process modeling and dynamic response of gas absorber, steam jacketed kettle, heat exchanger, distributed parameter model, non-interacting continuous stirred tank reactors, non-interacting stirred tank heaters.

Unit 3: Feedforward-feedback control configuration. Industrial examples of feedforward-feedback control of heat exchanger, jacketed continuous stirred tank reactor for exothermic and endothermic reactions, stirred tank heater, distillation column, drum boiler, level control, extraction column.

Unit 4: Industrial control system. Control configuration of Supervisory control and data acquisition SCADA, Working control components and network communication of SCADA. Industrial examples of SCADA. Control configuration of distributed control system DCS. Working of Programmable logic controller PLC. Real time monitoring control.

Unit 5: Programmed adaptive control, Gain programmed adaptive control. Reference model adaptive control, Inferential control. Industrial examples of adaptive and inferential control. Reaction curve method.

Recommended Books:

1. B. A. Ogunaike, W. H. Ray, Process Dynamics, Modeling and Control, Oxford University Press, NY, 1994
2. B. W. Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall International Series, 1998
3. D. E. Seborg, D. A. Mellichamp, T. F. Edgar, F. J. Doyle III, Process Dynamics and Control, 3rd Edition, Wiley.
4. G. Stephanopoulos, Chemical Process Control, Prentice-Hall, Englewood Cliffs, NJ, 1984
5. T. Marlin, Process Control, 2nd Edition, McGraw Hill Inc, US, 2000.
6. R.P. Vyas, Process control and Instrumentation, Seventh Edition, Denett& Co. publication, 2015.
7. R.P. Vyas, Measurement and Control, Denett& Co. Publication 2010.

3. Advanced Chemical Reaction Engineering

Unit 1: Reaction engineering overview- emerging challenges- ideal reactor design equations- multiple reactions, instantaneous and overall yields.

Unit 2: Energy balance in stirred batch, semi-batch and continuous vessels- energy balance in plug flow vessels - optimal design for exothermic reversible reactions - stability and multiplicity of steady states in CSTR.

Unit 3: Design of packed tubular reactors- Gas solid reactions, shrinking core model, pseudo steady state hypothesis for ash layer control, gas solid reactions in rotary kiln and fluid beds.

Unit 4: Non ideal flow, RTD of ideal vessels, modeling non ideal flow, conversion from RTD theory, tanks in series model, dispersion model -catalyst deactivation, design for deactivating catalysts.

Unit 5: Introduction to population balance, application to RTD of CSTR, application to gas solid reactions in Rotary kiln and fluid beds, performance of reactor regenerator system from PBE modeling.

Unit 6: Design for Immobilized cell reactor, design for fermentation alcohol, design for polymerization reactors, biological waste water treatment- flow and reaction through porous media, acid leaching of rocks-liquid liquid reactions-gas liquid reactions , applications in CO_2 capture and global warming.

References:

1. H. Scot Fogler : Elements of Chemical reaction engineering Prentice Hall.
2. J.M. Smith : Chemical Engineering Kinetics, Mcgraw Hill.
3. O Levenspiel : Chemical Reaction Engineering, Wiley.

PGCHT 204T/2 **Credit: 4**

ELECTIVE III (Discipline Specific BCHT)

4. Environment, Health and Safety in Industries

Unit 1: Introduction

Need for Developing Environment, Health and Safety Systems in Work Places. Status and Relationship of Acts, Regulations and Codes of Practice .Role of Trade Union Safety Representatives. International Initiatives. Ergonomics and Work Place.

Unit 2: Occupational Health And Hygiene

Definition of the Term Occupational Health and Hygiene. Categories of Health Hazards. Exposure Pathways and Human Responses to Hazardous and Toxic Substances. Advantages and Limitations of Environmental Monitoring and Occupational Exposure Limits. Hierarchy of Control Measures for Occupational Health Risks. Role of Personal Protective Equipment and the Selection Criteria. Effects on Humans, Control Methods and Reduction Strategies for Noise, Radiation and Excessive Stress.

Unit 3: Workplace Safety and Safety Systems

Features of the Satisfactory Design of Work Premises Hvac, Ventilation. Safe Installation and Use of Electrical Supplies. Fire Safety and First Aid Provision. Significance of Human Factors in the Establishment and Effectiveness of Safe Systems. Safe Systems of Work For Manual Handling Operations. Control Methods to Eliminate or Reduce the Risks Arising from the Use of Work Equipment. Requirements for the Safe Use of Display Screen Equipment. Procedures and Precautionary Measures Necessary When Handling Hazardous Substances. Contingency Arrangements for Events of Serious and Imminent Danger.

Unit 4: Techniques of Environmental Safety

Elements of a Health and Safety Policy and Methods of its Effective Implementation and Review. Functions and Techniques of Risk Assessment, Inspections and Audits. Investigation of Accidents- Principles of Quality Management Systems in Health and Safety Management. Relationship between Quality Manuals, Safety Policies and Written Risk Assessments. Records and Other Documentation Required by an Organisation for Health and Safety. Industry Specific Ehs Issues.

Unit 5: Education and Training

Requirements for and Benefits of the Provision of Information, Instruction, Training and Supervision. Factors to be Considered in the Development of Effective Training Programmes. Principles and Methods of Effective Training. Feedback and Evaluation Mechanism.

References:

1. Environmental And Health And Safety Management By Nicholas P. Cheremisinoff And Madelyn L. Graffia, William Andrew Inc. Ny.
2. The Facility Manager's Guide To Environmental Health And Safety By Brian Gallant, Government Inst Publ..
3. Effective Environmental, Health, And Safety Management Using The Team Approach By Bill Taylor, Culinary And Hospitality Industry Publications Services.

PGCHT 201T/3 **Credit: 4**

ELECTIVE - III (Discipline Specific BCHT)

1. ENVIRONMENTAL ASPECTS OF OIL AND ALLIED INDUSTRIES

Unit 1

Industrial pollution and its impact . Magnitude of industrial waste , Legislative regulations. Recycle and reuse of waste water , recovery of by/c0-product from industrial effluents.

Unit 2

Philosophy of waste treatment, scope of air and water pollution problems, economic considerations of waste disposal, separation and segregation of wastes, gaseous, liquid and solid waste disposal with special reference to oils and allied product processing.

Unit 3

Waste Management Pollution prevention and environment Management system ISO 14000. Waste audit, Quality management systems, Different regulation means & acts for air , water& solid pollution control.

Unit 4

Waste liquid treatment: Pretreatment methods, centrifugation filtration, evaporator and concentrator , extraction and distillation, treatment of dilute waste water. Treatment requirements, Neutralisation liquid-solid separation, biological oxidation, plant control programme, absorption, liquid phase system, reclamation of waste water effluent and by-product recovery, ion exchange system, acid and alkali purification, continuous ion-exchange,. Case studies on vegetable oil processing, soaps and detergents.

Unit 5

Solid waste treatment, waste gas treatment: spent earth, catalyst, fly ash boiler ash, Air pollution control by mechanical method: mechanical collectors, electrostatic precipitator, filters,wet scrubbers, vapour phase system, activated carbon. Typical air purification system

Reference Books:

1. Narula O.P., “Treaties on fats, fatty acids and oleo chemicals, “Vol I Industrial consultants. (India) New Delhi 1996.
2. Metcalf and Eddy, Wastewater Engineering: Treatment, Disposal and Reuse, Tata McGraw-Hill Pub. Co. Ltd., New Delhi, 1979.
3. S.P. Mahajan, Pollution Control in Process Industry, Tata McGraw Hill Publishers, 1987.
4. G.N. Pandey, G.C. Camey, Environmental Engineering, Tata McGraw-Hill Pub.Co.Ltd., 1992.
5. H.S. Peavy, D.R. Rowe, G. Tchobanoglous, Environmental Engineering, McGraw-Hill, 1986.
6. C.N. Sawyer, P.L. McCarty, G.F. Parkin, Chemistry for Environmental Engineering, Tata-McGraw-Hill Edition, 2003.
7. S.K. Garg , Sewage Disposal and Air Pollution Engineering, Khanna Publishers, 2010.
8.

PGCHT 201T/3 **Credit: 4**

ELECTIVE - III (Discipline Specific BCHT)

2. POLYMERIC SURFACTANTS

Unit 1

Classification of surfactant, Surface tension and surfactant mechanism, types of surfactants. Basic concepts in surfactants

Unit 2

Development of synthetic detergent industry, principle groups of synthetic detergent industry, Current trends and recent scenario of detergent industry

Unit 3

Alternative surfactant, their functional properties, reaction mechanism, production methods, and their industrial uses, polymeric surfactant based on carbohydrates, vegetable oils and natural rosin

Unit 4

Mechanism of Polymeric surfactant as a substitute for phosphates, release agent, emulsifier, dispersion stabilizer, anti redeposition agent

Unit 5

Biodegradability study of polymeric surfactant, environmental affect compared to traditional raw materials in cleaning industry. Economical aspects

Reference Books:

1. Paolo Zini, "Polymeric Additives for high performing detergent", Technomic publication, U.S.A. 1995
2. Suri S.K., "Synthetic Detergent Powders: Changing Trends – 1, Soaps, Detergent & toiletries Review, p 14-18, Sept. 2000.
3. Hui Y.H., "Bailey's Industrial oil and fats products", 5, p. 78-80, Fifth edition, John Wiley and Sons, Inc, New York, 1996.
4. Mani V.V.S., Shitole A.D., "Fats oleo chemicals and Surfactants, challenges in the 21st Century", Oxford and IBH publishing Co. Pvt. Ltd., New Delhi, 1997.
5. Schwartz A.M. & Perry J.W., "Surface active agents. Their Chemistry and Technology". Interscience Publishers, Inc. New York p 51, 1949
6. Harris J.C. "Detergency Evaluation and Testing", Interscience Publishers, Inc, New York, 1954.

PGCHT 204T/4 **Credit: 4**

ELECTIVE –III (Discipline Specific)

1. Functional Coatings
(Super hydrophobic and self-healing coatings)

Unit 1:

Introduction to Super-hydrophobicity. Natural Super hydrophobic Surfaces: Introduction, Self-Cleaning Properties Arising from Hierarchical Structures,

Unit 2:

Design of Super-hydrophobic Surfaces: Methods to Prepare Super-hydrophobic Surfaces. Super-hydrophobic Polymers/binders: Introduction, Design of Super-hydrophobic Polymers.

Unit 3:

Generation and Characterization of Super-Hydrophobic Micro- and Nano-structured Surfaces. Pigments and other additives for super-hydrophobic coatings. Formulations super-hydrophobic coatings

Unit 4:

Introduction of Self-healing. Release of Healing Agents, Microcapsule Embedment Miscellaneous Technologies , Nanoparticle migrations, Self-healing Polymers and Polymer Composites**:** Introduction, Preparation and Characterization of the Self-healing Agent Consisting of Microencapsulated Curing Agents, Characterization of the Microencapsules

Unit 5:

Self-healing Protective Coatings: Self-healing Coating-based Active Corrosion Protection, Conductive Polymer Coatings, Active Anticorrosion Conversion Coatings, Protective Coatings with Inhibitor-doped Matrix. Self-healing Anticorrosion Coatings based on Nano-/ Microcontainers of Corrosion Inhibitors

PGCHT 204T/4 **Credit: 4**

ELECTIVE –III (Discipline Specific)

2. Chemistry and Technology of Nano-pigments

Unit 1:

Importance of nano- pigments in coatings.

Unit 2:

Natural nano-materials, fullerenes, applications, (filtrations, biomedical, textiles, electrical and optical) modifications.

Unit 3:

Synthesis, applications & treatments of nano-silica & analogues materials, silver, ZnO_2, gold, nano-fibers, single and MW- CNTs, iron oxide etc

Unit 4:

Different methods of characterization of nano materials. Self assembled layers, Issues related to handling of nano-materials etc.

Unit 5:

Recent advances in nano-materials used in coating industries. Properties of coatings based on nano-pigments.

PGOPEN 301T **Credit: 4**

ELECTIVE IV :

COURSE SCHEME
EXAMINATION SCHEME
ABSORPTION SCHEME
&
SYLLABUS

Of

First, Second, Third & Fourth Semester
Choice Base Credit System (CBCS)

Of

Master of Technology (M.Tech)
In

CHEMICAL ENGINEERING

Of
RASHTRASANT TUKDOJI MAHARAJ
NAGPUR UNIVERSITY, NAGPUR

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIRST SEMESTER M.TECH (C.B.C.S.) (CHEMICAL ENGINEERING)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHE 101T	Modeling & Simulation in Chemical Engineering	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHE 102T	Advanced Transport Phenomena	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHE 103T	Advanced Reactor Design	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHE 104T	Elective-I	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGOPEN 105T	Elective-II	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHE 106P	Modeling & Simulation of Chemical Processes	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective	Subject Name			
	BOARD			
	BTCHE			
Elective-I (Discipline Specific)	1. Process Design, Integration and Intensification	2. Advanced Optimization Techniques	3. Fluidization Engineering	4. Computational Fluid Dynamics
Elective-II (Open)	1. Chemical Engineering Mathematics	2. Modern Chemical Instrumentation		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SECOND SEMESTER M.TECH (C.B.C.S.) (CHEMICAL ENGINEERING)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHE 201T	Advanced Separation Processes	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHE 202T	Advanced Process Dynamics & Control	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHE 203T	Advanced Biochemical Engineering	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHE 204T	Elective-III	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGFD 205T	Research Methodology	4	-	-	4	4	-	-	4	30	70	-	-	100
Total			20	-	-	20	20	-	-	20	150	350	-	-	500

Elective	Subject Name			
	BOARD			
	BTCHE			
Elective-III (Discipline Specific)	1. Energy Conservation & Planning	2. Artificial Neural Network and Evolutionary Algorithms	3. Multiphase Flow	4. Fuel Cell Technology

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
THIRD SEMESTER M.TECH (C.B.C.S.) (CHEMICAL ENGINEERING)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGOPEN 301T	Elective IV	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGFD 302T	Project Planning and Management	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHE 303P	*Project Seminar	-	3	-	3	-	8	-	8	-	-	100	100	200
Total			8	3	-	11	8	8	-	16	60	140	100	100	400

Elective-IV (Open)	1. Advanced Petroleum Refining	2. Nanotechnology		

*For Work Load: 2 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FOURTH SEMESTER M.TECH (C.B.C.S.) (CHEMICAL ENGINEERING)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHE 401P	*Project	-	6	-	6	-	16	-	16	-	-	200	200	400
Total			-	6	-	6	-	16	-	16	-	-	200	200	400

* For Work Load: 3 Hours/week/faculty

Scheme of Absorption for 1st semester M.Tech. Old Pattern to CBCS Pattern of 1st Semester M. Tech. (Chemical Engineering)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Semester Pattern)				As Per Rashtrasant Tukadoji Maharaj Nagpur University (CBCS Pattern Scheme)		
1st Semester M. Tech (Chemical Engineering)				1st Semester M. Tech (Chemical Engineering)		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	CT 1.01	Modern Chemical Instrumentation	Theory	PGOPEN 105T	Elective-II- Modern Chemical Instrumentation	Theory
2	----	---		PGCHE 101T	Modeling & Simulation in Chemical Engineering #	Theory
3	CE 1.02	Science & Technology of Materials	Theory	----	---	
4.	CE 1.03	Momentum and heat Transfer		PGCHE 102T	Advanced Transport Phenomena	Theory
5.	CE 1.04	Advanced Chemical Reaction Engineering	Theory	PGCHE 103T	Advanced Reactor Design	Theory
6.	CE 1.05	Plant Design	Theory	----	---	
7	----	---		PGCHE 104T	Elective-I	Theory
8	----	---		PGOPEN 105T	Elective-II	Theory
9	----	---		PGCHE 106P	Modeling & Simulation of Chemical Processes	Practical

Students will have to appear in University theory and practical examination as per the new scheme.

Scheme of Absorption for 2nd semester M.Tech. Old Pattern to CBCS Pattern of 2nd Semester M. Tech. (Chemical Engineering)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Semester Pattern)				**As Per Rashtrasant Tukadoji Maharaj Nagpur University (CBCS Pattern Scheme)**		
2nd Semester M. Tech (Chemical Engineering)				**2nd Semester M. Tech (Chemical Engineering)**		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	CT 2.01	Biotechnology	Theory	PGCHE 203T	Advanced Biochemical Engineering	Theory
2	CE 2.02	Environmental Engineering	Theory	---	----	
	CE 2.05	Process Dynamics and Control	Theory	PGCHE 202T	Advanced Process Dynamics & Control	Theory
3	CE 2.03	Mass Transfer	Theory	PGCHE 201T	Advanced Separation Processes	Theory
4.	CE 2.04	Optimization and Mathematical Modeling #	Theory	----	---	
5.	----	---		PGCHE 204T	Elective-III	Theory
6.	----	---		PGFD 205T	Research Methodology	Theory

Students will have to appear in University theory and practical examination as per the new scheme.

 # Students have to attend the classes and appear in University examination (Theory) of the subject Modeling & Simulation in Chemical Engineering **of First semester M. Tech (Chemical Engineering) (CBCS) which is equivalent to** Optimization and Mathematical Modeling **(Theory) of Second Semester M.Tech (Chemical Engineering) old Semester pattern respectively.**

Scheme of Absorption for 3rd semester M.Tech. Old Pattern to CBCS Pattern of 3rd Semester M. Tech. (Chemical Engineering)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Semester Pattern)				As Per Rashtrasant Tukadoji Maharaj Nagpur University (CBCS Pattern Scheme)		
3rd Semester M. Tech (Chemical Engineering)				3rd Semester M. Tech (Chemical Engineering)		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	CE 3.01	Elective	Theory	PGOPEN 301T	Elective IV	Theory
2	----	---		PGFD 302T	Project Planning and Management	Theory
3	CE 3.02	Seminar	Practical	PGCHE 303P	Project Seminar	Practical
4.	CE 3.03	Minor Project Sessional Practical	Practical	PGCHE 303P	Project Seminar	Practical

Students will have to appear in University theory and practical examination as per the new scheme.

Scheme of Absorption for 4th semester M.Tech. Old Pattern to CBCS Pattern of 4th Semester M. Tech. (Chemical Engineering)						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Semester Pattern)				As Per Rashtrasant Tukadoji Maharaj Nagpur University (CBCS Pattern Scheme)		
4th Semester M. Tech (Chemical Engineering)				4th Semester M. Tech (Chemical Engineering)		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	CE 4.01	Major Project Viva-Voice	Practical	PGCHE 401P	Project	Practical

Students will have to appear in University theory and practical examination as per the new scheme.

FIRST SEMESTER M. Tech Chemical Engineering

Subject	**: PGCHE 101T** (BCHE)	**Modeling & Simulation in Chemical Engineering (Theory)**	
Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction to process modeling, Applications of models, classification of models, Principles of Formulation, fundamental laws, general modeling procedure, industrial usage of process modelling and simulation; Macroscopic and microscopic mass, energy and momentum balances

Unit 2: Parameter estimation techniques in theoretical as well as numerical models, population balance, stochastic, and empirical models

Unit 3: Modeling of various mass and heat transfer equipment: distillation, absorption, extraction columns; evaporators; furnaces; heat exchangers; flash vessels etc.

Unit 4: Modeling of Chemical Reactors: single phase and multiphase reactors

Unit 5: Numerical Methods for chemical engineering applications. Introduction and use of different softwares for modeling and simulation

Recommended Books:

1. W. L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.
2. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
3. R.E.G. Franks, Modeling and Simulation in Chemical Engineering, Wiely Intrscience, NY, 1972.
4. J. Ingam, I. J. Dunn, Chemical Engineering Dynamic Modeling with PC simulation, VCH Publishers, 2008.
5. D. Himmelblau, K.B. Bischoff, Process Analysis and Simulation, John Wiley & Sons, 1968.

Subject **: PGCHE 102T** (BCHE) **Advanced Transport Phenomena (Theory)**

Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Review of mathematics: Scalar, Vectors, Tensors, divergence, relation between rectangular coordinates and cylindrical coordinates, relation between rectangular coordinates and spherical coordinates, partial derivative, substantial derivative, total derivative, line integral, surface integral, integral theorems.

Unit 2: Equations of continuity, equation of motion, the equation of mechanical energy, application of Navier-Stokes equation to solve problems, the equations of change for incompressible non- Newtonian fluids.

Unit 3: Developing equations for obtaining velocity & shear stress distribution for flow of Newtonian, Bingham plastic & power law fluids in spheres etc. from I^{st} principle, Introduction to 2 dimensional & turbulent momentum transfers

Unit 4: Equations of energy, the energy equation in curvilinear coordinates, use of equations of change to set up steady state heat transfer for problems.

Unit 5: Unsteady state heat conduction expression for rectangular, spherical and cylindrical co-ordinate system from I^{st} principles, Numerical methods for 2 dimensional steady state conduction and Schmidt method for unsteady state heat conduction with / without surface resistance for obtaining temperature profiles

Recommended Books:

1. R.B. Bird, W. E. Stewart and E. N. Light foot Transport Phenomena Wiley international Edition, New York 2002.
2. James R. Welty, Charles E. Wicks and Robert E. Wilson, Fundamentals of momentum, heat and mass transfer, John Wiley & sons, Inc, New York, 2008.

Subject	**: PGCHE 103T** (BCHE)	**Advanced Reactor Design (Theory)**	
Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Non ideal flow, RTD function, characteristics of RTD, Zero-parameter models, one-parameter models, two-parameter models

Unit 2: Heterogeneous catalysis: Diffusion with reaction in porous catalyst, Mechanism of catalytic reactions. Langmuir - Hinshelwood model, Rideal - Eiley Mechanism, Rate controlling steps**,** Development of rate equations for solid catalysed fluid phase reactions; External/internal mass and heat transfer resistances in catalyst particles, catalyst deactivation.

Unit 3: Heterogeneous Catalytic Reactors: Isothermal and adiabatic fixed bed reactors, Non-isothermal and non-adiabatic fixed bed reactors.

Unit 4: Introduction to multiphase reactor design, fluidized bed reactor, slurry reactor, Trickle bed reactor, Photocatalytic reactor, Sonochemical reactors

Unit 5: Theory of mass transfer with chemical reaction (regimes and examples), model contactors

Recommended Books:

1. H.S. Fogler, Elements of Chemical Reaction Engineering, Prentice – Hall, 1986.
2. O. Levenspeil, Chemical Reaction Engineering, 3rd Edition, Wiley, 1999.
3. J.M. Smith, Chemical Engineering Kinetics, McGraw-Hill, 1981.
4. G.F. Froment, K.B. Bischoff, Chemical Reactor Design and Analysis, Addision -Wesley, 1982.
5. L.K. Doraiswamy, M.M. Sharma, Heterogeneous Reactions vol. I and II, John Wiley & Sons Inc.
6. P.V. Danckwerts, Gas Liquid Reactions, McGraw-Hill Book Co., New York, 1970.

Subject **: PGCHE 104T** (BCHE) **Elective I- Process Design, Integration and Intensification (Theory)**

Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction to chemical process design, integration and intensification. Hierarchy and approach of chemical process design and integration

Unit 2: Choice of reactors: Performance, conditions, configurations, heat integration of reactors etc.

Unit 3: Distillation sequencing: multicomponent, extractive, azeotropic distillation systems etc. with and without heat integration.

Unit 4: Heat exchanger networks: Energy Target and network design, trade-off & utilities, Heat & power integration.

Unit 5: Case studies on chemical process design, integration and intensification.

Recommended Books:

1. R. Smith, Chemical Process Design and Integration, John Wiley and Sons. Ltd., New Delhi, 2005.
2. J. Douglas, Conceptual Design of Chemical Processes. New York, NY: McGraw-Hill Science/Engineering/Math, 1988.
3. W. D. Seider, J. D. Seader, D. R. Lewin. Product and Process Design Principles: Synthesis, Analysis, and Evaluation. 2nd ed. New York, Wiley, 2004.
4. R. Turton, R. C. Bailie, W. B. Whiting, J. A. Shaeiwitz. Analysis, Synthesis, and Design of Chemical Processes, 2nd Edition, Prentice Hall, 2002.
5. L.T. Biegler, I.E. Grossmann, A.W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall, 1997.

Subject **: PGCHE 104T** (BCHE) **Elective I - Advanced Optimization Techniques (Theory)**

Lecture : 4 Hours | No. of Credits : 4

University : 70 Marks | College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction to process optimization; formulation of various process optimization problems and their classification. Basic concepts of optimization-convex and concave functions, necessary and sufficient conditions for stationary points.

Unit 2: Optimization of one dimensional functions, unconstrained multivariable optimization direct search methods.

Unit 3: Indirect first order and second order method. Gradient-based methods

Unit 4: Constrained Optimization Algorithms: Kuhn-Tucker conditions, Transformation methods: Penalty function method, method of multipliers.

Unit 5: Multivariable Optimization Algorithms: Optimality criteria, Unidirectional search, direct search methods: Evolutionary optimization method, simplex search method, Powell's conjugate direction method. Gradient-based methods: Cauchy's (steepest descent) method, Newton's method.

Recommended Books:

1. S.S. Rao, Optimization Theory and Applications, Wiley Eastern Ltd., 1979.
2. T.F. Edgar, D.M. Himmelblau, optimization of chemical processes, McGraw Hill International editions, Chemical Engineering Series, 1989.
3. G.S. Beveridge, R.S. Schechter, Optimization theory and practice, McGraw Hill, New York, 1970.
4. G.V. Rekllitis, A. Ravindran, K.M. Ragdell, Engineering Optimization-Methods and Applications, John Wiley, New York, 1983.

Subject **: PGCHE 104T** (BCHE) **Elective I- Fluidization Engineering (Theory)**

Lecture : 4 Hours No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Introduction: Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode

Unit 2: Mapping of fluidization regimes: Characterization of particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption

Unit 3: Bubbles in dense bed: Davidson model for gas flow, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow. **Bubbling fluidized beds:** Emulsion movement, estimation of bed properties, bubble rise velocity, scale up aspects, flow models, two phase model, K-L model

Unit 4: Entrainment and elutriation: Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization. **Solids movement:** Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds. **Gas dispersion:** Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient

Unit 5: Design of fluidized bed reactors: Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts, Design of noncatalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size

Recommended Books:

1. O. Levenspiel, D. Kunnii, Fluidization Engineering, John Wiley, 1972.
2. Liang-Shih Fan, Gas-Liquid-Solid Fluidization Engineering, Butterworths, 1989.

Subject **: PGCHE 104T** (BCHE) **Elective I- Computational Fluid Dynamics (Theory)**

Lecture : 4 Hours No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Conservation Laws of Fluid Motion and Boundary Conditions: Governing equations of fluid flow and heat transfer, Equations of state, Navier-Stokes equations for a Newtonian fluid, Classification of physical behaviour, Classification of fluid flow equations, Auxiliary conditions for viscous fluid flow equations

Unit 2: Turbulence and its Modelling: Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model,The k-e model, Reynolds stress equation models, Algebraic stress equation models

Unit 3: The Finite Volume Method for Diffusion Problems: Introduction, one dimensional steady state diffusion, two-dimensional diffusion problems, three dimensional diffusion problems, discretised equations for diffusion problems

Unit 4: The Finite Volume Method for Convection-Diffusion Problems: Steady one dimensional convection and diffusion, The central differencing scheme, Properties of discretisation schemes-Conservativeness, Boundedness, Transportiveness, Assessment of the central differencing scheme for convection-diffusion problems, The upwind differencing scheme, The hybrid differencing scheme, The power-law scheme, Higher order differencing schemes for convection-diffusion, Quadratic upwind differencing scheme

Unit 5: The Finite Volume Method for Unsteady Flows and Implementation of Boundary Conditions: One-dimensional unsteady heat conduction, Discretisation of transient convection-diffusion equation, Solution procedures for unsteady flow calculations, Implementation of Inlet, outlet and wall boundary conditions, constant pressure boundary condition.

Recommended Books:

1. H. K. Versteeg, W. Malalasekera, An introduction to computational fluid dynamics: the finite volume method , Longman scientific & technical publishers, 2007
2. John D. Anderson, Computational fluid dynamics: The Basics with Applications McGraw-Hill, .New York, 1995.
3. Vivek V. Ranade, Computational flow modeling for chemical reactor engineering, Academic Press, San Diego, 2002

Subject : **PGOPEN 105T** (BCHE) **Elective II- Chemical Engineering Mathematics (Theory)**

Lecture : 4 Hours | No. of Credits : 4

University : 70 Marks | College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: **Algebraic Equations**: Systems of linear equations – Jacabi, Gauss Seidel, Successive over Relaxation methods, Thomas algorithm for tridiagonal systems; Systems of non-linear equations –Successive approximation method, methods for improved convergence, Muller method, Chebyshev third order method, Newton method and its variants, Continuation methods for multiple solutions.

Unit 2: **Ordinary Differential Equations**: Runge Kutta methods, step size control and estimates of error, stability of the steady state of a linear system, solution of stiff ODEs, ODE-IVPs coupled with algebraic equations.

Unit 3: **Ordinary Differential Equations (BVPs):** Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method, stability analysis, shooting methods.

Unit 4: **Partial Differential Equations – Finite Difference Method**: Parabolic equations – Explicit and implicit methods – Alternating direction explicit and implicit methods; Chemical reaction and diffusion in a spherical catalyst pellet – Elliptic equations – Point iterative methods – Finite difference solution of a Poisson BVP – First order hypabolic equations – methods of characteristics – explicit and implicit methods – numerical stability analysis, method of lines.

Unit 5: **Partial Differential Equations – Finite Element Method:** Partial differential equations – Finite element method – Orthogonal collocation method, Orthogonal collocation with finite element method, Galerkin finite element method – Function approximation.

Recommended Books:

1. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
2. K. J. Beers, Numerical methods for Chemical Engineering, Cambridge University Press, New York, 2007.
3. S.K. Gupta, Numerical methods for Engineers, New age publishers 2003.
4. M.K. Jain. S.R.K. Iyengar, R.K. Jain, Numerical methods: Problems and solutions, Wiley Eastern Limited, 2008
5. M.K. Jain, S.R. Iyenkar, M.B. Kanchi, R.K. Jain, Computational methods for partial differential equations, New Age publishers, 2007.

Subject : **PGOPEN 105T** (BCHE) **Elective II- Modern Chemical Instrumentation (Theory)**

Lecture : 4 Hours No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: UV & IR spectroscopy, basic principles of UV & IR, Microwave spectroscopy, radiation sources, monochromators, detectors, instrumentation & Application of qualitative & Quantitative chemical analysis, Raman spectroscopy, sample handling & illumination & applications

Unit 2: Atomic absorption & Atomic emission spectroscopy, flame & flame temperatures, instrumentation & Application, in chemical analysis, fluorescence & phosphoresce, spectrophotometry

Unit 3: Mass spectrometry, basic principles, commercial mass spectrometers, correlation of mass spectra with molecular structure for a few typical cases, application of mass spectral data

Unit 4 : NMR spectroscopy, NMR phenomena, principle & Instrumentation, chemical shift , its measurement, spin – spin coupling, spin – spin splitting, application of NMR in structural diagnosis & Quantitative analysis, electron spin resonance spectroscopy, principle & application in chemical analysis,

Unit 5: Gas chromatography, HPLC, GCMS, SEM, Basic principal of XRD & XRF techniques, Differential Thermal Analysis & Differential scanning calorimeter, thermogravimetry, thermometric titrimetry, electrogravimetry, colorometry, principles applications of colorometry, colorometric titration stripping analysis

Recommended Books:

1. V.M. Parikh, Absorption Spectroscopy of Organic Molecules, Addison - Wesley Publishing Company, 1974.

2. H.H. Willard, I.I. Merritt, J.A. Dean, F.A. Settle, Instrumental Methods of Analysis, Sixth edition, CBS publishers, 1986.

3. D.A. Skoog, D.M. West, Fundamentals of Analytical Chemistry, Saunders-College Publishing, 1982.

4. G.C. Banwell, Fundamentals of Molecular Spectroscopy, TMH, 1992.

Subject	**: PGCHE 106P** (BCHE)	**Modeling & Simulation of Chemical Processes (Practical)**	
Practical	: 4 Hours	No. of Credits	: 2
University	: 100 Marks	College Assessment	: 100 Marks

Modeling and Simulations should be performed based on but not limited to the following List of examples

1. Dynamics of a Stirred Tank Heater with variable Volume
2. Modeling and Dynamics of a Quadruple Tank System.
3. Decoupled SISO control of the Quadruple Tank System.
4. Multi-variable Control of the Quadruple Tank System.
5. Dynamic Matrix Control of the Stirred Tank System.
6. Experiment on Programmed Adaptive Control System
7. Experiment on Time-delay compensation (Smith-Predictor)
8. Experiment on Inverse Response compensation
9. Experiment on multiple outputs controlled by a single input
10. Experiment on a single output controlled by multiple input
11. Introduction to process simulators and CFD software- ASPEN PLUS, HYSYS.
12. Simulation of steady state and Dynamic processes using ASPEN PLUS
13. Simulation of a batch reactor, CSTR, Tubular Reactor, multiphase reactor systems
14. Simulation of a shell and tube heat exchanger
15. Simulation of a condenser
16. Simulation of a pump/compressor
17. Simulation of a fixed bed absorber
18. Simulation of a staged distillation column
19. Simulation of flow in channels and pipes
20. Simulation of flow in sudden expansion/contraction systems
21. Simulation of flow in a square cavity, cylindrical venturi, slit venturi and orifice plate.
22. Process simulation study (flow sheeting)- Production of hydrogen by stream reforming
23. Process simulation study (flow sheeting)- Production of vinyl chloride monomer flowsheet
24. Process simulation study (flow sheeting)- Production of nitric acid from anhydrous ammonia

For the simulation of the above Processes/Process Equipment using Computer Programs or Simulation Packages such as ASPEN PLUS/CHEMCAD/HYSYS (UNISIM)/gPROMS etc. can be used.

SECOND SEMESTER M. Tech Chemical Engineering

Subject : **PGCHE 201T** (BCHE) **Advanced Separation Processes (Theory)**
Lecture : 4 Hours No. of Credits : 4
University : 70 Marks College Assessment : 30 Marks
Duration of Examination: 3 Hours

Unit 1: Flux Definition, Differential Equations of Mass transfer, Molecular diffusivities, Molecular diffusion, Mass Transfer coefficients

Unit 2: Multicomponent distillation: Bubble point and dew point calculations, Lewis and Matheson calculation, Method of Thiele and Geddes; Azeotropic distillation; Extractive distillation; Molecular distillation; Reactive distillation

Unit 3: Azeotropic and extractive fractional distillation: Separation of homogeneous azeotropes, separation of heterogeneous azeotropes, quantitative treatment of separation of binary heterogeneous azeotropes, selection of addition agents, selectivity, factors affecting selectivity, methods for prediction, mechanism of relative volatility change, choice of entrainer or solvent, design of an azeotropic distillation process, design of an extractive distillation process, methods of solvent recovery

Unit 4: Membrane separation processes: Fundamentals, mechanism and equilibrium relationships, types and structure of membranes, membrane permeation of liquids and gases, effects of concentration, pressure and temperature, dialysis: mechanism, basic idea on dialyser design, industrial application, reverse osmosis, definitions and theory, design considerations, applications, ultra filtration.

Unit 5: Adsorption and Ion Exchange Processes: Adsorption and ion exchange equilibria. Various isotherms. Contact filtration, design of fixed bed adsorber including breakthrough curve.

Recommended Books:

1. R.E. Lacey, S. Loaeb, Industrial Processing with Membranes, Wiley –Inter Science, New York, 1972.
2. C.J. King, Separation Processes, Tata McGraw - Hill Publishing Co., Ltd., 1982.
3. C.J. Geankoplis, Transport Processes and Unit Operations, Prentice-Hall of India Pvt. Ltd., New Delhi, 2000.
4. R.E. Treybal, Mass-Transfer Operations, McGraw-Hill, New York, 1980.
5. J.D. Seader, E.J. Henley, Separation Process Principles, Wiley, 2011.
6. B.K. Dutta, Principles of Mass Transfer and Separation Processes, PHI, 2006
7. T.K. Sherwood, R.L. Pigford, C.R. Wilke, Mass Transfer, McGraw-Hill, New York, 1975.
8. H.M. Schoew, New Chemical Engineering Separation Techniques, Interscience Publishers, 1972.
9. Osadar, Varid Nakagawa, Membrance Science and Technology, Marcel Dekkar, 1992.

Subject **: PGCHE 202T** (BCHE) **Advanced Process Dynamics & Control (Theory)**

Lecture : 4 Hours
No. of Credits : 4

University : 70 Marks
College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Process Identification and Non-Linear Systems. Introduction and analysis of Non-liner control system. Phase plane analysis of second order control system, Analysis of critical points. Method of isoclines for non linear system.

Unit 2: Control of complex processes Process modeling and dynamic response of gas absorber, steam jacketed kettle, heat exchanger, distributed parameter model, non-interacting continuous stirred tank reactors, non-interacting stirred tank heaters.

Unit 3: Feedforward-feedback control configuration. Industrial examples of feedforward-feedback control of heat exchanger, jacketed continuous stirred tank reactor for exothermic and endothermic reactions, stirred tank heater, distillation column, drum boiler, level control, extraction column.

Unit 4: Industrial control system. Control configuration of Supervisory control and data acquisition SCADA, Working control components and network communication of SCADA. Industrial examples of SCADA. Control configuration of distributed control system DCS. Working of Programmable logic controller PLC. Real time monitoring control.

Unit 5: Programmed adaptive control, Gain programmed adaptive control. Reference model adaptive control, Inferential control. Industrial examples of adaptive and inferential control. Reaction curve method.

Recommended Books:

1. B. A. Ogunaike, W. H. Ray, Process Dynamics, Modeling and Control, Oxford University Press, NY, 1994
2. B. W. Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall International Series, 1998
3. D. E. Seborg, D. A. Mellichamp, T. F. Edgar, F. J. Doyle III, Process Dynamics and Control, 3rd Edition, Wiley.
4. G. Stephanopoulos, Chemical Process Control, Prentice-Hall, Englewood Cliffs, NJ, 1984
5. T. Marlin, Process Control, 2nd Edition, McGraw Hill Inc, US, 2000.
6. R.P. Vyas, Process control and Instrumentation, Seventh Edition, Denett& Co. publication, 2015.
7. R.P. Vyas, Measurement and Control, Denett& Co. Publication 2010.

Subject	**: PGCHE 203T** (BCHE)	**Advanced Biochemical Engineering (Theory)**	
Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: Enzyme Kinetics: Models for complex enzyme kinetics, modeling of effect of pH and temperature, models for insoluble substrate, models for immobilized enzyme systems, diffusion limitations in immobilized enzyme system, electrostatic and steric effects.

Unit 2: Major metabolic pathways, bioenergetics, Glucose metabolism, metabolism of nitrogenous compounds, respiration, metabolism of hydrocarbons, anaerobic metabolism, autotrophic metabolism.

Unit 3: Bioreactors: Sterilization techniques, Modifications of batch and continuous reactors, chemostat with recycle, multistage chemostat, fed-batch operation, perfusion system, active and passive immobilization of cells, diffusional limitations in the immobilized system, fermenters.

Unit 4: Homogeneous and heterogeneous reactions in bioprocesses: Reaction thermodynamics, growth kinetics with Plasmid instability, The Thiele Modulus and effectiveness factor, diffusion and reaction in waste treatment lagoon. Reactors and choice of reactors.

Unit 5: Biological waste water treatment: Microbial participation in natural cycle of matter, activated sludge process, design and modeling of activated sludge process, Nitrification, anaerobic digestion, mathematical modeling of anaerobic digester, anaerobic denitrification, phosphate removal.

Recommended Books:

1) Michael L. Shuler, Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, 2001.
2) J. E. Bailey, D. F. Ollis, Biochemical Engineering Fundamentals, McGraw- Hill, 1986.
3) P. M. Doran, Bioprocess Engineering Principles, Academic Press, 2nd Edition, 2012.
4) J. M. Lee, Biochemical Engineering, Prentice Hall, Englewood Cliffs, New Jersey, 1992.

Subject : **PGCHE 204T** (BCHE) **Elective III- Energy Conservation & Planning (Theory)**

Lecture : 4 Hours No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Energy Outlook, Energy conservation and its importance, Energy intensive industries

Unit 2: Global industrial energy efficiency benchmarking, Engineering fundamentals related to energy efficiency

Unit 3: Principles on energy management, Energy Audit, Detailed thermodynamic analyses of common unit operations

Unit 4: Opportunities and techniques/methods for energy conservation in equipment and utility systems in process industries, Process synthesis, Thermo-economics, Energy Management Information Systems (EMIS).

Unit 5: Software tools for industrial energy efficiency and savings, Case studies on energy conservation and management in process industries

Recommended Books:

1. W.F. Kenney, Energy Conservation in the Process Industries. Academic Press Inc., 1984.
2. Vladimir S. Stepanov, Analysis of Energy Efficiency of Industrial Processes. 1st Edition, Springer-Verlag, 1993.
3. Jakob de Swaan Arons, Hedzer van der Kooi, Krishnan Sankaranarayanan, Efficiency and Sustainability in the Energy and Chemical Industries, 1st Edition, Marcel Dekker, Inc., 2004.

Subject **: PGCHE 204T** (BCHE) **Elective III- Artificial Neural Network and Evolutionary Algorithms (Theory)**

Lecture : 4 Hours No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Biological Neuron and neural network, McCulloch-Pitts Neuron, Thresholds logic unit (TLU), simple net with bias, Hebb craining algoritm

Unit 2: Feed forward error back propagation network, flow chart algorithm, topology, architecture, learning principals, applications to chemical process modeling, advantages , limitations.

Unit 3: Fuzzy logic: Introduction, examples, principal fuzzy logic controller applications including chemical processes

Unit 4: Evolutionary algorithm I: Genetic algorithm, natural genetics, advantages applications and algorithm.

Unit 5: Evolutionary algorithm II: Bee algorithm principle, flow chart, algorithm, chemical reactor optimization, swarm particle optimization, case based reasoning system

Recommended Books:

1. James A. Anderson, An introduction to neural networks, MIT Press, 1995.
2. S. L. Pandharipande, Artificial neural networks with free software CD, Dennet and Co. 2004.
3. S. N. Shivanandan, S. N. Deepa, Principles of soft computing, Wiley International, 2nd Edition, 2011.
4. Lan Cloete, J.M. Zurada, Knowledge based neuro computing, University Press (India) Ltd. 2002.

Subject **: PGCHE 204T** (BCHE) **Elective III- Multiphase Flow (Theory)**

Lecture : 4 Hours No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Unit 1: Two phase flow: Gas/Liquid and Liquid/liquid systems: Flow patterns in pipes, analysis of two phase flow situations

Unit 2: Prediction of holdup and pressure drop or volume fraction, Bubble size in pipe flow, Lockchart-Martinelli parameters, Bubble column and its design aspects, Minimum carryover velocity. holdup ratios, pressure drop and transport velocities and their prediction.

Unit 3: Flow patterns - identification and classification - flow pattern maps and transition - momentum and energy balance - homogeneous and separated flow models -correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two phase flow - drift flux model - correlations for bubble, slug and annular flows

Unit 4: Introduction to three phase flow, Dynamics of gas-solid liquid contactors (agitated vessels, packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds), Flow regimes, pressure drop, holdup, distributions, mass and heat transfer, reactions, Applications of these contactors

Unit 5: Measurement techniques in multiphase flow: Conventional and novel measurement techniques for multiphase systems (Laser Doppler anemometry, Particle Image Velocimetry)

Recommended Books:

1. R. Clift, M.E. Weber, J.R. Grace, Bubbles, Drops, and Particles, Academic Press, New York, 1978.
2. Y. T. Shah, Gas-Liquid-Solid reactors design, McGraw Hill Inc, 1979
3. L. S. Fan, C. Zhu, Principles of Gas-solid Flows, Cambridge University Press, 1998
4. G. W. Govier, K. Aziz, The Flow of Complex Mixture in Pipes, Van Nostrand Reinhold, New York, 1972.
5. G.B. Wallis, One Dimensional Two Phase Flow, McGraw Hill Book Co., New York, 1969.
6. C. T. Crowe, M. Sommerfeld, Y. Tsuji, Multiphase Flows with Droplets and Particles, CRC Press, 1998
7. C. Kleinstreuer, Two-phase Flow: Theory and Applications, Taylor & Francis, 2003
8. M. Rhodes, Introduction to Particle Technology, John Wiley & Sons, New York. 1998.

Subject : **PGCHE 204T** (BCHE) **Elective III- Fuel Cell Technology (Theory)**
Lecture : 4 Hours No. of Credits : 4
University : 70 Marks College Assessment : 30 Marks
Duration of Examination: 3 Hours

Unit 1: Hydrogen Production Methods Production: from fossil fuels, electrolysis, thermal decomposition, photochemical, photocatalytic, hybrid; Hydrogen Storage Methods Storage: Metal hydrides, Metallic alloy hydrides, Carbon nano-tubes; Sea as the source of Deuterium.

Introduction and overview of fuel cells technology: low and high temperature fuelcells.

Unit 2: Fuel cell thermodynamics. Fuel cell reaction kinetics: Introduction to electrode kinetics. Exchange current and electrocatalysis, Simplified activation kinetics, Catalyst electrode design. Fuel cell thermodynamics - second law analysis of fuel cells, efficiency of fuel cells fuel cell electrochemistry - Nernst equation, Electrochemical kinetics,Butler-Volmer equation

Unit 3: Fuel cell types Classification by operating temperature/electrolyte type, Fuel Cell Performance, Activation, Ohmic and Concentration over potential Fuel cell charge and mass transport. Fuel cell characterization.

Unit 4: Fuel cell modeling and system integration: Balance of plant.

Unit 5: Safety issues and cost expectation and life cycle analysis of fuel cells. Description of some commercially available fuel cell stacks, overview on research activities on fuel cells in world, Research and development related to fuel cell development in India

Recommended Books:

1. R.P. O'Hayre, S. Cha, W. Colella, F.B. Prinz, Fuel Cell Fundamentals, Wiley, NY, 2006.
2. A. J. Bard, L. R. Faulkner, Electrochemical Methods, Wiley, N.Y. 2004.
3. S.(Ed) Basu, Fuel Cell Science and Technology, Springer, N.Y. 2007.
4. H. Liu, Principles of fuel cells, Taylor & Francis, N.Y. 2006.

Subject **: PGFD 205T** (BCHE) **Research Methodology (Theory)**
Lecture : 4 Hours No. of Credits : 4
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

Unit 1 Research Foundation

What is Research, Objectives of Research, Types of Research, Scientific Research, Research and Theory, Conceptual and theoretical Models, Importance of research methodology in scientific research

Unit 2 Review of Literature

Need for Reviewing Literature, What to Review and for what purpose, Literature Search Procedure, Sources of Literature, Planning of Review work, Note Taking, Library and documentation

Unit 3 Planning of Research

The planning process, Selection of a Problem for Research, Formulation of the Selected Problems, Hypothesis formation, Measurement, Research Design/Plan

Unit 4 Processing of Data and Statistical Analysis of Data

Introduction to Statistical Software, MINITAB, SPSS, Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, MATLAB and Neural Network based optimization, Optimization of fuzzy systems, Error Analysis, Results and their discussions

Unit 5 Report and Thesis writing

Types of Reports, Planning of Report Writing, Research Report Format, Principles of Writing, Data and Data Analysis Reporting in a Thesis, Use of Endnote, Bibliography, API , appendix, table, Observations arrangement, Preparation of type script and lay-out of thesis, Use of LATEX Indexing of Journals, Impact factor and social Media for Researchers.

Recommended Books:

1. Research Methodology: Methods and Techniques by C. R. Kothari, New Age International Publishers, ISBN:81-224-1522-9
2. Statistical Methods for Research Workers by Fisher R. A., Cosmo Publications, New Delhi ISBN:81-307-0128-6
3. Design and Analysis of Experiments by Montogomery D.C. (2001), John Wiley, ISBN: 0471260088
4. MINITAB online manual
5. Methodology of Research in Social Sciences by O. R. Krishnaswamy and M. Rangnatham Himalaya publication House, 2005, ISBN: 8184880936
6. SPSS online manual

THIRD SEMESTER M. Tech Chemical Engineering

Subject	**: PGOPEN 301T** (BCHE)	**Elective IV- Advanced Petroleum Refining (Theory)**	
Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1: History and development of Refining, Composition of Petroleum, Refinery products and Test methods, Evaluation of Oil stocks, Physical properties of Petroleum Oil.

Unit 2: Introduction to Processing, Refinery and Distillation Process, Auxillary processes and operations, Refinary metals and Corrosion

Unit 3: Vaporization and Condensation, Fractionation and Towers

Unit 4: Heat transfer and Exchangers, Tube-still Heaters.

Unit 5: Thermal Cracking and Decomposition Processes, Rebuilding Hydrocarbons, Catalytic Cracking and Reforming, Natural and Refinery gases

References

1. W.L. Nelson, Petroleum Refinery Engineering, McGraw Hill Publishing Company Limited, 1958.
2. G.D. Hobson, Modern petroleum Refining Technology, 4th Edition, Institute of Petroleum U.K, 1973.
3. J.H. Gary, G.E. Handwerk, M. J. Kaiser, Petroleum Refining: Technology and Economics, Fifth Edition, CRC Press, 2007.

Subject **: PGOPEN 301T** (BCHE) **Elective IV- Nanotechnology (Theory)**
Lecture : 4 Hours No. of Credits : 4
University : 70 Marks College Assessment : 30 Marks
Duration of Examination: 3 Hours

Unit 1: **Introduction to nanotechnology:** The nanoscale dimension and paradigm, definitions, history and current practice, Overview of current industry applications, Nanoscale science and engineering principles, Self-assembly of nano particles and nano structural molecular materials, Different structures anisotropic, asymmetric, symmetric particles, clay materials platelets structures, dendrimers, colloid structures

Unit 2: **Approach of synthesis of nanomaterials**: Methods of synthesis of nanomaterials Top down approach, Bottom up approaches, Bottom-up vs. top-down, Insitu Deposition Method, Colloidal Methods, Plasma Technique, Layer by Layer technique, Self-assembly, Nanotubes Carbon arc bulk synthesis in presence and absence of catalysts graphite, Chemical Vapor Deposition (CVD), Micro fluidics and Micro reactors Focus on emerging applications. Mini emulsion synthesis

Unit 3: **Instrumentation for nanoscale characterization**: Instrumentation required for characterization of properties on the nanometer scale. The measurable properties and resolution limits of each technique, with an emphasis on measurements in the nanometer range. Zeta Potential, XRD, TEM, SEM, XPS, DSC, Particle size distribution analysis methods and applications, Cryo TEM for material analysis. Contact angle, surface tension. Gel Permission Chromatography Atomic Force Microscopy, Focus on emerging applications.

Unit 4: **Properties of nanomaterials:** Mechanical properties: Strength of nano crystalline, Preparation for strength measurements, Mechanical properties, Magnetic properties, Electrical properties: electronic conduction with nano particles Optical properties: Optical properties. Polymer nanocomposites. Hiding powder improvement coating. New advancement reported in current literature. Population balance Quantum dots properties, dendrimer properties

Unit 5: **Applications of nanomaterials :** Catalysis : Using nanometal colloids as catalysts, Catalysts, Using, Other Types of Catalysts Made From Nanomaterials, Separations nanofiltration membranes, Magnetic Fluids - Processing Methods and Potential Applications Remediation : TiO_2 photocatalysis, disinfections, advance waste water treatments using metal oxides Drug delivery system, Introduction to industries which produces commercial nanomaterials.

Recommended Books:

1. G. Louis Hornyak, Joydeep Dutta, Harry F. Tibbals, Anil K. Rao, Introduction to Nano Science, CRC Press of Taylor and Francis Group LLC, 2008, 856pp, ISBN-13: 9781420048056

2. M. Di Ventra, S. Evoy, J. R. Heflin, Jr. (Eds.), Introduction to Nanoscale Science and Technology, Springer, 2004.

3. Ping Sheng, Zikang Tang, Nano science and technology: novel structures and phenomena, Taylor and Francis, 2003

4. Michael Rieth**,** Nano-Engineering in Science and Technology: An Introduction to the World of Nano design, World Scientific, 2003

5. R. Kelsall, I. Hamley, M. Geoghegan (Eds.), Nanoscale Science and Technology, Wiley, 2005.
6. C. P. Poole, Jr., F. J. Owens, Introduction to Nanotechnology, Wiley, 2003.
7. S. A. Campbell, The Science and Engineering of Microelectronic Fabrication, Oxford, 2001.

Subject : **PGFD 302T** (BCHE) **Project Planning and Management (Theory)**

Lecture	: 4 Hours	No. of Credits	: 4
University	: 70 Marks	College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Unit 1 : ***Basics of Project Management:*** Introduction, Need for Project Management, Project Management Knowledge Areas and Processes, The Project Life Cycle, The Project Manager (PM), Phases of Project Management Life Cycle, Project Management Processes, Impact of Delays in Project Completions, Essentials of Project Management Philosophy, Project Management Principles

Unit 2 : ***Project Identification and Selection:*** Introduction, Project Identification Process, Project Initiation, Pre-Feasibility Study, Feasibility Studies, Project Break-even point

Project Planning: Introduction, Project Planning, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS)

Organisational Structure and Organisational Issues: Introduction, Concept of Organisational Structure, Roles and Responsibilities of Project Leader, Relationship between Project Manager and Line Manager, Leadership Styles for Project Managers, Conflict Resolution, Team

Unit 3: ***Resources Considerations in Projects:*** Introduction, Resource Allocation, Scheduling, Project Cost Estimate and Budgets, Cost Forecasts

Project Risk Management: Introduction, Risk, Risk Management, Role of Risk Management in Overall Project Management, Steps in Risk Management, Risk Identification, Risk Analysis, Reducing Risks

Unit 4: ***Project Quality Management and Value Engineering:*** Introduction, Quality, Quality Concepts, Value Engineering

Project Management Information System: Introduction, Project Management Information System (PMIS), Planning of PMIS, Design of PMIS

Purchasing and Contracting for Projects: Introduction, Purchase Cycle, Contract Management, Procurement Process

Unit 5: ***Project Performance Measurement and Evaluation:*** Introduction, Performance Measurement, Productivity, Project Performance Evaluation, Benefits and Challenges of Performance Measurement and Evaluation, Controlling the Projects

Project Execution and Control: Introduction, Project Execution, Project Control Process, Purpose of Project Execution and Control

Project Close-out, Termination and Follow-up: Introduction, Project Close-out, Steps for Closing the Project, Project Termination, Project Follow-up

Project Management Software: Introduction, Advantages of Using Project Management Software, Common Features Available In Most of the Project Management Software, Project 2000.

Reference Books:

1. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, by John W. Creswell, 2^{nd} Edition , Sage Publication, 2003
2. Qualitative Inquiry and Research Design: Choosing among Five Approaches, by John W. Creswell, 3^{rd} Edition, Sage publication, 2013.
3. Evaluation: A Systematic Approach, Peter H. Rossi, Mark W. Lipsey, and Howard E. Freeman, 7^{th} edition , Sage publications, 2007.
4. Handbook of Practical Program Evaluation, Joseph S. Wholey, Harry P. Hatry, Kathryn E. Newcomer. 4^{th} edition, Wiley, 2015
5. Program Evaluation and Performance Measurement: An Introduction to Practice, James C. McDavid and Laura R. L. Hawthorn, Sage Publication, 2013.
6. Evaluation, Carol H. Weiss, 2^{nd} Edition, ABE books, 1997.
7. Case Study Research: Design and Methods, Robert K. Yin, 3^{rd} Edition, Sage Publications, 2011

Subject	**: PGCHE 303P** (BCHE)	**Project Seminar**	
Practical	: 3 Hours	No. of Credits	: 8
University	: 100 Marks	College Assessment	: 100 Marks

Each student will undertake an independent project seminar. The student is required to select the topic in consultation with his/her Guide. Student should undertake project concerning Chemical Engineering applications such as design and development, experimental work, industry based problems, generation of new ideas and concept, modification in the existing process/system, development of computer programs, modelling and simulation etc. A preliminary work is to be carried out in this stage of the project. Two neatly typed copies of the Report on the completed work at this stage include comprehensive report on literature survey, design and fabrication of experimental set up and/or development of model, relevant computer programs and the plan for stage II should be submitted at end on the 3rd semester. University and college assessment would be made on the basis of the submitted report and the presentation cum viva-voce examination conducted by the board of examiners.

FOUTH SEMESTER M. Tech Chemical Engineering

Subject	**: PGCHE 303P** (BCHE)	**Project**	
Practical	: 6 Hours	No. of Credits	: 16
University	: 200 Marks	College Assessment	: 200 Marks

Project work undertaken in the 3^{rd} semester will be continued and completed at the end of fourth semester. This stage will include comprehensive report on the work carried out at this stage and relevant portions from project seminar stage, including experimental studies, analysis and/or verification of theoretical model, conclusions. Two neatly typed and bound copies of the report consisting of project seminar stage of 3^{rd} semester and project stage from 4^{th} semester combined together along with its soft copy should be submitted at the end of fourth semester. The student are expected to publish at least one national/international paper based on the project work. The publication/accepted paper for publication shall be included in the report. University and college assessment would be made on the basis of the submitted report and the presentation cum viva-voce examination conducted by the board of examiners.

COURSE SCHEME
EXAMINATION SCHEME
ABSORPTION SCHEME
&
SYLLABUS

Of

First, Second, Third & Fourth Semester
Choice Base Credit System (CBCS)

Of
Master of Technology (M.Tech)

In
CHEMICAL TECHNOLOGY

Of
RASHTRASANT TUKDOJI MAHARAJ
NAGPUR UNIVERSITY, NAGPUR

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIRST SEMESTER M.TECH (C.B.C.S.) (FOOD TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 101T/1	Chemistry & Biochemistry of Food Components	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 102T/1	Food Product Development & Packaging	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 103T/1	Bioprocess Engineering	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 104T/1	Elective-I	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGOPEN 105T	Elective-II	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT 106P/1	Food Technology Practical	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective				
Elective-I (Discipline Specific)	1. Advances in Food Engineering	2. Molecular Biology	3. Advances in Nutrition	
Elective-II (Open)	1. Chemical Engineering Mathematics	2. Modern Chemical Instrumentation		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SECOND SEMESTER M.TECH (C.B.C.S.) (FOOD TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 201T/1	Advances in Food Science & Technology	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 202T/1	Food Biotechnology	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 203T/1	Food Safety & Food Regulations	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 204T/1	Elective III	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGFD205T	Research Methodology	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT206P	Seminar	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective	Subject Name			
Elective-III (Discipline Specific)	1. Food Industry Waste Management	2. Enzyme Technology		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
THIRD SEMESTER M.TECH (C.B.C.S.) (FOOD TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGOPEN 301T	Elective IV	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGFD 302T	Project Planning and Management	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 303P	*Project Seminar	-	3	-	3	-	8	-	8	-	-	100	100	200
Total			8	3	-	11	8	8	-	16	60	140	100	100	400

Elective-IV (Open)	1. Advanced Petroleum Refining	2. Nanotechnology		

*For Work Load: 2 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FOURTH SEMESTER M.TECH (C.B.C.S.) (FOOD TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 401P	*Project	-	6	-	6	-	16	-	16	-	-	200	200	400
Total			-	6	-	6	-	16	-	16	-	-	200	200	400

* For Work Load: 3 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIRST SEMESTER M.TECH (C.B.C.S.) (PETROCHEMICAL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 101T/2	Catalyst Science and Technology	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 102T/2	Petroleum Refinery Engineering	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 103T/2	Petrochemical Process Design	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 104T/2	Elective-I	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGOPEN 105T	Elective-II	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT 106P/2	Process Simulation Laboratory	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective				
Elective-I (Discipline Specific)	1. Oil & Natural Gas Processing	2. Modelling & Simulation in Chemical Engineering	3. Advanced Transport Phenomena	4. Advanced Thermodynamics
Elective-II (Open)	1. Chemical Engineering Mathematics	2. Modern Chemical Instrumentation		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SECOND SEMESTER M.TECH (C.B.C.S.) (PETROCHEMICAL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 201T/2	Multicomponent Distillation	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 202T/2	Process Equipment and Piping Design	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 203T/2	Petroleum Specialty Products	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 204T/2	Elective III	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGFD205T	Research Methodology	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT206P	Seminar	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective	Subject Name			
Elective-III (Discipline Specific)	1. Advanced Separation Processes	2. Advanced Process Dynamics & Control	3. Advanced Chemical Reaction Engineering	4. Environment, Health and Safety in Industries

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
THIRD SEMESTER M.TECH (C.B.C.S.) (PETROCHEMICAL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGOPEN 301T	Elective IV	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGFD 302T	Project Planning and Management	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 303P	*Project Seminar	-	3	-	3	-	8	-	8	-	-	100	100	200
Total			8	3	-	11	8	8	-	16	60	140	100	100	400

Elective-IV (Open)	1. Advanced Petroleum Refining	2. Nanotechnology		

*For Work Load: 2 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FOURTH SEMESTER M.TECH (C.B.C.S.) (PETROCHEMICAL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 401P	*Project	-	6	-	6	-	16	-	16	-	-	200	200	400
Total			-	6	-	6	-	16	-	16	-	-	200	200	400

* For Work Load: 3 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIRST SEMESTER M.TECH (C.B.C.S.) (OIL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 101T/3	Advanced Oil Chemistry and Oleochemicals	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 102T/3	Advanced Quality Control Techniques	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 103T/3	Technology of Expression, Extraction and Refining of Oil Bearing Materials	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 104T/3	Elective-I	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGOPEN 105T	Elective-II	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT 106P/3	Oil Technology Practical	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective				
Elective-I (Discipline Specific)	1. Technological Advancement in Oleochemicals	2. Process Economics, Utilities and Byproducts of Oil Industry		
Elective-II (Open)	1. Chemical Engineering Mathematics	2. Modern Chemical Instrumentation		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SECOND SEMESTER M.TECH (C.B.C.S.) (OIL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 201T/3	Technology of Soaps, Detergents & Surfactants	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 202T/3	Technological Advancement of Cosmetics and Allied Products	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 203T/3	Modification of Oil and Fat Products including Surface Coatings	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 204T/3	Elective III	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGFD205T	Research Methodology	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT206P	Seminar	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective	Subject Name			
Elective-III (Discipline Specific)	1. Environmental Aspects of Oil and Allied Industries	2. Polymeric Surfactants		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
THIRD SEMESTER M.TECH (C.B.C.S.) (OIL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGOPEN 301T	Elective IV	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGFD 302T	Project Planning and Management	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 303P	*Project Seminar	-	3	-	3	-	8	-	8	-	-	100	100	200
Total			8	3	-	11	8	8	-	16	60	140	100	100	400

Elective-IV (Open)	1. Advanced Petroleum Refining	2. Nanotechnology		

*For Work Load: 2 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FOURTH SEMESTER M.TECH (C.B.C.S.) (OIL TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 401P	*Project	-	6	-	6	-	16	-	16	-	-	200	200	400
Total			-	6	-	6	-	16	-	16	-	-	200	200	400

* For Work Load: 3 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIRST SEMESTER M.TECH (C.B.C.S.) (PAINT TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 101T/4	Chemistry of Film Forming Materials & Polymerization Techniques	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 102T/4	Technology of Pigment Extenders and Additives	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 103T/4	Principle and Formulation of Surface Coatings	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 104T/4	Elective-I	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGOPEN 105T	Elective-II	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT 106P/4	Paint Technology Practical	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective				
Elective-I (Discipline Specific)	1. Automotive and Coil Coatings	2. Technology of Cosmetics and Polishes	3. Bio-Polymers in Coatings	
Elective-II (Open)	1. Chemical Engineering Mathematics	2. Modern Chemical Instrumentation		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SECOND SEMESTER M.TECH (C.B.C.S.) (PAINT TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
			L	P	T	Total	L	P	T	Total	Theory		Practical		
											Sessional	University	Sessional	University	
1.	PGCHT 201T/4	Manufacturing Methods, machinery & Planning	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGCHT 202T/4	Processing, Application & Technology of Inks	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 203T/4	Application, Evaluation of Surface Coating & Industrial Waste Treatment	4	-	-	4	4	-	-	4	30	70	-	-	100
4.	PGCHT 204T/4	Elective III	4	-	-	4	4	-	-	4	30	70	-	-	100
5.	PGFD205T	Research Methodology	4	-	-	4	4	-	-	4	30	70	-	-	100
6.	PGCHT206P	Seminar	-	4	-	4	-	2	-	2	-	-	100	100	200
Total			20	4	-	24	20	2	-	22	150	350	100	100	700

Elective	Subject Name			
Elective-III (Discipline Specific)	1. Functional Coatings (Super Hydrophobic and Self Healing Coatings)	2. Chemistry and Technology of Nano-Pigments		

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
THIRD SEMESTER M.TECH (C.B.C.S.) (PAINT TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGOPEN 301T	Elective IV	4	-	-	4	4	-	-	4	30	70	-	-	100
2.	PGFD 302T	Project Planning and Management	4	-	-	4	4	-	-	4	30	70	-	-	100
3.	PGCHT 303P	*Project Seminar	-	3	-	3	-	8	-	8	-	-	100	100	200
Total			8	3	-	11	8	8	-	16	60	140	100	100	400

Elective-IV (Open)	1. Advanced Petroleum Refining	2. Nanotechnology		

*For Work Load: 2 Hours/week/faculty

RASHTRASANT TUKDOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FOURTH SEMESTER M.TECH (C.B.C.S.) (PAINT TECHNOLOGY)

Sr. No.	Code (Board) Theo./Pract	Subject	Workload				Credit				MARKS				Total Marks
											Theory		Practical		
			L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	PGCHT 401P	*Project	-	6	-	6	-	16	-	16	-	-	200	200	400
Total			-	6	-	6	-	16	-	16	-	-	200	200	400

* For Work Load: 3 Hours/week/faculty

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Food Technology) FIRST SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT1.03-4	Special Technology I (Biochemistry and Analysis of Food Components)	Theory		PGCHT 101T/1	Chemistry & Biochemistry of Food Components	Theory
2.	CT 1.04-4	Special Technology II (Molecular Biology)	Theory		PGCHT 104T/1	Elective-I (Molecular Biology)	Theory
3.	CT 1.05-4	Special Technology III (Bioprocess Engineering)	Theory		PGCHT 103T/1	Bioprocess Engineering	Theory
4.	----	----	----				Theory
5.	CT1.01	Modern Chemical Instrumentation	Theory		PGOPEN 105T	Elective-II(Modern Chemical Instrumentation)	Theory
6.	----	----	----		*PGCHT 106P/1	Food Technology Practical	Practical
7.	CE 1.02	Science and Technology of Materials	Theory		----	----	----

*Subject is covered in Second Semester for Old Pattern according to subject CT 2.06. They may be exempted.

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Food Technology) SECOND SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT2.03-4	Special Technology IV (Modern Trends in Food Science and Technology)	Theory		PGCHT 201T/1	Advances in Food Science & Technology	Theory
2.	CT2.04-4	Special Technology V (Food Biotechnology)	Theory		PGCHT 202T/1	Food Biotechnology	Theory
3.	CT2.05-4	Special Technology VI (Biotechnology Applications)	Theory		PGCHT 204T/1	Elective III (Food Industry Waste Management)	Theory
4.	----	----	----				Theory
5.	----	----	----		PGFD205T	Research Methodology	Theory
6.	----	----	----		PGCHT206P	Seminar	Practical
7.	CT2.01	Industrial Fermentations	Theory		----	----	----
8.	CE2.02	Environmental Engineering	Theory		----	----	----
9.	CT 2.06	Practical: Food Technology	Practical		----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Food Technology) THIRD SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	----	----	----		PGOPEN 301T	Elective IV	Theory
2.	----	----	----		PGFD 302T	Project Planning and Management	Theory
3.	----	----	----		PGCHT 303P	Project Seminar	Practical
4.	CT3.01	Seminar	Practical		----	----	----
5.	CT3.02	Training Report/Minor Project/Home Assignment	Practical		----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Food Technology) FOURTH SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT 4.01	Project and Viva-voce	Practical		PGCHT 401P	Project	Practical

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Petrochemical Technology) FIRST SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT1.03-3	Special Technology-I (Science & Technology of Polymerisation)	Theory		PGCHT 101T/2	Catalyst Science and Technology	Theory
2.	CT1.04-3	Special Technology II (Natural gas technology)	Theory		PGCHT 104T/2	Elective I (Oil & Natural Gas Processing)	Theory
3.	CT1.05-3	Special Technology III (Lubricant waxes and Petroleum Special Product)	Theory		PGCHT 103T/2	Petroleum Specialty Products	Theory
4.	----	----	----		PGCHT 104T/2	Elective-I	Theory
5.	CT 1.01	Modern Chemical Instrumentation	Theory		PGOPEN 105T	Elective-II (Modern Chemical Instrumentation)	Theory
6.	----	----	----		*PGCHT 106P/2	Process Simulation Laboratory	Practical
7.	CE 1.02	Science and Technology of Materials	Theory		----	----	----

*Subject is covered in Second Semester for Old Pattern according to subject CT 2.06. They may be exempted.

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Petrochemical Technology) SECOND SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT2.03-3	Special Technology IV (Project Engineering of Petroleum and Petrochemical Plants)	Theory		PGCHT 201T/2	Process Equipment and Piping Design	Theory
2.	CT2.04-3	Special Technology V (Petroleum Refinery Processing)	Theory		PGCHT 202T/2	Multi Component Distillation	Theory
3.	CT2.05-3	Special Technology VI (Petrochemical Process Engineering)	Theory		PGCHT 203T/2	Petrochemical Process Design	Theory
4.	----	----	----		PGCHT 204T/2	Elective III	Theory
5.	----	----	----		PGFD205T	Research Methodology	Theory
6.					PGCHT206P	Seminar	Practical
7.	CT2.01	Biotechnology	Theory		----	----	----
8.	CE2.02	Environmental Engineering	Theory		----	----	----
9.	CT 2.06	Practical: Petrochemical Technology	Practical		----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Petrochemical Technology) THIRD SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	----	----	----		PGOPEN 301T	Elective IV	Theory
2.	----	----	----		PGFD 302T	Project Planning and Management	Theory
3.	----	----	----		PGCHT 303P	*Project Seminar	Practical
4.	CT3.01	Seminar	Practical		----	----	----
5.	CT3.02	Training Report /Minor Project/Home Assignment	Practical		----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Petrochemical Technology) FOURTH SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT 4.01	Project and Viva-voce	Practical		PGCHT 401P	Project	Practical

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Oil Technology) FIRST SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT1.03-1	Special Technology I (Chemistry and Biochemistry of lipids and fatty materials)	Theory		PGCHT 101T/3	Advanced Oil Chemistry and Oleochemicals	Theory
2.	CT1.04-1	Special Technology II (Analytical Techniques and Quality Control)	Theory		PGCHT 102T/3	Advanced Quality Control Techniques	Theory
3.	CT1.05-1	Special Technology III (Technology of oil bearing materials and processing of oils)	Theory		PGCHT 103T/3	Technology of Expression, Extraction and Refining of Oil Bearing Materials	Theory
4.	----	----	----		PGCHT 104T/3	Elective-I	Theory
5.	CT 1.01	Modern Chemical Instrumentation	Theory		PGOPEN 105T	Elective-II(Modern Chemical Instrumentation)	Theory
6.	----	----	----		*PGCHT 106P/3	Oil Technology Practical	Practical
7.	CE 1.02	Science and Technology of Materials	Theory		----	----	----

*Subject is covered in Second Semester for Old Pattern according to subject CT 2.06. They may be exempted.

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Oil Technology)
SECOND SEMESTER

As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT2.03-1	Special Technology IV (Technology of Soaps, detergents and Surfactants)	Theory	PGCHT 201T/3	Technology of Soaps, Detergents & Surfactants	Theory
2.	CT2.04-1	Special Technology V (Technology of Cosmetics and allied products)	Theory	PGCHT 202T/3	Technological Advancement of Cosmetics and Allied Products	Theory
3.	CT2.05-1	Special Technology VI (Technology of Miscellaneous Oil and Fat Products, including Surface Coatings)	Theory	PGCHT 203T/3	Modification of Oil and Fat Products including Surface Coatings	Theory
4.	----	----	----	PGCHT 204T/3	Elective III	Theory
5.	----	----	----	PGFD205T	Research Methodology	Theory
6.	----	----	----	PGCHT206P	Seminar	Practical
7.	CT2.01	Biotechnology	Theory	----	----	----
8.	CE2.02	Environmental Engineering	Theory	----	----	----
9.	CT 2.06	Oil Technology : Practical	Practical	----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Oil Technology) THIRD SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	----	----	----		PGOPEN 301T	Elective IV	Theory
2.	----	----	----		PGFD 302T	Project Planning and Management	Theory
3.	----	----	----		PGCHT 303P	*Project Seminar	Practical
4.	CT3.01	Seminar	Practical		----	----	----
5.	CT3.02	Training Report /Minor Project/Home Assignment	Practical		----	----	----

<table>
<tr><th colspan="9">Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Oil Technology)
FOURTH SEMESTER</th></tr>
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(Old Pattern)</th><th rowspan="3"></th><th colspan="3">As Per Rashtrasant Tukadoji Maharaj Nagpur University
Choice Based Credit Scheme</th></tr>
<tr><th>Sr. No.</th><th>Sub. Code Theory/ Practical</th><th>Subject</th><th>Theory/ Practical</th><th>Sub. Code Theory/ Practical</th><th>Subject</th><th>Theory/ Practical</th></tr>
<tr><td>1.</td><td>CT 4.01</td><td>Project and Viva-voce</td><td>Practical</td><td>PGCHT 401P</td><td>Project</td><td>Practical</td></tr>
</table>

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Paint Technology) FIRST SEMESTER						
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)				**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT1.03-2	Special Technology I (Chemistry of film forming materials and polymerization techniques)	Theory	PGCHT 101T/4	Chemistry of Film Forming Materials & Polymerization Techniques	Theory
2.	CT1.04-2	Special Technology II (Technology of pigments extenders and additives)	Theory	PGCHT 102T/4	Technology of Pigment Extenders and Additives	Theory
3.	CT1.05-2	Special Technology III (Principles of formulations of surface coatings)	Theory	PGCHT 103T/4	Principle and Formulation of Surface Coatings	Theory
4.	----	----	----	PGCHT 104T/4	Elective-I	Theory
5.	CE 1.01	Modern Chemical Instrumentation	Theory	PGOPEN 105T	Elective-II	Theory
6.	----	----	----	*PGCHT 106P/4	Paint Technology Practical	Practical
7.	CE 1.02	Science and Technology of Materials	Theory	----	----	----

*Subject is covered in Second Semester for Old Pattern according to subject CT 2.06. They may be exempted.

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Paint Technology) SECOND SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	CT2.03-2	Special Technology IV (Manufacturing methods, machinery and planning)	Theory		PGCHT 201T/4	Manufacturing Methods, machinery & Planning	Theory
2.	CT2.04-2	Special Technology - V (Processing applications and Technology of inks)	Theory		PGCHT 202T/4	Processing, Application & Technology of Inks	Theory
3.	CT2.05-2	Special Technology - VI (Application, evaluation of surface coatings and industrial waste treatment)	Theory		PGCHT 203T/4	Application, Evaluation of Surface Coating & Industrial Waste Treatment	Theory
4.	----	----	----		PGCHT 204T/4	Elective III	Theory
5.	----	----	----		PGFD205T	Research Methodology	Theory
6.	CT2.01	Biotechnology	Theory		PGCHT206P	Seminar	Practical
7.	CE2.02	Environmental Engineering	Theory		----	----	----
8.	CT 2.06	Practical : Paint Technology	Practical		----	----	----

Scheme of Absorption for Old Pattern to CBCS Pattern of M. Tech. (Paint Technology) THIRD SEMESTER							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					**As Per Rashtrasant Tukadoji Maharaj Nagpur University Choice Based Credit Scheme**		
Sr. No.	**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub. Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1.	----	----	----		PGOPEN 301T	Elective IV	Theory
2.	----	----	----		PGFD 302T	Project Planning and Management	Theory
3.	----	----	----		PGCHT 303P	*Project Seminar	Practical
4.	CT3.01	Seminar	Practical		----	----	----
5.	CT3.02	Training Report /Minor Project/Home Assignment	Practical		----	----	----

<table>
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<tr><td>1.</td><td>CT 4.01</td><td>Project and Viva-voce</td><td>Practical</td><td></td><td>PGCHT 401P</td><td>Project</td><td>Practical</td></tr>
</table>

SYLLABUS FOR FIRST SEMESTER M. TECH. (C.B.C.S.)

PGCHT101T/1 **Credit: 4**

Chemistry and Biochemistry of Food Components

Unit 1: Chemistry of carbohydrates, fats and proteins. Colloidal properties of foods. Browning Reaction

Unit 2: Structure and Composition of Plant tissues. Physiology of plant tissues. Post harvest biochemical changes of fruits & vegetables. Transpiration and respiration of plant tissues. Changes during ripening of climacteric and non climacteric fruits. Controlled Atmospheric and Modified Atmospheric storage. Post harvest management of fruits & vegetables. Natural plant pigments. Effect of processing on plant pigments.

Unit 3: Structure and composition of animal muscle tissues. Biochemical changes in animal muscle. Conversion of animal muscle tissue into meat. Rigor mortice. Post mortem biochemical changes in animal muscle. Preservation techniques. Effect of cooking & processing. Tenderness in meat.

Unit 4: Natural and developed toxins in foods of plant and animal origin. Types of food additives and their role in food products. Non nutritive sweeteners. Intentional and non intentional food additives,

Unit 5: Assessment of food safety. Modern methods of food analysis such as spectrophotometry, chromatography, electrophoresis, Immuno assay techniques, Biosensors, etc.

PGCHT 101T/2 **Credit: 4**

Catalyst Science and Technology

Unit 1: Heterogeneous Catalytic Processes, Types of Heterogeneous Reactions, Absorption, Absorption Isotherms, Rates of Absorption, Physisorption and Chemisorptions.

Unit 2: Solid Catalysis, Types of Catalysts, Catalyst Formulations and Preparation Methods, Catalysts Characterization Methods: Surface Area and Pore Volume Determinations, XRD, Various Spectroscopic Techniques, Temperature Programmed Reduction & Oxidation, Electron Microscopy.

Unit 3: Testing of Catalysts, Various Types of Reactors, Activity and Selectivity Studies, Effect of External Transport Processes on observed rate of reactions.

Unit 4: Effect of Internal Transport Processes: Reactions and Diffusion in Porous Catalysts, Mechanism of Catalytic Reactions, Rates of Adsorption, Desorption, Surface Reactions, Rate Determining Steps.

Unit 5: Kinetic Modelling and Parameter Estimations, Model Discriminations, Catalysts Promoters, Inhibitors, Catalyst Deactivations, Kinetics of Catalyst Deactivations.

Unit 6: Industrial Processes involving Heterogeneous Solid Catalysts, New Development in Solid Catalysis, Monolith Catalysts , Nano-catalysts, Fuel Cell Catalysts, Environmental Catalysts, Insitu Characterization, Design of Catalysts ; Simulation Techniques.

References:

1. G. Ertl, H. Knozinger and J. Weitkamp, "Handbook of Heterogeneous Catalysis" Vol 1-5, Wiley - VCH.
2. B. Viswanathan, S. Sivasanker , A.V. Ramaswamy, "Catalysis : Principles & Applications" CRC Press.
3. J. M. Smith, "Chemical Engineering Kinetics" McGraw-Hill Book Company.
4. J. M. Thomas and W. J. Thomas, "Principles and Practice of Heterogeneous Catalysis", Wiley-VCH.
5. H. S. Fogler, "Elements of Chemical reaction engineering" Prentice – Hall of India.
6. J.J. Carberry , "Chemical and catalytic reaction Engineering", Dover Publications.
7. C. H. Bartholomew and R. J. Farrauto "Fundamentals of Industrial catalytic Processes", Wiley-VCH.

PGCHT 101T/3 **Credit: 4**

ADVANCED OIL CHEMISTRY AND OLEO CHEMICALS

Unit-1 Natural sources of fats and oils, their geographic distribution. Fatty acid and triglyceride composition of fats, its types, nomenclature, structure. Theories of tri glyceride composition. Classification of fat, various types of classification and their basis, constituent of fats and fatty acids

Unit-2 Mechanism related to chemical and biochemical reactions of fats and fatty acids; Hydrolysis, Acidolysis, Saponification, Esterification, Inter-esterification, Trans-esterification, Isomerisation, polymerization, Hydrogenation, Dehydration, Pyrolysis and Oxidation. Polymorphism of fats and fatty acids. Chemical synthesis of fatty acids and their derivatives

Unit-3 Elementary chemical analytical constants of oils and fats like Acid value, Iodine value, Acetyl Value, Hydroxyl value, Ester value, HBr Value, Peroxide value, RM, Krischner and Polenske values. Elementary physical analytical constants of oils and fats like Refractive index, specific gravity, titer, smoke point, flash point, Cloud Point.

Unit-4 Non glyceride components of oils & fats phospholipids, glycol lipids, neutral lipids, sterols, etc. Toxic constituents & Detoxification Biosynthesis of oils & fatty acids. Role of fat in human metabolism. Nutritional functions of fats and oils

Unit-5 Fatty acids, distillation, crystallization, Fractionation, High purity fatty acid products blend distillation.

Reference Book

1. The Chemical Constitution of Natural Fats, Hilditch T.P., Chapman and Hall Ltd., London.
2. Fatty acids: Their chemistry, properties, production, and uses, Markley K.S., Interscience Publishers, New York

3. An introduction to the chemistry and biochemistry of fatty acids and their triglycerides, Gunstone F.D.. Chapman & Hall Ltd., London.
4. Bailey's Industrial Oil and Fat Products, 6th Edition, Wiley-Interscience Publication, New York .
5. The Analysis of Fats and Oils, Mehlenbacher, V. C., The Garrard Press, Champaign, Illinois.
6. AOCS Official and Tentative Methods for Analysis of Oils and fats, Vol. 1and 2,, Third Edition, AOCS, Champaign IL,USA.
7. Modern Technology Of Oils, Fats & Its Derivatives,National Institute of Industrial Research, New Delhi.

PGCHT 101T/4 **Credit: 4**
Chemistry of film forming materials and polymerization techniques

Unit 1: Natural Resins and Chemistry of drying oils

Natural resins, Composition of major natural resins: Rosin, Copals, Shellac, Damar, etc. used in coatings, Recovery and purification, Modification of natural resins. Applications of natural resins in coatings.

Drying oils and their modificationsModifications of drying and semidrying oils for surface coatings. Synthetic drying oils

Unit 2: Synthetic Resins-I Chemistry and Technology of synthetic resins: Alkyd resins, Polyester, Amino resins, Phenolic resins and Polyamide resins. Recent trends in the alkyd, polyester, amino, phenolic and polyamide resins technology.

Unit 3: Synthetic Resins-II

Chemistry and Technology of synthetic resins: Epoxy resins, polyurethane resins, silicone resins, Recent trends in the epoxy resin, polyurethane resins. Modification of epoxy resins. Inorganic binders.

Unit 4: Synthetic Resins-III Techniques of polymerization, manufacture of film forming materials such as acrylic and vinyl resins for use in surface coating. Cellulose and rubber derivatives for coatings.

Unit:5: Development and evaluations of binders:Recent developments in the formulation of vehicles, Evaluation of film forming materials for surface coating.

PGCHT102T/1 **Credit: 4**
Food product Development and Packaging

Unit 1: Concept of new product development, principles of product development, product development strategic orientation, process tools for NPD, product planning, PD process flow, protecting new product, new product failure and considerations during NPD. Acceptance sampling: operational characteristics, risks, attribute sampling plans, administration of attribute sampling plans, sampling error; Physical, chemical and rheological properties of food; Principles of analysis of various food constituents and subsequent changes on packaging;

Unit 2: Sensory attributes of foods: mechanisms of sensation and perception of colour, taste, odour, and flavour; importance and use of sensory evaluation methods; facilities required for sensory evaluation; selection of trained panelists: type of panelists suitable for different tasks and methods; conditions for sensory analysis: room, serving and preparation of samples; application of consumer tests;

Unit 3: affective and analytical methods: discrimination methods, preference and ranking; rating with use of scales, magnitude determination, sensory profiling, flavour profile; descriptive analysis: Quantitative

Descriptive Analysis and Spectrum techniques; texture profile; control of factors affecting accuracy and precision of sensory data; analysis of sensory data; statistical testing; correlating instrumental and sensory measurements.

Unit 4: Packaging as a method for conservation of foods Packaging materials and their physico-chemical characteristics Evaluation of quality of packaging materials; Package design; Test procedures for packages; Cushioning materials; Selection of packaging materials

Unit 5: package design for food products; Prepackaging. Packaging materials for newer techniques like radiation processing, microwave and radiowave processing, high pressure processing, modified atmosphere and thermal processing as retortable pouches; Biodegradable packaging, Edible packaging, smart packaging.

Reference Books:

A. V. Sathe, *A First Course in Food Analysis*, New Age International Pvt. Ltd. 1999
S. S. Nielsen, *Food Analysis, 3rd ed*., Kluwer Academic Publishers, 2003
S. S. Nielsen, *Food Analysis Laboratory Manual*, Kluwer Academic Publishers, 2003
R.Wood, L.Foster, A.Damant and P.Key, *Analytical Methods for Food Additives*, Woodhead Publishing, 2004
Y. Pomeranz and C.E.Meloan, *Food Analysis: Theory and Practice*, *3rd ed*., Chapman & Hall, 1994
AOAC, *Official Methods of Analysis and AOAC International*, 2005
R.E.Wrolstad, T.E. Acree, E.A.Decker, M.H.Penner and D.S.Reid, *Handbook of Food Analytical Chemistry*, John Wiley & Sons, 2004
Modern food packaging, Indian Institute of Packaging, 1998
Profile on food packaging/C.F.T.R.I and Indian Institute of packaging, 1995.
Food packaging and preservation by M.Malthlouthi, 1994
Food and Packaging Interactions by Risch.S.H. 1991
Handbook of Food Packaging by F.A. Paine and H.Y. Paine 1983
Food Packaging Technology (Vol.1 & 2) by G. Bureau and J.L.Multon, 1996

PGCHT 102T/2 **Credit: 4**

Petroleum Refinery Engineering

Unit 1: History and development of Refining, Composition of Petroleum, Refinery products and Test methods, Evaluation of Oil stocks, Physical properties of Petroleum Oil.

Unit 2: Introduction to Processing, Refinery and Distillation Process, Auxillary processes and operations, Refinary metals and Corrosion

Unit 3: Vaporization and Condensation, Fractionation and Towers;

Unit 4: Heat transfer and Exchangers, Tube-still Heaters.

Unit 5: Thermal Cracking and Decomposition Processes, Rebuilding Hydrocarbons.

Unit 6: Catalytic Cracking and Reforming, Natural and Refinery gases

References

1. Nelson, W.L "Petroleum Refinery Engineering" McGraw Hill Publishing Company Limited.
2. Hobson, G.D. – Modern petroleum Refining Technology, 4th Edition, Institute of Petroleum U.K.
3. J.H. Gary And G.E. Handwerk " Petrolem Refinery Technologies And Economics ".

PGCHT 102T/3 **Credit: 4**

ADVANCED QUALITY CONTROL TECHNIQUES

Unit -1: Importance of Quality control, Techniques of separation of glyceride and fatty acids: Liquid – liquid extraction; fractional distillation; low temperature crystallization. Testing of DOC and Oil beyond conventional testing for export. Detection of adulteration in oils and fats

Unit -2

Chromatography: History, theoretical developments and various techniques e.g., thin layer chromatography,, gas-liquid chromatography, HPLC and Super critical Chromatography; their principles, practices and applications to the analysis of oils and allied products. Application of chromatographic techniques in the quality control and quality assurance of oils, fats and products

Unit –3

Spectral methods of application; Ultra-violet, visible, infrared infra red spectroscopy techniques: principles, practices and application to the analysis of oils and allied products. Nuclear magnetic resonance spectroscopy: principle, analysis of spectra and quantitative applications.

Unit –4

Special quality control methods like iron, sulphur and phosphatide content of crude and refined vegetable oils; wax content of vegetable oils; amino acid analysis by chemical and instrumental methods.

Unit –5

Lipase hydrolysis, Dilatometry measurements and their significance, Determination of color and viscosity of oils and fats, solid fat index of oils and fats. Essential Fatty acids and Trans fats.

Reference Books:

1. Fatty acids; Their chemistry, properties, production and uses Part – III Edited by K.S. Markley
2. Principles of Instrumentation analysis, Edition- III (1985) Edited by Douglas A. Skog
3. Sharma Y.R. Vig O.P., "Elementary Organic spectroscopy" S. Chand & Company Ltd, 1994, P. No. 63-127, 133-199.
4. Silverstein R. M., Webster F.X., "Spectroscopc identfication of organic compound", 6th edition to John Willey & sons, Inc, New York, 1998, P. No. 71-143, 217-250.
5. Puri B.R, Sharma I.R, "Principles of physical chemistry", S. Chand & co. New Delhi, 1997.

PGCHT 102T/4 **Credit: 4**

Technology of Pigments, Extenders and Additives

Unit I1: General properties of pigments, Classification of pigments, extender, lakes and toners. General methods of manufacture of pigments. General properties of pigments and extenders. Metal pigments and metallic stearates: Composition, manufacture, properties and applications. Extenders: Composition and properties, occurrence and manufacture of extenders.

Unit 2: White and black Pigments

White pigments, composition and comparison of properties, occurrence and manufacture of white pigments.Black pigments, comparison of various black pigments and their composition.

Unit 3: Coloured Pigments:

Coloured inorganic pigments, comparison of properties and their composition, methods of manufacture of red, organic, yellow, green and blue pigments.

Unit 4: Organic Pigments:

Organic pigments, methods of manufacture, important class and properties of organic pigments, production of lakes and toners.

Unit 5: Specialty pigments, additives and solvents

Introduction of important pigments and their evaluation, special purpose pigments.

Classification, properties of various types of driers, manufacture of driers. Additives for surface coatings.

Solvents for surface-coatings, classification, selection and evaluation,

PGCHT 103T/1 **Credit: 4**

Bioprocess Engineering

Unit 1: Thermodynamics of biosystem. Material and energy balances. Microbial growth dynamics. Kinetics of substrate utilization, biomass production and product formation in cell cultures.

Unit 2: Design, Preparation and sterilization of fermentation media and bioreactor. Air sterilization and asepsis.

Unit 3: Bioreactor configuration. Practical considerations for bioreactor construction. Monitoring and control of Bioreactors. Ideal reactor operation.

Unit 4: Rheological properties of fermentation broths, factors affecting broth viscosity. Mixing power requirement for mixing, scale up of mixing systems, improving in mixing in fermenters. Design equation for heat transfer systems in fermenter.Development and applications of Biosensors

Unit 5: Role of diffusion in bioprocessing. Mass transfer and microbial respiration. Oxygen uptake in cell cultures. Oxygen transfer in fermenters. Measuring dissolved oxygen concentrations. Mass transfer correlations. Measurement of K_La. Oxygen transfer in Large Vessels.

Reference Books:

1. J. E. Bailey, D F Ollis, Biochemical Engineering Fundamentals, McGraw- Hill 1986
2. P. M. Doran, Bioprocess Engineering Principles, Academic Press
3. J. M. Lee, Biochemical Engineering , Prentice Hall, Englewood Cliffs, New Jersey
4. Michael L. Shuler and Fikret Kargi, Bioprocess Engineering- Basic Concept, Second edition, Prentice Hall.

PGCHT 103T/2 **Credit: 4**

Petrochemical Process Design

Unit-1: Complex reaction, consecutive reaction, parallel reaction and parallel and consecutive reactions, acetylene production from hydrocarbons, kinetics and thermodynamics, different process details, parallel-consecutive reaction in a batch and flow reaction(TFR and CSTR), kinetics, derivation, industrial processes of chlorination of hydrocarbon, amines and glycols, effect of reactant ratio on distribution of products in different types of reactors.

Unit-2: Pyrolysis of hydrocarbon for production of olefins, thermodynamics and kinetics, thermal cracking mechanism, role of self inhibition, surface reactions and isomerisation of radicals in mechanism product distribution in cracking processes, condition of operation of pyrolysis reactors, concept of equilibrium approach and its influence on conversion, selectivity, steam dilution and yield of products desirable condition for ethylene productions use of kinetics models in the design, kinetics of petroleum fractions for olefin production. Effect of various process design parameters like tube diameter, hydrocarbon to steam ratio, pressure drop etc on conversion and yields.

Unit-3: Exothermic catalytic reactions – some industrially important reactions like production of phthalic anhydride, ethylene oxide, vinyl chloride and cyclohexane. Reactor operating condition. Kinetics of phthalic anhydride, simple and complex models operating features of different reactors used, factors influencing the choice of conditions of fluidized beds, mathematical derivations involved , analysis of naphthalene oxidation in fixed beds, one dimensional and two dimensional models, their derivation.

Unit-4: Ethylene oxide manufacture, its status among ethylene derivatives, direct oxidation process, chemistry and mechanism, side reaction, process design aspects such as thermal factors, exothermicity on selectivity, ethylene conversion, feed stock preparation, inhibitors, plant safety, catalyst details manufacturing process details, reversible exothermic reactions, important features , manufacture of ammonia.

Unit -5: Production of styrene from ethylene benzene, theoretical considerations, variables effecting styrene yields, such as pressure, temperature, steam to ethyl benzene ratio, catalyst particle size, purity of feed catalyst to ethyl benzene ratio, different reactor systems employed in styrene production, practical considerations, process details and styrene purification.

Unit-6: Mass transfer influence on kinetics of Ziegler-Natta ethylene polymerization, types of polymerization, fundamentals of polymerization, design aspects of polymer reactors. Mass transfer influence on hydroformylation reaction, reactor design process details, kinetic models, effect of olefin structure on reactivity, engineering problem in reactor design with a flow scheme.

References:

1. Chemical Engineering process analysis, A.M. Mearns
2. Chemistry of Catalytic processes, B.C. Gats, J.R. Katzer and G.C.A. Schuit
3. Chemical reactor design and process plants, vol 1 and 2, H.A. Rase.

4. Equipment Design Handbook for Refineries and Chemical Plants, F.L. Evans.
5. Applied Process Design For Chemical and Petrochemical Plants Vol I, II, and III, E.E. Ludwig.

PGCHT 103T/3 **Credit: 4**

TECHNOLOGY OF EXPRESSION, EXTRACTION AND REFINING OF OIL BEARING MATERIALS

Unit-1 Domestic and world production of oil seeds and oils. Processing of oil-bearing materials: Storage of raw materials, handling, sampling, pretreatments prior to storage, methods of cleaning, and milling, crushing, cooking and mechanical expression of oil. Newer Methods in of oil extraction. Rendering of animal fats. Utilization of oil cakes.

Unit-2 Plant and Machinery employed for expression of oils viz. Mechanical expression of oil in Ghanis, hydraulic presses, screw presses, low pressure and high pressure expellers' expander- extruder system

Unit-3 Pre-treatments of oil bearing materials prior to solvent extraction: cleaning, size reduction, pre-pressing, flaking, extrusion, pelletization, stabilization (for rice bran), dehulling etc. Plants & Processes and the machinery and equipments used.

Unit-4 Solvent extraction: Theory, solvents and their availability, selection of solvents, advantages and limitations, properties of different solvents. Solvent extraction techniques: Batch and continuous plants and processes employed for solvent extraction of low and high oil bearing materials. Recent trends in solvent extraction.

Unit-5 Refining of fats: Various physical and chemical methods of refining such as degumming, Neutralization, bleaching & deodorization. Plants and equipment used in batch and continuous refining. Quality control in processing

Reference Books:

1. Refining of Oils& Fats, Anderson, A. J. C, The MacMillan Co., New York.
2. Fats and Oils, D O'Brien, Third Edition, CRC Press,London
3. Bailey's Industrial Oil and Fat Products, 6 Volumes, Wiley-Interscience Publication,New York 4. Confectionary fats Handbook, Timms, R. E. The Oily Press Lipid Library, UK
5. Practical Short Course on Processing and Products of Vegetable Oil / Biodiesel ,College Station, Texas, Held on October 18-22, 2009
6. Vegetable Oils in Food Technology (Chemistry and Technology of Oils and Fats), Frank Gunstone, Wiley Blackwell; USA
7. Edible Oils and Fats--A Global Overview of Technological Developments, Guinness Centre, Taylors Lane,, Ireland.

PGCHT 103T/4 **Credit: 4**

Principles and Formulations of Surface Coatings

Unit 1: Concept of Formulations

Principles of formulations of surface coating with special reference to paints, varnishes, lacquer.

Unit 2: Protective and Decorative coatings

Selection of raw materials for its specific applications, viz. Protective, decorative and their types. Architectural finishes,.

Unit 3: Industrial and Specialty Finishes

Industrial and Specialty coatings like, heat resistant, marine, traffic & fluorescent. Recent trends in industrial and specialty coatings.

Unit 4: Rheology of paints

Rheology of paint systems and its importance in coatins. Film formation, film structure and its correlation to formulation. PVC and CPVC, Thioxtropy.

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Unit 5: Powder Coatings

Solvents less and powder coatings. Binder for powder coatings and their classification. Selection of pigments, extenders and additives. Manufacture of coating powders: Methods and equipments. Application techniques in powder coatings.

Recent developments in powder coatings

PGCHT 104T/1 **Credit: 4**

ELECTIVE - I (Discipline Specific BCHT)

1. **Advances in Food Engineering**

Unit 1: Application of Transport Phenomena for food systems. Flow behaviour of non Newtonian fluids. Unsteady state Heat Transfer with phase change. Heat transfer during freezing and thawing. Rheology of dough with reference to wheat and bakery products.

Unit 2: Design of autoclave, Pasteurizer, Continuous Sterilizer, Steam Jacketed Pan and

Vacuum Concentrator. Materials used for food processing equipment and corrosion control.

Unit 3: Design of Basket Press, Screw type Juice Extractor, Solid Mixer, Kneader; Oil Expeller, filters and extruder.

Unit 4: Design of Tray Drier, Drum Drier, Spray Drier, Fluidized Bed Drier and Rotary Roaster, solar dryers.

Unit 5: Design of Homogenizer, Pulping Machine, Plate Type Freezer and Freeze Drier.

Reference Books:

Food Engineering Operations by Brennan J.G, 1976

Fundamentals of food process engineering by Romeo Toledo, 1999

Engineering Properties of Foods by Rao MA and Rizvi SSH, 1986

Elements of Food Engineering by Watson EL and Harper JC, 1989

Food Process Engineering by Heldman DR and Singh RP, 1984

Food Engg. Fundamentals by J. Clair Batty, 1983

Chemical Engineer's Handbook; Perry, Chilton & Green; MGH.

Fundamentals of Food Process Engineering, 2nd ed; Toledo Romeo T; CBS Publishers.

Preservation of Fruits & Vegetables; Lal G, Sidhapa GS & Tandon GL; ICAR.

Introduction to Chemical Equipment Design – Mechanical Aspects; Bhattacharyya BC; CBS Publishers.

Process Equipment Design; Hesse HC & Rushton JH; Van Nostrand, East West Press Selection of Material and Fabrication for Chemical Process Equipment; Bhattacharyya BC; Chemical engineering Education Development Centre, IIT Madras.

Process Equipment Design; Brownell LE & Young EH; John Wiley and Sons, Inc.

Computer Aided Design of Chemical Process Equipment; Bhattacharyya BC & Narayanan CM; New Central Book Agency.

Mechanical Design and Fabrication of Process Equipment; Bhattacharyya BC; sKhanna Publishers.

PGCHT 104T/1 **Credit: 4**

ELECTIVE - I (Discipline Specific BCHT)

2. **Molecular Biology**

Unit 1: Chemical structure and base composition of nucleic acid. Double helical structures, triple helical structures. Properties of DNA. DNA denaturation and renaturation.
DNA replication and repair mechanisms in eukaryots, bacteria and phages.

Unit 2: Transcription: RNA polymerases in prokaryots and eukaryots. Process of transcription. Concept of promoters and promoters types. Post transcriptional processing of RNA, Translation: Genetic Code. Post translational modifications. Protein targeting. Non ribosomal polypeptide synthesis.

Unit 3: Regulation of gene expression: Constitutive and inducible enzymes Gene regulation, operon concept (Lac operon and trp operon). Induction of genes under stress conditions in plants. Differential processing of mRNA.

Unit 4: Mutation: Spontaneous and induced mutations. Insertion, deletion, point, frame shift and suppressor mutation. Chemical & physical mutagens. Selection and isolation of mutants.

Unit 5: Genetic Engineering: Recombinant DNA technology. Isolation and amplification of gene cloning vectors. Application of recombinant DNA technology.

PGCHT 104T/1 **Credit: 4**

ELECTIVE - I (Discipline Specific BCHT)

3. **Advances in Nutrition**

Unit 1: Recent advances in metabolism and nutritional aspects of foods; Nutritional requirements of special target groups such as aged, infants, pregnant & lactating mothers, etc.

Unit 2: Therapeutic nutrition & formulation of special dietary foods; Relation of food and diseases; Nutrition related diseases. Assessment of nutritional status & RDA; Effect of processing on nutrients;

Unit 3: Functional foods and nutraceuticals for lifestyle disorders such as cardiovascular diseases, obesity, diabetics, etc. Glycemic Index and Glycemic load of composite foods.

Unit 4: Protective foods: Role of food ingredients in aging, cancer and immunomodulation. Food components and nutrients affecting immune systems, phytosterols, polyphenols, flavonoids and antioxidants.

Unit 5: Functional aspects of dietary fibre, amino acids & peptides, probiotic foods, antioxidants, vitamins, fatty acids etc. Regulatory aspects for functional foods and nutraceuticals.

Reference Books:

Advances in food and nutrition research by Steve L. Taylor
Human nutrition by Alfin-Slater, 1979,
Human nutrition by Burton, BT, 1976,
Food, Nutrition and Diet Therapy by Krause and Mahan 1996,
Modern Nutrition in Health & Disease by Young & Shils.

PGCHT 104T/2 **Credit: 4**

ELECTIVE I (Discipline Specific BCHT)

1. **Oil & Natural Gas Processing**

Unit 1: Introduction

Brief history of natural gas industry, characteristics of various utility and industrial gases, sources of natural gas, occurrence, composition, chemical properties and characteristics of natural gas

Unit 2: Phase Behaviour

Phase behavior of natural gas, pressure-volume-temperature diagram for pure hydrocarbons. Phase rule, solubility of gases in liquids, binary mixtures.

Unit 3: Properties

Properties of natural gases and volatile hydrocarbon liquids, diffusion coefficient, compressibility factors, density of gases and liquids, surface tension, thermodynamic properties, heating value, flammability limits, critical properties, viscosity and thermal conductivity.

Unit 4: Gas Hydrates

Water-hydrocarbon system, general phase relations for water-hydrocarbon system, measurement of water contents of natural gas, gas hydrates, conditions of formation, prediction of hydrate formation condition, prevention of hydrate formation.

Unit 5: Gas Flow Measurement

Gas flow measurement, flow and compressor calculations, flow equation, pipeline flow calculations, calculations of work required to compress natural gas.

Unit 6: Gas Processing

Low temperatures processing of natural gas, natural gas liquefaction, dehydration and sweetening of natural gas, methods of dehydration and sweetening.

References:

1. Donald L.Katz and Robert L.Lee, Natural Gas Engineering, McGraw – Hill Publishing Company, NY.
2. Speight, J.G Fuel Science and Technology Handbook, Marcel Decker Inc.
3. Dring, M.M – The Natural Gas Industry – A review of World Resources and Industrial Applications, Butterworth, London.
4. Lom. W.L and A.F. Williams, Substitute Natural Gas, Kalstod Willey, New York.
5. Dermott, M.C. Liquified Natural Gas Technology, NeysosPark Ridge, N.J.
6. M.J. EcononidesA.Daniel "Petroleum Production Systems", Prentice Hall Petroleum Engineering series.
7. Michael J.Economides, A.Daniel Hill and Christine Ehlig – Economides, Petroleum Production Systems, PTR Prantice Hall, NJ.
8. Guide to Natural Gas Utilization Technologies, Fairmount Press Inc.

PGCHT 104T/2 **Credit: 4**

ELECTIVE I (Discipline Specific BCHT)

2. Modeling & Simulation in Chemical Engineering

Unit 1: Introduction to process modeling, Applications of models, classification of models,Principles of Formulation, fundamental laws, general modeling procedure, industrial usage of processmodelling and simulation; Macroscopic and microscopic mass, energy and momentum balances

Unit 2: Parameter estimation techniques in theoretical as well as numerical models, population balance, stochastic, and empirical models

Unit 3: Modeling of various mass and heat transfer equipment: distillation,absorption, extraction columns; evaporators; furnaces; heat exchangers; flash vessels etc.

Unit 4: Modeling of Chemical Reactors: single phase and multiphase reactors

Unit 5: Numerical Methods for chemical engineering applications. Introduction and use of different softwares for modeling and simulation

Recommended Books:

1. W. L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.
2. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
3. R.E.G. Franks, Modeling and Simulation in Chemical Engineering, WielyIntrscience, NY, 1972.
4. J. Ingam, I. J. Dunn, Chemical Engineering Dynamic Modeling with PC simulation, VCH Publishers, 2008.
5. D. Himmelblau, K.B. Bischoff, Process Analysis and Simulation, John Wiley & Sons, 1968.

PGCHT 104T/2 **Credit: 4**

ELECTIVE I (Discipline Specific BCHT)

3. Advanced Transport Phenomena

Unit 1: Review of mathematics: Scalar, Vectors, Tensors, divergence, relation between rectangular coordinates and cylindrical coordinates, relation between rectangular coordinates and spherical coordinates, partial derivative, substantial derivative, total derivative, line integral, surface integral, integral theorems.

Unit 2: Equations of continuity, equation of motion, the equation of mechanical energy, application of Navier-Stokes equation to solve problems, the equations of change for incompressible non-Newtonian fluids.

Unit 3: Developing equations for obtaining velocity & shear stress distribution for flow of Newtonian, Bingham plastic & power law fluids in spheres etc. from I^{st} principle, Introduction to 2 dimensional & turbulent momentum transfers

Unit 4: Equations of energy, the energy equation in curvilinear coordinates, use of equations of change to set up steady state heat transfer for problems.

Unit 5: Unsteady state heat conduction expression for rectangular, spherical and cylindrical co-ordinate system from I^{st} principles, Numerical methods for 2 dimensional steady state conduction and Schmidt method for unsteady state heat conduction with / without surface resistance for obtaining temperature profiles

Recommended Books:

1. R.B. Bird, W. E. Stewart and E. N. Light foot Transport Phenomena Wiley international Edition, New York 2002.
2. James R. Welty, Charles E. Wicks and Robert E. Wilson, Fundamentals of momentum, heat and mass transfer, John Wiley & sons, Inc, New York, 2008.

PGCHT 104T/2 **Credit: 4**

ELECTIVE I (Discipline Specific BCHT)

4. Advanced Thermodynamics

Unit 1: Quantum Considerations: Introduction, Internal energy levels, Microstates, Macrostates and Probability, Case or repeated trials, Phase space, combinatorial problems with respects to particles and energy states.

Unit 2: Entropy and Probability: Thermodynamic probability, State of maximum Thermodynamic probability, Microscopic meaning of entroy, Use of Lagrangion multipliers, Stirling's approximation.

Unit 3: Statistical Mechanics: The statistical distribution laws, Maxwell – Boltzmann statistics, The Fermi-Dirac and Bose -Einstein Statistics, Partition functions, Transnational, Rotational etc., Applications of physical models.

Unit 4: Statistical Evaluation Of Thermodynamic Properties: Ideal Monatomic gas, Partition function, Calculation of the translational properties of an ideal monatomic gas, Sector - Tetrode equation, Potential energy function for a diatomic molecule, Rigid rotor harmonic – oscillator approximation, Rotational and vibrational partition functions of ideal polyatomic gases.

Unit 5: Thermodynamic of Irreversible Processes: Irreversible processes, Phenomenological laws, Application of onsager - reciprocal relations, Seebeek effect, Peltier effect, Thompson effect.

Recommended Books:

1. R.E. Sonntag, G.I. Van wylen, Fundamental of Statistical Thermodynamics, John wiley and Sons, New York, 1966.

2. D.A. McQuarric, Statistical Thermodynamics, Harper and row Pub. New York, 1973.

3. M.T. Howerton, Engineering Thermodynamics, D. Van Nostrand Co., Inc., New York, 1962.

4. C.L. Tien, J.H. Lienhard, Statistical Thermodynamics, Halt Rinhart and Winston Inc., New York, 1971.

5. J. Otto Beran, Juliana Boerio, Gates Vol I & II, Chemical Thermodynamics: Advanced Applications", Academic press, 2000.

6. Reid, Prausnitz, Poling, The Properties of Gases and Liquids, McGraw Hill Publication

PGCHT 104T/3 **Credit: 4**

ELECTIVE - I (Discipline Specific BCHT)

1. <u>TECHNOLOGICAL ADVANCEMENT IN OLEOCHEMICALS</u>

Unit- 1

Hydrogenation of oils and fats, Types of processes, methods of manufacture of hydrogen (pure), Types of catalysts and their production, hydrogenation plant. Selective hydrogenation. quality control in hydrogenation plant.

Unit 2

Manufacture of butter, ghee, margarine, and vanaspati, Trans esterified oils and fats, cooking oils, salad oils and their fatty edible products. Plastic shortening agents and confectionary fats. Causes of rancidity and prevention. Detection of adulteration, winterization of oils and fats.

Unit- 3

Sources, properties, grades, and types of glycerol, recovery and purification of glycerin from fat splitting crudes and waste soap lye's, analysis and industrial uses of glycerol. Synthetic glycerin

Unit-4

Lipid Associates and Applications of non-traditional oils such as Karanja, Neem, Mahua, Sal, Rubber seed, Jojoba, Jatropha, Kokum etc., Fish Oils, Rendering of Animal Fats. Membrane Processing of Fats and Oils, Utilization of waste products from oil processing industries.

Unit- 5

Detoxification of oil cakes, Manufacture of value added products from oil meals. Utilization of deteriorated deep fried oil for industrial utilization.

Reference Book

1. The Chemical Constitution of Natural Fats, Hilditch T.P., Chapman and Hall Ltd., London.
2. Bailey's Industrial Oil and Fat Products, 6th Edition, Wiley-Interscience Publication, New York .
3. Modern Technology Of Oils, Fats & Its Derivatives,National Institute of Industrial Research, New Delhi.
4. Edible Oils and Fats--A Global Overview of Technological Developments, Guinness Centre, Taylors Lane,, Ireland.

PGCHT 104T/3 **Credit: 4**

ELECTIVE - I (Discipline Specific BCHT)

2. PROCESS ECONOMICS, UTILITIES AND BYPRODUCTS OF OIL INDUSTRY

Unit- 1

Industrial pollution and its impact . Magnitude of industrial waste , Legislative regulations. Recycle and reuse of waste water , recovery of by/c0-product from industrial effluents.

Unit 2

Components of Costing; Utilities, power , steam, air, water; Cost and analysis of plant e.g. Break Even Point, Rate of Return, Pay Back Period, Depreciation etc

Unit- 3

Utilities in expression, solvent extraction refining plant, hydrogenation plant, a typical other oleo chemical unit. A working layout and calculation of cost of production for above plants

Unit-4

Introduction to by- products of refining industry; Phospholipids, production of industrial and edible grade Lecithin, gums. Manufacture of compound cattle feed; production of protein concentrates and isolates. Re-esterification of fatty acid with glycerin and its trans-esterification for production of biodiesel

Unit- 5

Segregation of deodorizer distillate and isolation of value added products by conventional and molecular distillation and other plants and machinery involved. Classification of effluents of oil and allied industries, GOI specifications of effluents and various treatment techniques

Reference Books:

1. Bailey's Industrial Oil and Fat Products, Edible Oil and Fat Products: Chemistry, Properties, and Health Effects, 6th Edition, John Wiley & Sons, USA.
2. Hand Book of Oils, Fats and Derivatives with Refining and Packaging Technology, Published by Indian Institute of Consultants, Engineers India Research Institute, New Delhi
3. Essential Oils and Culinary Herbs*James E. Simon
4. Industrial Fatty Acids and their Applications," edited by E. Scott Pattison, Reinhold Publ. Corp. New York.
5. Fatty acids; Their chemistry, properties, production and uses Part – III Edited by K.S. Markley

PGCHT 104T/4 **Credit: 4**

ELECTIVE –I (Discipline Specific)

1. **Automotive and Coil Coatings)**

Unit 1: Introduction

Introduction, Automotive and automotive paint market. Materials and Concept in body construction. Surface Treatments of multimetals in automotives.

Polymeric materials in automotive coatings

Unit 2: Coating systems for automotives

Primers for automotives, Surfacers, Topcoats for automotive industry. Paint for plastics (non-metals). Paint shops and quality control in automotive coatings, Coatings for rail-road engines, passenger cars, fright carrier, truck, bus, etc.

Recent advances in automotive coatings.

Unit 3: Applications and quality control

Application techniques in automotive coatings. Electro-deposition techniques. Defects and their remedies in automotive coatings. Evaluation of automotive coatings.

Unit 4: Coil Coatings

Introduction to coil coatings, requirements of coil coatings, metal pre-treament processes,

Detail study of binders, pigments and additives for coil coatings.

Unit 5: Coil coating systems:

Primers, Surfacers, and top coat formulation for coil coatings. Application techniques.

Recent advances in coil coatings.

PGCHT 104T/4 **Credit: 4**

ELECTIVE –I (Discipline Specific)

2. **Technology of Cosmetics and polishes)**

Unit 1:

Nature of human skins and other parts of body. Classification of cosmetics.

Unit 2:

Creams, lotions and face powders, Functions of cream, lotions and face powderRaw materials for cream, lotions and face powders, formulations and evaluations of cream, lotions and face powders.

Unit 3 :

Lipsticks: Functions of lipstick, raw materials, manufacture and evaluations.

Unit 4:

Cosmetic preparation such as eye-make up, Nail lacquers, and polishes.

Unit 5:

Hair dyes. Raw materials, preparation, and properties. Evaluation of hair colours.Recent trends and other miscellaneous cosmetic preparations.

PGCHT 106P/1 **Credit: 2**

FOOD TECHNOLOGY PRACTICAL (P)

Estimation of Reducing and non Reducing sugars by Lane Eynon Method

Proximate analysis of Food Product

Estimation of Protein Content By Folin –Lowry Method

Estimation of Protein Content By Biurett Method

Estimation of Iron Content

Estimation of Phosphorus Content

Estimation of Reducing Sugar By Nelson-Semogyi Method

Estimation of Reducing Sugar By DNS Method

To Determine Ascorbic Acid By 2,6 Dichloroendophenol

Estimation of Starch By Anthrone Method.

Estimation of Amylose & Amylosepectin Content

Immobilization of Invertase Enzyme from Yeast

PGCHT 106P/2

Process Simulation Laboratory (Petrochemical Technology)

Credit : 2

Softwares

Simulation exercises using
A) ASPEN software
B) Fluent code software
C) Prosim software (steady and unsteady state processes) and
D) Response Surface Methodology.

List of experiments

Group A

Simulation exercises using aspen
1. Physical property estimations;
2. Mass and energy balances; handling user specifications on output streams;
3. Simulation of individual units like,
    I. Mixers
    II. Splitters,
    III. Heat Exchangers,
    IV. Flash Columns,
    V. Reactors,
    VI. Distillation Columns Etc.
4. Heat Exchanger Networks
5. Distillation Trains

6. Pipeline Networks
7. Dynamic Simulation
8. Costing and Economic Analysis

Group B

Simulation Exercises Using Prosim Software

9. Steady State Simulation of Unit Operations
    A. Evaporator
    B. Plug Flow Reactor
    C. Cyclone Separator
    D. Continuous Stirred Tank Reactor
10. Dynamic Simulation of Chemical Processes
    A. Cascade Control System
    B. Feed Forward Control
    C. Ratio Control
    D. On-Off Control

Group C

Simulation Exercises Using Fluent Code Software

11. To Study Flow Pattern Inside the Various Unit Operation & Processes using Fluent and Work Bench for Grid Generation.
    A. Heat Exchanger
    B. Rotating Disc Contactor
    C. Atmospheric flow simulation
    D. Flow through pipe viz., bends, elbow, valves etc.
    E. Evaporators
    F. Dispersion study

Minimum experiments of 5 from group A, 3 from group B and 3 from group C

List of softwares needed

A) Aspen Software
B) Fluent Code Software.
C) Prosim Software (Steady And Unsteady State Processes).

PGCHT 106P/3 **Credit: 2**

OIL TECHNOLOGY – PRACTICAL I (P)

1. Estimation of Physico – Chemical properties of Oils and Fats
2. Beliers Test (Turbidity Temp.) Acetic Acid Method
3. Detection of Colour by Tintometer Method
4. Estimation of RM and Polenske Value
5. Extraction of oil by Soxhlet Method
6. Extraction of essential oil by Clevenger's Assembly
7. Isolation and detection of Protein Content from de oiled cake
8. Preparation of Mixed Fatty Acids and its analysis
9. Preparation of Bio-diesel and its analysis
10. Preparation of Malenized oil and its analysis
11. Analysis of Mono and Di glycerides in oil and fats.

12. To prepare the red oxide metal primer and evaluation of its properties
13. To prepare synthetic enamel and evaluation of its properties.
14. To prepare universal strainer and evaluation of its properties.
15. To prepare cleansing creams, lotions and metallic Soaps
16. To prepare lubricating grease
17. To prepare detergent and liquid detergent
18. Analysis of soaps and soap stocks
19. Analysis of detergent, metallic soaps and cosmetics.
20. Analysis of waxes and paints

Reference Books

1. Analysis of Oil and Soaps by R.N.Mathur
2. AOCS, official and tentative methods Da 2a-48, (For moisture and volatile matter of soap and soap products) 1973.
3. Bailey's Industrial Oil and Fat Products, 6th Edition, Wiley-Interscience Publication,New York .
4. The Analysis of Fats and Oils, Mehlenbacher, V. C., The Garrard Press, Champaign, Illinois.
5. AOCS Official and Tentative Methods forAnalysis ofOils and fats, Vol. 1and 2,, Third Edition, AOCS, Champaign IL,USA.

<u>SYLLABUS FOR SECOND SEMESTER M. TECH. (C.B.C.S.)</u>

PGCHT 201T/1 **Credit: 4**

Advances in Food Science and Technology

Unit 1: Functional properties of food macromolecules, their evaluation and modifications, Protein Technology: Protein concentrates, isolates and hydrolysates. Methods of manufacturing protein hydrolysates; Factors affecting quality of hydrolysates; Food uses of hydrolysates; Carbohydrate technology: Functional properties of starch and other polysaccharides, Process technology and food application of dextrins, chemical and enzymatic modification of starch, high fructose corn syrup.

Unit 2 : Recent trends in processing of foods such as application of high pressure, low temperature, ohmic heating, and microwave heating, supercritical fluid extraction and membrane separation in food processing Minimal processing of foods, Ohmic heating, pulsed electric field, high-intensity light pulses, radio-frequency heating, microwave, thermo-sonication,

Unit 3: Applications of high pressure extrusion in food processing. High hydrostatic processing of foods. Effect on enzymes, microorganisms in various food systems Equipment for batch and continuous processing. Other applications of HPP including thawing

Unit 4: Speciality foods such as simulated and restructured foods, functional and health foods, fast foods, space foods, Textured protein gels and expanded products; Simulated milk products; Restructured protein; Nonconventional sources of protein and its Utilizations.

Unit 5: Hybrid drying technologies: combined microwave vacuum drying, combining microwave vacuum drying with other processes, equipment for microwave vacuum drying, product quality degradation during dehydration. Advanced Membrane Technology for water and liquid foods. RTE frozen foods with reference to packaging and Recent developments in Food Processing with focus on Indian Industry

Reference Books:

Advances in food and nutrition research by Steve L. Taylor, 2009

Advances in food research by C.O.Chichester, 1986

Handbook of food and bioprocess modeling by Sablani S., Rahman M, 2007

Advances in food processing and technology by Peter Fellows

Food processing and technology: Principle and practice by P Fellows, taylor and Francis, 2009

PGCHT 201T/2 **Credit: 4**

Multicomponent Distillation

Unit 1: Multicomponent Vapor Liquid Equilibria

Rules and Law describing Equilibrium, Vapor Liquid Equilibria – Binary system, Prediction of Binary Vapor Liquid Equilibrium Data from pure component properties, Consistency tests for Binary Vapor Liquid Equilibrium, Ideal Multicomponent systems, Ideal Ternary systems, Non Ideal Vapor Liquid Equilibria – Multicomponent systems, Relationship between Li and Coull and Bonham Vapor Liquid Equlibrium Relations.

Unit 2: Phase Equilibrium for Petroleum Fractions at Super Atmospheric Pressure

Data resources, Analytical Distillation, Equilibrium Flash Vaporisation, Empirical Correlations, EFV Correlations, ASTM – TBP – EFV Relationships, Pressure effect on EFV curves, EFV Vapor and Liquid Properties.

Unit 3: Phase Equilibrium for Petroleum Fractions at Sub - Atmospheric Pressure

Conversion of ASTM Distillation Assays, Phase Equilibrium for Sub – Atmospheric Pressure, Pressure effect on 30% and 50% Points, Vacuum Phase Diagram Constructions, Consistency between Atmospheric and Vacuum EFV Correlations.

Unit 4: Atmospheric tower

Analysis of crude petroleum and its fraction, Basic processes for Atmospheric Crude Distillation, Separation criteria in petroleum fractionation, atmospheric charge data, Estimate of material balance, Heat and mass transfer balance calculations for type U tower, Heat and Mass Balance calculation for Type R Towers, Heat and Mass Balance calculation for Type A tower, Alternate Procedure for Type A tower calculations.

Unit 5: Vacuum Tower

Types of operations in Vacuum Distillation, Lube or Speciality Vacuum Distillate Operations, Fuels operation, Economic consideration in Vacuum Tower Design, Vacuum Unit Charge Data, Estimate of Material Balance, Lube-Asphalt Operation, Fuels-Pitch Operation, Flash zone and Tower Base Calaculations, Flash Zone Pressure, Steam Requirement, Heat Quantities, Heat and mass balance Calculation for Lube-Type Towers, Steam to Product Strippers , Tower Top Condition, Estimate Tower Temprature Profile, Overflash Liquid Condensation section, First sidestream Product Draw Tray, Second Sidestram Product Draw Tray Tower, Top Sidestream Product Draw Tray, Vapor-Liquid Traffic, Fractionation Analysis, Heat and Material Balance Calculation for Fuels-Type Towers, Temperature Profiles, Overflash Liquid Condensation Section, Sidestream Products condensing Section.

Unit 6: Refinary Light Ends Fractionation

Introduction, Process Design Consideration, Example Design Calculation, Reboiled Absorber.

References:

1. Matthew Van Winkle, Distillation, McGraw Hill Book Company, New York.
2. Wayne C. Edmister, Applied Hydrocarbon Thermodynamics Vol.2, Gulf Publishing Company, Houston.
3. Watkins, R.N "Petroleum Refinery Distillation", 2nd Edition, Gulf Publishing Company, Texas.

PGCHT 201T/3 **Credit: 4**

<u>TECHNOLOGY OF SOAPS, DETERGENT AND SURFACTANTS</u>

Unit- 1

Types of soaps, selection of raw materials, physical chemistry of soaps in boiling pan, manufacturing process batch and continuous and the sequences of operations, recent advances in the manufacturing methods. Metallic, transparent & herbal soaps. Analysis of soaps. Quality control during manufacture

Unit 2

Plants and process employed in soap manufacture of household and toilet soaps by age old and newer techniques, details of machinery employed and quality specifications, , Continuous processes of soap manufacture. Modern process and plants for the production of house hold and toilet soaps from Fatty acid based soaps,

Unit 3

Surfactants: Classification, chemistry and preparation. Hydrophilic lypophilic balance. Correlation of structure of the surfactant and its performance, manufacture of detergents. Formulation of detergents, wetting agents, foam boosters, dispersing agents.

Unit- 4

Modern developments in the detergent industry. Recent trends and modern developments in the Detergent industry. Biodegradation of detergents, pollution control in soap and detergent utilization

Unit-5

Analysis of soaps and detergents, BIS methods of testing, Properties of soaps and soap solutions, phase separation in soap boiling, various types of soaps andcleaning Preparations,

Reference Books:

1. The Handbook Of Soap Manufacture, Simmons ,W. H. and Appleton ,H. A. Kindle Books, USA.
2. Soap, Detergent & Perfume Industry,Srivastava S.B ,Small Industry Research Institute,New Delhi.
3 . Sulphonation Technology In The Detergent Industry, Herman W. and De Groot, Springer-Verlag New York.
4. Surface Active Agents , Goliath Company,The Gale Group, USA
5. Powdered Detergents , Showell, M. The Procter & Gamble Company, Cincinnati, Ohio, USA.
6. The manufacture of glycerol,by Martin, G. Technical Press, London

7. Soap-Chemistry and Technology, Kane,J. G.,
9. The Manufacture of Soaps, Other Detergents, and Glycerine,Woollatt, Edgar, Mountainview Books, PA, U.S.A.

PGCHT 201T/4 **Credit: 4**

Manufacturing methods, Machinery, and Planning

Unit 1:

Manufacture of modified drying oils, plants and equipments for varnishes lacquer manufacture.

Unit 2:

General principles of grinding, mixing, dispersion of surface coating. Equipment and machinery for grinding, mixing and dispersion.

Unit 3:

Ball mills, Roll mills, Attritors, Kady mills, Sand mills, Cone mills, Age runners, Amalgamator, planetary and impellor mixing.

Unit 4:

Selection of machinery for manufacture of surface coating including printing inks.

Unit 5:

Project planning. Plant location, planning and layout. Planning of disposal of waste.

Preparation of project for manufacture of paint, varnish, lacquer, printing inks.

PGCHT 202T/1 **Credit: 4**

Food Biotechnology

Unit 1: Production of baker's yeast; Lactic starter cultures, Physiology and biochemistry of starters, Propagation and management of starters; Production of mushrooms, Spawn production, mushroom harvesting; Production of single cell proteins from algae and bacteria, Product quality and safety, Merits and demerits.

Unit 2: Microbiology and Biochemistry of fermented Foods; Fermented Dairy products such as cheese, yoghurt, sweet curd, paneer, sheekhand; Fermented Cereal/legume products, including bread; Traditional fermented foods like idli, dosa, dhokla,

Unit 3: Raw materials, fermentation and processing of alcoholic beverages; Fruit based alcoholic beverage like wine; Cereal based alcoholic beverage like Beer, distilled beverages gen and whisky. soya based oriental fermented foods soya sauce, Tofu, Tempeh; Fermented pickles.

Unit 4: Production of industrial alcohol, microrganism used, fermentation condition, recovery; lactic acid production, Production of citric acid by surface and submerged culture process; acetic acid, glycerol and acetone butanol by fermentation.

Unit 5: Process technology for Microbial production of Vitamins, Production of Microbial polysaccharides such as Xanthan and Dextran gum production and their application, flavors and fragnances, Industrially produced enzymes from microbial sources and their applications; antibiotics e.g. Penicillin and Streptomycin.

Reference Books:

1. Industrial Microbiology by Casida L. E., John Wiley & Sons Inc New York, 1964
2. Industrail Microbiology by Presscot & Dunn, McGraw Hill Book Co. Inc. New York, 1940
3. Biotechnology B. D. Singh Kalyani Publishers, Ludhiana, 1999.

PGCHT 202T/2 **Credit: 4**

Process Equipment and Piping Design

Unit 1: Fundamentals of Piping Engineering

Definitions, Piping Components, Their Introduction, Applications. Piping Moc, Budget Codes and Standards, Fabrication and Installations of Piping.

Unit 2: Pipe Hydraulics and Sizing

Pipe Sizing Based on Velocity and Pressure Drop Consideration Cost, Least Annual Cost Approach, Pipe Drawing Basics, Development of Piping General Arrangement Drawing, Dimensions and Drawing of Piping.

Unit 3: Plot Plan

Development of Plot Plan for Different Types of Fluid Storage, Equipment Layout, Process Piping Layout, Utility Piping Layout. Stress Analysis -Different Types of Stresses and its Impact on Piping, Methods of Calculation, Dynamic Analysis, Flexibility Analysis.

Unit 4: Piping Support

Different Types of Support Based on Requirement and its Calculation.

Unit 5: Instrumentation

Final Control Elements; Measuring Devices, Instrumentation Symbols Introduction to Process Flow Diagram (PFD) and Piping & Instrumentation Diagram (P&I)

References:

1. Piping Handbook, 6 Th Edition, M.L. Nayyar, P.E., Mc Graw-Hill, Inc
2. Piping Design Handbook Edited By Johan J Mcketta, Crc Press.
3. Process Modeling Simulation And Control For Chemical Engineers, Luyben, W. L., Mcgraw Hill.

PGCHT 202T/3 **Credit: 4**

TECHNOLOGICAL ADVANCEMENT OF COSMETICS AND ALLIED PRODUCTS

Unit- 1

Classification of cosmetics and cosmetic preparations:- Cosmetic preparations such as Shampoos and Conditioners, their Ingredients , types, Functions, formulation, Production techniques, evaluation and safety considerations,

Unit 2

Face care products: Beauty Masks , face creams, Cleansing and Emollient Creams and Lotions, Vanishing Creams, Foundation Makeup., face/body Formulation, Hand Creams and Lotions , Skin Lighteners and Bleach Creams ,sun care cosmetics, Rouge, Moisturizing Creams etc.

Unit 3

Face care products: Lipsticks, face powders, talcum powders, Eye makeup cosmetics, Hormone Creams, Bath and shower products Shaving soaps and creams: After shave products, hair oils, hair dyes, Hair Conditioners, brilliantine's.

Unit 4

Dentifrices: Toothpaste, tooth powders, Mouthwashes, teeth whiteners, evaluation of cosmetic preparations, Plant and Machinery used in cosmetic manufacture. Lay out and Hygiene aspect of cosmetic. Miscellaneous Cosmetics, Anti per spirants and deodorants, depilatories, Baby Toiletries, nail lacquers and polishes, recent trends and other miscellaneous cosmetic preparations

Unit- 5

Herbal Cosmetic preparations; Chemical components of herbs & its extraction, Application of herbs & its extracts, Application of herbs in cosmetics application, preservation; Advantages in perfumery: Notes of perfume, compatibility of perfume , fixation and stability of perfume ; analysis of perfumes, Medicinal applications of herbal and other essential oils & perfumes.

Reference Books:

1. Handbook of Cosmetic Science and Technology, Barel,A.. Paye,M.,Howard I. and Maibach,H. I. Marcel Dekker, Inc.270 Madison Avenue, New York.
2.Cosmetics Formulations, Technology & Project Estimations, Institute of Natural & Modern Cosmetech,USA.
3. Cosmetic Formulation of Skin Care Products, Series EditorEricJungermann ,Jungermann Associates, Inc. New York.
4. Cosmetics-Science and Technology, Vol-2, 2nd Ed,Sagarin, E. andBalsam, M,Wiley India Pvt. Ltd,New Delhi.
5.Analysis of Cosmetic Products,Salvador,E.,Elsevier, New York.

PGCHT 202T/4 **Credit: 4**

Processing, Application and Technology of Printing Inks

Unit 1:

Development of printing ink Industry. Nature of various printing process.

Unit 2:

Requirements for topographic, Plano graphic, intaglio, flexographic and silkscreen printing process.

Unit 3:

Relation of rheological and their properties of printing ink with substrate to be printed. Natural of stock of paper.

Unit 4:

Formulations of printing ink, special additives. Nature of additives and its effects on the final performance, special pigments for printing inks.

Unit 5:

Standard of printing inks. Evaluation printing inks. Methods of test.

Special purpose inks, UV-cured inks & modern developments in inks.

PGCHT 203T/1 **Credit: 4**

Food Safety and Food Regulation

Unit 1: Types of food hazards: biological, chemical and physical; Risk assessment; Newer systems of safety evaluation such as HACCP. Salient features of Food Safety & Standards Act, 2006, Structure of FSSAI, Administrative set up at the State level. Roles and Responsibilities of diff. Food safety Regulators, Licensing and registration, Documents/ Format required for Registration/ Licensing

Unit 2: Introduction to Food Safety, Food Contaminants (Microbial, Chemical, Physical), Food Adulteration (Common adulterants), Food Additives (functional role, safety issues), Food Packaging & labelling (Packaging types, understanding labelling rules & Regulations, Nutritional labelling, labelling requirements for pre-packaged food as per CODEX)

Unit 3: Organic food, Identifying Organic foods, Advantages, The Organic Certification Process, Organic Food labeling, GM food, Why are GM food produced, Main issues of concern for Human Health, How are GM Food regulated Internationally, Regulation in India.

Role of WHO to improve evaluation of GM food, Benefits & Controversies, Irradiated Food, Labelling of Irradiated Food. Freeze dried food, Functional Foods & Nutraceuticals, Functional foods from plant sources, animal sources, dietary supplements, Regulation.

Unit 4: Food & Agriculture Organization (FAO)in India, Technical Cooperation programmes, Bio-security in Food and Agriculture, World Health Organization (WHO), World Animal Health Organization (OIE), International Plant Protection Convention (IPPC) Codex Alimentarius Commission - Codex India – Role of Codex Contact point, National Codex contact point (NCCP), National Codex Committee of India – ToR, Functions, Shadow Committees etc.

Unit 5: Good Hygienic Practices (GHP), Good Manufacturing Practices (GMP), HACCP, ISO 9001 (Quality Management System), ISO 22000 (Food Safety Management System), Traceability, Food Recall Need for Food analysis, Accreditation of Food Laboratory, Referral labs. Risk analysis and management in food safety, What is food surveillance, Steps to be taken for reporting and dealing with food incidents. Food alerts. Offences in food, Trials (Case Study) and procedure to launch prosecution

Reference Books:

Environmental regulation and food safety by Veena Jha.

Microbiological safety of food by Hobbs, 1973

Emerging technologies; food process by Da-wen, 2005

Food safety by Laura K Egendorf, 2000

International standards of food safety by Naomi Rees, David Watson, 2000

Codex alimentarius by FAO & WHO, 2007

Nutritional and safety aspects of food processing by Tannenbaum SR

The food safety information handbook by Cynthia A. Robert, 2009

PGCHT 203T/2 **Credit: 4**

Petroleum Specialty Products

Unit 1: Lubricating Oil Base Stocks and their Blending:

Conventional Processes, Catalytic Dewaxing, API Classification of Base Oils.

Classification of Lube Oils by Viscosity, additive Types, International Standards, Automotive Engine Oils and their additives, Effect of Viscosity on Fuel Economy, Additive Depletion, Engine Oil Formulation, Effect of Base Stock Quality, API Service Classifications.

Unit 2: Metal Working Fluids:

Types & Functions of MWF's, Cutting Oil Formulation, Maintenance & Disposal.

Quenchants: Heat Treating Processes, Quenching, Types of Quenchants, three stages of Heat Removal, Quench System Design, Other HeatTreating Processes.

Unit 3: Turbine Oils, Gear Oils & Hydraulic Fluids:

Base oils, formulation, life, Test methods.

SAE Gear oil Calssification, Automotive lubricant Test Methods, Cold Crank Simulator (ASTM D 5293) and Four Ball Wear Test (ASTM D 4172).

Physical Properties of Hydraulic Fluids, Biodegradability, base oils for Hydraulic Fluids, Brake Fluids.

Unit 4: Lubricating Greases & Waxes:

Grease Composition, Base Oil, Thickeners, Additives, Grease manufacture, Grease Quality, Automotive Greases, Aircraft Greases, Heavy Machinery Greases, Marine Greases, High-Temperature Greases.

Paraffin Waxes, Classification, Properties, Test Methods, Petroleum Wax Manufacture, Non Petroleum Waxes and Petrolatums.

Unit 5: Transformer/ Electrical Insulating Oils & White Mineral Oils:

Properties, Specifications, Transformer Oil Manufacture.

Properties, Uses, Manufacturing of White Oils, Process description, Intermediate Product Nomenclature and Storage, Sulfonate Blending, petroleum Sulfonates,

Unit 6: Bitumen & Carbon Black:

Composition of Bitumen, Bitumen for Pavement, Evaluation, Grading Systems, Hot- Mix Asphalt, Test Methods, Types of Bitumen, Air Blowing Process, Industrial Uses, Storage and Handling.

Manufacturing Processes for Carbon Black viz.Channel Black Process, Gas Black Process, Thermal Black Process, Acetylene Black Process, Lamp Black Process, Furnace Black Process, Reactor, Oxidised Carbon Black, Properties, Secondary Properties, Test Methods, Application and Uses, Printing Inks, Cosmetics Usage.

References:

1. Petroleum Fuels Manufacturing Handbook, Surinder Prakash, Mc Graw Hill.
2. Modern Petroleum Technology, G. D. Hobson & Pohl., Applied Science Publications.
3. Asphalts and Road Materials, Modern Technology, J. E. Parson, Noyes Data Corporation.
4. Lubricant Additives, M. W. Ranney, Noyes Data Corporation.

PGCHT 203T/3 **Credit: 4**

MODIFICATION OF OIL AND FAT PRODUCTS INCLUDING SURFACE COATINGS

Unit- 1

Fat Based Products, Industrial lubricants. Bio Lubricants, Lubricant additives, Plasticizers, biodiesel, Lubricating Greases, Manufacture, Properties, types, ingredients, additives, analysis. Fatty Alcohols and Amines

Unit 2

Technology of Drying oils, Chemistry, Thermal and chemical modification methods; Properties and uses, drying, semi drying oils, yellowing of oils : modified oils like heat treated oils, Malenized oils, Co-polymerized oils, dehydration, isomerised oils, segregated, reconstituted oils.

Unit 3

Principles of paint formulations and testing, varnishes and lacquers ,primers, undercoats and finish coats. Manufacture, classification and types of powder coating. Sketches of the machinery used. Manufacture of different types of wall finishes. Convertible and Non-convertible coatings

Unit 4

Technology of Pigments and Extenders, Definition, classification ,Sources, properties, manufacture, testing and evaluation of pigments, preparation and uses of important pigments such as White, yellow, black, blue, green and red pigments, Metallic pigments, Natural organic pigments, comparison of organic pigments, Extenders:- Sources, manufacture, properties and uses,, recent developments.

Unit 5

Solvents and General Paint Properties Hazards and precautions. Diluents, thinners, lacquers-Types, general properties, classification, evaluation of solvents, solubility parameters. Safety measures for coatings, ISI methods of testing of paints, specialty paints, paint film defects, recent developments. Industrial Formulation and Applications of paints

Reference Books:

1. Protective and Decorative Coatings, Paint, Varnishes, Lacquers, and Inks, Mattiello, J. J., John Wiley and Sons, New York.
2. Organic Coating Technology Vol, 1 & 11 by, Payne, H.Y.
3. Paint Technology Manuals., Oil and color chemists Association, Vol-I – Vol. VIII, Chapman and Hall , London
4. Pigment Hand book Vol. 1 – Vol. VIII,. Patton, T. C., Wiley-Inter science Publications, New York.
5. The Testing of Paints, Vol – V, Paint Technology Manual,. Dunkley F.G. and Collier, C.W., Chapman and Hall. London
6. Paint film defects and their remedies, Manfred, H., Chapman and Hall Ltd. London.
7. Introduction to paint chemistry – Principles of paint technology, Turner G.P.A.,, Chapman and Hall , London
8. Outline of paint technology, Morgans, W.M. Edward Arnold Publishers, London

PGCHT 203T/4 **Credit: 4**

Applications, Evaluation of Surface Coating and Industrial Waste Treatment

Unit1:

Study of metal and nonmetal surfaces for coatings. Surface preparation and treatment.

Unit 2:

Methods of application of paints and the coatings, their advantages and disadvantages.

Plant and equipment used for application. Maintenances of equipments.

Unit 3:

Drying of coating. Analysis and evaluation of paints, varnishes, lacquer, and other coating. Accelerated and exposer tests for coating .I.S.I. standards for coatings.

Unit 4:

Electrodeposition technique anodic & cathodic deposition. Plant for electrodeposition.

Unit 5:

Paint film defects. Methods of improving performance, removal of defects, and correlation of formulation and defect of paint and films.

Safety in paint industry hazard and pollution control.

PGCHT 204T/1 **Credit: 4**

ELECTIVE - III (Discipline Specific BCHT)

1. **Food Industry Waste Management**

Unit 1: Standards for disposal of water, physical, chemical and biological characteristics of waste water; measurement of organic content in waste water; Physical unit operations in waste water treatment - screening; racks, mixing, flocculation, sedimentation, floatation, elutriation, vacuum filtration, incineration;

Unit 2: Chemical unit operations in waste water treatment-chemical precipitation, aeration and gas transfer process, rate of gas transfer, adsorption, disinfection; Alternative techniques to reduce the use of chlorine for water treatment, zero-discharge system, zero-emission system , Ion exchange treatment of waste water, Drinking-Water treatment

Unit 3: Biological unit operations - Aerobic and anaerobic treatment of effluents from food processing industry [Trickling filters, rotating biological contractor, Activated sludge, sludge treatment, oxidation ponds].

Unit 4: Waste management of fruits and vegetable such as production of pectin, ethanol, natural gas, citric acid, activated charcoal, fibre extract from apple pomace, vitamins , Production of citrus oil from peels of citrus fruits; Manufacture of candied peel. Recovery of Protein from potato starch plant waste. Waste management of cereals such as Feed for livestock from wheat and corn bran and germ. Extraction of oil & wax from rice bran, Puffed cereals from broken rice; Starch, modified starch and industrial alcohol from nonusable cereals; Silica from rice husk; Extraction of plolamin (Zein & katirin); Protein from sorghum; Beer spent graining.

Unit 5: Waste management of fish, meat, poultry such as Production of fish meal; Fish protein concentrate; Animal feed; Shell product;Glue from seafood processing waste. Texturised fish protein concentrate (marine beef); Utilization of organs and glands of animal as human food. Production of human food from animal blood and blood protein; Marketable products like chitin, chitosan, fertilizer, nutritional enhancer animal feed from shells. Waste management of Dairy, tea and coffee industry such as Fermentation products from whey. Condensed & dried products from whey; Production of lactose and protein from whey; Utilization of tea waste as feed for livestock & poultry.

Reference Books:

1. The potato in the human diet-Jennifer A Woolfe

2. Edible meat by products- A M Pearson & T R Dutson

3. By products from milk- Webb & Whitier.

4. Fish & Krill protein processing technology- Taneko Suzuki.

5. Processed apple products-Downing

6. Citrus fruits and their products- Ting & Rouseft.

7. Cocoa- Wood & Lass

8. Wheat- Peterson

9. Sweetness & Sweetener- Birch, Green & Coulson.

10. Outlines of Food Technology- Hanx W. VonLoesecke (ab)- Agrabios (India) 2nd

Edition, 200 1.

Food Industry Wastes: Disposal and Recovery; Herzka A & Booth RG; 1981, Applied Science Pub Ltd.

Water & Wastewater Engineering; Fair GM, Geyer JC & Okun DA; 1986, John Wiley & Sons, Inc.

Wastewater Treatment; Bartlett RE; Applied Science Pub Ltd.

Symposium: Processing Agricultural & Municipal Wastes; Inglett GE; 1973, AVI.

Food Processing Waste Management; Green JH & Kramer A; 1979, AVI.

Environmental Biotechnology: Principles and Applications; Rittmann BE & McCarty PL; 2001, Mc-Grow-Hill International editions.

Environmental Biotechnology; Bhattacharyya B C & Banerjee R; Oxford University Press.

PGCHT 204T/1 **Credit: 4**

ELECTIVE - III (Discipline Specific BCHT)

2. **Enzyme Technology**

Unit 1: Enzymes: classification, properties, coenzymes and cofactors, enzyme kinetics, regulatory enzymes, isoenzymes. Introduction to enzyme technology; Industrial enzymes – present status and opportunities with special reference to food industries;

Unit 2: enzyme inhibition and kinetics of enzyme inhibition, enzyme purification;

Types of enzyme reactions. Catalytic properties of enzymes; Intracellular and extra-cellular enzymes.

Unit 3: Enzyme production technology; Enzyme reactors and process design; Isolation of enzymes from various sources like plant, animals and microbiological.

Unit 4: Cell disintegration by physical, chemical and biological methods; Enzyme purification methods.

Unit 5: Enzyme applications in industry. Application of enzymes for production in biochemical and food processing industries; Application of immobilized enzymes and cells. Advantages and constraints of immobilized enzymes and microbial cells.

Reference Books:

1.Methods of Enzymology

2. Biochemical Engg Fundamentals-Baily, Ollis. MGH

3. Prescott & Dunn's Industrial Microbiology Macmiller

4. Principles of Fermentation Technology-Wittaker and Stanby

PGCHT 204T/2 **Credit: 4**

ELECTIVE III (Discipline Specific BCHT)

1. **Advanced Separation Processes**

Unit 1: Flux Definition, Differential Equations of Mass transfer, Molecular diffusivities, Molecular diffusion, Mass Transfer coefficients

Unit 2: Multicomponent distillation: Bubble point and dew point calculations, Lewis and Matheson calculation, Method of Thiele and Geddes; Azeotropic distillation; Extractive distillation; Molecular distillation; Reactive distillation

Unit 3: Azeotropic and extractive fractional distillation:Separation of homogeneous azeotropes, separation of heterogeneous azeotropes, quantitative treatment of separation of binary heterogeneous azeotropes, selection of addition agents, selectivity, factors affecting selectivity, methods for prediction, mechanism of relative volatility change, choice of entrainer or solvent, design of an azeotropic distillation process, design of an extractive distillation process, methods of solvent recovery

Unit 4: Membrane separation processes:Fundamentals, mechanism and equilibrium relationships, types and structure of membranes, membrane permeation of liquids and gases, effects of concentration, pressure and temperature, dialysis: mechanism, basic idea on dialyser design, industrial application, reverse osmosis, definitions and theory, design considerations, applications, ultra filtration.

Unit 5: Adsorption and Ion Exchange Processes: Adsorption and ion exchange equilibria. Various isotherms. Contact filtration, design of fixed bed adsorber including breakthrough curve.

Recommended Books:

1. R.E. Lacey, S. Loaeb, Industrial Processing with Membranes, Wiley –Inter Science, New York, 1972.
2. C.J. King, Separation Processes, Tata McGraw - Hill Publishing Co., Ltd., 1982.
3. C.J. Geankoplis, Transport Processes and Unit Operations, Prentice-Hall of India Pvt. Ltd., New Delhi, 2000.
4. R.E. Treybal, Mass-Transfer Operations, McGraw-Hill, New York, 1980.
5. J.D. Seader, E.J. Henley, Separation Process Principles, Wiley, 2011.
6. B.K. Dutta, Principles of Mass Transfer and Separation Processes, PHI, 2006
7. T.K. Sherwood, R.L. Pigford, C.R. Wilke, Mass Transfer, McGraw-Hill, New York, 1975.
8. H.M. Schoew, New Chemical Engineering Separation Techniques, Interscience Publishers, 1972.
9. Osadar, Varid Nakagawa, Membrance Science and Technology, Marcel Dekkar, 1992.

2. Advanced Process Dynamics & Control

Unit 1: Process Identification and Non-Linear Systems. Introduction and analysis of Non-liner control system. Phase plane analysis of second order control system, Analysis of critical points. Method of isoclines for non linear system.

Unit 2: Control of complex processes Process modeling and dynamic response of gas absorber, steam jacketed kettle, heat exchanger, distributed parameter model, non-interacting continuous stirred tank reactors, non-interacting stirred tank heaters.

Unit 3: Feedforward-feedback control configuration. Industrial examples of feedforward-feedback control of heat exchanger, jacketed continuous stirred tank reactor for exothermic and endothermic reactions, stirred tank heater, distillation column, drum boiler, level control, extraction column.

Unit 4: Industrial control system. Control configuration of Supervisory control and data acquisition SCADA, Working control components and network communication of SCADA. Industrial examples of SCADA. Control configuration of distributed control system DCS. Working of Programmable logic controller PLC. Real time monitoring control.

Unit 5: Programmed adaptive control, Gain programmed adaptive control. Reference model adaptive control, Inferential control. Industrial examples of adaptive and inferential control. Reaction curve method.

Recommended Books:

1. B. A. Ogunaike, W. H. Ray, Process Dynamics, Modeling and Control, Oxford University Press, NY, 1994
2. B. W. Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall International Series, 1998
3. D. E. Seborg, D. A. Mellichamp, T. F. Edgar, F. J. Doyle III, Process Dynamics and Control, 3rd Edition, Wiley.
4. G. Stephanopoulos, Chemical Process Control, Prentice-Hall, Englewood Cliffs, NJ, 1984
5. T. Marlin, Process Control, 2nd Edition, McGraw Hill Inc, US, 2000.
6. R.P. Vyas, Process control and Instrumentation, Seventh Edition, Denett& Co. publication, 2015.
7. R.P. Vyas, Measurement and Control, Denett& Co. Publication 2010.

3. Advanced Chemical Reaction Engineering

Unit 1: Reaction engineering overview- emerging challenges- ideal reactor design equations- multiple reactions, instantaneous and overall yields.

Unit 2: Energy balance in stirred batch, semi-batch and continuous vessels- energy balance in plug flow vessels - optimal design for exothermic reversible reactions - stability and multiplicity of steady states in CSTR.

Unit 3: Design of packed tubular reactors- Gas solid reactions, shrinking core model, pseudo steady state hypothesis for ash layer control, gas solid reactions in rotary kiln and fluid beds.

Unit 4: Non ideal flow, RTD of ideal vessels, modeling non ideal flow, conversion from RTD theory, tanks in series model, dispersion model -catalyst deactivation, design for deactivating catalysts.

Unit 5: Introduction to population balance, application to RTD of CSTR, application to gas solid reactions in Rotary kiln and fluid beds, performance of reactor regenerator system from PBE modeling.

Unit 6: Design for Immobilized cell reactor, design for fermentation alcohol, design for polymerization reactors, biological waste water treatment- flow and reaction through porous media, acid leaching of rocks-liquid liquid reactions-gas liquid reactions , applications in CO_2 capture and global warming.

References:

1. H. Scot Fogler : Elements of Chemical reaction engineering Prentice Hall.
2. J.M. Smith : Chemical Engineering Kinetics, Mcgraw Hill.
3. O Levenspiel : Chemical Reaction Engineering, Wiley.

PGCHT 204T/2 **Credit: 4**

ELECTIVE III (Discipline Specific BCHT)

4. Environment, Health and Safety in Industries

Unit 1: Introduction

Need for Developing Environment, Health and Safety Systems in Work Places. Status and Relationship of Acts, Regulations and Codes of Practice .Role of Trade Union Safety Representatives. International Initiatives. Ergonomics and Work Place.

Unit 2: Occupational Health And Hygiene

Definition of the Term Occupational Health and Hygiene. Categories of Health Hazards. Exposure Pathways and Human Responses to Hazardous and Toxic Substances. Advantages and Limitations of Environmental Monitoring and Occupational Exposure Limits. Hierarchy of Control Measures for Occupational Health Risks. Role of Personal Protective Equipment and the Selection Criteria. Effects on Humans, Control Methods and Reduction Strategies for Noise, Radiation and Excessive Stress.

Unit 3: Workplace Safety and Safety Systems

Features of the Satisfactory Design of Work Premises Hvac, Ventilation. Safe Installation and Use of Electrical Supplies. Fire Safety and First Aid Provision. Significance of Human Factors in the Establishment and Effectiveness of Safe Systems. Safe Systems of Work For Manual Handling Operations. Control Methods to Eliminate or Reduce the Risks Arising from the Use of Work Equipment. Requirements for the Safe Use of Display Screen Equipment. Procedures and Precautionary Measures Necessary When Handling Hazardous Substances. Contingency Arrangements for Events of Serious and Imminent Danger.

Unit 4: Techniques of Environmental Safety

Elements of a Health and Safety Policy and Methods of its Effective Implementation and Review. Functions and Techniques of Risk Assessment, Inspections and Audits. Investigation of Accidents- Principles of Quality Management Systems in Health and Safety Management. Relationship between Quality Manuals, Safety Policies and Written Risk Assessments. Records and Other Documentation Required by an Organisation for Health and Safety. Industry Specific Ehs Issues.

Unit 5: Education and Training

Requirements for and Benefits of the Provision of Information, Instruction, Training and Supervision. Factors to be Considered in the Development of Effective Training Programmes. Principles and Methods of Effective Training. Feedback and Evaluation Mechanism.

References:

1. Environmental And Health And Safety Management By Nicholas P. Cheremisinoff And Madelyn L. Graffia, William Andrew Inc. Ny.
2. The Facility Manager's Guide To Environmental Health And Safety By Brian Gallant, Government Inst Publ..
3. Effective Environmental, Health, And Safety Management Using The Team Approach By Bill Taylor, Culinary And Hospitality Industry Publications Services.

PGCHT 201T/3 **Credit: 4**

ELECTIVE - III (Discipline Specific BCHT)

1. ENVIRONMENTAL ASPECTS OF OIL AND ALLIED INDUSTRIES

Unit 1

Industrial pollution and its impact . Magnitude of industrial waste , Legislative regulations. Recycle and reuse of waste water , recovery of by/c0-product from industrial effluents.

Unit 2

Philosophy of waste treatment, scope of air and water pollution problems, economic considerations of waste disposal, separation and segregation of wastes, gaseous, liquid and solid waste disposal with special reference to oils and allied product processing.

Unit 3

Waste Management Pollution prevention and environment Management system ISO 14000. Waste audit, Quality management systems, Different regulation means & acts for air , water& solid pollution control.

Unit 4

Waste liquid treatment: Pretreatment methods, centrifugation filtration, evaporator and concentrator , extraction and distillation, treatment of dilute waste water. Treatment requirements, Neutralisation liquid-solid separation, biological oxidation, plant control programme, absorption, liquid phase system, reclamation of waste water effluent and by-product recovery, ion exchange system, acid and alkali purification, continuous ion-exchange,. Case studies on vegetable oil processing, soaps and detergents.

Unit 5

Solid waste treatment, waste gas treatment: spent earth, catalyst, fly ash boiler ash, Air pollution control by mechanical method: mechanical collectors, electrostatic precipitator, filters,wet scrubbers, vapour phase system, activated carbon. Typical air purification system

Reference Books:

1. Narula O.P., “Treaties on fats, fatty acids and oleo chemicals, “Vol I Industrial consultants. (India) New Delhi 1996.
2. Metcalf and Eddy, Wastewater Engineering: Treatment, Disposal and Reuse, Tata McGraw-Hill Pub. Co. Ltd., New Delhi, 1979.
3. S.P. Mahajan, Pollution Control in Process Industry, Tata McGraw Hill Publishers, 1987.
4. G.N. Pandey, G.C. Camey, Environmental Engineering, Tata McGraw-Hill Pub.Co.Ltd., 1992.
5. H.S. Peavy, D.R. Rowe, G. Tchobanoglous, Environmental Engineering, McGraw-Hill, 1986.
6. C.N. Sawyer, P.L. McCarty, G.F. Parkin, Chemistry for Environmental Engineering, Tata-McGraw-Hill Edition, 2003.
7. S.K. Garg , Sewage Disposal and Air Pollution Engineering, Khanna Publishers, 2010.
8.

PGCHT 201T/3 **Credit: 4**

ELECTIVE - III (Discipline Specific BCHT)

2. POLYMERIC SURFACTANTS

Unit 1

Classification of surfactant, Surface tension and surfactant mechanism, types of surfactants. Basic concepts in surfactants

Unit 2

Development of synthetic detergent industry, principle groups of synthetic detergent industry, Current trends and recent scenario of detergent industry

Unit 3

Alternative surfactant, their functional properties, reaction mechanism, production methods, and their industrial uses, polymeric surfactant based on carbohydrates, vegetable oils and natural rosin

Unit 4

Mechanism of Polymeric surfactant as a substitute for phosphates, release agent, emulsifier, dispersion stabilizer, anti redeposition agent

Unit 5

Biodegradability study of polymeric surfactant, environmental affect compared to traditional raw materials in cleaning industry. Economical aspects

Reference Books:

1. Paolo Zini, "Polymeric Additives for high performing detergent", Technomic publication, U.S.A. 1995
2. Suri S.K., "Synthetic Detergent Powders: Changing Trends – 1, Soaps, Detergent & toiletries Review, p 14-18, Sept. 2000.
3. Hui Y.H., "Bailey's Industrial oil and fats products", 5, p. 78-80, Fifth edition, John Wiley and Sons, Inc, New York, 1996.
4. Mani V.V.S., Shitole A.D., "Fats oleo chemicals and Surfactants, challenges in the 21st Century", Oxford and IBH publishing Co. Pvt. Ltd., New Delhi, 1997.
5. Schwartz A.M. & Perry J.W., "Surface active agents. Their Chemistry and Technology". Interscience Publishers, Inc. New York p 51, 1949
6. Harris J.C. "Detergency Evaluation and Testing", Interscience Publishers, Inc, New York, 1954.

PGCHT 204T/4 **Credit: 4**

ELECTIVE –III (Discipline Specific)

1. Functional Coatings
(Super hydrophobic and self-healing coatings)

Unit 1:

Introduction to Super-hydrophobicity. Natural Super hydrophobic Surfaces: Introduction, Self-Cleaning Properties Arising from Hierarchical Structures,

Unit 2:

Design of Super-hydrophobic Surfaces: Methods to Prepare Super-hydrophobic Surfaces. Super-hydrophobic Polymers/binders: Introduction, Design of Super-hydrophobic Polymers.

Unit 3:

Generation and Characterization of Super-Hydrophobic Micro- and Nano-structured Surfaces. Pigments and other additives for super-hydrophobic coatings. Formulations super-hydrophobic coatings

Unit 4:

Introduction of Self-healing. Release of Healing Agents, Microcapsule Embedment Miscellaneous Technologies , Nanoparticle migrations, Self-healing Polymers and Polymer Composites**:** Introduction, Preparation and Characterization of the Self-healing Agent Consisting of Microencapsulated Curing Agents, Characterization of the Microencapsules

Unit 5:

Self-healing Protective Coatings: Self-healing Coating-based Active Corrosion Protection, Conductive Polymer Coatings, Active Anticorrosion Conversion Coatings, Protective Coatings with Inhibitor-doped Matrix. Self-healing Anticorrosion Coatings based on Nano-/ Microcontainers of Corrosion Inhibitors

PGCHT 204T/4 **Credit: 4**

ELECTIVE –III (Discipline Specific)

2. Chemistry and Technology of Nano-pigments

Unit 1:

Importance of nano- pigments in coatings.

Unit 2:

Natural nano-materials, fullerenes, applications, (filtrations, biomedical, textiles, electrical and optical) modifications.

Unit 3:

Synthesis, applications & treatments of nano-silica & analogues materials, silver, ZnO_2, gold, nano-fibers, single and MW- CNTs, iron oxide etc

Unit 4:

Different methods of characterization of nano materials. Self assembled layers, Issues related to handling of nano-materials etc.

Unit 5:

Recent advances in nano-materials used in coating industries. Properties of coatings based on nano-pigments.

PGOPEN 301T **Credit: 4**

ELECTIVE IV :