



RAMAIAH
Institute of Technology

CURRICULUM

Academic Year 2018 – 2019

DEPARTMENT OF CHEMICAL ENGINEERING

III & IV Semester B. E.

RAMAIAH INSTITUTE OF TECHNOLOGY

(Autonomous Institute, Affiliated to VTU)

BANGALORE – 54

About the Institute

Ramaiah Institute of Technology (RIT) (formerly known as M. S. Ramaiah Institute of Technology) is a self-financing institution established in Bangalore in the year 1962 by the industrialist and philanthropist, Late Dr. M S Ramaiah. The Institute is accredited with A grade by NAAC in 2016 and all engineering departments offering bachelor degree programs have been accredited by NBA. RIT is one of the few institutes with faculty student ratio of 1:15 and achieves excellent academic results. The institute is a participant of the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. All the departments are full with competent faculty, with 100% of them being postgraduates or doctorates. Some of the distinguished features of RIT are: State of the art laboratories, individual computing facility to all faculty members. All research departments are active with sponsored projects and more than 130 scholars are pursuing PhD. The Centre for Advanced Training and Continuing Education (CATCE), and Entrepreneurship Development Cell (EDC) have been set up on campus. RIT has a strong Placement and Training department with a committed team, a fully equipped Sports department, large air-conditioned library with over 80,000 books with subscription to more than 300 International and National Journals. The Digital Library subscribes to several online e-journals like IEEE, JET etc. RIT is a member of DELNET, and AICTE INDEST Consortium. RIT has a modern auditorium, several hi-tech conference halls, all air-conditioned with video conferencing facilities. It has excellent hostel facilities for boys and girls. RIT Alumni have distinguished themselves by occupying high positions in India and abroad and are in touch with the institute through an active Alumni Association. RIT obtained Academic Autonomy for all its UG and PG programs in the year 2007. As per the National Institutional Ranking Framework, MHRD, Government of India, Ramaiah Institute of Technology has achieved 60th rank in 2018 among the top 100 engineering colleges across India.

About the Department

Instituted in 1978, the Department was the first to offer a course in Chemical Engineering by a self-financing engineering institution in Bangalore and the fifth in RIT. Since its inception the department has moved steadily towards the fulfilment of its mission and is emerging as a significant player in the academic landscape of Chemical Engineering education in our country. The Department is certified four times in succession by the National Board for Accreditation. Over 2000 students have graduated in 33 batches. The Department offers excellent infrastructure and students have won various prestigious awards, international internships and high accolades for innovative projects. The Department has secured majority of the university ranks. The expertise of the faculty covers a wide range of disciplines and they are engaged in cutting edge technological research. The average experience of faculty in the department is more than twenty years and they are alumni of IISc, IIT and NITs. Enriching insights by eminent dignitaries from the practicing world are arranged under the activities of Society of Chemical Engineers & IChE Student Chapter at the Institute. The Department is approved as Research Center by VTU for higher qualifications like M.Sc. Engg. (By Research) and Ph.D. degrees. Research Projects from DRDO, AICTE and DST have been successfully completed. The Annual Technical Symposium organized by the department for students – RASAYAN encompasses a plethora of events such as Paper presentations, Poster presentations, M.S. Ramaiah Memorial Technical Quiz etc to challenge the young minds. The Bangalore Regional Centre of the Indian Institute of Chemical Engineers is functioning from this department for more than a decade. The country's most prestigious event in Chemical Engineering - Indian Chemical Engineering Congress - CHEMCON-2011 was organized here. The event invited the top chemical engineers of the nation to our Institute. A joint session with Canadian Universities in the area of Energy and Environment was also a part of this event.

VISION OF THE INSTITUTE

To evolve into an autonomous institution of international standing for imparting quality technical education

MISSION OF THE INSTITUTE

MSRIT shall deliver global quality technical education by nurturing a conducive learning environment for a better tomorrow through continuous improvement and customization

QUALITY POLICY

We at M S Ramaiah Institute of Technology strive to deliver comprehensive, continually enhanced, global quality technical and management education through an established Quality Management System complemented by the synergistic interaction of the stake holders concerned

VISION OF THE DEPARTMENT

To be a leading chemical engineering department for imparting quality technical education and progressive research at global level.

MISSION OF THE DEPARTMENT

1. To provide a state of art environment and a rigorous academic program that train students to excel in fundamental sciences, chemical and allied engineering fields.
2. To offer a programme that inculcates creative thinking and lifelong learning contributing to the advancements in chemical sciences and its application.
3. To foster principles of sustainability and promote environmentally benign technologies for the benefit of society.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

The B.E. Chemical Engineering Program at Ramaiah Institute of Technology aims to provide a strong foundation of scientific and technical knowledge in a state of art learning ambience. It equips the graduates with problem solving abilities, teamwork, and communication skills necessary throughout their careers. They are consistent with the following Educational Objectives:

1. To produce graduates with a strong foundation and understanding of the fundamental principles of mathematics, science and engineering enabling graduates to pursue their careers as practicing chemical engineers in Chemical and Allied Engineering fields.
2. To produce graduates who are prepared to pursue their post-graduation and Research in the emerging and allied areas of Chemical Engineering and Business.
3. To produce graduates who possess skills with professional integrity and ethics to assume professional leadership roles and administrative positions.
4. To provide students with opportunities to integrate with multidisciplinary teams to develop and practice written and oral communication skills.

PROGRAM OUTCOMES (POs):

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs):

The Chemical Engineering graduate will be able to

PSO1: Acquire in-depth knowledge of chemical engineering, process economics, management, safety and environmental aspects required to pursue their career in chemical industry and allied engineering areas.

PSO2: Apply computational and simulation tools to solve, design and optimize chemical engineering problems/ processes.

PSO3: Design processes, perform experiments, prepare technical and management modules, economic evaluation and demonstrate professional engineering competence.

**Curriculum Course Credits Distribution
Batch 2017-18**

Semester	Humanities & Social Sciences (HSS)	Basic Sciences / Lab (BS)	Engineering Sciences/ Lab (ES)	Professional Courses- Core (Hard core, soft core, Lab) (PC-C)	Professional Courses - Electives (PC-E)	Other Electives (OE)	Project Work (PW)	Internship/ other activities (IS/ECA)	Total semester load
First	2	9	14						25
Second	4	9	12						25
Third		9		16					25
Fourth		4		21					25
Fifth	2			19	4				25
Sixth				15	4		6		25
Seventh				14	8	4			26
Eighth					4		14	6	24
Total	8	31	26	85	20	4	20	6	200

**SCHEME OF TEACHING
III SEMESTER**

Sl. No.	Course Code	Course Name	Category	Credits					Contact Hours
				L	T	P	S	Total	
1.	CH31	Engineering Mathematics – III	BS	3	1	0	0	4	05
2.	CH32	Technical Chemistry	BS	4	0	0	0	4	04
3.	CH33	Chemical Process Calculations	PC-C	3	1	0	0	4	05
4.	CH34	Momentum Transfer	PC-C	4	0	0	0	4	04
5.	CH35	Mechanical Operations	PC-C	3	0	0	1	4	05
6.	CH361 CH362	Materials Science Biology for Engineers	PC-C	3	0	0	0	3	03
7.	CHL37	Technical Chemistry Laboratory	BS	0	0	1	0	1	02
8.	CHL38	Momentum Transfer Laboratory	PC-C	0	0	1	0	1	02
Total				20	2	2	1	25	30

**SCHEME OF TEACHING
IV SEMESTER**

Sl. No.	Course Code	Course Name	Category	Credits					Contact Hours
				L	T	P	S	Total	
1.	CH41	Engineering Mathematics- IV	BS	3	1	0	0	4	05
2.	CH42	Mass Transfer-I	PC-C	3	1	0	0	4	05
3.	CH43	Chemical Engineering Thermodynamics	PC-C	3	1	0	0	4	05
4.	CH44	Process Heat Transfer	PC-C	3	1	0	0	4	05
5.	CH45	Chemical Reaction Engineering-I	PC-C	3	0	0	1	4	04
6.	CH461	Instrumental Methods of Analysis/ Plant Utilities	PC-C	3	0	0	0	3	03
	CH462								
7.	CHL47	Heat Transfer Laboratory	PC -C	0	0	1	0	1	02
8.	CHL48	Mechanical Operations Laboratory	PC-C	0	0	1	0	1	02
Total				18	4	2	1	25	31

III Semester

ENGINEERING MATHEMATICS – III

Course Code: CH 31

Credits: 3:1:0:0

Prerequisites: Engineering Mathematics I and II

Contact Hours: 70

Course Coordinator/s: Department of Mathematics

Unit I

Numerical solution of Algebraic and Transcendental equations: Method of false position, Newton - Raphson method.

Numerical solution of Ordinary differential equations: Taylor series method, Euler & modified Euler method, fourth order Runge-Kutta method.

Statistics: Curve fitting by the method of least squares, fitting a linear curve, fitting a parabola, fitting a Geometric curve, Correlation and Regression.

Unit II

Linear Algebra: Elementary transformations on a matrix, Echelon form of a matrix, rank of a matrix, Consistency of system of linear equations, Gauss elimination and Gauss – Seidel method to solve system of linear equations, eigen values and eigen vectors of a matrix, Rayleigh power method to determine the dominant eigen value of a matrix, diagonalization of a matrix, system of ODEs as matrix differential equations.

Unit III

Fourier Series: Convergence and divergence of infinite series of positive terms. Periodic functions, Dirchlet conditions, Fourier series of periodic functions of period 2π and arbitrary period, half range Fourier series, Practical harmonic analysis.

Unit IV

Complex Variables - I: Functions of complex variables ,Analytic function, Cauchy-Riemann Equations in cartesian and polar coordinates, Consequences of Cauchy-Riemann Equations, Construction of analytic functions.

Transformations: Conformal transformation, Discussion of the transformations $w = z^2$, $w = e^z$ and $w = z + \frac{a^2}{z}$ ($z \neq 0$), Bilinear transformations.

Unit V

Complex Variables-II: Complex integration, Cauchy theorem, Cauchy integral formula. Taylor & Laurent series (statements only). Singularities, Poles and residues, Cauchy residue theorem (statement only).

Text Books:

1. Erwin Kreyszig – Advanced Engineering Mathematics – Wiley publication – 10th edition-2015.
2. B. S. Grewal – Higher Engineering Mathematics – Khanna Publishers – 43rd edition – 2015.

References:

1. Glyn James – Advanced Modern Engineering Mathematics – Pearson Education – 4th edition – 2010.
2. Dennis G. Zill, Michael R. Cullen - Advanced Engineering Mathematics, Jones and Barlett Publishers Inc. – 3rd edition – 2009.
3. Dennis G. Zill and Patric D. Shanahan- A first course in complex analysis with applications- Jones and Bartlett publishers-second edition-2009.

Course Outcomes:

At the end of the course, students will be able to

1. Solve the problems of algebraic, transcendental and ordinary differential equations using numerical methods and fit a suitable curve by the method of least squares and determine the lines of regression for a set of statistical data. (PO-1,2, PSO-1)
2. Analyze the concept of rank of a matrix and test the consistency of the system of equations and solution by Gauss Elimination and Gauss Seidel iteration methods. Solve the system of ODE's by matrix differential equations. (PO-1,2, PSO-1)
3. Apply the knowledge of Fourier series and expand a given function in both full range and half range values of the variable and obtain the various harmonics of the Fourier series expansion for the given numerical data. (PO-1,2, PSO-1)
4. Analyze functions of complex variable in terms of continuity, differentiability and analyticity. Apply Cauchy-Riemann equations and harmonic functions to solve problems related to Fluid Mechanics, Thermo Dynamics and Electromagnetic fields and geometrical interpretation of conformal and bilinear transformations. (PO-1,2, PSO-1)
5. Find singularities of complex functions and determine the values of integrals using residues. (PO-1,2, PSO-1)

TECHNICAL CHEMISTRY

Sub Code: CH32

Pre-requisites: Engineering Chemistry

Course coordinator: Chemistry Department

Credit: 4:0:0:0

Contact Hours: 56

Unit I

Kinetics of reactions: Determination of order, Rate equations for second order reactions, Theory of reaction rates-Arrhenius theory. Transition state theory of reaction rates; complex reactions—branching Chain reactions- kinetics of Explosive reactions and kinetics in chemical Engineering.

Adsorption: Adsorption of gases on solids, Factors affecting adsorption, Different types of adsorption isotherms, Freundlich and Langmuir theories of adsorption, adsorption from solution, B.E.T. Theory of adsorption of gases, activation energy, numerical on above.

Catalysis: characteristics, types, adsorption theory of catalysis, promoters, poisons, enzyme catalysis, industrial applications of catalysts; i) Zeolites- structure, properties (adsorption, catalysis), applications as catalyst for reactions (Amination of alcohol. alkylation, cracking conversion of methanol), ii) Co-ordination catalysts- In Wacker process, carbonylation, photolysis of water iii) Oxide catalysts- oxide surface structure, application of V_2O_5 for oxidation.

Unit II

Properties of liquids: Physical properties and molecular structure determination- viscosity, surface tension, molar refraction and dielectric constant.

Colligative properties: Lowering of vapour pressure-Raults law-Determination of M.W. Elevation of B.P Depression of freezing point determination of M.W, Osmotic pressure- determination of molecular weight and experimental measurements. Isotonic solutions and abnormal molecular weight.

Unit III

Basic Principles of Organic Chemistry: Introduction, Homolytic and Heterolytic cleavages. Concept of reactive intermediates: free radicals Carbocations, carbanions-Structure, stability and their reactivity. Types of reactions: addition reactions Elimination and substitution reactions. Review of electron displacement of covalent bond. Inductive and resonance effects; Mechanism of nucleophilic substitution (SN_1 and SN_2) in alkyl halides; Mechanistic concept of elimination reactions (E_1 and E_2).

Basics of stereochemistry: Isomerism-Structural,-Structural, chain, positional, functional, metamerism, tautomerism and ring-chain isomerism. Stereo isomerism-

cis-trans isomerism, optical activity of organic compounds, optical isomerism, Configuration- *R,S* and *E, Z*. Conformation.

Unit IV

Industrially Important Organic reactions: Beckmann Rearrangement, Perkin reaction, The Hofmann rearrangement, Reamer-Tiemann reaction, Cannizzaro reaction, Skraup synthesis, The Diels-Alder reaction, Aldol condensation.

Unit V

Organic Materials of industrial importance

Oils and fats-Vegetable oils- Examples; Analysis of oils- Saponification value, iodine value and acid value - their determination, Extraction of oils- Solvent extraction, Refining of oils, Hydrogenation - manufacture of Vanaspati.

Soaps and detergents – Manufacture of soap by hot process; Types of soaps - Liquid soap, Toilet soaps-opaque and transparent; Mechanism of cleansing action of soap; Synthetic detergents– Ionic detergents-anionic and cationic; Non-ionic detergents-Manufacture.

Classification and structure of drugs: Study of the following drugs with reference to structure and synthesis: Antipyretics-Paracetamol, Anti-inflammatory drugs-Ibuprofen, Antibiotics-Penicillin, Anti-malarial drugs-Quinine, Anti-cancer drugs, and Anti-hypertensive drugs.

Text Books:

1. Morrison B.R. and Boyd L.L., Organic Chemistry 6th Edition, ELBS, New Delhi, 1999.
2. B.R. Puri, L.R. Sharma & Pathania, M.S., Principles of Physical Chemistry, 33rd Ed., S. Naginchand & Co., 1992.
3. House, H.O., Modern synthetic reactions, ULBS Publishers, New Delhi.

Reference Books:

1. Sykes Peter, Organic Reactions Mechanism, ULBS Publishers, and New Delhi.
2. Finar, Organic Chemistry Vol I & II ULBS Publishers, New Delhi.
3. Sharma B.K., Industrial Chemistry, 11TH edition, Chand S, and Co. New Delhi, 2001.
4. Tiwari Melhotra and Vishnoi, Organic Chemistry, 7th Edition, Chand S. and Co. New Delhi, 1996.
5. Bahl, A. and Bahl B.S., A Text Book of Organic Chemistry, 15th Edition.S. Chand and & Co, New Delhi, 1998.
6. Bikerman, J.J., Surface Chemistry: Theory and Applications, Academic press, New York, 1972.
7. Adamson, A.W., Physical Chemistry of Surfaces, Interscience Publishers Inc. New York.

Course Outcomes: On successful completion of this course students will be able to

1. Explain the effects of solutes on boiling point, freezing point, and osmotic pressure and to calculate the molecular weight of the unknown solute using freezing point depression. (PO-1,2,7, PSO-1)
2. Explain catalytic reactions and the manufacture of dyes and applications in industry. (PO-1,2,3,7, PSO-1)
3. Write reaction mechanisms in various types of reactions. (PO-1,2,3,7, PSO-1)
4. Identify the different organic reactions using the various industries in the manufacture of drugs and organic compounds. (PO-1,2,3,7, PSO-1)
5. Explain manufacture of soap and detergents, and their cleaning action mechanism. (PO-1,2,7, PSO-1)

CHEMICAL PROCESS CALCULATIONS

Sub Code: CH33

Credit: 3:1:0:0

Pre-requisites: Nil

Contact Hours:70

Course coordinator: Chemical Engineering Department

Unit I

Basic Chemical Calculations: Fundamentals and derived units. Conversion of units. Dimensional consistency of equations. Dimensionless groups and constants. Conversion of equations. Concept of mole, mole fraction etc. Compositions of mixtures of solids and liquids and gases. Concept of molarity, molality, normality and ppm. Use of semilog and log-log graphs, Triangular graphs.

Unit II

Vapour-Gas Concepts: Ideal gas law calculations, Vapour pressure concepts and calculations for miscible and immiscible systems. Humidity related terms, humidity chart, and humidification and dehumidification operation.

Unit III

Material Balance without Reaction: General material balance equation for steady and unsteady states. Typical Steady state material balances in mixing, evaporation, drying, distillation, absorption, extraction, crystallization and evaporation. Material balances involving Bypass, Recycle and Purging.

Unit IV

Steady State Material Balance With Reaction: Principles of stoichiometry, Concept of limiting and excess reactants and inerts, fractional and percentage conversion, fractional yield and percentage yield, Selectivity, related Problems – without reactions and with reactions.

Fuels and Combustion: Ultimate and Proximate analysis of fuels, Calculations involving burning of solid, liquid and gaseous fuels, excess air, Air – fuel ratio calculations.

Unit V

Energy Balance: General Steady State Energy Balance equation, Thermo physics: Heat Capacity, Thermochemistry and laws. Heat Capacity. Enthalpy, Heat of Formation, Heat of Reaction, Heat of Combustion and Calorific Value. Heat of Solution, Heat of Mixing, Heat of Crystallization. Determination of ΔH_R at standard and elevated temperature. Theoretical and flame temperatures and adiabatic flame temperature.

Text Books:

1. Hougen, O.A., Waston, K.M. and Ragatz, R.A., Chemical Process Principles Part –I, Material and Energy Balances, Second Edition, CBS publishers and distributors, New Delhi, 1995.
2. Himmelblau, D.M., Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall Of India, New Delhi, 1997.

Reference Books:

1. Bhatt, B.L. and Vora, S.M., Stoichiometry (SI Units), Third Edition, 1996, Tata McGraw Hill Publishing Ltd., New Delhi, 1996.
2. Richard M. Felder and Ronald W. Rousseau, Elementary Principles of Chemical Processes, John Wiley & Sons, 3rd Edition, 2005.

Course Outcomes: On successful completion of this course students will be able to

1. Apply various types of unit systems and convert units from one system to another. (PO-1,2,3, 12, PSO-1)
2. Develop strategy for solving problems involving gases, vapours etc. (PO-1,2,3, 12, PSO-1)
3. Adopt the tools learned from the course to solve numerical problems which contain one or more unit operations. (PO-1,2,3, 12, PSO-1)
4. Able to solve material balance problems involving reactions. (PO-1,2,3,12, PSO-1)
5. Develop mathematical relations for both mass and energy balances for different processes. (PO-1,3, 12, PSO-1)

MOMENTUM TRANSFER

Sub Code: CH34

Pre-requisites: Engineering Mathematics

Course coordinator: Chemical Engineering Department

Credit:4:0:0:0

Contact Hours: 56

Unit-I

Fluid Statics and its Application: Concepts of pressure, force, torque, momentum and angular momentum; variation of pressure with height – hydrostatic equilibrium, barometric equation, measurement of fluid pressure – manometers.

Unit-II

Newtons law of viscosity, Newtonian and Non Newtonian fluids, Types of flow- laminar and turbulent flow, Flow in boundary layers, Reynolds number, Boundary layer separation.

Basic Equations of Fluid Flow: Average velocity, mass velocity, continuity equation, Euler and Bernoulli's equations, Modified equation for real fluids with correction factors. Pump work in Bernoulli's equations, Angular momentum equation.

Unit-III

Flow of Incompressible Fluids:Laminar flow through circular and non-circular conduits. Hagen-Poisuelle equation, Laminar flow of non-Newtonian liquids, turbulent flow in pipes and closed channels, friction factor chart. Friction from changes in velocity or direction. Form friction losses in Bernoulli's equation. Flow of fluids in thin layers.

Unit-IV

Flow of Compressible Fluids: Continuity equation, concept of Mach number, Total energy balances, Velocity of sound, ideal-gas equations. Flow through variable area conduits, adiabatic frictional flow. Isothermal frictional flow (elementary treatment).

Unit-V

Transportation and Metering of Fluids: Pipes, fittings and valves, measurement of liquid and gas flow rates by orifice meter, Venturi meter, Rota meter and Pitot tube. Flow through open Channels- weirs and notches. Performance and characteristics of pumps – positive displacement and centrifugal pumps. Fans, compressor and blowers. Introduction to Unsteady State Flow –Time to empty the liquid from a tank.

Text Books:

1. McCabe, W.L., Unit operations of Chemical Engineering, 5th Edition, McGraw Hill, New York, 1993.
2. Bansal, R.K., Fluid Mechanics and Hydraulic Machines, 7th Edition, Laxmi Publications, 2007.

Reference Books:

1. Coulson and Richardson J.F., Chemical Engineering Vol. 1, 3rdedn., Pergamon Press, 1991.
2. Badger, W.I. and Banchero, J.T., Introduction to Chemical Engineering, Tata McGraw Hill, New York, 1997.
3. Foust, A.S., Principles of Unit Operation, III Edition, John Wiley and Sons, New York, 1997.

Course Outcomes: On successful completion of this course students will be able to

1. Analyze different types of fluids and measure fluid pressure. (PO-1,2, PSO-1)
2. Understand the different types of fluids and analyze the relationship between kinetic and potential energy and pressure energy in complex flow systems using Bernoulli's equation. (PO-1,2,4, PSO-1,2)
3. Analyze and calculate friction factor for different types of flow channels. (PO-1,2,4 PSO-1,3)
4. Understand flow of compressible fluids. Develop mathematical equations for adiabatic and isothermal flow conditions. (PO-1,2, PSO-1)
5. Understand various types of pumps and transportation and metering devices for fluid handling. (PO-2,3,4 PSO-1,3)

MECHANICAL OPERATIONS

SubCode:CH35

Pre-requisite: Engineering Mathematics

Course coordinator: Chemical Engineering Department

Credit:3:0:0:1

Contact Hours:56

Unit I

Particle Technology: Particle shape, particle size, different ways of expression of particle size, shape factor, sphericity, mixed particles size analysis, screens – ideal and actual screens, Tyler series, differential and cumulative size analysis, effectiveness of screen, specific surface of mixture of particles, number of particles in a mixture, standard screens industrial screening equipment, motion of screen, grizzly, gyratory screen, vibrating screen, trommels, sub sieve analysis – Air permeability method.

Unit II

Size Reduction: Introduction – types of forces used for comminution, criteria for comminution, characteristics of comminuted products, laws of size reduction, work index, energy utilization, methods of operating crushers – free crushing, choke feeding, open circuit grinding, closed circuit grinding, wet and dry grinding, equipment for size reduction – Blake jaw crusher, gyratory crusher, smooth roll crusher, tooth roll crusher, impactor, attrition mill, ball mill, critical speed of ball mill, ultra-fine grinders, fluid energy mill, colloid mill, cutters – knife cutter.

Unit III

Flow of Fluid Past Immersed Bodies: Drag, drag coefficient, pressure drop – Kozeny – Carman equation, Blake- Plummer, Ergun equation, fluidization, conditions for fluidization, minimum fluidization velocity, types of fluidization, application of fluidization.

Motion of Particles Through Fluids: Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, terminal velocity, drag coefficient, motion of spherical particles in Stoke's region, Newton's region and intermediate region, criterion for settling regime, hindered settling, modification of equation for hindered settling, centrifugal separators, cyclones and hydro cyclones.

Unit IV

Sedimentation: Batch settling test, application of batch settling test to design of continuous thickener, Coe and Clevenger theory, Kynch theory, thickener design, determination of thickener area.

Filtration: Introduction, classification of filtration, cake filtration, clarification, batch and continuous filtration, pressure and vacuum filtration constant rate filtration and cake filtration, characteristics of filter media, industrial filters, sand filter, filter press, leaf filter, rotary drum filter, horizontal belt filter, bag filter, centrifugal filtration – suspended batch centrifuge, filter aids, application of filter aids, principles of cake filtration, modification of Kozeny – Carman for filtration

Unit V

Agitation And Mixing: Application of agitation, Agitation equipment, Types of impellers – Propellers, Paddles and Turbines, Flow patterns in agitated vessels, Prevention of swirling, Standard turbine design, Power correlation and Power calculation, Mixing of solids, Types of mixers- change can mixers, Muller mixers, Mixing index, Ribbon blender, Internal screw mixer, Tumbling mixer.

Sampling, Storage and Conveying of Solids: Sampling of solids, storage of solids, Open and closed storage, Bulk and bin storage, Conveyors – Belt conveyors, Chain conveyor, Apron conveyor, Bucket conveyor, Bucket elevators, Screw conveyor, Slurry transport, pneumatic conveying.

Self-Study Topics:

Industrial screening equipment- gyratory screen, vibrating screen.

Particle size distribution –Normal, Binomial. Ultra-fine grinders, fluid energy mill, colloid mill, cutters – knife cutter.

Particle Technology- Selection function, grinding function, probability function. Cyclones and hydro cyclones. Horizontal belt filter, bag filter.

Ribbon blender, internal screw mixer, tumbling mixer. Jensen formula in solid storage.

Text Books:

1. McCabe W.L., Unit Operation of Chemical Engineering, V Edition, McGraw Hill International, Singapore, 2000.
2. Badger, W.L. and Banchero J.T., Introduction to Chemical Engineering, III Edition, McGraw Hill International, Singapore, 1999.
3. Coulson, J.M. and Richardson, J.F., Chemical Engineering Vol.2, 4, Particle Technology and Separation Process, 1998.

Reference Books:

1. Brown G., Unit Operation, I Edition, CBS Publishers, New Delhi, 1995.
2. Perry, R and Green, W.D., Perry's Chemical Engineering Hand book, VII Edition, McGraw Hill International Edition, New York, 2000.
3. Foust, A.S. *et.al*, Principles of Unit Operation, III Edition, John Wiley and Sons, New York, 1997.

Course Outcomes: On successful completion of this course students will be able to

1. Classify and suggest different type of separation processes required for a given feed material. (PO-1,2,3,7 PSO-1)
2. Select suitable equipment for size reduction depending on the type and size of the material. (PO-1,2,3,7 PSO-1)
3. Calculate the terminal velocity of the particles and understand fluid flow through packed and fluidized bed. (PO-1,2,3,7 PSO-1)
4. Handle filtration problems and design thickener. (PO-1,2,3,7 PSO-1)
5. Understand mixing processes, conveying of solids and calculate the power requirements. (PO-1,2,3,7 PSO-1)

MATERIALS SCIENCE

Sub Code: CH361

Pre-requisites: Engineering Chemistry

Course coordinator: Chemical Engineering Department

Credit: 3:0:0:0

Contact Hours: 42

Unit I

Introduction: Introduction to Materials Science, Classification of Engineering Materials, Levels of Structure, Structure-Property relationship in materials, Primary and secondary bonds.

Crystal Geometry and Structure Determination: Geometry of crystals- the Bravais lattices, Crystal directions and Planes- Miller indices, Structure determination-X – ray diffraction- Bragg's Law, the powder method.

Unit II

Crystal Imperfections: Point Imperfections, Line imperfections- edge and screw dislocations, Surface imperfections.

Phase Diagram And Phase Transformations: Phase rule, Single component systems, Binary Phase Diagrams, Lever rule, Typical Phase diagrams for Magnesia-Alumina, Copper-Zinc, Iron-carbon system, Nucleation and growth, Solidification, Allotropic transformation, Cooling curves for pure iron, Iron-carbon equilibrium diagram, Isothermal transformations (TTT curves).

Unit III

Deformation of Materials: Metals - Elastic deformation, Plastic deformation, Dislocation and Strengthening mechanism, Failure – Fracture, Fatigue.

Ceramics- Brittle fracture, Stress-Strain behavior, Plastic deformation

Polymers - Visco-elastic deformation, Fracture, Elastomer deformation.

Unit IV

Materials Processing: Metals and Alloys – Fabrications – Forming, Casting.

Thermal Processing: Annealing, Heat treatment of Steels. Surface hardening methods.

Ceramics – Fabrication and processing of glass

Polymers – Polymerization, Additives, Forming methods, Fabrication of elastomers and fibres.

Unit V

Corrosion And its Prevention: Electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, Corrosion rate and its prediction, Prevention of corrosion. Corrosion charts.

Materials Selection and Design Considerations, Environmental considerations and recycling.

Text Books:

1. William D. Callister ,Materials Science and Engineering: An Introduction, 6th Edition, Wiley, 2006.
2. Hajra Choudhary S. K., Material Science and Processes, Indian Book Distributing Co., 1982.

Reference Books:

1. Van Vlack, H.L., Elements of Materials Science, 2nd Edition, Addison-Wesly Publishing Company, NY, 1964.
2. Raghavan V., Material Science and Engineering- A First Course, 3rd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 1996.

Course Outcomes: On successful completion of this course students will be able to

1. Classify different types of engineering materials depending on structure property, crystal geometry and X-Ray diffraction. (PO-1,2,3, PSO-1)
2. Draw phase diagrams of different metals, TTT curves and explain crystal imperfections. (PO-2,3, PSO-1)
3. Explain mechanism of deformation of materials. (PO-3,5,7, PSO-1)
4. Suggest different type fabrication methods for materials. (PO-6,7,PSO-1)
5. Select materials depending on type of application. (PO-6 PSO-1)

BIOLOGY FOR ENGINEERS

Sub Code: CH362

Pre-requisites: Nil

Course coordinator: Chemical Engineering Department

Credit: 3:0:0:0

Contact Hours: 42

Unit I

Introduction to biomolecules, Cellular, Chemical and Physical Foundations, Chemical bonding, structure and function of carbohydrates, Monosaccharides and Disaccharides, Polysaccharides, Amino Acids, proteins and lipid, water and their properties.

Unit II

Protein structures and physical properties of proteins, charge, size, methods for observing these properties, electrophoresis with SDS, proteins binding and catalytic enzymes. Nucleic acids - structure synthesis and regulation, nucleic acid chemistry, storage lipids, structural lipids in membranes, fatty acid biosynthesis. Bioenergetics and kinetics.

Unit III

General chemistry in biochemistry: Isomerization, hydrolysis, elimination, oxidation/reduction, aldol condensation/cleavage, thermodynamics, use and making of ATP and coupling hydrolysis of ATP to 'reverse' reactions, metabolic processes central to ATP synthesis, glycolysis, Krebs Cycle and oxidative phosphorylation. Central dogma of biological systems, DNA, RNA, protein, DNA replication, transcription, translation, mutation, genetic manipulation, gene therapy.

Unit IV

Origin of life on earth, basics of cell biology and cell theory, biogenesis of cellular organelles, structure and function of prokaryotic cells, membrane structure & transport and cell cycle.

Unit V

Introduction to microbiology, study of microbial structures, growth and control, ecology, symbiosis and pathogenicity.

Text Books

1. Biochemistry Ed Lubert Stryer. W.H. Freeman and Company, New York.
2. Channarayappa (2010) Cell Biology, Orient Blackswan Publications
3. Pelczar (1998) Microbiology, Tata McGraw-Hill Education, USA

Reference Book

1. Principles of Biochemistry. Ed Lehninger, Nelson and Cox. CBS publishers and distributors.
2. Harper's Biochemistry. Ed. R.K. Murray, D.K. Granner, P.A. Mayes and V.W. Rodwell. Appleton and Lange, Stamford, Connecticut.

Course Outcomes: On successful completion of this course students will be able to

1. Explain biomolecules (carbohydrates, proteins, lipids) and their properties. (PO-1,2,3,4 PSO-1,2)
2. Understand protein structures, lipids and biosynthesis. (PO-1,2,3,4 PSO-1,2)
3. Explain various chemical reactions of biochemistry and understand metabolism. (PO-1,2,3,4 PSO-1,2)
4. Understand cell biology and membrane transportation. (PO-1,2,3,4 PSO-1,2)
5. Understand the basic concepts of microbiology. (PO-1,2,3,4,12 PSO-1,2)

TECHNICAL CHEMISTRY LABORATORY

Sub Code: CHL37

Pre-requisites: Engineering Chemistry

Course coordinator: Chemistry Department

Credit:0:0:1:0

Contact Hours: 28

Following experiments are suggested:

1. Determination of partition coefficient of iodine between water and carbon tetrachloride.
2. Study of Kinetics of the reaction between $K_2S_2O_8$ and KI.
3. Effect of Salt on the critical solution temperature of phenol-water system.
4. Determination of nickel as nickel dimethyl glyoximate gravimetrically (after separating Iron) in the given stainless steel solution.
5. Determination of iron as ferric oxide gravimetrically (after separating copper) in the given Chalcopyrite ore solution.
6. Preparation of acetanilide by acetylation of aniline using acetic anhydride.
7. Preparation of Aspirin. Determination of acid value, iodine value and saponification value of the given sample of oil.
8. Estimation of carboxylic acid by Iodometric method
9. Determination of % composition of binary mixture using Ostwald's viscometer.

Reference Books:

1. Arthur, I. Vogel's Qualitative Inorganic analysis including elementary instrumental analysis, ELBS, Longmann group, 5th Edition, 1989.
2. Clair N. Sawyer and Perry L, McCarty, Chemistry for Environmental Engineering, Third Edition, McGraw-Hill Book Company, New York, 1978.
3. Lab Manual 2016-17.

Course Outcomes: On successful completion of this course students will understand

1. Determination of chloride, nickel and iron in samples (PO1, PO2, PSO1, PSO2)
2. Preparation of organic compounds acetanilide, P-amino benzoic acid and analysis of oils and fats (PO1, PO2, PSO1, PSO2).
3. Effect of salt on CST and kinetics of the reaction (PO1, PO2, PO3, PO12, PSO1, PSO2).

MOMENTUM TRANSFER LABORATORY

Sub Code: CHL38

Credit:0:0:1:0

Pre-requisites: Nil

Contact Hours: 28

Course coordinator: Chemical Engineering Department

The experiments should be based on the following topics:

1. Friction in Circular Pipes
2. Friction in Non-Circular Pipes
3. Friction in Helical/Spiral Coils
4. Flow rate measurement using Venturi/ Orifice meters
5. Local velocity measurement using Pitot tube
6. Flow over Notches
7. Hydraulic coefficients – Open Orifice
8. Pressure drop in Packed bed
9. Minimum fluidization velocity-Fluidized bed
10. Study of characteristics for Centrifugal pump
11. Study of Pipe Fittings and their equivalent lengths
12. Venturi/ Orifice meters, Air flow measurement
13. Reynolds apparatus
14. Positive displacement pump
15. Bernoulli's apparatus

Course Outcomes: On successful completion of this course students will be able to

1. Determine energy loss due to friction in flow systems. (PO-1,2,3,4, PSO-1,2)
2. Measure flow rate of incompressible fluids. (PO-1,2,3,4 PSO-1,2)
3. Determine pump characteristics and recommend for specific usage. (PO-1,2,3, PSO-1,2)

IV Semester

ENGINEERING MATHEMATICS – IV

Sub Code: CH41

Credit:3:1:0:0

Pre-requisites: Engineering Mathematics I, II and III

Contact Hours: 70

Course coordinator: Mathematics Department

Unit I

Finite Differences and Interpolation: Forward, Backward differences, Interpolation, Newton-Gregory Forward and Backward Interpolation formulae, Lagrange interpolation formula and Newton divided difference interpolation formula (no proof).

Numerical Differentiation and Numerical Integration: Derivatives using Newton-Gregory forward and backward interpolation formulae, Newton-Cotes quadrature formula, Trapezoidal rule, Simpson 1/3rd rule, Simpson 3/8th rules.

Unit II

Fourier Transforms: Infinite Fourier transform, Infinite Fourier sine and cosine transforms, properties, Inverse transforms, Convolution theorem, Parseval identities (statements only).

Z-Transforms: Definition, standard Z-transforms, Single sided and double sided, Linearity property, Damping rule, Shifting property, Initial value and Final value theorems, Inverse Z-transforms, Application of Z-transforms to solve difference equations.

Unit III

Partial Differential Equations-: Classification of second order PDE, Application of Fourier transforms to solve Partial Differential equations. Numerical solution of One - dimensional heat and wave equations, Two - dimensional Laplace equation, Poisson equation.

Unit IV

Random Variables: Random Variables (Discrete and Continuous), Probability density function, Cumulative density function, Mean, Variance, Moment generating function..

Probability Distributions: Binomial distribution, Poisson distributions, Normal distribution, Exponential distribution, Gamma distribution, Uniform distribution, Joint probability distribution (both discrete and continuous), Conditional probability, Conditional expectation.

Unit-V

Sampling and Statistical Inference: Sampling, Sampling distributions, Standard error, Weak law of large numbers(without proof), Central limit theorem(no proof), Basics of parametric estimation, Test of Hypothesis for means, Confidence limits for means, Z-test Student's t-distribution, F-distribution, Chi-Square distribution as a test of goodness of fit.

Text Books:

1. B.S.Grewal-Higher Engineering Mathematics-Khanna Publishers-43rd edition-2015.
2. R.E. Walpole, R. H. Myers, R. S. L. Myers and K. Ye – Probability and Statistics for Engineers and Scientists – Pearson Education – Delhi – 9th edition – 2012.

Reference Books:

1. Erwin Kreyszig – Advanced Engineering Mathematics – Wiley publication – 10th edition-2015.
2. Glyn James- Advanced Modern Engineering Mathematics-PearsonEducation-4th edition-2010
3. Kishor S. Trivedi – Probability & Statistics with reliability, Queuing and Computer Science Applications – John Wiley & Sons – 2nd edition – 2008.
4. Murray R. Spiegel, John Schiller & R. Alu Srinivasan - Probability & Statistics - Schaum's outlines -4th edition - 2013.

Course Outcomes: On successful completion of the course students will be able to

1. Use a given data for equal and unequal intervals to find a polynomial function for estimation. Compute maxima, minima, curvature, radius of curvature, arc length, area, surface area and volume using numerical differentiation and integration. PO-1, 2, PSO-2.
2. Evaluate Fourier transforms, Fourier sine and Fourier cosine transforms of functions and apply the knowledge of z-transforms to solve difference equations. PO-1,2, PSO-2.
3. Solve partial differential equations analytically and numerically. PO-1,2, PSO-2.
4. Apply the concept of probability distribution to solve engineering problems. PO-1,2, PSO-2.
5. Use the concepts of sampling to make decision about the hypothesis. PO-1,2, PSO-2.

MASS TRANSFER-I

Sub Code: CH42

Credit:3:1:0:0

Pre-requisites: Chemical Engineering Thermodynamics

Contact Hours: 70

Course coordinator: Chemical Engineering Department

Unit I

Introduction: Various modes of mass transfer: Diffusion – Fick’s laws; Convection – mass transfer coefficient.

Diffusion in gases, liquids, and solids, Molecular picture. Measurement and estimation of diffusivities. Steady state unidirectional mass transfer through stagnant films of one and two immiscible fluids with equilibrium at interface. Numerical problems.

Convection: Mass transfer coefficients for laminar and turbulent flows and their correlations. Interpretation in terms of film model and movement of eddies. Overall mass transfer coefficients. Problems on mass transfer resistance.

Unit II

Material balance for co-current, cross-current and counter-current operations. Concept of stages, efficiencies, cascades operation, continuous contacting equipment, NTU and HTU concepts.

Humidification: General theory. Psychrometric chart. Concepts in humidification, dehumidification. Cooling towers, Design of cooling towers and related equipment.

Unit III

Drying: Drying Equilibria. Drying rate curves. Mechanism of drying. Calculation of batch and continuous drying. Equipment for drying. Design of continuous rotary dryer.

Unit IV

Crystallization: Factors governing nucleation and crystal growth rates. Controlled growth of crystals. Yield calculations and energy balance. Different types of crystallizer equipment. Fractional crystallization.

Unit V

Adsorption: Theories of adsorption. Isotherms, Industrial adsorbents. Stage wise operations, Adsorptions calculations and equipment.

Ion exchange: Process & equipment.

Text Books:

1. Treybal, R.E., Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.
2. Dutta, B.K., Principles of Mass Transfer and Separation Processes, 1st Edition, PHI, 2006.

Reference Books:

1. Narayanan, K.V., Laksmikutty, B, Mass Transfer – Theory and Applications, 1st Edition, CBS, 2014.
2. Badger & Bancho, Introduction to Chemical Engineering, TMH, 6th Reprint, 1998.
3. Geankoplis, C. J., Transport Processes and Unit Operation, Prentice Hall (I), 2000.

Course Outcomes: On successful completion of the course students will be able to

1. Develop mathematical expression for one dimensional diffusion process and solve problems on diffusion process. (PO-1, 2, 3, PSO-1)
2. Analyze stage wise operations and solve problems on humidification and dehumidification. (PO-1, 2, 3, PSO-1)
3. Solve problems on drying process and explain the types of dryers required for different drying operations. (PO-1, 2, PSO-1, 2)
4. Solve problems on crystallization and explain the types of crystallizers required for different crystallization process. (PO-1, 2, PSO-1, 2)
5. Understand and analyze adsorption and ion exchange process. (PO-1, 2, 7, PSO-1, 2)

CHEMICAL ENGINEERING THERMODYNAMICS

Sub Code:CH43

Credit:3:1:0:0

Pre-requisites: Nil

Contact Hours: 70

Course coordinator: Chemical Engineering Department

Unit I

Basic Concepts and First Law: System, surrounding, processes, state and properties- intensive and extensive properties, State and path functions, Reversible & irreversible processes, Zeroth law of thermodynamics. General statement of first law of thermodynamics, First law for cyclic process and non-flow processes, Heat capacity. Derivation for closed system and steady state flow process- flow calorimeter and heat capacity.

Unit II

P-V-T Behaviour: P-V-T behaviour of pure fluids, Equations of state and ideal gas law, Processes involving ideal gas law: Constant volume, constant pressure, Constant temperature, adiabatic and polytropic processes, Equations of state for real gases: Van der Waals equation, Redlich – Kwong equation, Peng – Robinson equation, Virial equation, Principles of corresponding states, Generalized compressibility charts, Thermodynamic diagrams.

Second Law of Thermodynamics: General statements of the Second law, concept of Entropy, Carnot's principle, Calculations of entropy change, Clausius Inequality, Entropy and Irreversibility, Third law of thermodynamics.

Unit III

Thermodynamic Properties of Pure Fluids: Work function, Gibbs free energy, Fundamental property relations, Maxwells equations, Equations for U and H, Effect of temperature on U, G, H and S, Entropy heat capacity relations, Relationship between C_p , C_v , Clapeyron equation, Gibbs-Helmholtz equation, Fugacity and fugacity coefficient, determination of fugacity of pure fluids.

Properties of Solutions: Partial molar properties, estimation, Gibbs-Duhem equation, Chemical potential, Fugacity in solutions, Henry's law and dilute solutions, Activity in solutions, Activity coefficients, Property changes of mixing, excess properties (Qualitative treatment) Activity & Activity coefficients. Ideal and non-ideal solutions.

Unit IV

Phase Equilibria: Chemical potential, criterion for VLE for ideal solutions, Raoult's law, P-x,y and T-x,y diagrams, Non ideal solutions- Azeotropes types, VLE

at low pressures, VLE correlations- van laar, Margules and Wilson equation. Co-existence equation, G-D equation for VLE, Consistency tests, VLE at high pressures, Liquid-liquid equilibrium.

Unit V

Chemical Reaction Equilibrium: Reaction stoichiometry, Criteria of chemical reaction equilibrium, Equilibrium constant and standard free energy change, Effect of temperature, pressure on equilibrium constants and other factors affecting equilibrium conversion, Liquid phase reactions, Heterogeneous reaction equilibria, Phase rule for reacting system.

Text Books:

1. Smith, J.M. and Vanness, H.C., Introduction to Chemical Engineering Thermodynamics, 5th Edition, McGraw Hill, New York 1996.
2. Narayanan, K.V., Textbook of Chemical Engineering Thermodynamics, Prentice Hall of India Private Limited, New Delhi, 2001.
3. B.G.Kyle, Chemical and process thermodynamics, 2nd edition, Prentice Hall of India Pvt.Ltd, 2000.

Reference Book:

1. Rao, Y.V.C., Chemical Engineering Thermodynamics, New Age International Publication, Nagpur, 2000.

Course Outcomes: On successful completion of this course students will be able to

1. Calculate the heat and work requirements for the given flow or non-flow processes. (PO-1,2, 3, PSO-1)
2. Analyze and find properties such as Pressure, Volume and Temperature for equations of states. Calculate entropy for the processes, and various types of energies such as internal energy, enthalpy, Helmholtz free energy and Gibbs free energy. (PO-1,2, 3, PSO-1,2)
3. Differentiate between ideal and non-ideal solution and estimate partial molar properties. (PO-1,2, 3, PSO-1,2)
4. Generate Vapor Liquid Equilibrium data for ideal and non-ideal solutions and check for their consistency by various methods. (PO-1,2, 3, PSO-1,2)
5. Evaluate the feasibility and extent of conversion for any reaction.(PO-1,2, 3, PSO-1,2)

PROCESS HEAT TRANSFER

Sub Code: CH44

Credit: 3:1:0:0

Pre-requisites: Engineering Mathematics

Contact Hours: 70

Course coordinator: Chemical Engineering Department

Unit I

Introduction: Various modes of heat Transfer and governing laws.

Conduction: Thermal conductivity, Steady state unidirectional heat flow through compound walls, Numerical Problems. Heat conduction with heat generation in a slab, cylinder and sphere.

Unit II

Elementary treatment of unsteady state heat conduction: Biot number, Lumped heat capacity model, unsteady state heat conduction through a slab, Numerical Problems.

Insulation: Properties of insulation materials. Types of insulation, Critical and optimum thickness of insulation.

Extended Surfaces: Types of fins, fin efficiency. Fin effectiveness, Numerical Problems.

Unit III

Convection: Individual and Overall heat transfer coefficients, LMTD, Empirical correlations for forced and natural convection.

Heat Transfer With Phase Change: Boiling phenomenon, nucleate boiling and film boiling, Condensation- Film and drop wise condensation. Nusselt equation.

Unit IV

Heat Transfer Equipment: Construction and working - Double pipe heat exchanger. Shell and tube heat exchangers. Condensers.

Design of Heat Transfer Equipment: Elementary design of double pipe heat exchanger and Shell and tube heat exchanger.

Evaporators: Types, Performance of tubular evaporator- evaporator capacity, evaporator economy, Multiple effect evaporators.

Unit V

Radiation: Properties and definitions, Stefan-Boltzmann law, Wein's displacement law, Kirchoff's law, View factors, Radiation between surfaces, Radiation involving gases and vapors. Radiation shields. Numerical Problems.

Text Books:

1. McCabe, Unit Operations of Chemical Engineering, McGraw Hill, NY, 5th Edition, 2000.
2. Coulson, J.M and Richardson, J.F, Chemical Engineering, Vol 1, Chemical Engineering, Pergemon and ELBS, 5th Edition, McGraw Hill, 2000.

Reference Books:

1. Rao, Y.V.C., Heat Transfer, I Edition, University Press (India) Ltd, New Delhi, 2000.
2. Hollman, J. P., Heat Transfer, 8th Edition.
3. Kern, D. Q., Process Heat Transfer, McGraw Hill, NY, 1965.

Course Outcomes: On successful completion of this course students will be able to

1. Write all fundamental heat transfer laws and relations. Develop mathematical expressions for heat flux through multilayer systems with and without heat generation. (PO-1,2, PSO-1)
2. Calculate critical thickness of insulation & analyze its significance. Develop relation for heat flow through fins & its relevance to industry.(PO-1,2,3,4, PSO-1,3)
3. Apply various correlations of convective heat transfer to different problems, estimate LMTD and heat transfer coefficients. Understand boiling and condensation phenomena in process industry. (PO-1,2, 3, PSO-1)
4. Design various types of heat exchangers and condensers. Study the various types of evaporators and their performance. (PO-1,3,4, PSO-1,3)
5. Understand radiation heat transfer between surfaces. (PO-1,2, PSO-1)

CHEMICAL REACTION ENGINEERING-I

Sub Code:CH45

Credit: 3:0:0:1

Pre-requisites: Chemical Process Calculations,
Engineering Chemistry

Contact Hours:56

Course coordinator: Chemical Engineering Department

Unit I

Introduction: Review of chemical kinetics, Temperature dependency of rate constant from Arrhenius, Collision and Transition state theories.

Non-elementary reactions: Difference between elementary and non-elementary reactions. Kinetic models and mechanisms for non-elementary reactions.

Unit II

Homogeneous reactions: Interpretation of batch reactor data. Constant Volume batch reactor. Analysis of total pressure data in a constant volume system. Integral method of Analysis of data. Irreversible, zero, first, second, and n^{th} order reactions (Uni-molecular and bimolecular type). Reversible first order reactions, series and parallel reactions, Autocatalytic reactions. (For both constant and variable volume reactions). Differential method. Overall orders from half-life method.

Unit III

Design of ideal reactors: Concept of ideality. Development of design expressions for batch, tubular, and stirred tank reactors for both constant and variable-volume reactions. Evaluation of rate equations from data obtained in these reactors. Comparison of ideal reactors: General graphical comparison. Multiple Reactor Systems: Plug flow and/or mixed flow reactors in Series, parallel and series parallel. Reactors of different types and sizes in series.

Unit IV

Recycle reactors: Introduction and qualitative treatment for single reactions only.

Design of reactors for multiple reactions: Design of Batch reactor, Plug and Mixed flow reactors for Parallel and Series reactions (Only irreversible reactions must be considered).

Thermal characteristics of reactors: General graphical design procedure for non-isothermal reactors. Optimum temperature Progression.

Design of adiabatic reactors: Estimation of Conversion and Design of reactors solving material and energy balance equations simultaneously (For single/ simple reactions only).

Unit V

Basics of Non-Ideal flow: Importance & interpretation of RTD, C, E & F curves & Statistical interpretation. Dispersion model. Tanks in series model. Conversion in non-ideal flow reactors for simple systems.

Self-Study Topics:

Temperature dependency of rate constant from Collision and Transition state theories. Analysis of total pressure data in a constant volume system. Overall orders from half-life method. Reactors of different types and sizes in series. Design of adiabatic reactors solving material and energy balance equations simultaneously (For single/ simple reactions only). Tanks in series model.

Text Books:

1. Levenspiel, O., Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, 2001.
2. Fogler, H. S., Elements of Chemical Reaction Engineering, 3rd Edition, Prentice Hall, 2001.

Reference Book:

1. Smith, J.M., Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, 1984.

Course Outcomes: On successful completion students will be able to

1. Understand the types of reactions and the effect of temperature on the rate of reaction. (PO-1,2,4, PSO-1)
2. Explain the methods for determining kinetics of a reaction. (PO-1,2,4, PSO-1)
3. Develop expressions for batch, tubular and stirred tank reactors and evaluate rate equations. Compare the reactors and systems of multiple reactors. (PO-1,2,3,4, PSO-1)
4. Find thermal characteristics of reactors and their usage in design procedure. (PO-1,2,3, PSO-1)
5. Explain the extent of non-ideality in a reactor. (PO-1,2,4, PSO-1)

INSTRUMENTAL METHODS OF ANALYSIS

Sub Code:CH461

Credit:3:0:0:0

Pre-requisites: Engineering Chemistry,
Technical Chemistry-I

Contact Hours: 42

Course coordinator: Chemistry Department

Unit I

Spectroscopy: Introduction: Interaction of electromagnetic radiation, energies corresponding to various kinds of radiations, types of spectroscopy, representation of a spectrum, atomic and molecular transitions, selection rules.

Electronic spectroscopy: Introduction, Principle of electronic spectroscopy, Beer-Lamberts law definition, derivation and its limitations, terminology associated with electronic spectroscopy, Intensity shifts, and types of absorption bands. Electronic energy levels and electronic transitions in organic molecules. Woodward-Fisher rules for conjugated dienes and carbonyl compounds. Quantitative applications.

Unit II

Infrared spectroscopy: Introduction, Regions of infrared region spectrum, Theory-correct wavelength of radiation and change in electric dipole moment of a molecule. Types of vibrations, Factors affecting the group frequencies, electronic effects and hydrogen bonding. Force constant, coupled interactions, Instrumentation FTIR spectroscopy. Applications, Numerical problems.

Mass Spectrometry: Introduction, basic principles, instrumentation, methods of generating positively charged ions-electron impact, molecular ion peak, base peak, metastable peak and isotopic peak, modes of fragmentation.

Unit III

NMR Spectroscopy: General introduction and definition, Theory of NMR, Types of nuclei, chemical shift definition, factors affecting chemical shift, spin-spin interaction, shielding mechanism of measurement, Instrumentation, sample handling, representation of NMR spectrum, NMR spectra of ethanol, methanol and simple organic molecules. Applications. Structural elucidation of simple organic compounds UV, IR, and Mass and NMR spectrometers.

Unit IV

Flame Photometry and Atomic Absorption Spectroscopy: Introduction, principle, flame ionization and dissociation in flames, types of flames used in AAS and flame spectra, variation of emission intensity with flame, metallic spectra in flame, role of temperature on absorption emission, comparative study of flame emission spectroscopy and atomic absorption spectroscopy. Instrumentation,

Applications-Qualitative and quantitative determination of alkali and alkaline earth metals.

Chromatography: Introduction, Classification-Theory-distribution coefficient, rate of travel, retention time, adjusted retention time, retention volume, adjusted retention volume, net retention volume, specific retention volume, column capacity, separation number, peak capacity, shapes of chromatic peak, column efficiency, resolution, optimization of column performance, Numerical problems.

Unit V

Thin layer chromatography: Principle, experimental procedure, applications.

Gas chromatography: Principle, instrumentation, sample injection, detectors (TCD, FID, ECD, atomic emission detector).

High performance liquid chromatography: Principle, instrumentation, column, sample injection, detectors (absorbance, refractive index, electrochemical).

Text Books:

1. Silverstein, R.M. and Webster, W.P., Spectrometric Identification of organic compounds, Wiley & Sons, 1999.
2. Willard, H.H., Merritt, L.L., Dean, J.A. and Settle, F. A., Instrumental Methods of Analysis, CBS Publishers, 7th Edition, 1988.

Reference Books:

1. Ewing, G.W., Instrumental Methods of Chemical Analysis, 5th Edition, McGraw-Hill, New York, 1988.
2. Skoog, D.A, Holler, S.J., Nilman, T.A., Principles of Instrumental Analysis, 5th Edn., Saunders college publishing, London, 1998.
3. Chatwal, A., Instrumental Methods of Chemical Analysis, Himalaya Publishing House.
4. Riley, T. and Tomilinson, C., Principles of Electro-Analytical Methods, John Wiley and Sons.
5. Sharma, K., Instrumental Methods of Chemical Analysis, Goel Publishing House Meerut 2000.
6. Jaffery, Gill, Basset. J, Vogel's Text Book of Quantitative Inorganic analysis, et al. 5th Edn., ELBS, 1998.

Course Outcomes: On successful completion of the course students will be able to

1. Interpret the various spectra using spectroscopic techniques. (PO-1,2,4, 5, 9,12, PSO-1,2,3)
2. Usage and analysis of FTIR Spectroscopic data(PO-1,2,4, 5, 9,12, PSO-1,2,3)
3. Elucidate UV, IR & WMR spectrosopes.(PO-1,2,4, 5, 9,12, PSO-1,2,3)
4. Analyze the various samples using AAS and FES. (PO-1,2,4,5,9,12, PSO-1,2,3)
5. Conceptualize the usage of GC, TLC and HPLC for chemical analysis. (PO-1,2,4,5,9,12, PSO-1,2,3)

PLANT UTILITIES

Sub Code: CH462

Pre-requisites: Nil

Course coordinator: Chemical Engineering Department

Credit: 3:0:0:0

Contact Hours: 42

Unit I

Introduction: Different utilities. Role of utilities in process plant operations and criteria for selection and estimation of suitable utilities.

Water: Water resources. Process water, Cooling water, drinking water and boiler feed water Quality Standards. Water treatment processes for drinking, process and boiler feed. Storage and handling of water. Types and selection of pumps, piping and accessories. Water pre-treatment, reuse and recycling.

Unit II

Steam and Power: Steam generation in chemical plants. Types of boilers and waste heat boilers. Fuels-types, emissions and global warming, green fuels. Calorific value. Proximate and ultimate analysis. HHV, LHV and related calculations. Cogeneration power plants. CHPs and Boiler performance. Related Calculations. Economy of steam generation with different fuels, related calculation. Steam storage and handling-piping and accessories.

Unit III

Air: Compressed air, blower air, fan air. Types of compressor and vacuum pumps and selection. Power requirements, performance and related calculations. Booster and receivers. Quality of compressed air for instruments and processes. Compressed air distribution system- piping and accessories. Air-water vapour system: humidification/ dehumidification and evaporative cooling-related calculations.

Unit IV

Refrigeration: Different refrigeration systems and their characteristics. Air-conditioning systems. Coefficient of performance. Power requirements and refrigeration effect- related calculations for each type of refrigeration system. Refrigerant properties and selection. Some commonly used refrigerants and secondary refrigerants. Air-conditioning.

Unit V

Insulation: Insulation Materials and Selection- Economics of insulation. Insulating factors. Properties & Classification. Cold insulation and cryogenic insulation.

Text / Reference Books:

1. Fair, G.M., Geyer, J.C. and Okun, D. A., Water and Waste Water Engineering, Vol 2, Wiley, 1966.
2. Narayan and Viswanathan, Chemical and Electrochemical Energy Systems, University Press, 1998.
3. Perry, Chemical Engineers Handbook, 8th Edition, McGraw Hill.
4. Sinnott, R.K., Coulson and Richardson's Chemical Engineering- Vol 6, Pergamon, 1996.
5. Abbi, Handbook of Energy Audit, Environmental Management, TERI Press, 2002.

Course Outcomes: On completion of course, students will be able to

1. Understand the role of various utilities in process industry. (PO-1, 3, 4, 7, PSO-1)
2. Evaluate the quality of water, its requirements in process industries. (PO-1, 3, PSO-1)
3. Explain about steam properties, usage in industry and types of boilers.(PO-1, 3, PSO-1)
4. Assess requirements of air in industry and mode of its supply. (PO-1, 3, PSO-1)
5. Apply refrigeration principles and decide insulators for a process. Perform energy audits in plants. (PO-1, 3, 5, 7, PSO-1)

PROCESS HEAT TRANSFER LABORATORY

Sub Code:CHL47

Credit: 0:0:1:0

Pre-requisites: Nil

ContactHours: 28

Course coordinator: Chemical Engineering Department

List of experiments suggested:

1. Natural Convection in Bare and Finned tube
2. Vertical Shell and Tube Heat exchanger (Condenser)
3. Horizontal Shell and tube Heat exchanger (Condenser)
4. Helical Coil Heat Exchanger
5. Emissivity Determination
6. Effect of Geometry on Natural Convection
7. Heat Transfer in Packed Beds
8. Double Pipe Heat Exchanger
9. Heat Transfer in Jacketed Vessel
10. Determination of Insulation Thickness
11. Transient Heat Conduction
12. Heat Transfer in Fluidized Beds
13. Evaporator
14. Solar Heater
15. Spiral Plate Heat Exchanger
16. Cross Flow Heat Exchanger

Course Outcome: On completion of the laboratory, the student will be able to

1. Determine the design parameters for design and selection of heat exchangers. (PO-1,2,3, PSO-1)
2. Evaluate the performance of different types of heat exchangers. (PO-1,2,3,PSO-1)
3. Explain the necessity of insulation and fins. (PO-1,2,3, PSO-1)

MECHANICAL OPERATIONS LABORATORY

Sub Code: CHL48

Pre-requisites: Nil

Course coordinator: Chemical Engineering Department

Credit:0:0:1:0

Contact Hours: 28

The experiments should be based on the following topics:

1. Air elutriation
2. Air permeability
3. Ball mill
4. Batch sedimentation
5. Beaker decantation
6. Cyclone separator
7. Drop weight crusher
8. Froth flotation
9. Grindability index
10. ICI sedimentation
11. Jaw crusher
12. Leaf filter
13. Plate and frame filter press
14. Pneumatic conveyor
15. Screen effectiveness
16. Sieve analysis
17. Thickener

Course Outcomes: On successful completion of the course students will be able to

1. Perform particle size analysis. (PO-1,3, PSO-1,2)
2. Evaluate performance of size reduction and filtration equipment.
(PO-1,3, PSO-1,2)
3. Suggest their applications. (PO-1,3, PSO-1,2)