RAMAIAH
Institute of Technology

CURRICULUM

for the Academic year 2019 – 2020

(Revised Scheme)

CHEMICAL ENGINEERING

III & IV SEMESTER B.E

RAMAIAH INSTITUTE OF TECHNOLOGY
(Autonomous Institute, Affiliated to VTU)
Bangalore – 560054.

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 2014 and all engineering departments offering bachelor degree programs have been accredited by NBA. RIT is one of the few institutes with prescribed faculty student ratio and achieves excellent academic results. The institute was a participant of the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. All the departments have 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 140 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 good Mentoring/Proctorial system, a fully equipped Sports department, large air-conditioned library with over 1,00,000 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 and all are 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 64th rank in 2019 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 & IIChE Student Chapter at the Institute. The Department is approved as Research Centre 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 be an Institution of International Eminence, renowned for imparting quality technical education, cutting edge research and innovation to meet global socio-economic needs

MISSION OF THE INSTITUTE

MSRIT shall meet the global socio-economic needs through

- Imparting quality technical education by nurturing a conducive learning environment through continuous improvement and customization
- Establishing research clusters in emerging areas in collaboration with globally reputed organizations
- Establishing innovative skills development, techno-entrepreneurial activities and consultancy for socio-economic needs

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.

Semester wise Credit Breakdown for B E Degree Curriculum
Batch 2018-22

Course Category \ Semester	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Total Credits
Basic Sciences (BSC)	9	8	4	4					**25**
Engineering Sciences (ESC)	11	10							**21**
Humanities, Social Sciences and Management (HSMC)		2			3		3		**8**
Professional Courses – Core (PCC)			21	21	15	11	10		**78**
Professional Courses– Elective (PEC)					3	3	6	3	**15**
Other Open Elective Courses (OEC)					3	3			**6**
Project Work (PROJ), Internship (IN)						4	1	17	**22**
Total Credits	**20**	**20**	**25**	**25**	**24**	**21**	**20**	**20**	**175**

SCHEME OF TEACHING
III SEMESTER

Sl. No.	Course Code	Course Name	Category	Credits				Contact Hours
				L	T	P	Total	
1.	CH31	Engineering Mathematics – III	BSC	3	1	0	4	05
2.	CH32	Technical Chemistry	BSC	4	0	0	4	04
3.	CH33	Chemical Process Calculations	PCC	3	1	0	4	05
4.	CH34	Chemical Engineering Thermodynamics	PCC	3	1	0	4	05
5.	CH35	Momentum Transfer	PCC	4	0	0	4	04
6.	CH36	Material Science	PCC	3	0	0	3	03
7.	CHL37	Technical Chemistry Lab	BSC	0	0	1	1	02
8.	CHL38	Momentum Transfer Lab	PCC	0	0	1	1	02
9.	AM01*	Additional Mathematics - I	BSC	3	0	0	0	03
			Total	**23**	**3**	**2**	**25**	**33**

* Non Credit Mandatory Course L – Lecture (one hour) T - Tutorial (Two hours) P - Practical (Two hours)

Note:

1. The Non Credit Mandatory Course, Additional Mathematics – I is prescribed for III Semester Lateral Entry Diploma students admitted to III Semester of BE Program. The student shall register for this course along with other III semester courses. The students shall attend classes for the course during the semester and complete all formalities of attendance and CIE to appear for SEE. This Course shall not be considered for vertical progression, but completion of the course shall be mandatory for the award of the degree.
2. **AICTE Activity Points to be earned by students admitted to BE program (For more details refer to Chapter 6, AICTE, Activity Point Program, Model Internship Guidelines):**
   Every regular student, who is admitted to the 4 year degree program, is required to earn 100 activity points in addition to the total credits earned for the program. Students entering 4 years Degree Program through lateral entry are required to earn 75 activity points in addition to the total credits earned for the program. The activity points earned by the student shall be reflected on the students 8th Semester grade card. The activities to earn the points can be spread over the duration of the course. However, minimum prescribed duration should be fulfilled. Activity Points (non-credit) have no effect on SGPA/CGPA and shall not be considered for vertical progression.
   Incase student fail to earn the prescribed activity points, Eight semester Grade Card shall be issued only after earning the required activity Points. Students shall be eligible for the award of degree only after the release of the Eight Semester grade card.

SCHEME OF TEACHING
IV SEMESTER

Sl. No.	Course Code	Course Name	Category	Credits				Contact Hours
				L	T	P	Total	
1.	CH41	Engineering Mathematics- IV	BSC	3	1	0	4	05
2.	CH42	Mass Transfer-I	PCC	3	1	0	4	05
3.	CH43	Process Heat Transfer	PCC	4	0	0	4	04
4.	CH44	Chemical Reaction Engineering-I	PCC	3	1	0	4	05
5.	CH45	Mechanical Operation	PCC	4	0	0	4	04
6.	CH46	Biology for Engineers	PCC	3	0	0	3	03
7.	CHL47	Heat Transfer Lab	PCC	0	0	1	1	02
8.	CHL48	Mechanical Operations Lab	PCC	0	0	1	1	02
9.	AM02*	Additional Mathematics - II	BSC	3	0	0	0	03
			Total	**23**	**3**	**2**	**25**	**33**

* Non Credit Mandatory Course L – Lecture (one hour) T - Tutorial (Two hours) P - Practical (Two hours)

Note:

1. The Non Credit Mandatory Course, Additional Mathematics – II is prescribed for IV Semester Lateral Entry Diploma students admitted to BE Program. The student shall register for this course along with other IV semester courses. The students shall attend classes for the course during the semester and complete all formalities of attendance and CIE to appear for SEE. This Course shall not be considered for vertical progression, but completion of the course shall be mandatory for the award of the degree.
2. **AICTE Activity Points to be earned by students admitted to BE program (For more details refer to Chapter 6, AICTE, Activity Point Program, Model Internship Guidelines):**

   Every regular student, who is admitted to the 4 year degree program, is required to earn 100 activity points in addition to the total credits earned for the program. Students entering 4 years Degree Program through lateral entry are required to earn 75 activity points in addition to the total credits earned for the program. The activity points earned by the student shall be reflected on the students 8th Semester grade card. The activities to earn the points can be spread over the duration of the course. However, minimum prescribed duration should be fulfilled. Activity Points (non-credit) have no effect on SGPA/CGPA and shall not be considered for vertical progression.

   Incase student fail to earn the prescribed activity points, Eight semester Grade Card shall be issued only after earning the required activity Points. Students shall be eligible for the award of degree only after the release of the Eight Semester grade card.

III Semester

ENGINEERING MATHEMATICS – III	
Course Code: CH31	**Credits: 3:1:0**
Prerequisites: Calculus	**Contact Hours: 42L+14T**
Course Coordinator: Dr. G. Neeraja and Mr. Vijaya Kumar	

Course Content:

Unit I

Numerical solution of Algebraic and Transcendental equations: Method of false position, Newton - Raphson method.
Numerical solution of Ordinary differential equations: Taylor's series method, Euler's & modified Euler's method, fourth order Runge-Kutta method.
Statistics: Curve fitting by the method of least squares, fitting linear, quadratic and geometric curves, 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, Solution of system of ODE's using matrix method.

Unit III

Fourier Series: Convergence and divergence of infinite series of positive terms, Periodic functions, Dirichlet 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's & Laurent's 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 – 44th edition – 2017.

References:

1. David C. Lay – Linear Algebra and its Applications – Pearson Education – 3rd edition – 2011.
2. Glyn James – Advanced Modern Engineering Mathematics – Pearson Education – 4th edition – 2010.
3. Dennis G. Zill and Patric D. Shanahan- A First Course in Complex Analysis with Applications- Jones and Bartlett Publishers – 2nd edition–2009.

Course Outcomes (COs):

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

1. Apply numerical techniques to solve engineering problems and fit a least squares curve to the given data. (PO-1, 2, PSO-2)
2. Test the system of linear equations for consistency and solve ODE's using Matrix method. (PO-1, 2, PSO-2)
3. Construct the Fourier series expansion of a function/tabulated data. (PO-1, 2, PSO-2)
4. Examine and construct analytic functions. (PO-1, 2, PSO-2)
5. Classify singularities of complex functions and evaluate complex integrals. (PO-1, 2, PSO-2)

TECHNICAL CHEMISTRY

Course Code: CH32 **Credits: 4:0:0**
Pre-requisites: CY12 **Contact Hours: 56L**
Course coordinator: Department of Chemistry

Course Content:

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 (COs):

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

Course Code: CH33 **Credits: 3:1:0**
Pre-requisites: Nil **Contact Hours:42L+14T**
Course coordinator*:* Mr. Neelesh Singhal

Course Content:

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 semi log 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 (COs):

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)

CHEMICAL ENGINEERING THERMODYNAMICS

Course Code:CH34 **Credits:3:1:0**
Pre-requisites: Nil **Contact Hours: 42L+14T**
Course coordinator: Dr. Mahendra Chintala

Course Content:

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 Cp, Cv, 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 (COs):

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)

MOMENTUM TRANSFER

Course Code: CH35 **Credits: 4:0:0**
Pre-requisites: Nil **Contact Hours: 56 L**
Course coordinator*:* Dr.Archna

Course Content:

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

Newton's 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

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.

Unit-IV

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-V

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).

Dimensional Analysis: Dimensional homogeneity, Rayleigh and Buckingham-π method. Significance of different dimensionless numbers. Elementary treatment of similitude between model and prototype.

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 (COs):

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 analyse 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 various types of pumps and transportation and metering devices for fluid handling. (PO-2,3,4 PSO-1,3)
5. Understand flow of compressible fluids. Develop mathematical equations for adiabatic and isothermal flow conditions. (PO-1,2, PSO-1), applying dimensional method of analysis for finding relations

MATERIAL SCIENCE

Course Code: CH36 **Credits: 3:0:0**
Pre-requisites*:* CY22 **Contact Hours: 42L**
Course coordinator: Mrs. Annapurna S.M

Course Content:

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- Braggs Law, the power 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 behaviour, 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, Addision-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 (COs):

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)

TECHNICAL CHEMISTRY LAB

Course Code: CHL37 **Credits: 0:0:1**
Pre-requisites: CY22 **Contact Hours: 14P**
Course coordinator: Department of Chemistry

Course Content:

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 (COs):

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 LAB

Course Code: CHL38 **Credits: 0:0:1**
Pre-requisites: Nil **Contact Hours: 14P**
Course coordinator: Mrs. Annapurna S.M

Course Content:

The experiments should be based on the following topics:

1. Friction in 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 (COs): 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

Course Code: CH41 **Credits: 3:1:0**
Pre-requisites*:* Calculus & Probability **Contact Hours: 42L +14T**
Course coordinator: Dr. G. Neeraja & Mr. Vijaya Kumar

Course Content:

Unit I

Finite Differences and Interpolation: Forward and Backward differences, Interpolation, Newton-Gregory Forward and Backward Interpolation formulae, Lagrange's interpolation formula and Newton's 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's 1/3rd rule, Simpson's 3/8th rule (no proof).

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, Numerical solution of one dimensional heat equation using implicit and explicit finite difference methods. Numerical solution of one dimensional wave equation, two - dimensional Laplace and Poisson equations.

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

Unit IV

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

Unit-V

Sampling and Statistical Inference: Sampling, Sampling distributions, Standard error, 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. 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.

2. B. S. Grewal - Higher Engineering Mathematics - Khanna Publishers - 44th edition-2017.

Reference Books:

1. Erwin Kreyszig –Advanced Engineering Mathematics – Wiley Publication – 10th edition-2015.
2. Kishor S. Trivedi – Probability & Statistics with Reliability, Queuing and Computer Science Applications – John Wiley & Sons – 2nd edition – 2008.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Find functional values, derivatives, areas and volumes numerically from a given data. (PO-1, 2, PSO-2)
2. Evaluate Fourier transforms and use Z-transforms to solve difference equations. (PO-1, 2, PSO-2)
3. Solve PDE's numerically and compute various moments of random variables. (PO-1, 2, PSO-2)
4. Apply the concept of probability distributions to solve engineering problems. (PO-1, 2, PSO-2)
5. Use Sampling theory to make decision about the hypothesis. (PO-1, 2, PSO-2)

MASS TRANSFER-I

Course Code: CH42 **Credits: 3:1:0**
Pre-requisites: Chemical Engineering Thermodynamics Contact Hours: 42L+14T
Course coordinator: Dr. Mahendra Chintala

Course Content:

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.

Analogies in mass, heat and momentum transfer processes.

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 &Banchero, Introduction to Chemical Engineering, TMH, 6th Reprint, 1998.
3. Geankoplis, C. J., Transport Processes and Unit Operation, Prentice Hall (I), 2000.

Course Outcomes (COs):

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)

PROCESS HEAT TRANSFER

Course Code: CH43 **Credits: 4:0:0**
Pre-requisites: Engineering Mathematics **Contact Hours: 56L**
Course coordinator: Dr.Archna

Course Content:

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, Dimensional Analysis, Empirical correlations for forced and natural convection. Analogy between momentum and heat transfer-Reynolds, Colburn and Prandtl.
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, Wien's displacement law, Kirchoff's law, View factors, Radiation between surfaces, Radiation involving gases and vapours. 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 (COs):

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

Course Code:CH44 **Credits: 3:1:0**

Pre-requisites: Chemical Process Calculations & Engineering Chemistry **Contact Hours:42L+14T**

Course coordinator: Dr.Sravanthi

Course Content:

Unit I

Temperature dependency of rate constant, Kinetic models and mechanisms for non-elementary reactions.

Interpretation of batch reactor data. Constant Volume batch reactor. Integral method of Analysis of data. Irreversible, zero, first, second, and n^{th} order reactions (Uni-molecular and bimolecular type).

Unit II

Reversible first order reactions, Overall orders from half-life method.

Variable volume system, Interpretation of batch reactor data by differential method of analysis.

Enzyme kinetics in a batch reactor: Mechanism, turn over number, Michaelis–Menten rate equation. Experimental determination of rate parameters.

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. Enzyme kinetics in a continuous reactor.

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 IV

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.

Text Books:

1. Levenspeil, 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 (COs):

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)

MECHANICAL OPERATIONS

Course Code:CH45 **Credits: 4:0:0**
Pre-requisite*:* Engineering Mathematics **Contact Hours:56L**
Course coordinator*:* Dr.J. Koteswara Rao

Course Content:

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 communition, criteria for communition, characteristics of communited 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.

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 (COs):

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)

BIOLOGY FOR ENGINEERS

Course Code: CH46 **Credits: 3:0:0**
Pre-requisites: Nil **Contact Hours: 42L**
Course coordinator: Dr.Ramasivakiran Reddy

Course Content:

Unit I

Introduction to biomolecules, Cellular, Chemical and Physical Foundations, Chemical bonding, structure and function of carbohydrates, Monosaccharaides 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. Fermentation Technology, Operation and maintenance of typical aseptic aerobic fermentation processes.

Unit V

Introduction to microbiology, study of microbial structures, growth and control (sterilization), ecology, symbiosis and pathogenicity. Transient growth kinetics (Different phases of batch cultivation), Cell Growth Kinetics in Batch and Continuous reactors, Substrate limited growth, Chemostat. Strategies and Steps involved in product purification.

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.
3. Bioprocess Engineering: Basic Concepts, Shuler & Kargi, 2nd Edition, Pearson, UK

Course Outcomes (COs):

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-1,2,3,4,12 PSO-1,2)
5. Understand the basic concepts of microbiology and growth kinetics. (PO-1,2,3,4,12 PSO-1,2)

PROCESS HEAT TRANSFER LAB

Course Code:CHL47 **Credits: 0:0:1**
Pre-requisites: Nil **Contact Hours: 14P**
Course coordinator: Dr.Ramasivakiran Reddy

Course Content:

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 (COs):

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 LAB

Course Code: CHL48 **Credits: 0:0:1**
Pre-requisites: Nil **Contact Hours: 14P**
Course coordinator: Dr.J.Koteswara Rao and Mr.Sagar

Course Content:

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 (COs):

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)