RAMAIAH
Institute of Technology

CURRICULUM

for the Academic year 2020 – 2021

CHEMICAL ENGINEERING

VII & VIII SEMESTER B.E

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

About the Institute:

Dr. M. S. Ramaiah a philanthropist, founded 'Gokula Education Foundation' in 1962 with an objective of serving the society. M S Ramaiah Institute of Technology (MSRIT) was established under the aegis of this foundation in the same year, creating a landmark in technical education in India. MSRIT offers 13 UG programs and 15 PG programs. All these programs are approved by AICTE. All the UG programs & 09 PG programs are accredited by National Board of Accreditation (NBA). The institute is accredited with 'A' grade by NAAC in 2014. University Grants Commission (UGC) & Visvesvaraya Technological University (VTU) have conferred Autonomous Status to MSRIT for both UG and PG Programs till the year 2029. The institute is a participant to the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. The institute has 380 competent faculty out of which 60% are doctorates. Some of the distinguished features of MSRIT are: State of the art laboratories, individual computing facility to all faculty members, all research departments active with sponsored funded projects and more than 300 scholars pursuing Ph.D. To promote research culture, the institute has established Centre of Excellence for Imaging Technologies, Centre for Advanced Materials Technology & Schneider Centre of Excellence. **M S Ramaiah Institute of Technology has obtained "Scimago Institutions Rankings" All India Rank 65 & world ranking 578 for the year 2020.** The Centre for Advanced Training and Continuing Education (CATCE), and Entrepreneurship Development Cell (EDC) have been set up on campus to incubate startups. **M S Ramaiah Institute of Technology secured All India Rank 8th for the year 2020 for Atal Ranking of Institutions on Innovation Achievements (ARIIA), an initiative of Ministry of Human Resource Development (MHRD), Govt. of India.** MSRIT 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 good collection of book volumes and subscription to International and National Journals. The Digital Library subscribes to online e-journals from Elsevier Science Direct, IEEE, Taylor & Francis, Springer Link, etc. MSRIT is a member of DELNET, CMTI and VTU E-Library Consortium. MSRIT has a modern auditorium and several hi-tech conference halls with video conferencing facilities. It has excellent hostel facilities for boys and girls. MSRIT Alumni have distinguished themselves by occupying high positions in India and abroad and are in touch with the institute through an active Alumni Association.

As per the National Institutional Ranking Framework, MHRD, Government of India, M S Ramaiah Institute of Technology has achieved 59th rank among 1071 top Engineering institutions of India for the year 2020 and 1st rank amongst Engineering colleges (VTU) in Karnataka.

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 34 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.

Curriculum Course Credits Distribution
Batch 2017-2021

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 VII SEMESTER

Sl. No.	Course Code	Course Name	Category	Credits					Contact Hours
				L	T	P	S	Total	
1.	CH71	Process Integration	PCC	3	1	0	0	4	05
2.	CH72	Process Control	PCC	3	1	0	0	4	05
3.	CH73	Transport Phenomena	PCC	3	1	0	0	4	05
4.	OE7X	Open Elective-I	OE	4	0	0	0	4	04
5.	CHE7X	**Elective – Group C**	PCE	4	0	0	0	4	04
6.	CHE7X	**Elective – Group D**	PCE	4	0	0	0	4	04
7.	CHL75	Chemical Process Simulation Laboratory	PCC	0	0	1	0	1	02
8.	CHL76	Process Control Laboratory	PCC	0	0	1	0	1	02
Total				**21**	**3**	**2**	**0**	**26**	**31**

Elective –Group C		Elective-Group D	
CHE71	Principles of Food Processing and Preservation	CHE76	Polymer Processing Technology
CHE72	Advance Bioprocess Engineering	CHE77	Interfacial Phenomenon and Surface Engineering
CHE73	Electrochemical Technology	CHE78	Separation Techniques
CHE74	Process Optimization	CHE79	Multicomponent Distillation
CHE75	Modelling of Chemical Processes	CHE710	Applied Mathematics in Chemical Engineering

Open Electives Offered	
CHOE01	Green Technology

Note:

Professional Elective / Open Elective: For the electives to be offered, a minimum of 10 students must register for the elective as per the VTU norms.

SCHEME OF TEACHING
VIII SEMESTER

Sl. No.	Course Code	Course Name	Category	Credits					Contact Hours
				L	T	P	S	Total	
1.	CHE8X	**Elective – Group E**	PCE	4	0	0	0	4	04
2.	CHIN	In plant training/ Industry Course	**IS/ECA**	0	0	4	0	4	
3.	CHP	Project Work	PW	0	0	14	0	14	28
4.	ECA	Extracurricular activities	ECA	0	0	2	0	2	
Total				**4**	**0**	**20**	**0**	**24**	**32**
5.	+CHL81	Seminar		0	0	1	0	1	02
6.	+CHL82	Technical report writing		0	1	1	0	1	04

+ Optional for Old Scheme Students with credit shortage

Elective –Group E	
CHE81	Solid Waste Management
CHE82	Scale Up of Chemical Processes
CHE83	Principles of Management
CHE84	Introduction to Nanotechnology
CHE85	Research Methodology and Report Writing

Note:

Professional Elective / Open Elective: For the electives to be offered, a minimum of 10 students must register for the elective as per the VTU norms.

Semester VII

PROCESS INTEGRATION	
Course Code:CH71	**Credits**: 3:1:0:0
Pre-requisites: Process Heat Transfer Mass Transfer I and II	**Contact Hours**: 42L+14T
Course coordinator: Dr. G. M Madhu	

Course content

Unit I

Introduction to Process Integration: Graphical Techniques. Overall mass targeting.

Unit II

Synthesis of Mass Exchange Network: Graphical approach. Direct recycle strategies.

Unit III

Visualization Strategies: For development of mass integrated system. Algebraic approach to targeting direct recycles

Unit IV

Algebraic Approach: To targeting mass exchange. Network. Recycle strategies using property integration.

Heat Integration: Synthesis of Heat Exchange Networks (HENs), Heat Exchange Pinch Diagram, Screening of Multiple Utilities Using the Grand Composite Representation

Unit V

Combined heat and power integration.
Optimization: Mathematical approach to direct recycle.

Text Books:

1. Robin Smith, Chemical Process Design & Integration, Wiley, 2005.
2. Mahmoud. M., El – Hawalgi, Process Integration, Elsevier, 2006.

Reference Book:

1. Kemp I.C, Pinch Analysis and Process Integration - A user guide on process integration for efficient use of energy, 2nd Edition, Butterworth – Heinneman, 2006.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain the need for Mass and Heat integration in chemical industries and basic principles involved in process integration. (PO-1,4,6,7,8, PSO-1)
2. Calculate the minimum amount of heat required in heat integration. (PO-1, 2, 4,6,7,8, PSO-1, 2)
3. Calculate the minimum fresh solvent required in mass exchange networks by graphical and algebraic methods. (PO-1,2,3,4,6,7,8, PSO-1,2)
4. Calculate the minimum heating and cooling requirements for given process using pinch analysis by graphical and algebraic methods. (PO-1,2,3,4,6,7,8, PSO-1,2)
5. Able to find the quality heating requirements in process flow diagram and able to optimize mass and heat integration problems by Linear programming method. (PO-1,2,3,4, PSO-1,2)

PROCESS CONTROL

Course Code: CH72 **Credits**: 3:1:0:0
Pre-requisites: Engineering Mathematics II **Contact Hours**: 42L+14T
Course coordinator: Dr.Rama Sivakiran Reddy

Course content

Unit I

Laplace transforms: Transforms of simple functions, transforms of derivaties, solution of differential equations, inversion by partial fractions, partial fractions.
First order systems: Thermometer, level, mixing tank, STR: Linearisation: I order systems in series. Response for various input forcing functions.

Unit II

Second order systems: Characteristics. Transfer functions. Response for various input forcing functions. Transportation lag.
Control System: Basic components, Servo and Regulator control.
Controllers: P.I.D and on-off modes. Controller combinations.

Unit III

Final Control Elements: Valves, actuators, valve positioners, valve characteristics.
Close Loop: Block diagram. Closed loop transfer function.
Transient response of servo and regulator control systems with various controller modes and their characteristics.

Unit IV

Stability: Stability of linear control systems. Routh Test
Root Locus: Root locus techniques, plotting.
Frequency Response – Bode diagrams, Bode criterion.

Unit V

Control system Design by Frequency Response: Gain and Phase margins. Ziegler – Nichols rules. Cohen & Coon tuning method.
Advanced Control Strategies: Cascade Control, Feed Forward Control. Ratio Control.

Text Books:

1. Coughanowr, D.R., Process System Analysis and Control, 3rd Edition, McGraw Hill, 1991.
2. Stephanopolous, G., Chemical Process Control- An Introduction to Theory and Practice, Eastern Economy Edition, 2008.

3. D.E. Seborg, Thomas F. Edgar, D. A. Mellichamp, Process Dynamics and Control, 3rd Edition, Wiley, 2013

Reference Book:

1. Harriott, Process Control, Tata McGraw Hill, 1982.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Learn Laplace transforms, analyze simple I order systems. (PO-1,2, PSO-1)
2. Analyze second order systems, different controllers. (PO-1,2,3, PSO-1)
3. Analyze the transient response of feedback systems. (PO-1,2, PSO-1)
4. Design stable control systems for processes. (PO-1,2,3, PSO-1)
5. Understand Frequency Response and tune controllers. (PO-1,5, PSO-1)

TRANSPORT PHENOMENA

Course Code:CH73 **Credits:** 3:1:0:0
Pre-requisites: Momentum Transfer **Contact Hours:** 42L+14T
Process Heat Transfer, Mass transfer
Course coordinator: Dr. Rajeswari M Kulkarni

Course content

Unit I

Velocity Distribution in Turbulent Flow: Comparison of laminar and turbulent flows; time smoothed equations of change for incompressible fluids; time- smoothed velocity profile near a wall; Turbulent flow in ducts; numerical problems
Temperature distribution in turbulent flow: Time-smoothed equations of change for incompressible non isothermal flow; the time-smoothed temperature profile near a wall; Empirical expressions for the turbulent heat flux; Temperature distribution for turbulent flow in tubes

Unit II

Energy transport: Free convection heat transfer and forced convection heat transfer. Equations of change for non-isothermal systems; Energy transport by radiation; Numerical problems.

Unit III

Transport Phenomena in Bioprocess Systems: Gas Liquid Mass transfer in cellular systems, determination of oxygen transfer rates, mass transfer for freely rising or falling bodies, forced convection mass transfer, overall Kla estimates and power requirements for sparged and agitated vessels, Mass transfer across free surfaces, other factors affecting Kla

Unit IV

Concentration Distributions in Laminar Flow: Concepts and definitions on transport velocities in a multicomponent system, Steady state Shell mass balances. Diffusion through stagnant gas and liquid films (isothermal and non-isothermal films). Equimolar counter diffusion. Diffusion with homogeneous and heterogeneous reaction. Diffusion into falling film – Forced convection mass transfer.

Unit V

Distributions with more than one independent variable: Time-dependent flow of Newtonian fluids; unsteady heat conduction in solids; Time-dependent diffusion.

Text Book:

1. Bird, Stewart and Lightfoot, Transport Phenomena, John Wiley, 1994.
2. Biochemical Engineering Fundamentals by James E. Bailey, David F. Ollis, Publisher: McGraw Hill Inc., US, 2nd Edition.

Reference Books:

1. Welty, Wicks and Wilson, Fundamentals of Momentum, Heat and Mass Transport, 3rd Edition, John Wiley, 1983.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain velocity distributions in turbulent flow. (PO-1, 2, 3, PSO-1)
2. Explain free convection heat transfer and forced convection heat transfer. (PO-1, 2, 3, PSO-1, 2)
3. Explain temperature distribution in turbulent flow. (PO-1, 2, 3, PSO-1, 2)
4. Derive mathematical equations by shell balance technique for different practical mass transfer situations. (PO-1, 2, 3, PSO-1, 2)
5. Explain Distributions with more than one independent variable. (PO-1, 2, 3, PSO-1, 2)

OPEN ELECTIVE

Course Code:OE7X **Credits**:4:0:0:0
Pre-requisites: NIL **Contact Hours**: 56L
Course coordinator*:* Other Departments

The students will select an elective offered by other departments.

PRINCIPLES OF FOOD PROCESSING AND PRESERVATION

Course Code: CHE71 **Credits:** 4:0:0:0
Pre-requisites: Nil **Contact Hours**: 56L
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

Basic consideration: Quality attributes of food, aim and objectives of preservation and processing of foods, food deterioration, and causes of quality deterioration and spoilage of foods, unit operations in food processing.

Unit II

Low temperature Preservation and Processing of foods: Chilling temperatures: Considerations relating to storage of foods at chilling temperature, applications and procedures, controlled and modified atmosphere storage of foods, post-storage handling of foods.

Freezing temperature: Freezing process, slow and fast freezing of foods and its consequences, other occurrences associated with freezing of foods. Technological aspects of pre-freezing, Actual freezing, frozen storage and thawing of foods.

Unit III

High temperature preservation and processing of foods: Basic concepts in thermal destruction of microorganisms-D, Z, F, values Heat resistance and thermophilisms in micro-organisms. Cooking, blanching, pasteurization and sterilization of foods. Assessing adequacy of thermal processing of foods, general process of canning of foods, spoilages in canned foods.

Unit IV

Preservation by Dehydration and concentration: Principles, technological aspects and applications of concentration processes, drying and dehydration of food.

Other techniques in preservation: Food irradiation, microwave heating, ohmic heating

Unit V

Processing and preservation of food products: Processing and preservations of milk and milk products, vegetables and food, beverages, meat and meat products.

Text Books:

1. Potter, N.N. and Hotchkiss, J.H., Food Science, 5th Edition, CBS Publishers and Distributors, 2006.
2. Sivasankar, B., Food Processing and Preservation, Eastern Economy Edition, 2005.

Reference Books:

1. Shakuntala, N., Manay and Shadaksharamurthy, M., Foods: Facts and Principles, 3rd Edition, New Age International, 2008.
2. Subbulakshmi, G., and Udupi, S.A., Food Processing and Preservation, 1st Edition**,** New Age International, 2006.
3. Sahu, J.K., Fundamentals of Food Process Engineering, Narosa Publishing, 2014.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Know different characteristics of food along with the processing and preservation methods. (PO-1, PSO-1)
2. Explain low temperature preservation and processing systems and for storage of foods.(PO-1, 3, PSO-1)
3. Explain high temperature preservation and processing of foods(PO-1, 3, PSO-1)
4. Explain other preservation techniques for food.(PO-1, 3, PSO-1, 2)
5. Understand processing and preservation of some important food products. (PO-1, 6, 7, 10, PSO-1)

ADVANCE BIOPROCESS ENGINEERING

Course Code: CHE72 **Credits**: 4:0:0:0
Pre-requisites: Biochemical Engineering **Contact Hours:** 56L
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

Design and analysis of biological reactors: Review of bio reactors-chemostat with & without recycle, multistage operation. Sterilization of Reactors. Sterilization of Medium (Batch and continuous).

Cell Growth Kinetics: Review of Unstructured Models and Introduction to Structured models of Cell Growth.

Unit II

Transport phenomena in bioprocess systems: Overall K_{la} Estimation, and power requirements (review) for sparged and agitated vessels. General heat and mass transfer correlations applicable to biological systems.

Enzyme Immobilization: Review of methods of immobilization. Immobilized enzyme kinetics, Effects of diffusion, reaction kinetics of immobilized enzymes, Effect of other environmental parameters like pH and temperature, Immobilized Cells: Formulations, Characterization and Applications.

Unit III

Multiphase bioreactors: Packed, fluidized and trickle bed reactor. Bubble column reactor, design equations with their applications.
Fermentation Technology: Animal and Plant Cell Reactor Technology.
Mixed Cultures: Introduction. Major Classes of Interactions: Simple Models describing mixed cultures, Industrial utilizations of mixed cultures.

Unit IV

Biological Waste Treatment: Methods, Conversion of waste water to useful products.

Industrial Bioprocess: Anaerobic process for the production of lactic acid, acetone-butanol. Aerobic Processes for the production of Citric Acid, Baker’s Yeast, High fructose corn syrup.

Unit V

Introduction to Genetic Engineering (GE): Aim. Techniques. Achievements and prospects of GE; Translation & Transcription of genetic code. DNA Replication and Mutation and Alteration of cellular DNA. Viruses and Phages. Genetic manipulation: Plasmids. Recombinant DNA Technology.

Text Book:

1. Bailey and Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, 1976.
2. Shuler M L and Kargi F, Bioprocess Engineering, 2nd Edition, Prentice Hall, 2002.

Reference Books:

1. Aiba, S., Biochemical Engineering, Academic Press, London, 1965.
2. Atkinson, A., Biochemical Reactors, Pion Ltd, London. 1975.
3. Pelczar, Microbiology Concept and Application, 5th Edition, McGraw Hill, 2001 Reprint.
4. Doran, P.M., Bioprocess Engineering Principles, Academic Press.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain the design principles of biological reactors, like chemo stat with & without recycle including multistage operation and cell growth kinetics. (PO-1,2,3,PSO-1)
2. Develop transport models for bioprocess systems and techniques of enzyme immobilization. (PO-1,2,3,PSO-1)
3. Explain multiphase bioreactor systems used in bioprocess industry including plant and animal cells and also mixed culture systems. (PO-1,2,3,PSO-1)
4. Apply the methods of biological waste treatment and technology of some important Industrial Bioprocesses. (PO-1,2,3,6,PSO-1)
5. Explain Genetic Engineering concepts.(PO-1,2,12,PSO-1)

ELECTROCHEMICAL TECHNOLOGY

Course Code: CHE73	**Credits:** 4:0:0:0
Pre-requisites: Engineering Chemistry	**Contact Hours:** 56L
Course coordinator: Chemical Engineering Faculty	

Course content

Unit I

Introduction to theoretical aspects: Faradays laws, mechanism of conduction in solids, liquids and gases and in ionic melts. Conduction in metals and semiconductors.

Unit II

Reversible electrodes and potentials, electrode processes and electrode kinetics. Various types of over potentials. Polarization. Butler-volmer for one electron and mute electron steps. Models of electrical Double layer.

Unit III

Applied aspects: Potentiometry and ion-selective electrodes. Amperometric and Volta metric electro analysis, Polarography.

Unit IV

Electrode deposition of metals and alloys. Primary, Secondary and Fuel Cells.

Unit V

Corrosion and its prevention. Electro winning. Electro organic and inorganic synthesis (and some typical examples). Environmental electrochemistry. Bio-electro chemistry**.**

Text Books:

1. Bockris, J.O.M., & Reddy, A.K.N., Modern Electrochemistry, Vol.1 & 2, Plenum, New York.
2. Kuhn, Industrial Electrochemical Processes, Elsevier, Amsterdam.
3. James A. Plam Beck, Electroanalytical chemistry- Basic Principles and applications, John Willey & Sons, Wiley Publication, 1982.

Reference Books:

1. Lingane, J.J., Electro Analytical Chemistry, John Wiley, New York.
2. Potter, E.C., Electrochemistry, Principles and Applications, Cleaver Hume Press, London.

3. Baizer, M.M., Marcel Dekker, Organic Electrochemistry, John Wiley, New York.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain different fundamental laws of electro chemical technology. (PO-1.PSO-3)
2. Derive different kinetic theories of electrode processes. (PO-1, 2, PSO-1)
3. Apply potentiometric and polarographic principles to practical systems. (PO-1, PSO-3)
4. Design a simple methodology for metals and alloys deposition on surfaces put into practice Primary, Secondary and Fuel Cells. (PO-1, 2, 12, PSO-1)
5. Apply the principles of corrosion and its prevention to different environmental conditions in a chemical process industry. (PO-1, 2, 3,7,12, PSO-1)

PROCESS OPTIMIZATION

Course Code: CHE74 **Credits**: 4:0:0:0
Pre-requisites: Engineering Mathematics IV **Contact Hours:** 56L
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

The Nature and Organization of Optimization Problems: Scope and Hierarchy, Applications, General procedure, obstacles.

Developing models for optimization: Classifications of models, building models, selecting functions to fit empirical data, factorial experimental design, and degrees of freedom.

Basic concepts of optimization: Function continuity, NLP programming, convexity and its application, quadratic approximation, conditions for extremum of an unconstrained function.

Unit II

Optimization of unconstrained function: One dimensional search: Numerical methods for optimization a function with one variable, Region elimination methods, scanning and bracketing procedure, Methods using derivatives – Newton's method, Bisection method, Secant method, polynomial approximation methods.

Unit III

Unconstrained multivariable optimization: Methods using functions values only- Random search, grid search, univariate search, Simplex Search, Hooke-Jeeves Pattern Search, and Powell's Conjugate Direction Search.

Gradient- Based Methods – Cauchy's Steepest Descent Method, Conjugate Gradient Method. Newton's method, Quasi Newton's method, Marquardt's Method.

Unit IV

Linear Programming and its applications: Formulation of linear programs, Graphical solution, Simplex algorithm, Transportation problem.

Unit V

Nonlinear Programming with constraints: Direct Substitution. First Order necessary condition for a local extremum, Lagrange Multiplier Method, KKT Conditions, Quadratic Programming, Generalized Reduced Gradient Method.

Text Book:

1. Edgar, T.F., Himmelblau, D.M., Ladson, L.S., Optimization of Chemical Processes, McGraw Hill, 2nd Edition, 2001.
2. A Ravindran, KM Ragsdell, GV Reklitis, Engineering Optimization – Methods and Applications, John Wiley & Sons, 2nd Edition, 2006.

Reference Book:

1. SS Rao, Engineering Optimization – Theory and Practice, New Age International (P) Limited, 4th Edition.
2. Kenneth Lange, Optimization, Springer-Verlag, 2004.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Develop objective function and constraint equations for chemical engineering problems. (PO-1, 2, PSO-2)
2. Optimize functions with single variable using numerical methods. (PO-1, 2, PSO-2)
3. Optimize unconstrained functions. (PO-1, 2, 12, PSO-2)
4. Optimize multivariable problems using numerical methods. (PO-1, 2, 12, PSO-2)
5. Apply linear programming methods in optimization. (PO-1, 2, 12, PSO-2)

MODELING OF CHEMICAL PROCESSES

Course Code: CHE75 **Credits**: 4:0:0:0
Pre-requisites: Engineering Mathematics I and II **Contact Hours**: 56L
Momentum Transfer, Process Heat Transfer,
Chemical Reaction Engineering-I, Chemical Process Calculations
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

Modelling: Models and model building, principles of model formulations, precautions in model building, Fundamental laws: Review of shell balance approach, continuity equation, energy equation, equation of motion, transport equation of state equilibrium and Kinetics, classification of mathematical models.

Unit II

Mathematical Modelling and Solutions to the Following: Basic tank model – Level V/s time. Multi component flash drum. Batch Distillation – Vapour composition with time. Batch Reactor. Solvents extraction (steady & unsteady state), stirred tank (steady state and unsteady state), multistage gas absorption, multistage distillation.

Unit III

Models in heat transfer operation: Heat conduction through cylindrical pipe (steady & unsteady state), cooling of tanks, and unsteady state heat transfer by conduction.

Models in fluid flow operation: Fluid through packed bed column, flow & film on the outside of a circular tube.

Unit IV

Models in Reaction Engineering: Chemical reaction with diffusion in a tubular reactor, chemical reaction with heat transfer in a packed bed reactor, reactor in series.

Unit V

Introduction to flow sheeting: Property estimation, tearing and flow sheeting, Modular and Equation-solving approach (Elementary treatment only).

Text Books:

1. Luyben, W.L., Process Modelling Simulation and Control for Chemical Engineering, 2nd Edition, McGraw Hill, 1990.
2. Babu, B.V., Process Plant Simulation, Oxford Press.

Reference Books:

1. Fogler, H.S., Elements of Chemical Reaction Engineering, 2nd Edition, Prentice Hall, 2001.
2. Smith, J. M. and Vanness, H.C., Introduction to Chemical Engineering Thermodynamics, 5th Edition, MGH 1996.
3. Himmelblau, D.M., Basic Principles and Calculations in Chemical Engineering, Pearson, 7th Edition.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Apply the shell balance method and application of various equations to simple chemical engineering problems. (PO-1, 2, 3, PSO-1)
2. Develop the models for practical engineering problems of mass transfer. (PO-1, 2, 3, PSO-2)
3. Develop the strategies for development of models for momentum and heat transfer applications. (PO-1, 2, 3, PSO-2)
4. Apply the methods for the transport problems involving reactions also. (PO-1, 2, 3, PSO-2)
5. Apply tools for flow sheeting, parameter estimation and modular approach. (PO-1, 2, 3, PSO-2)

POLYMER PROCESSING TECHNOLOGY

Course Code: CHE76 **Credits**: 4:0:0:0
Pre-requisites: Nil **Contact Hours**: 56L
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

Principles of processing of polymers: Melt processing of thermoplastics. Classification of processes. Thermoset plasting processing, crystallization, orientation & shrinkage, co polymers blending, compounding for engineering application, stress – strain behaviour, WLF equation, practical assessment for long term behaviour.

Unit II

Polymer extrusion: Requirements of Polymer for extrusion. Single screw and double screw plasticising extruder zones in extrusion, breaker plates, extruder screw, power calculation. PVC extruder. Die and calibration equipment prime mover for extrusion, co extrusion, extrusion coating, extrusion film blowing reactive extrusion. Extrusion blow moulding for PET bottles, wire drawing-PVC, spinning – various types and applications. Application of various extruded products. Rheological aspects of extrusion and extrusion defects. Operational and maintenance of extrusion equipment.

Unit III

Injection moulding: Polymer characteristics for injection moulding. Reciprocating screw injection moulding. Single impression mould. Multi impression moulds. Cooling requirements in moulds. Hot runner moulds, gate, mould clamping force calculations. Control of pressure, temperature and time of injection thermostat and fibre reinforced polymer injection moulding, sandwich moulding and injection blow moulding. Rheological aspects and defects of injection. Comparison of injection moulding and extrusion of injection. Operational and maintenance of injection moulding equipment's. Reaction injection moulding. Applications.

Unit IV

Compression moulding: Applications. Principles. Comparison with other processing methods. Derivation of compression mould thickness or compaction force. Transfer moulding.
Calendaring: Characteristics of polymer for calendaring. Principles and operation of calendaring. Derivation of film thickness and pressure required for rollers. Guage control during calendaring. Application of PVC calendared products.

Unit V

Thermoforming: Basic principles. Vacuum forming. Pressure forming. Description of operations. Product design. Application. Derivation of thermoformed product thickness.
Rotational moulding: Principles. Operation & applications. Thickness. Cooling calculations.
Testing of plastics: Thermal, electrical, optical, mechanical properties testing.

Text Books:

1. Johnes, M., Principles of Polymer Processing, Chapman and Hall, 1989.
2. Crawford, R.J., Plastic Engineering, 3rd Edition, Butterworth-Hienemann, 1998.

Reference Books:

1. McCrum, N.G., Buckley, C.P., Principles of Polymer Engineering, Oxford Press, 1988.
2. Manas Chandha, Polymer Materials –Vol 1,2 & 3, Springer.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Assess and use equipment's and choose a suitable polymer for specific fabrication. (PO-1, 2, 3, PSO-1)
2. Understand a product design, production rate and choose an appropriate shaping operation. (PO-1, 2, 3, PSO-1)
3. Test the manufactured product for suitability. (PO-1, 2, PSO-1)
4. Make modifications to moulds and dies for product development. (PO-1, 2, 3, PSO-1)
5. Suggest packaging solutions. (PO-1, 2, 3, PSO-1)

INTERFACIAL PHENOMENA AND SURFACE ENGINEERING

Course Code: CHE77 **Credits**: 4:0:0:0
Pre-requisites: Chemical Engineering Thermodynamics **Contact Hours**: 56L
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

Introduction: Concept of Interface and its formation with examples. Mechanical and Thermodynamic approaches to Interface. Equivalence in the concepts of surface energy and surface tension. Applications.

Excess Pressure: Generalized equation for excess pressure across a curved surface- the equation of Young and Laplace. Pressure jump across cylindrical surface, flat surface. Vapour pressure of a drop Solubility of drops. Ostwald ripening. Capillary condensation. Super saturation. Nucleation.

Unit II

Measurement of Interfacial tension: Capillary rise method. Drop weight method, Wilhemy plate method, du nuoy method. Methods based on shape of static drops or bubbles. Dynamic methods-Flow and capillary waves.

Thermodynamics of Interfaces: Thermodynamic treatment of interfaces. Free energy at interface. Temperature dependence of the surface tension. Effect of pressure on interfacial tension. Effect of curvature on surface tension. Thermodynamics of binary systems-Gibbs Equation. Surface excess concept. Verification of Gibbs equation. Gibbs monolayers.

Unit III

Wetting fundamentals and contact angles: Work of adhesion, cohesion. Criteria for spreading of liquids. Kinetics of spreading. Lens formation- three phase systems. Young's equation. Neumann triangle. Theories of equilibrium contact angles. Contact angle hysteresis.

Unit IV

Electrical aspects of surfaces: The electrical double layer. Stern treatment of electrical double layer. Free energy of a diffused double layer. Repulsion between two plane double layers. Colloidal dispersions. Combined attractive and electrical interaction-DLVO theory. Kinetics of coagulation.

Unit V

Surfactants: Anionic and non-ionic. Other phases involving surfactant aggregates. Surface films of insoluble surfactants. Thermodynamics of micro emulsions. Phase behaviour of oil-water-surfactant systems. Effect of composition changes. Applications of surfactants-emulsions and detergency.

Introduction to interfaces in motion: Linear analysis of interfacial stability. Damping of capillary wave motion by insoluble surfactants. Stability and wave motion of thin liquid films-foams. Interfacial stability for fluids in motion.

Text Books:

1. Miller, C.A. & Niyogi, P., Interfacial Phenomena, Equilibrium and Dynamic Effects, Marshel Deckder, 1985.
2. Adamson, A.W., Physical Chemistry of Surfaces, John Wiley, 5th Edition, 1981.

Reference Books:

1. Millet, J.L., Surface Activity, 2nd Edition, Van Nostrad, 1961.
2. Gorrett, H.E., Surface Active Chemicals, Pergemon Press, 1974.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain mechanical and thermodynamic approaches to interface and Derive the equation for excess pressure across different surfaces. (PO-1, PSO-1)
2. Explain different methods of interfacial tension measurement. (PO-1, PSO-1)
3. Explain concepts of kinetics of spreading, contact angle hysteresis. (PO-1, 2, 12, PSO-1)
4. Explain electrical aspects of surfaces. (PO-1, 2, 12, PSO-1)
5. Explain thermodynamic and mass transfer considerations of surfactants. (PO-1, 2, 12, PSO-1)

SEPARATION TECHNIQUES

Course Code: CHE78 **Credits:** 4:0:0:0
Pre-requisites: Mass Transfer I and II **Contact Hours**: 56L
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

Adsorptive separations: Review of fundamentals. Mathematical modelling of column factors. Pressure swing & thermal swing adsorption. Counter current separations.

Unit II

Chromatography: Chromatography fundamentals. Different types. Gradient & affinity chromatography. Design Calculations for chromatographic columns.

Unit III

Membrane separation processes: Thermodynamic considerations. Mass transfer considerations. Design of RO &UF. Ion selective membranes. Micro filtration. Electro dialysis. Pervaporation. Gaseous separations.

Unit IV

Surfactant based separations: Fundamentals. Surfactants at inter phases and in bulk. Liquid membrane permeation. Foam separations. Micellar separations.

Super critical fluid extraction: Thermodynamics and physico chemical principles. Process description. Application. Case Study.

Unit V

External field induced separations: Electric & magnetic field separations. Centrifugal separations and calculations.

Other Separations: Separation by thermal diffusion, electrophoresis and crystallization.

Text Books:

1. Rousseu, R.W., Handbook of Separation Process Technology, John Wiley & Sons.
2. Seader JD, Henley EJ, Roper, Separation process principles, John Wiley & Sons, 3rd edition.

Reference Books:

1. Kirk-Othmer, Encyclopaedia of Chemical Technology, 5^{th} Edition, 2007.
2. Wankat, P.C., Rate Controlled Separations, Springer, 2005.
3. Wankat, P. C., Large Scale Adsorption Chromatography, CRC Press, 1986.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain different types of adsorptive separations and design the adsorption column. (PO-1,2,PSO-1)
2. Analyze the separation system for multi-component mixtures and design the chromatographic columns. (PO-1,2,PSO-1)
3. Analyze the rate of permeate flux of membranes for separation processes reverse osmosis, dialysis, ultra-filtration, and electro dialysis.(PO-1,2,PSO-1)
4. Explain concepts of surfactant based separations, physico-chemical aspects and applications of super critical fluid extraction. (PO-1,2, PSO-1)
5. Analyze the applicability of electric, magnetic and centrifugal separation processes. (PO-1,2,PSO-1)

MULTICOMPONENT DISTILLATION

Course Code: CHE79 **Credits**: 4:0:0:0
Pre-requisites*:* Mass Transfer-II, Chemical Engg. Thermodynamics, Engineering Mathematics IV **Contact Hours:** 56L
Course coordinator*:* Chemical Engineering Faculty

Course content

Unit I

Phase Equilibria: For Multi component distillation. Thermodynamic relationships for multi component mixture, prediction of phase equilibria. Use of fugacity's and activities. Introduction to the method of convergence characteristics. The Theta method for converging temperature. Profile-Development & application to conventional distillation columns. The 2N Newton-Raphson method- Introduction and the Algorithm. The method of successive approximations.

Unit II

Methods of multicomponent distillation: Azeotropic and extractive distillation process- qualitative characteristics and applications.

Unit III

Phase behaviors at constant pressure: Homogeneous and Heterogeneous Azeotropes.

Unit IV

Reactive Distillation: Distillation accompanied by chemical reaction. Application of the theta method of convergence in reactive method. Formulation of N[r+2] Newton Raphson method.

Unit V

Complex Mixture: Determination of minimum number of stages required to effect a specified separation.
Optimum and economic design of distillation column for the complex mixtures.

Text Books:

1. Holland, C.D., Fundamentals of Multicomponent Distillation, Prentice Hall, 1969.

Reference Books:

1. King, C.J., Separation Processes, McGraw Hill, 1980.
2. Kai Sundmacher, AchimKienle, Reactive Distillation, Wiley, 2003.
3. Billet, R., Distillation Engineering, Chem. Publ. Co. NY, 1979.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Predict phase equilibrium and determine thermodynamic properties. (PO-1, 2, PSO-1)
2. Apply numerical methods to determine parameters for multicomponent distillation. (PO-1, 2, 3, PSO-1)
3. Explain different types of multicomponent distillation. (PO-1, 2, PSO-1)
4. Explain reactive distillation and applications. (PO-1, 2, 3 PSO-1)
5. Determine the number of stages for multicomponent distillation. (PO-1, 2, 3 PSO-1, 2)

APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

Course Code: CHE710 **Credits**: 4:0:0:0
Pre-requisites: Engineering Mathematics I, II, III **Contact Hours**: 56L
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

Formulation of problems in chemical engineering, with applications of laws of conservation. Linear algebraic equations, vectors, vector functions and vector spaces. Theory of Linear operators. Existence and uniqueness of solutions. Eigen values, Eigen vectors, Eigen functions. Linear transformations. Diagonalization of matrices. Applications to problems in chemical engineering.

Unit II

Ordinary differential equations involving engineering problems: formulations and solution procedures. Systems of linear differential equations, decoupling of a system of homogenous first order differential equations. Linear transformations of variables for decoupling.

Unit III

Partial differential equations involving engineering problems: formulations and solution procedures. Gradient, divergence, curl, Laplacian, vector calculus and their applications in chemical engineering. Coordinate systems and their interconversions. Applications of probability and statistics in chemical engineering systems.

Unit IV

Introduction to non-linear dynamics and its importance in chemical engineering. One dimensional systems, fixed points and their stabilities. Oscillations and potentials. Logistic equation and other non-linear systems. Bifurcations in one dimensional systems and their applications. Applications of complex analysis in engineering systems.

Unit V

Two-dimensional systems, linear systems and linearization. Phase space analysis, conservative systems, bifurcations in two dimensions and their applications. Introduction to limit cycles and chaos.
Sequences and series in real number systems and their applications to engineering problems. One dimensional logistic maps, convergence and stability.

Text Books:

1. Gilbert Strang, Linear Algebra, Wiley Publications 2008.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Publications, 2013
3. Strogatz, S., Non-Linear Dynamics and Chaos, CRC Press, 2018
4. Michael T. Heath, A survey of scientific computing, McGraw Hill, 2006 (second edition)
5. Varma & Morbidelli, Mathematical methods in chemical engineering, Indian edition, 2008

Reference Books:

1. H.S. Mickley, T.K. Sherwood and C.E. Reed, Applied Mathematics in Chemical Engineering, 3rd Edition, Tata McGraw Hill, 1999.
2. S. Pushpavanam, Mathematical Methods in Chemical Engineering, Eastern Economy Edition, 2004
3. V.G. Jenson & G.V. Jeffreys, Mathematical Methods in Chemical Engineering, Academic Press, London, 1977.
4. L.M. Rose, Applications of Mathematical Modelling to Process Development and Design, Applied Science Publishers Ltd., London, 1998.
5. S. Chapra, R. Canale, Numerical methods for Engineers, McGraw Hill, 2015 (7th Edition)

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain basic laws for formulation of mathematical models. (PO-1, PSO-1)
2. Apply methods of solving ordinary differential equations related to chemical engineering. (PO-1, 2, PSO-1)
3. Apply partial differential equations to solve problems in chemical engineering (PO-1, 2, PSO-1)
4. gather basic understanding of nonlinear dynamics on engineering (PO-1, 2, PSO-1).
5. Apply the concept of bifurcations in two dimensions for solving engineering problems. (PO-1, 2, PSO-1)

CHEMICAL PROCESS SIMULATION LABORATORY

Course Code: CHL75 **Credits**: 0:0:1:0
Pre-requisites: Nil **Contact Hours**: 14P
Course coordinator: Dr.Rama Sivakiran Reddy

Course content

List of simulations suggested:

a. Flowsheet simulation and Optimization of parameters
b. Sensitivity analysis
c. Azeotropic distillation
d. Reactive distillation
e. Batch distillation
f. Bioprocess simulation
g. Crude refining
h. Heat exchanger design HTFS/EDR
i. Dynamic simulation
j. Solids operations
k. User model and MS EXCEL integration

Software Suggested: ASPEN ONE, ASPEN HYSYS, CHEMCAD, DESIGN-II, gPROM, UNISIM

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Use any chemical process simulation software. (PO-2,3,5,12,PSO-2)
2. Simulate a chemical engineering process. (PO-2,3,5,12,PSO-2)
3. Optimize the parameters in a process using simulation software. (PO-2,3,5,12,PSO-2)

PROCESS CONTROL LABORATORY

Course Code:CHL76 **Credits**: 0:0:1:0
Pre-requisites: Nil **Contact Hours**: 14P
Course coordinator: Dr.Rama Sivakiran Reddy

Course content

List of experiments:

1. Thermometer
2. Single tank - Step Response
3. Non Interacting Tanks – Step Response
4. Interacting Tanks – Step Response
5. Pressure Tank
6. U – Tube Manometer
7. Single tank - Impulse Response
8. Non Interacting Tanks – Impulse Response
9. Interacting Tanks – Impulse Response
10. Level/Flow/Pressure/pH/Temperature control – P controller
11. Level/Flow/Pressure/pH/Temperature control – PI controller
12. Level/Flow/Pressure/pH/Temperature control – PD controller
13. Level/Flow/Pressure/pH/Temperature control – PID controller
14. Valve characteristics.
15. Flapper Nozzle System
16. Valve Positioner.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Analyse various control systems. (PO-2,4,10,PSO-1,3)
2. Evaluate their performance. (PO-2,3,4,10,PSO-1,3)
3. Suggest their applications in process industry.(PO-1,10,PSO-1)

Semester VIII

SOLID WASTE MANAGEMENT

Sub Code: CHE81 **Credits**: 4:0:0:0
Pre-requisites: Environmental Engineering **Contact Hours**: 56L
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

Introduction: Definition, characteristics and perspectives of solid waste. Types of solid waste. Physical and chemical characteristics. Variation of composition and characteristics. Municipal, industrial, special and hazardous wastes.
General aspects: Overview of material flow in society. Reduction in raw material usage. Reduction in solid waste generation. Reuse and material recovery. General effects on health and environment. Legislations.

Unit II

Engineered systems: Typical generation rates. Estimation and factors effecting generation rates. On site handling. Storage and processing. Collection systems and devices. Transfer and transport.

Unit III

Processing Techniques: Mechanical volume reduction. Thermal volume reduction. Component separation. Land filling and land forming. Deep well injection.

Unit IV

Material recovery: Mechanical size alteration. Electromagnetic separation. Drying and dewatering. Other material recovery systems. Recovery of biological conversion products. Recovery of thermal conversion products.
Energy recovery: Energy recovery systems and efficiency factors. Determination of output and efficiency. Details of energy recovery systems. Combustion incineration and heat recovery. Gasification and pyrolysis. Refuse derived fuels (RDF).

Unit V

Case studies: Major industries and management methods used in typical industries – Coal fired power stations, textile industry, oil refinery, distillery, sugar industry, and radioactive waste generation units.

Text Books:

1. Howard S. Peavy, Environmental Engineering, McGraw Hill International Edition, 1986.
2. Dutta, Industrial Solid Water Management and Land Filling Practice, Narose Publishing House, 1999.

Reference Books:

1. Sastry C.A., Waste Treatment Plants, Narose Publishing House, 1995.
2. Lagrega, Hazardous Waste Management, McGraw Hill, 1994.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Apply knowledge to characterize the solid waste. (PO-1, 2, 4, 9, PSO-1)
2. Understand various components of solid waste and perform calculations. (PO-1, 2, 4, 9, PSO-1)
3. Apply various processing techniques and suitable design considerations for land filling sites. (PO-1, 2, 4, PSO-1)
4. Apply techniques of material recovery and energy recovery from solid waste. (PO-1, 2, 3, 4, PSO-1)
5. Develop a management plan for handling solid waste for various process industries and municipalities. (PO-1, 2,3,4,9, PSO-1)

SCALE UP OF CHEMICAL PROCESSES

Course Code: CHE82 **Credits**: 4:0:0:0
Pre-requisites: Nil **Contact Hours**: 56L
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

Introduction: Concept of prototypes, models, scale ratios, element. Principles of similarity**:** Geometric similarity. Distorted similarity. Static, dynamic, kinematics, thermal and chemical similarity with examples.

Unit II

Dimensional analysis: (Review of Rayleigh's, Buckingham ∏ methods), Differential equation for static systems, flow systems, thermal systems, mass transfer processes, chemical processes-homogeneous and heterogeneous.

Unit III

Regime concept: Static regime. Dynamic regime. Mixed regime concepts. Criteria to decide the regimes. Equations for scale criteria of static, dynamic processes, Extrapolation. Boundary effects.

Unit IV

Scale up: Mixing process, agitated vessel, Chemical reactor systems-Homogeneous reaction systems. Reactor for fluid phase processes catalysed by solids. Fluid-fluid reactors.

Unit V

Stage wise mass transfer processes. Continuous mass transfer processes. Scale up of momentum and heat transfer systems. Environmental challenges of scale up.

Text Books:

1. Attilio Bisio, Robert L. Kabel., Scale up of Chemical Processes, John Wiley & Sons, 1985
2. Johnstone and Thring, Pilot Plants, Models and scale up method in Chemical Engineering.

Reference Book:

1. Ibrahim and Kuloor, Pilot Plants and Scale up Studies, IISc.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Apply similitude principles. (PO-1,2,3,4,5,PSO-1)
2. Develop relations in terms of dimensionless parameters. (PO-1,2,3,4,5,PSO-1)
3. Identify process regimes and develop equations for static and dynamic processes. (PO-1,2,3,4,5,PSO-1)
4. Develop scale up criteria for mixing processes and reactors. (PO-1,2,3,4,5,10, PSO-1, 2, 3)
5. Develop scale up relations for mass transfer operations and assess environmental challenges. (PO-1,2,3,4,5,10, PSO-1,2,3)

PRINCIPLES OF MANAGEMENT

Course Code: CHE83 **Credits**: 4:0:0:0
Pre-requisites: Nil **Contact Hours:** 56L
Course coordinator: Humanities/ Chemical Engineering Faculty

Course content

Unit I

Management: Introduction: Meaning – nature and characteristics of Management, Scope and functional areas of management – Management as a science, art or profession – Management & Administration – Roles of Management, Levels of Management.

Unit II

Planning: Nature, importance and purpose of planning process – Objectives – Types of plans (Meaning only) – Decision making – Importance of planning – Steps in planning & planning premises – Hierarchy of plans.

Unit III

Organizing And Staffing: Nature and purpose of organization – Principles of organization – Types of organization – Depart mentation – Committees – Centralization Vs Decentralization of authority and responsibility – Span of control – MBO and MBE(Meaning only). Nature and importance of Staffing – Process of Selection & Recruitment (in brief).

Unit IV

Directing & Controlling: Meaning and nature of directing – Leadership styles, Motivation Theories, Communication – Meaning and importance.

Unit V

Directing & Controlling: Coordination, meaning and importance and Techniques of Co – ordination. Meaning and steps in controlling – Essentials of a sound control system – Methods of establishing control (in brief).

Text Books:

1. Tripathi, P.C., Reddy, P.N., Principles of Management, Tata McGraw Hill.
2. Koontz , H., Principles of Management, McGraw Hill, 2004.

Reference Books:

1. Lusier, R., Thomson, Management Fundamentals – Concepts, Application, Skill Development.
2. Robbins, S., Management, Pearson Education/PHI, 17^{th} Edition, 2003.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Understand the role of management and its functions. (PO-6,8,10,PSO-3)
2. Explain importance of the various steps in planning. (PO-6,8,10,PSO-3)
3. Explain authority and responsibility, process of recruitment and explain leadership and motivation theories. (PO-6,8,10,PSO-3)
4. Analyze modes and barriers in communication. (PO-6,8,10,PSO-3)
5. Apply various methods of directing and controlling. (PO-6,8,10,PSO-3)

INTRODUCTION TO NANOTECHNOLOGY

Course Code: CHE84 **Credits:**4:0:0:0
Pre-requisites: Material Science, Chemical Engineering Thermodynamics **Contact Hours**: 56L
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

Overview to Thermodynamics: The first and second laws of thermodynamics. Thermodynamic functions, heat capacity, enthalpy and entropy. Phase equilibrium in one component system, real gases, and the interactions between gases. Ehrenfest classification of phase transition, the physical liquid surface; surface tension, curved surfaces, capillary action.

Theory of Solution and related topics: Liquid mixtures: free energy as a function of composition, ideal solutions and excess functions.

Equilibrium Electrochemistry; electrochemical cells, Methods for calculation of thermodynamic equilibrium. Electrochemical processes.

Unit II

Fabrication of Nanomaterials by Physical Methods: -Inert gas condensation, Arc discharge, RF plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and Electro deposition.

Unit III

Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, X-ray diffraction.

Unit IV

Optical Microscope and their description, operational principle and application for analysis of nanomaterial's, UV-VIS-IR Spectrophotometers, Principle of operation and application for band gap measurement.

Unit V

Nanolithography and Nano manipulation, E beam lithography and SEM based nanolithography and Nano manipulation, Ion beam lithography, oxidation and metallization. Mask and its application. Deep UV lithography, X-ray based lithography.

Reference Books:

1. Mark James Jackson, Microfabrication and Nano manufacturing, CRC Press, 2005.
2. Principe, E. L., Gnauck, P. and Hoffrogge, P., A Three Beam Approach to TEM Preparation Using In-situ Low Voltage Argon Ion Final Milling in a FIB-SEM Instrument Microscopy and Microanalysis, 11: 830-831 Cambridge University Press, 2005.
3. Shaw, L.L., Processing & properties of structural Nano materials, John Wiley and Sons, 2010.
4. Narayanan, K.V., Textbook of Chemical Engineering Thermodynamics**,** Prentice Hall of India Private Limited, New Delhi, 2001.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain the underlying thermodynamic principles. (PO-1,2, PSO-1)
2. Determine the thermodynamic equilibrium. (PO-1,2, PSO-1)
3. Apply the methods of fabrications and applications of nanomaterial's. (PO-1,2,5, PSO-1)
4. Use applied analytical instruments. (PO-1,2,5, PSO-1)
5. Explain lithography and its applications. (PO-1,2,5, PSO-1)

RESEARCH METHODOLOGY AND REPORT WRITING

Course Code: CHE85 **Credits**: 4:0:0:0
Pre-requisites: Engineering Mathematics IV **Contact Hours**: 56L
Course coordinator: Chemical Engineering Faculty

Course content

Unit I

Research Methodology: Introduction, Defining the research problem, research design.

Unit II

Method of data collection: Sampling design. Measurement and scaling techniques, methods of data collection, sampling fundamentals.

Unit III

Data Analysis: Processing and analysis of data, Testing of Hypotheses parametric), Chi-square test, Analysis of variance and covariance.

Unit IV

Data Analysis: Testing of hypotheses (non-parametric), Techniques of multivariate analysis.

Unit V

Report writing and Presentation: Interpretation of results and report writing.

Text Books:

1. Kothari, C.K., Research Methodology: Methods and Techniques, 2^{nd} Edition, 2012 Reprint.
2. Bhattacharya, D.K., Introduction to Research Methodology, Excel Books India, 2009.

Reference:

1. Suresh Chandra, Mohit Sharma, Research Methodology, Narosa Publishing, 2013.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Apply techniques for defining a research problem. (PO-6,8,9,11,PSO-3)

2. Explain the methods for sampling, scaling techniques and methods of data collection. (PO-4,10,11,PSO-3)
3. Perform investigation using mathematical methods, explain and take position on the results as well as summarize related work. (PO-10, 11,PSO-3)
4. Test non-parametric hypothesis using multivariate techniques. (PO-4 PSO-3)
5. Interpret the research findings and use the knowledge to write a scientific report. (PO-10,PSO-3)

INPLANT TRAINING/ INDUSTRY COURSE

Course Code: CHIN **Credits**: 0:0:4:0
Pre-requisites: Nil **Contact Hours**: -
Course coordinator: Chemical Engineering Faculty

Course content

Students are required to carry out training in a chemical industry or research in any organisation for not less than four weeks after 4^{th} or 6^{th} semester OR attend industry course organised at the department between sixth and seventh semester. Students are required to submit a report on the same in the format provided by the industrial training committee. The students will be evaluated by the industrial training committee based on the rubrics informed to students by the committee.

Students who fails to complete Inplant training has to take up an industry course offered by the department for 04 credits. [Scale up of chemical process OR Hazard analysis and risk management]

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Understand functioning of chemical process industry, gain knowledge on the recent developments in the area and integrate his theoretical knowledge with practical processes. (PO-2,4,7,11,12,PSO-1,2,3)
2. Enhance his communication skills to work in interdisciplinary teams in industry. (PO-9, 10)
3. Realize his professional and ethical responsibility. (PO-6, 7, 8)

PROJECT WORK

Course Code: CHP **Credits:**0:0:14:0
Pre-requisites: NIL **Contact Hours**:-
Course coordinator: Chemical Engineering Faculty

Course content

A group of students will be assigned an experimental work, case study, or an analytical problem to be carried out under the supervision of a guide. The group shall not contain more than four students. Guides are allocated in the beginning of sixth semester. The students are required to give three comprehensive presentations in the on the progress of their project work during the eighth semester and submit the report at the end of the semester. During the semester, performance of the students is evaluated by the guide and project co-ordination committee to award the CIE marks as per the rubrics defined by the committee. The final project report will be evaluated and examined at the end of the eighth semester for SEE.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Carry out literature review on selected topics from peer review journals and magazine. (PO-2,3,6,7,8,PSO-3)
2. Write protocols and perform the experiments and theoretical analysis. (PO-1,2,3,4,6,7,12, PSO-1,3)
3. Carry out computational analysis and analyze the results obtained. (PO-2,3,4,5,12, PSO-1,2,3)
4. Write precise project reports with appropriate references. (PO-8,10,11,12, PSO-3)
5. Present the work progress from time to time with the results obtained and contribute as a team member. (PO-8,9,10, PSO-3)

SEMINAR	
Course Code: CHL81	**Credits**: 0:0:1:0
Pre-requisites: NIL	**Contact Hours**: -
Course coordinator: Chemical Engineering Faculty	

Course content

+ Optional for Old Scheme Students with credit shortage

The students are required to give a presentation and submit a brief report on any topic related to upcoming areas of chemical engineering.

Course Outcomes (COs):

The student will be able to

1. Communicate orally, give presentation. (PO-10,PSO-3)
2. Address certain societal issues. (PO-1, 6)
3. Present recent solutions for sustainable development. (PO-2,7, PSO-3)

TECHNICAL REPORT WITHOUT

Course Code: CHL82 **Credits**: 0:1:1:0
Pre-requisites: NIL **Contact Hours**: 14T+14P
Course coordinator: Chemical Engineering Faculty

Course content

+ Optional for Old Scheme Students with credit shortage

The students are required to give a presentation and submit a detailed technical report on a research topic assigned by the faculty in-charge of the course.

Course Outcomes (COs):

The student will be able to

1. Communicate orally, give presentation. (PO-10, PSO-3)
2. Address certain societal issues. (PO-1, 6)
3. Present recent solutions for sustainable development. (PO-2,7, PSO-3)

OPEN ELECTIVE OFFERED BY THE DEPARTMENT

GREEN TECHNOLOGY

Course Code: CHOE01 **Credits**: 4:0:0:0
Pre-requisites: Engineering Chemistry **Contact Hours:** 56L
Course coordinator: Sri Sagar J S

Course content

Unit I

Introduction: Green chemistry and technology for sustainable development, Environmental laws, carbon credits, environmental management system standards- ISO 14000 series.

Unit II

Green Chemistry: Principles of Green Chemistry, Atom efficiency, Energy conservation, Waste minimization, Substitution.

Unit III

Life-Cycle Assessment: History, Process, Methodology, Streamlining and Application.

Unit IV

Pollution prevention planning: Structure of the pollution prevention process, Environmental Audits, toxic release inventory

Unit V

Design for the environment and improvement in manufacturing operations, design for disassembly/DE manufacturing, Packaging, case studies.

Text Books:

1. Paul L. Bishop, Pollution Prevention: Fundamentals and Practice, McGraw Hill, 2000.
2. Anastas P.T., Warner J.C., Green Chemistry: Theory and Practice. Oxford Science Publications, Oxford, 1998.

Reference Books:

1. Mike Lancaster, Green Chemistry- An Introductory Text, Royal Society of Chemistry Publishing, 2010

2. Boyle, Godfrey, Bob Everett, Janet Ramage, Energy Systems and Sustainability: Power for a Sustainable Future, Oxford University Press, 2004.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain environment laws, carbon credits, ISO 14000 series. (PO-1, 4, 6, 7, PSO-1)
2. Understand the principles of green chemistry. (PO-3, 4, 6,7,12, PSO-1)
3. Explain the importance of green technology in sustainable development. (PO-3, 4, 6,7,12, PSO-1)
4. Apply tools of green technology and life cycle assessment. PO-3, 4, 6, 7, 12, PSO-1)
5. Conduct pollution prevention planning and environment friendly design. (PO-3, 4, 6,7,12, PSO-1)