Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Science & Technology

Structure & Syllabus

3rd and 4th Semester B. Tech

(Chemical Engineering)

SCHEME OF EXAMINATION
RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
THIRD SEMESTER B. TECH (CHEMICAL ENGINEERING)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Work Load Hrs				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	CE-PCC-301T	Material & Energy Balance Computations	BCE	3	0	1	4	3	0	1	4	30	70	-	-	100	45%
2	CE-PCC-302T	Particle & Fluid Particle Processing	BCE	3	0	1	4	3	0	1	4	30	70	-	-	100	45%
3	CE-PCC-303T	Thermodynamics – II	BCE	3	0	1	4	3	0	1	4	30	70	-	-	100	45%
4	CE -GES -304 T	Material Science	BGE	3	0	0	3	3	0	0	3	30	70	-	-	100	45%
5	CE- BS -305 T	Maths - III	BGE	3	0	0	3	3	0	0	3	30	70	-	-	100	45%
6	CE -BS -306 T	Elementary Molecular Approach	BGE	3	0	0	3	3	0	0	3	30	70	-	-	100	45%
7	CE -GES -307P	Material Science Laboratory	BGE	0	2	0	2	0	1	0	1	-	-	25	25	50	50%
8	CE -BS -308 P	Elementary Molecular Approach – Laboratory	BGE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50	50%
9	CE -GES -309 P	Engineering workshop	BGE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50	50%
10	CE-PCC-310P	Particle & Fluid Particle Processing Lab	BCE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50	50%
		Total		**18**	**11**	**3**	**32**	**18**	**5.5**	**3**	**26.5**	180	420	100	100	800	-

SCHEME OF EXAMINATION
RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FOURTH SEMESTER B. TECH (CHEMICAL ENGINEERING)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Work Load Hrs				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	CE-PCC-401T	Process Technology & Economics	BCE	3	0	1	4	3	0	1	4	30	70	-	-	100	45%
2	CE-PCC-402T	Mass Transfer I	BCE	3	0	0	3	3	0	0	3	30	70	-	-	100	45%
3	CE-PCC-403T	Fluid Mechanics	BCE	3	0	1	4	3	0	1	4	30	70	-	-	100	45%
4	CE-PCC-404T	Numerical Methods in Chemical Engineering	BCE	2	0	0	2	2	0	0	2	15	35	-	-	50	45%
5	CE- BS -405 T	Inorganic Process Technology	BGE	3	0	0	3	3	0	0	3	30	70	-	-	100	45%
6	CE- HSMC-HS 406T	HASS II: Functional English	BGE	2	0	0	2	2	0	0	2	15	35	-	-	50	45%
7	CE-PCC-407P	Fluid Mechanics Lab	BCE	0	2	0	2	0	1	0	1	-	-	25	25	50	50%
8	CE-PCC-408P	Numerical Methods in Chemical Engineering Lab	BCE	0	2	0	2	0	1	0	1	-	-	25	25	50	50%
9	CE- BS -409 P	Inorganic Process Technology Laboratory	BGE	0	3	0	3	0	1.5	0	1.5	-	-	25	25	50	50%
10	MC	Environmental Sciences	BCE	2	0	0	2	0	0	0	0	-	-	-	-	-	Audit Course S/NS**
		Total		**18**	**7**	**2**	**27**	**16**	**3.5**	**2**	**21.5**	**150**	**350**	**75**	**75**	**650**	-

** **S/NS Grade for Audit Course S – Satisfactory or NS – Not Satisfactory**

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Science & Technology

Syllabus for

Third Semester B.Tech. Chemical Engineering

Subject: CE-PCC-301T(BCE) Material & Energy Balance Computations (Theory)

Lecture	: 3 Hours	Tutorial: 1 Hour		No. of Credits	: 4
University	: 70 Marks			College Assessment	: 30 Marks

Duration of Examination: 3 Hours

Course Objectives:

- 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 to:

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 1: 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 2: 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 3: Material balance without chemical reaction, recycle, purge and bypass calculations, material balance with chemical reaction.

Unit 4: Energy balance without chemical reaction, combined material and energy balances.

Unit 5: 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. K.V. Narayana, B. Laxmikutty, Stoichiometry and Process Calculation, Prentice Hall of India 2006.

2. D.M. Himmalblau, Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall, 2011.
3. B.I. Bhatt, S.M. Vora, Stoichiometry, 4th Edition, Tata-McGraw-Hill, 2004.
4. A. Hougen, M. Watson, Chemical Process Calculation, Third Edition, John Wiley & Sons, 2000.

Subject: CE-PCC-302T (BCE) **Particle & Fluid Particle Processing (Theory)**

Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Course Objectives:

- 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:

CO1: understand solid particle characterization & relevance of fluid and particle mechanics and mechanical operations in chemical engineering

CO2: understand crushing and screening principles and equipment's used for them.

CO3: understand handling & transportation of solids and fluid solid systems.

CO4: understand separation of solids from fluids by using sedimentation and basic principles, operation and equipment's used for them.

CO5: understand separation of solid from fluids by using Filtration, flotation and classification and basic principles, operation and equipment's used for them

Unit 1: 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 2: Solids: size reductions, types of equipment's used in the various stages of reductions, laws of crushing and grinding power requirements. Screening: screening equipments, effectiveness of screens, sieve analysis, particle size distribution, classification of particles, size enlargement, nucleation and growth of particles.

Unit 3: 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 4: 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. Colloidal particles: stabilization, flocculation

Unit 5: 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.

Books Recommended:

1. W. L. McCabe, J. CS mith, P. Harriott, Unit Operations of Chemical Engineering, 6th edition, McGraw Hill. 2001.
2. J. F. Richardson, J. H. Harker, J. R. Backhurst, Coulson and Richardson's Chemical Engineering, Vol. 2, Fifth edition, Butterworth-Heinemann, 2002.
3. G.G. Brown, Unit operation, First Edition, CBS publication 1995, reprint 2005.
4. M. J. Rhodes, Introduction to Particle Technology, 2nd edition, John Wiley, Chichester; New York, 2008.
5. T. Allen, Powder Sampling and Particle Size Determination, Elsevier, 2003.
6. H. Masuda, K. Higashitani, H. Yoshida, Powder Technology Handbook, CRC, Taylor and Francis, 2006.
7. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Ed., Wiley, 2013.

Subject: CE-PCC-303T (BCE) **Thermodynamics II (Theory)**

Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Course Objectives:

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 equilibria, vapour liquid-liquid equilibria, solid-liquid, and solid-vapour equilibria.

Course Outcomes:

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

CO1: Understand and apply the laws and rules of thermodynamics, equilibrium and phase rule.

CO2: Understand various thermodynamics properties and relationships, and coefficients of species and their properties.

CO3: Understand Liquid phase properties from VLE, Models for excess Gibbs energy, heat effects and property change on mixing

CO4: Understand different Equilibria, equilibrium criterion, evaluation of equilibrium constant and equilibrium conversion at different conditions.

CO5: Understand molecular/statistical thermodynamics

Unit 1: 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 2: 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 3: 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 4: 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 5: Introduction to molecular/statistical thermodynamics

Books Recommended:

1. J. M. Smith, H. C. Van Ness, 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.
3. S. Sandler, Chemical, Biochemical and Engineering Thermodynamics, 4th edition, Wiley, India.
4. Y. V. C. Rao, Chemical Engineering Thermodynamics, University Press, Hyderabad, 1997.

Subject: CE-GES-304T (BGE) **Material Science (Theory)**

Lecture : 3 Hours No. of Credits : 3

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Course 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:

At the end of the course, the student will be able to understand:

CO1: Various bonding between atoms, thermal expansion, elastic modulus and melting point of materials & role of materials selection in design.

CO2: Miller Indices, packing of atoms, close-packed structure, ionic solids, glass and polymers.

CO3: Different imperfections, impurities, dislocations, defects, and stacking faults.

CO4: Different structure and strength of materials, strain behaviour of metals, ceramics and polymers.

CO5: 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.

Books Recommended:

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

Subject: CE-BS-305T (BGE)	**Maths –III (Theory)**
Lecture : 3 Hours	No. of Credits : 3
University : 70 Marks	College Assessment : 30 Marks
Duration of Examination: 3 Hours	

Course Objectives:

- To develop the logical understanding of the subject.
- 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.
- To make the students aware about the significance and interrelation between Mathematics and Engineering.

Course Outcomes:

After completion of the course, 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 1: 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 2: 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 3: 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 4: Fourier Transform

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

Unit 5: 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.

Books Recommended:

1. H. K. Das, Er. Rajnish Verma, Higher Engineering Mathematics, S Chand, 2014.
2. N. P. Bali, Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications Pvt Limited. 2016.
3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers.

Subject: CE-BS-306T (BGE)	**Elementary Molecular Approach (Theory)**
Lecture : 3 Hours	No. of Credits : 3
University : 70 Marks	College Assessment : 30 Marks
Duration of Examination: 3 Hours	

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 to:

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, CO_2 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, A2B2 etc.), 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.

Books Recommended:

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

Subject: CE-GES-307P (BGE) **Material Science Laboratory (Practical)**

Practical : 2 Hours No. of Credits : 1

University : 25 Marks College Assessment : 25 Marks

Duration of Examination: 3 Hours

Course Objectives:

- To introduce crystal structure, common crystal defects and to recognize their role in materials behavior.
- To provide students with basic knowledge of how material properties ultimately influence engineering design in their respective disciplines, and how these properties lead to limitations.
- To experimentally demonstrate the mechanical properties of materials.
- To enable students to create lab reports using enhanced skills for presenting and interpreting experimental results.

Course Outcomes:

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

CO1: Understand the elementary concepts of materials science in the aspects of structure of atoms, crystal structure and to describe crystal imperfections in the materials.

CO2: Analyze the failure of materials under tension, impact loading and to interpret fatigue and creep behavior of materials in order to select the materials and properties suitable for particular application.

CO3: Explain features, Classify the thermosetting plastics and thermoplastics and study these materials for specific uses based on the properties, characteristics, and service of the materials.

CO4: Perform and conduct scientific and engineering experiments to study the material properties and to analyze and interpret data.

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. Tensile test on mild steel sample using UTM.
8. Fatigue test on the mild steel sample.

Books Recommended:

1. 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.

Subject: CE-BS-308P (BGE)

Elementary Molecular Approach Laboratory (Practical)

Practical	: 3 Hours	No. of Credits	: 1.5
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 3 Hours

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:

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

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.

Books Recommended:

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.

Subject: CE-GES-309P (BGE)	**Engineering Workshop (Practical)**
Practical : 3 Hours	No. of Credits : 1.5
University : 25 Marks	College Assessment : 25 Marks
Duration of Examination: 3 Hours	

Course 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:

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

CO1: To apply correct layout and safety rules for industrial applications

CO2: To select the correct tools and operations used to prepare the job in different shops.

CO3: To decide the sequence of operations and prepare the job in different shops.

CO4: To prepare process sheet for the manufactured product.

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.

Books Recommended:

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.

Subject: CE-PCC-310P (BCE)

Particle & Fluid Particle Processing Lab (Practical)

Practical	: 3 Hours	No. of Credits	: 1.5
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 6 Hours

Course Objectives:

- 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:

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

CO1: 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

Required to perform minimum 8 practical from the list given below:

1. To study relationship between the Drag coefficient and modified Reynolds number for body falling through fluid (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 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 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.

Books Recommended:

1. W. L. McCabe, J. CS mith, P. Harriott, Unit Operations of Chemical Engineering, 6th edition, McGraw Hill. 2001.
2. J. F. Richardson, J. H. Harker, J. R. Backhurst, Coulson and Richardson's Chemical Engineering, Vol. 2, Fifth edition, Butterworth-Heinemann, 2002.
3. G.G. Brown, Unit operation, First Edition, CBS publication 1995, reprint 2005.
4. M. J. Rhodes, Introduction to Particle Technology, 2nd edition, John Wiley, Chichester; New York, 2008.
5. T. Allen, Powder Sampling and Particle Size Determination, Elsevier, 2003.
6. H. Masuda, K. Higashitani, H. Yoshida, Powder Technology Handbook, CRC, Taylor and Francis, 2006.
7. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Ed., Wiley, 2013.

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Science & Technology

Syllabus for

Fourth Semester B.Tech. Chemical Engineering

Subject: CE-PCC-401T (BCE) **Process Technology & Economics (Theory)**

Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 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 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 to:

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

CO2: understand about 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 raw materials, operating conditions, basic block diagram and simplified process flow diagram for manufacturing of various Petrochemicals

CO4: understand about industrially relevant fuels, coal, coal-based chemicals and fuels Common utilities

CO5: 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

Books Recommended:

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

Subject: CE-PCC-402T (BCE) **Mass Transfer I (Theory)**

Lecture : 3 Hours No. of Credits : 3

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Course Objectives:

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 equipments

Course Outcomes:

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

CO1: To understand concept and theories of diffusion.

CO2: To understand convective mass transfer, interphase mass transfer and theories of mass transfer and their applications.

CO3: To understand gas absorption in plate and packed column and design; absorption in wetted wall columns, packed tower and spray tower.

CO4: 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 1: 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 2: 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 3: 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 4: Absorption in tray towers, absorption and stripping factors, tray efficiencies, calculation of number of trays for absorption, Equipment for Absorption

Unit 5: 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

Books Recommended:

1. B. K. Dutta, Principles of Mass transfer and separation processes, PHI Learning, 2007.
2. R. E. Treybal, Mass Transfer Operations, 3rd edition, McGraw Hill, 1980.
3. E.D. Cussler, Diffusion - Mass Transfer in Fluid Systems, Cambridge University Press, Cambridge 1984.
4. S. Foust, Principles of Unit Operations, 2nd Edition, Wiley, New York, 1980.
5. C. J. Geankoplis, Transport Processes and Separation Process Principles, 4 Edition, Prentice Hall, 2003
6. 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
7. 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
8. J. D. Seader, E. J. Henley, Separation Process Principles, Wiley, 1998

Subject: CE-PCC-403T (BCE) **Fluid Mechanics (Theory)**

Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4

University : 70 Marks College Assessment : 30 Marks

Duration of Examination: 3 Hours

Course Objectives:

- 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 to:

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 2: 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 3: 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 4: 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 5: 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, Centrifugal pump, Volute pump, Volute pump with vortex chamber and diffuser vanes, Cavitation, Priming, Net positive suction head.

Books Recommended:

1. M. White, Fluid Mechanics, 8th Edition, Tata-McGraw Hill, 2016.
2. V. Gupta, S. K. Gupta, Fundamentals of Fluid Mechanics, 2nd Edition, New Age International 2011.
3. W. L. McCabe, J. C. Smith, P. Harriot, Unit Operations of Chemical Engineering, 7th 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, A. T. McDonald, Introduction to Fluid Mechanics, 7th Edition, Wiley-India 2010.
6. R. Welty, C. E. Wicks, R. E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th Edition, Wiley, 2007.
7. R.P. Vyas, Fluid Mechanics, Second Edition, Dennet & Co. Publication,2008
8. R.K. Bansal, Fluid Mechanics and Hydraulic Machines Laxmi Publication 7th Publication 2017
9. B. R. Munson, D. F. Young, T. H. Okiishi, W. W. Huebsch, 6th Edition, Wiley-India 2010.
10. R. L. Panton, Incompressible Flow, 3rd Edition, Wiley-India 2005.
11. R. B. Bird, W. E. Stewart, E. N. Lightfoot, Transport Phenomena, 2nd Edition, Wiley- India 2002.

Subject: CE-PCC-404T (BCE)

Numerical Methods in Chemical Engineering (Theory)

Lecture	: 2 Hours	No. of Credits	: 2
University	: 35 Marks	College Assessment	: 15 Marks

Duration of Examination: 2 Hours

Course Objectives:

- 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 to:

CO1: To understand and solve the linear and non-linear algebraic equations written for chemical processes using numerical methods

CO2: To understand and apply suitable curve fitting techniques for estimation of the parameters of the empirical equation for various chemical processes.

CO3: To understand and apply various methods of numerical integration to chemical engineering problems.

CO4: To understand and apply suitable numerical methods to solve Ordinary Differential Equations (IVP and BVP) and Partial Differential Equations written for chemical engineering problems.

Unit 1: Introduction, Approximation and Concept of Error & Error Analysis, Methods of solution of **linear algebraic equations** (Gauss Elimination, Gauss Jordon, Gauss Seidel, Jacobi etc.) and **nonlinear algebraic equations** (Bisection, False Position, Newton- Raphson and Secant method etc.) applied to Chemical engineering problems.

Unit 2: **Curve fitting techniques**: Least square regression (linear, polynomial, multiple linear etc.), Interpolation, Applications to chemical engineering problems.

Unit 3: **Numerical integration**: Trapezoidal rule, Simpson's rule, integration with unequal segments, Applications to chemical engineering problems.

Unit 4: **Ordinary Differential Equations**: Initial value problem (Euler method, Modified Euler method, Runge-Kutta method) and boundary value problem (shooting method, Finite difference method) with emphasis on Chemical engineering problems. **Partial Differential Equations**: Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method with emphasis on Chemical engineering problems.

Recommended Books:

1. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
2. S.K. Gupta, Numerical Methods for Engineers, 2nd Edition, New Age International, 2010.
3. R.L. Burden, J. D. Faires, Numerical Analysis, 7th Edition, Brooks Coles, 2000.
4. K. E. Atkinson, An Introduction to Numerical Analysis, John Wiley & Sons, 1978.

5. W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery, Numerical Recipes: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

Subject: CE-BS-405T(BGE)	**Inorganic Process Technology (Theory)**
Lecture : 3 Hours	No. of Credits : 3
University : 70 Marks	College Assessment : 30 Marks
Duration of Examination: 3 Hours	

Course Objectives:

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

Course Outcomes:

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

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

Unit 2: 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 3: Nuclear industries: Nuclear fission & fusion reactions, Feed materials, extraction of Uranium, uranium enrichment, nuclear reactor, reprocessing of nuclear materials, protection from radioactivity.

Unit 4: 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 5: 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. B. K. Sharma, Industrial Chemistry, Goel Pub. House, Meerut.
2. M. Gopala Rao, Marshall Sittig, Dryden's Outlines of Chemical Technology, East West Press, 1997
3. George T. Austin, Shreve's Chemical Process Industries, McGraw-Hill International Editions Series, 1984
4. G. N. Pandey, Text book of Chemical Technology, Vol. I, 2nd revised edition, 1994.
5. S. S. Dara, A Text Book of Engineering Chemistry, S. Chand & Co., New Delhi.

Subject: CE- HSMC-HS-406T (BGE) **HASS II Functional English (Theory)**

Lecture : 2 Hours No. of Credits : 2

University : 35 Marks College Assessment : 15 Marks

Duration of Examination: 2 Hours

Course Objectives:

- 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 completion of the course, students will be able to:

CO1: acquire knowledge of structure of language.

CO2: face competitive exams and the interview process and can become employable.

CO3: develop business writing skills.

CO4: 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 2: 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 3: 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 4: 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)

Books Recommended:

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

Subject: CE-PCC-407P (BCE) **Fluid Mechanics Lab (Practical)**

Practical : 2 Hours No. of Credits : 1

University : 25 Marks College Assessment : 25 Marks

Duration of Examination: 6 Hours

Course Objectives:

- 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.

Course Outcomes:

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

CO1: to understand and solve typical problems in fluid dynamics at the appropriate level.

CO2: 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: to understand and analyze the applications to industrial flows.

LIST OF EXPERIMENTS:

Required to perform minimum 8 practicals from the list given below:

1. To verify 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. 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.

Books Recommended:

1. M. White, Fluid Mechanics, 8th Edition, Tata-McGraw Hill, 2016.
2. V. Gupta, S. K. Gupta, Fundamentals of Fluid Mechanics, 2nd Edition, New Age International 2011.
3. W. L. McCabe, J. C. Smith, P. Harriot, Unit Operations of Chemical Engineering, 7th 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, A. T. McDonald, Introduction to Fluid Mechanics, 7th Edition, Wiley-India 2010.
6. R. Welty, C. E. Wicks, R. E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th Edition, Wiley, 2007.
7. R.P. Vyas, Fluid Mechanics, Second Edition, Dennet & Co. Publication,2008
8. R.K. Bansal, Fluid Mechanics and Hydraulic Machines Laxmi Publication 7th Publication 2017
9. B. R. Munson, D. F. Young, T. H. Okiishi, W. W. Huebsch, 6th Edition, Wiley-India 2010.
10. R. L. Panton, Incompressible Flow, 3rd Edition, Wiley-India 2005.
11. R. B. Bird, W. E. Stewart, E. N. Lightfoot, Transport Phenomena, 2nd Edition, Wiley- India 2002.

Subject: CE-PCC-408P (BCE)

Numerical Methods in Chemical Engineering Lab (Practical)

Practical	: 2 Hours	No. of Credits	: 1
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 6 Hours

Course Objectives:

- To introduce various numerical methods that are important in the solution of a linear / non-linear algebraic equations, ordinary / partial differential equations.
- To perform experiments/develop the algorithms to solve linear / non-linear algebraic equations, ordinary / partial differential equations using appropriate numerical method.
- Students will be made acquainted with theoretical aspects of mathematical softwares and commercial simulators.

Course Outcomes:

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

CO1: Apply various simulation approaches like MS-Excel, Mathcad etc. to solve linear and non-linear algebraic equations.

CO2: Apply various simulation approaches like MS-Excel, Mathcad etc. to solve ordinary / partial differential equations

CO3: develop the algorithms to solve linear / non-linear algebraic equations, ordinary / partial differential equations using appropriate numerical method

CO4: understand the use of modern process simulators like Aspen Plus/Aspen Hysys/ MATHCAD/MATLAB/ CHEMCAD/ Scilab/ POLYMATH etc.

LIST OF EXPERIMENTS:

Required to perform minimum 8 practical from but not limited to the list given below:

1. Introduction to use of computers for numerical calculations
2. Solution of linear algebraic equations using Gauss elimination, Gauss-Seidel 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

Recommended Books:

6. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
7. S.K. Gupta, Numerical Methods for Engineers, 2nd Edition, New Age International, 2010.
8. R.L. Burden, J. D. Faires, Numerical Analysis, 7th Edition, Brooks Coles, 2000.
9. K. E. Atkinson, An Introduction to Numerical Analysis, John Wiley & Sons, 1978.

10. W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery, Numerical Recipes: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

Subject: CE- BS-409 P (BGE)

Inorganic Process Technology Laboratory (Practical)

Practical	: 3 Hours	No. of Credits	: 1.5
University	: 25 Marks	College Assessment	: 25 Marks

Duration of Examination: 3 Hours

Course Objectives:

- To perform experiments related to synthesis/preparation of some inorganic compounds.
- To perform the experiments on quantitative estimation of some of inorganic cations/anions.
- To analyse the waste of processes and some components in inorganic compounds.

Course Outcomes:

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

CO1: To demonstrate the fundamental concepts of chemistry to quantitative analysis of inorganic compounds and its importance in engineering and technology.

CO2: To demonstrate the fundamental concepts of chemistry to preparation of inorganic compounds.

CO3: To demonstrate laboratory skills in chemistry, including proper laboratory notebook and record keeping skills, recognizing hazards, minimizing risks, and safe laboratory practices

CO4: To emphasize on planning of experiments, working in teams and improving experimental skills.

LIST OF EXPERIMENTS:

Required to perform minimum 8 practical from the list given below:

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.

Books Recommended:

1. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney – Vogel's Textbook of quantitative chemical analysis V edition, Longman scientific technical, John willey and sons, Newyork1989.

Subject: MC **Environmental Sciences (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:

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

CO1: To understand and apply the Multidisciplinary nature of environmental studies.

CO2: To understand the importance of Natural Resources and its conservation.

CO3: To understand the classification of ecosystem and importance of conservation of biodiversity.

CO4: 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

Books Recommended:

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".