RAMAIAH
Institute of Technology

CURRICULUM

for the Academic year 2020 – 2021

CHEMICAL ENGINEERING

V & VI 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 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 2018-2022

Semester / Course Category	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	6	6		**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**	**24**	**20**	**17**	**175**

SCHEME OF TEACHING
V SEMESTER

Sl. No.	Course Code	Course Name	Category	Credits				Contact Hours
				L	T	P	Total	
1.	CH51	Chemical Reaction Engineering-II	PCC	3	1	0	4	5
2.	CH52	Mass Transfer II	PCC	3	1	0	4	5
3.	CH53	Chemical Process Industries	PCC	4	0	0	4	4
4.	CH54	Intellectual Property Rights	HSS	3	0	0	3	3
5.	CHE55x	Professional Elective- I	PEC	3	0	0	3	3
6.	CHOE01	Open Elective-1	OEC	3	0	0	3	3
7.	CHL56	Chemical Reaction Engineering Lab	PCC	0	0	1	1	2
8.	CHL57	Computational Methods Laboratory	PCC	0	0	1	1	2
9.	CHL58	Process Equipment Drawing	PCC	0	0	1	1	2
			Total	**19**	**2**	**3**	**24**	**29**

Professional Elective- I

CHE551	Petroleum Technology	CHE554	Principles of Management
CHE552	Biochemistry	CHE555	Industrial Waste Water Treatment
CHE553	Applied Mathematics in Chemical Engineering	CHE556	Hazard Analysis and Risk Management
	Open Elective I	CHOE01	Solid Waste Management

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 VI SEMESTER

Sl. No.	Course Code	Course Name	Category	Credits				Contact Hours
				L	T	P	Total	
1.	CH61	Process Equipment Design	PCC	2	1	1	4	6
2.	CH62	Process Control	PCC	3	1	0	4	4
3.	CHE63x	Professional Elective-II	PEC	3	0	0	3	3
4.	CHE64x	Professional Elective-III	PEC	3	0	0	3	3
5.	CHOE02	Open Elective-2	OEC	3	0	0	3	3
6.	CH65	Design Project/ Mini Project /NPTEL	PW	0	0	4	4	8
7.	CHL66	Pollution Control laboratory	PCC	0	0	1	1	2
8.	CHL67	Mass Transfer Laboratory	PCC	0	0	1	1	2
9.	CHL68	Simulation Laboratory	PCC	0	0	1	1	2
			Total	**14**	**2**	**8**	**24**	**33**

Professional Elective- II

CHE631	Natural Gas Engineering and Transportation	CHE634	Operations Research
CHE632	Molecular Biology	CHE635	Air Pollution Control
CHE633	Modelling of Chemical Processes	CHE636	Separation Techniques

Professional Elective- III

CHE641	Polymer Processing Technology	CHE644	Electrochemical Technology
CHE642	Interfacial Phenomenon and Surface Engineering	CHE645	Introduction to Nanotechnology
CHE643	Principles of Food Processing and Preservation	CHE646	Research Methodology and Report Writing
	Open Elective II	CHOE02	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.

V Semester

CHEMICAL REACTION ENGINEERING-II

Course Code: CH51 **Credits:** 3:1:0
Prerequisites: Chemical Reaction Engineering-II **Contact Hours:** 42L+14T
Course Coordinator/s: Dr. V. Sravanthi

Course content

Unit I

Fluid-particle reactions: kinetics- selection of a model, shrinking core model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles, extensions, determination of rate controlling. Fluid –particle reactor design for non-catalytic heterogeneous reactions

Unit II

Fluid-fluid reactions: kinetics- the rate equation. Introduction to catalysis. Steps in a catalytic reaction, Adsorption on solid surfaces, Physical properties of catalysts, Classification and Preparation of catalyst, Estimation methods for catalytic properties. Promoters, inhibitors and accelerators.

Unit III

Mechanism of catalysis, Rate controlling steps and their derivation for finding rates. **Deactivating catalysts**- mechanisms of catalyst deactivation, the rate and performance equations.

Unit IV

Solid catalysed reactions: Spectrum of kinetic regimes. Rate equation for surface kinetics. Pore diffusion resistance combined with surface kinetics. Porous catalyst particles. Heat effects during reaction. Performance equations for reactors containing porous catalyst particles. Experimental methods for finding rates.

Unit V

Packed bed catalytic reactor and reactors with suspended solid catalyst. Fluidized reactors of various type. Qualitative design of fluidized bed reactor. Kinetics of trickle bed and slurry reactors.

Text Books:

1. Levenspiel, O., Chemical Reaction Engineering, 3rd Edition, John Wiley &Sons.
2. Smith, J.M., Chemical Engineering Kinetics, 3rd Edition, McGraw Hill.

Reference Books:

1. Fogler, H.S., Elements of Chemical Reaction Engineering, 3rd Edition, Prentice Hall.
2. Carberry, J.J., Chemical & Catalytic Reaction Engineering, McGraw Hill.

Course Outcomes (COs):

On successful completion of this course students will be able to

1. Explain the kinetics of heterogeneous reaction system and design a reactor for non-catalytic reaction. (PO-1,2,3,4,PSO-1,2)
2. Prepare the catalysts of required properties and can evaluate its performance. (PO-1,2,3,4,PSO-1,2)
3. Develop the mechanism and determine the deactivation rate of catalytic reactions. (PO-1,2,3,4,PSO-1,2)
4. Determine the effectiveness of catalyst and calculate rate experimentally. (PO-1,2,3,4,PSO-1,2)
5. Explain and design various types of reactors. (PO-1,2,3,4,PSO-1,2)

MASS TRANSFER-II

Course Code: CH52 **Credits:** 3:1:0
Prerequisites : Mass Transfer-II **Contact Hours:**42L+14T
Course Coordinator/s: Dr. Brijesh

Course content

Unit I

Absorption: Absorption. Solvent selection for absorption. Material balance and concept of driving force and minimum solvent rates. Multistage absorption columns. Design of Plate columns. Absorption and desorption factors. Construction details. HETP and HTU concepts. Liquid phase hold up and pressure drop in absorption towers. Operating line and minimum solvent flow rates. Design of packed towers (height and diameter).Multi-component absorption. Absorption with chemical reaction.

Unit II

Distillation: Introduction. Vapour liquid equilibrium (T-x,y, P-x,y. H-x,y and x-y diagrams for binary mixtures). Relative volatility. Prediction of VLE from vapour pressure data using Raoult's law. VLE for multi-component systems. Non-ideal systems. Azeotropes. Immiscible systems. Steam distillation. Flash and simple distillation.

Unit III

Multistage distillation. Multi-stage rectification column. Design using McCabe-Thiele method for binary mixtures. Ponchon-Savarit method. Efficiencies–overall, local, and Murphree plate efficiencies. Multicomponent distillation. Vacuum, molecular, extractive and Azeotropic distillations.

Unit IV

Extraction – Liquid-Liquid Extraction: Ternary equilibrium. Solvent selection. Single stage. Multistage-cross-current, counter-current extraction. Equipment for liquid-liquid extraction.

Solid-Liquid Extraction: Equipment for leaching. Preparation of solids for leaching. Equilibrium diagrams. Calculation of single stage and multi-stage leaching operation.

Unit V

Membrane Separations: Membranes. Membrane modules. Concentration Polarisation and Fouling. Classification of Membrane Separation Processes. Microfiltration. Ultrafiltration, Reverse Osmosis. Dialysis. Gas Permeation, Electro dialysis, Pervaporation, Nano filtration

Text Books:

1. Dutta, B.K., Mass Transfer Principles and Separation Processes, 1st Edition, PHI, 2006.
2. Narayanan, K.V., Laksmikutty, B., Mass Transfer - Theory and Practice, 1st Edition, CBS, 2014.

Reference Books:

1. Treybal, R.E., Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.
2. Foust, A., Principals of Unit Operation, 2nd Edition, John Wiley, 1994.
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. Explain absorption, desorption operations and design equipment's for carrying out such operations. (PO- 1, 2, 3 PSO-1)
2. Explain vapour-liquid equilibrium and single stage and batch operation using the principles. (PO- 1, 2, 3, PSO-1)
3. Design equipment for continuous rectification. (PO- 1, 2, 3, 12, PSO-1)
4. Explain liquid-liquid and solid-liquid extraction and select/design for carrying out such operations. (PO- 1, 2, 3, 12, PSO-1)
5. Select and design equipment's for membrane separation operations. (PO- 1, 2, 3, 12, PSO-1)

CHEMICAL PROCESS INDUSTRIES

Course Code:CH53 **Credits:** 4:0:0
Prerequisites: Nil **Contact Hours:** 56L
Course Coordinator/s: Dr. J. Koteswararao

Course content

Unit I

Sulfur: Elemental Sulfur mining, Sulfur from ores, Oxides of Sulfur (SO_2, SO_3).
Industrial Gases: CO_2, H_2, O_2, N_2, Water gas.
Acids: Sulfuric, Nitric, Hydrochloric, phosphoric acid.

Unit II

Chlor-Alkali Industries: Sodium chloride, Soda ash, Caustic soda, Chlorine, Bleaching powder.
Fertilizers: Ammonia, Urea, Ammonium chloride, Ammonium nitrate, Ammonium phosphate, Ammonium sulfate, DAP, Bio fertilizers.

Unit III

Phosphorous Industries: Manufacture of white and Red Phosphorus, Pentoxide, Phosphatic Fertilizers, Super Phosphate and Triple Super Phosphate.
Fermentation Industries: Production of alcohol, acetic acid and citric, penicillin.

Unit IV

Petroleum Industries: Constituents of crude petroleum refining and processing. Production of Ethylene, Propylene.

Unit V

Polymers and Rubber: Polymerization, PVC, LDPE, Polypropylene, cross linked polymers, natural rubber, synthetic rubber and rubber compounding.
Miscellaneous Industries: Paints, Pigments, Vanishes, Enamel, Lacquers - White Lead and Zinc oxide, Hydrogen peroxide (H_2O_2), Silicon carbide (SiC), Glass, Cement (Types, manufacture of Portland cement, slag cement).

Text Books:

1. Shreve's, Chemical Process Industries, McGraw Hill, 4th Edition.
2. Rao Gopal & Sittig Marshall, Dryden – Outlines of Chemical Technology for 21st Century, 3rd Edition, and EWP.

Reference Book:

1. Bose, P.K., Chemical Engineering Technology, Vol. 1, 2, Books and Allied (Pvt) Ltd, 2011.
2. Desikan and Sivakumar, Unit Processes in Organic Chemical Industries (Eds.), CEDC, IITM, 1982.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Develop flow chart which includes various unit processes and unit operations for sulfur based chemicals, industrial gases and acids. (PO- 1, 2, 3, 4, 7, 12, PSO- 1)
2. Write manufacturing process based on reactions, operations involved in the production of chlor-alkali chemicals and fertilizer industries. (PO- 1, 2, 3, 4, 7, 12, PSO- 1)
3. Explain and develop the material requirements, flow diagrams in the manufacturing of phosphorous based chemicals and fermentation industries. (PO- 1, 2, 3, 4, 7, 12, PSO- 1)
4. Design based on the knowledge of processing of crude petroleum and petro chemicals. (PO- 1, 2, 3, 4, 7, 12, PSO- 1)
5. Develop flow chart and explain the production of polymer based chemicals, rubber and miscellaneous industries. (PO- 1, 2, 3, 4, 7, 12, PSO- 1)

INTELLECTUAL PROPERTY RIGHTS

Course Code: CH54 **Credits:** 3:0:0
Prerequisites: Nil **Contact Hours:** 42L
Course Coordinator/s: Mr. Sagar J S

Course content

Unit I

Introduction to IPR: Globalization, Knowledge era, History of IPR.

Different forms of IPR – Copy Rights, Trade Marks, Industrial designs, Patents and Trade secrets; Role of IPR in Research and Development.

Design: Designs that can be registered, Procedures of registration.

Unit II

Patents: patent as an intellectual property, Brief history of patents-Indian and global scenario, Principles underlying Patent law.

Ideas: Generation and review of ideas, process and Product Patents.

Unit III

Procedure for Obtaining Patent: Patent Contents – Patent Drafting: Filing requirements.

Case Studies on Patents: Related to chemical and allied industries

Unit IV

Trademarks: Nature, Essentials, Protection, Trademarks **(**contd.) Service marks and Laws.

Case Studies on Trademarks: Related to chemical and allied industries.

Unit V

Copy Right: Characteristics and Requirements; Neighbouring rights, Ownership; Infringement of Copy right.
Case Studies on Copy Rights: Related to chemical and allied industries.

Text Book:

1. Wadehra, B.L., Law relating to Patents, Trademarks, Copyright, Designs and Geographical Indications, 2nd Edition, Universal Law publishing Co. Pvt. Ltd., 2002.

Reference Books:

1. Prabudha Ganguli, Intellectual Property Rights, Tata McGraw Hill Publishing Co. Ltd., 2001.
2. Manish Arora, Guide to Patents Law, 4th Edition, Universal Law Publishing Co. Pvt. Ltd., 2007.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Understand the role of IPR and its importance. (PO-8, 10, 12 PSO-3)
2. Understand Indian and global scenario of patents. (PO-8, 10, 12 PSO-3)
3. Search for patents and apply for the same. (PO-8, 10, 12 PSO-3)
4. Understand the nature and protection of trade marks. (PO-8, 10, 12 PSO-3)
5. Understand the requirements and infringement of Copyright. (PO-8, 10, 12 PSO-3)

PETROLEUM TECHNOLOGY

Course Code: CHE551 **Credits:** 3:0:0
Prerequisites: Nil **Contact Hours:** 42L
Course Coordinator/s: Chemical Engineering Faculty

Course content

Unit I

Indian Petroleum industry: Prospects & Future. Major companies. World production, Markets, Offshore and onshore, Oil well technology.

Composition of crude: Classification. Evaluation of petroleum. UOP-k factor, TBP analysis, EFV analysis. Average boiling point. ASTM curves. Thermal properties of petroleum fractions.

Product properties and test methods: Gas. Various types of gas and LPG. Reid vapour pressure analysis. Gasoline and naphtha. Octane No. Oxidation stability.
Additives for gasoline. Kerosene. Characterization for flash point or fire point, volatility, burning qualities etc., Diesel, octane testing, viscosity etc. Grades of diesels e.g. HSD, LDO. Diesel additives. Lube oils: Types, tests-carbon residue and viscosity index

Unit II

Crude pre-treatment: Pumping of crude oils. Dehydration of crude by chemical, gravity, centrifugal, electrical de-salter and comparison of each. Heating of crude-heater, different types of pipe still heaters including box type, cylindrical etc. Crude distillation, arrangement of towers for various types of reflux. Design aspects for atmospheric and vacuum column. Atmospheric distillation unit: internals and operational.

Unit III

Treatment techniques: Types of impurities present and various desulphurisation processes. Production and treatment of LPG.LNG technology. Sweetening operations for gases including merox, ethanolamine, copper chloride, Stretford etc. Catalytic de sulphonisation. Treatment of kerosene, De-aromatisation and merox. Treatment of diesel, naphtha: desulphurisation by hydrogen and catalysts. Treatment of lubes: sulphuric acid, clay treatment, solvent treatment-phenol, furfural.

Unit IV

Thermal Processes: Thermal cracking reactions- theory of thermal cracking. Properties of cracked materials and factors influencing the properties of cracked materials. Visbreaking, dubbs two coil cracking process.

Catalytic cracking: Comparison of thermal and catalytic cracking. Carbonium ion chemistry. Feedback requirements. Cracking conditions. Commercial cracking analysis. Various catalytic cracking processes. Fixed bed crackers. Moving bed crackers. Fluid catalytic cracking-flexi cracking-ortho-flow reactor. Theory of coking: various types of coking processes. Delayed coking, fluid coking, contact coking, flexi coking. Naphtha cracking, naphtha cracking for ethylene as feed selection and gas yield. Hydro cracking. Theory of hydro cracking. Catalysts for hydro cracking.

Unit V

Catalytic reforming: Theory of reforming. Factors influencing, reforming, reforming catalysts, feedstock requirements. Platforming, isoplushondriforming, refining forming, power forming and flexi forming.

Text Books:

1. Nelson, Petroleum Refinery Engineering, 4th Edition, McGraw Hill, 1964.
2. Bhaskara Rao, Modern Petroleum Refining Processes, 3rd Edition, Oxford and IBH, 1997.

Reference Books:

1. Desikan and Sivakumar, Unit Processes in Organic Chemical Industries (Eds.), CEDC, IITM, 1982.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Classify the crude and understand the composition. (PO-1, 2, 3, PSO-1, 2)
2. Explain crude pretreatment methods and operations involved in it. (PO-1, 3, PSO- 2)
3. Explain various impurities present in the crude and methods for their treatment to produce useful products like LPG, LNG, Gasoline, lube etc (PO-2, 3, 4 PSO-1, 2)
4. Explain various petroleum cracking processes. (PO-2, PSO- 2)
5. Explain crude processing methods. (PO-1, 3, PSO- 1)

BIOCHEMISTRY

Course Code: CHE552 **Credits:** 3:0:0
Prerequisites: Nil **Contact Hours:** 42L
Course Coordinator/s: Chemical Engineering Faculty

Course content

UNIT-I

Introduction to Biomolecules: Carbohydrates, Fats and lipids, Amino acids and Proteins. Structure, Properties and Classification. Biologically important peptides, Purines, pyrimidines, nucleotides, Nucleic Acids- DNA and RNA.

UNIT-II

Bioenergetics & Transport Mechanism: Energy, energy flow cycle, Structure and properties of ATP. High energy compounds, Coupling reactions of ATP and NAD. Biological membranes: structure, permeability, properties, passive transport and active transport, facilitated transport, energy requirement, mechanism of Na+ / K+, glucose and amino acid transport. Organization of transport activity in cell.

UNIT-III

Carbohydrate Metabolism: Glycolysis – Aerobic and anaerobic pathway and energetics, TCA cycle and its regulation, Calvin Cycle, Glyoxylate cycle, Pentose Phosphate Pathway. Electron transport chain and oxidative phosphorylation, Gluconeogenesis –regulation of gluconeogenesis. Biosynthesis of polysaccharides.

UNIT-IV

Lipid Metabolism: Biosynthesis of fatty acids, Fatty acid synthase, Biosynthesis of cholesterol, phospholipids, glycolipids. Biodegradation of fatty acids-beta oxidation pathway and its energetics.

UNIT-V

Amino Acid & Nucleotide Metabolism: Biosynthesis of amino acids starting from acetyl CoA (with reference to oxaloacetate family). Biodegradation of amino acids, deamination, transamination and urea cycle. Biosynthesis, and biodegradation of Purine & pyrimidine nucleotides: Denova pathway, salvage pathway. Regulation of nucleotide metabolism.

Textbooks:

1. David L. Nelson, Michel M. Cox (2008) Lehninger Principles of Biochemistry,4th Edn., Palgrave Macmilan, W H Freeman Publisher, Newyork, USA.

2. Jereny M. Berg, John L. Tymoczko, Lubert Stryer (2006) Biochemistry, 6th Edn. W H Freeman Publisher, New York, USA.

Reference Books

1. Donal J. Voet, Judith G. Voet, Charlotte W. Pratt (2005) Fundamentals of Biochemistry, Upgrade Edn. Wiley Publishers, New York, USA.
3. Robert K Murray, Daryl K Granner, Peter A Mayes (2006) Harper's Illustrated Biochemistry 27th Edn. McGraw Hill Book Company, USA.

Course Outcomes (COs):

On completion of this course student will have improved ability to

1. Classify the macromolecules and analyse the structure, functions and their properties. (PO-1; PSO-1)
2. Differentiate between various biological transport processes and bioenergetics. (PO-1, 2, 4; PSO-1)
3. Analyse the importance of carbohydrate metabolism in human body. (PO-1, 4; PSO-1)
4. Analyse the importance of Lipid metabolism in human body. (PO-1; PSO-1)
5. Analyse the importance of Amino acid and nucleotide metabolism in human body. (PO-1; PSO-1)

APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

Course Code: CHE553 **Credits**: 3:0:0
Pre-requisites*:* Engineering Mathematics I, II, III **Contact Hours**: 42L
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)

PRINCIPLES OF MANAGEMENT

Course Code:CHE554 **Credits**:3:0:0
Pre-requisites*:* Nil **Contact Hours:** 42L
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, 17th 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)

INDUSTRIAL WASTE WATER TREATMENT

Course Code: CHE555 **Credits:** 3:0:0
Prerequisites: Engineering Chemistry& Environmental Studies **Contact Hours:** 42L
Course Coordinator/s: Chemical Engineering Faculty

Course content

Unit I

Waste water Engineering – An Overview, Environmental laws pertaining waste water. Norms and standards of treated water.

Sources, sampling and analysis of wastewater: Water resources. Origin of wastewater. Evaluation, classification and characterization of wastewater. Physical and chemical characteristics. BOD, COD and their importance. Types of water pollutants and their effects. Sampling, and methods of analysis. Analysis and selection of waste water flowrates and constituent loadings.

Unit II

Process Analysis and selection – Reactors used, Types, applications, mass balance analysis, modeling ideal flow reactors, non-ideal flow in reactors, modeling treatment process kinetics – batch reactor, complete mix reactors, ideal plug flow reactor, treatment involving mass transfer – gas-liquid mass transfer, liquid-solid mass transfer, Process selection based on reaction kinetics, selection based on mass transfer, selection based on loading criteria, batch tests, pilot plant studies, reliability considerations in process selection.

Unit III

Wastewater treatment: Preliminary, primary, secondary and tertiary treatments of wastewater. Sludge treatment and disposal. Modern treatment methods. Recovery of materials from process effluents.

Unit IV

Biological treatment: Types, biomass growth rates, modeling suspended growth treatment processes, anaerobic fermentation and oxidation.

Unit V

Applications to Industries: Origin, characters, and treatment methods of typical industries – petroleum refinery, pulp and paper, fertilizer, distillery, and textile processing.

Text Books:

1. Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, Environmental Engineering, Mc Graw Hill, 1985
2. Rao, C.S., Environmental Pollution Control Engineering, New Age International, Reprint 2002.
3. Mahajan, S.P., Pollution Control in Process Industries, Tata McGraw Hill, 1999.

Reference Books:

1. Perkins, H.C., Air Pollution, McGraw Hill, 1974.
2. Metcalf and Eddy, Waste Water Engineering, Treatment, Disposal & Reuse, Tata McGraw Hill, 4th Edition, 2003.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Explain the types of pollutions and their sources and analyze effects of pollutants in water. (PO-1, 2, 3, 4, 6, 7, PSO-1)
2. Design waste water treatment plants depending on the type of industrial waste waters. (PO-1, 2, 3, 4, 6, 7, PSO-1)
3. Identify the sources of air pollution by carrying out air sample analysis and suggest schemes for its prevention. (PO-1, 2, 3, 4, 6, 7, PSO-1)
4. Suggest schemes for processing municipal and industrial solid-wastes. (PO-1, 2, 3, 4, 6, 7, PSO-1)
5. Determine noise levels and suggest suitable technique for abatement of noise levels. Explain industrial process safety needs based on the history and operation methods of a process industry. (PO-1, 2, 3, 4, 6, 7, PSO-1)

HAZARD ANALYSIS AND RISK MANAGEMENT

Course Code: CHE556 **Credits:** 3:0:0
Prerequisites: Nil **Contact Hours:** 56L
Course Coordinator/s: Chemical Engineering Faculty

Course content

Unit I

Plant Hazards: Fire hazards. Chemical hazards, Toxic hazards, Explosion hazards, Electrical hazards, Mechanical hazards, Radiation hazards, Noise hazards. Control, precautions & prevention, Safety measures in plant.

Unit II

Fire hazards, Chemical hazards, Toxic hazards, Explosion hazards, Electrical hazards, Mechanical hazards, Radiation hazards, Noise hazards, Control, precautions & prevention, Safety measures in plant.

Unit III

Storage & Transportation of chemicals: Characteristics of chemical with special reference to safe storage & handling of chemicals, Layout of storage, various modes of transport and Safety precautions in transportation of different types of chemicals.

Unit IV

Risk Analysis Techniques: Hazard & Operability (HAZOP) studies, Hazard Analysis (HAZAN), Fault Tree Analysis, and Consequence Analysis.

Unit V

Onsite and Offsite emergency management plans. Human Error Analysis. Accident Error Analysis. Economics of Risk Management.

Text Book:

1. K. V. Raghavan and AA. Khan, Methodologies in Hazard Identification and Risk Assessment, Manual by CLRI, 1990.
2. V. C. Marshal, Major Chemical Hazards, Ellis Horwood Ltd., Chichester, 1987.
3. Sam Mannan, Lees, Loss Prevention in the Process Industries, Hazard Identification, Assessment and Control, 4th Edition, Butterworth Heineman, 2012.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Classify and identify hazards in chemical industries. (PO-1, 2, 3, 7, PSO, 1)
2. Explain various types of hazards in process industry. (PO-1, 2, 3, 7, PSO, 1)
3. Apply precautions in chemical storage and handling. (PO-1, 2, 3, 7, PSO, 1)
4. Perform fault tree and event tree risk analysis and quantify them. (PO-1, 2, 3, 7, PSO, 1)
5. Train plant personnel and prepare emergency management plans. (PO-1, 2, 3, 7, PSO, 1)

CHEMICAL REACTION ENGINEERING LAB

Course Code: CHL56 **Credits:** 0:0:1
Prerequisites: Chemical Reaction Engineering **Contact Hours:** 14P
Course Coordinator/s: Dr. V. Sravanthi

Course content

List of experiments suggested:

1. Batch Reactor
2. Isothermal plug flow reactor
3. Mixed flow reactor
4. Semi batch reactor
5. Heterogeneous catalytic Reactor
6. Segregated flow reactor
7. Adiabatic Reactor
8. Packed bed Reactor
9. RTD Studies in Tubular Reactor
10. Effect of temperature on Rate of reaction
11. Bio Chemical Reaction (Batch)
12. Enzyme catalyzed reactions in batch reactor
13. RTD Studies in mixed flow reactor
14. Sono-chemical reactor
15. Photochemical reactor

Course Outcome (COs):

The student will be able to

1. Understand the kinetics of the reaction. (PO- 1, 2, 4, 9, 11, PSO- 1, 3)
2. Evaluate the activation energy of the reactions. (PO- 1, 2, 4, 9, 11, PSO- 1, 3)
3. Evaluate the non-ideality in the reactors. (PO- 1, 2, 4, 9, 11, PSO- 1, 3)

COMPUTATIONAL METHODS LAB

Course Code: CHL57 **Credits:** 0:0:1
Prerequisites: Engineering Mathematics IV, Fundamentals of Computing **Contact Hours:** 14P
Course Coordinator/s: Dr. Brijesh

Course content

List of programmes:

1. MATLAB – Matrices/ Polynomials/ Integral/ Differential/ Plots
2. Data handling and regression using MS-Excel
3. Non-linear algebraic equation
4. Problems on general material balance
5. Numerical Integration- Simpson's 1/3 Rule
6. Ordinary Differential Equation- R-K Method
7. Curve Fitting-Least Square
8. Calculation of Bubble Point and Dew Point for Ideal multi-component system
9. P-x,y and T-x,y data generation from the given vapor pressure data
10. Flash Vaporization for multi-component system
11. Design of Batch Reactor/ PFR/ CSTR
12. Double pipe heat exchanger (Area, Length and Pressure drop)

Course Outcome (COs):

On successful completion of the course students will be able to

1. Analyze chemical engineering problems by using numerical methods. (PO- 1, 2, 3, 4, 5, PSO-2)
2. Write programs in C for solving problems using computational techniques and execute them in laboratory. (PO- 1, 2, 3, 4, 5, PSO-2)
3. Write programs in MATLAB for solving problems using computational techniques and execute them in laboratory. (PO- 1, 2, 3, 4, 5, PSO-2)

PROCESS EQUIPMENT DRAWING

Course Code: CHL58 **Credits:** 0:0:1
Prerequisites: Engineering Graphics **Contact Hours:** 14P
Course Coordinator/s: Dr. J. Koteswararao

Course content

List of drawings to be prepared using AutoCAD

1. Types of Joints – Flange, Union, Cotter
2. Vessel Components - Types of Heads, Types of Nozzles, Types of Supports, Agitators, Stuffing Box
3. Valves – Ball, Stop, Globe, Gate
4. Equipment - Reaction Vessel, Distillation Column, Evaporator, Shell and Tube Heat Exchanger
5. Piping and Instrumentation Diagrams

Course Outcome (COs):

On successful completion of the course students will be able to

1. 1. Prepare Engineering Drawing using AutoCAD. (PO- 2, 3, 5, PSO-2)
2. Show details of Process Equipment through Drawings. (PO- 2, 3, 5, PSO-2)
3. Draw P&ID for chemical operations. (PO- 2, 3, 4, 5, PSO-2)

OPEN ELECTIVE OFFERED BY THE DEPARTMENT

SOLID WASTE MANAGEMENT

Sub Code: CHOE01 **Credits**: 3:0:0
Pre-requisites: Environmental Engineering **Contact Hours**: 42L
Course coordinator*:* Dr.Rama Sivakiran reddy

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)

VI Semester

PROCESS EQUIPMENT DESIGN AND DRAWING	
Course Code: CH61	**Credits:** 2:1:1
Prerequisites: Chemical Process Calculations Process Heat Transfer, Mass Transfer-I and II	**Contact Hours:** 28L+14T+14P
Course Coordinator/s: Dr. G M Madhu	

Course content

Detailed chemical engineering process and mechanical design of the equipment:
Pressure vessel - Jacketed vessel, Double pipe Heat exchanger, Shell & Tube Heat exchanger, Condensers – Horizontal and vertical, Evaporator – Single effect, Distillation Column, Packed Bed Absorption Column, Rotary Dryer.
Standard Code books to be used. The detailed dimensional drawings shall include sectional front view, Full Top/side view depending on equipment and major component drawing with dimensioning using AutoCAD software.

Reference Books:

1. Joshi, M.V., Process Equipment Design, Macmillan India, 1991.
2. Brownell, L.E. and Young, E.H., Process Equipment Design - Vessel Design, John Wiley and Sons, Inc.1959.
3. Ludwig, E.E., Applied Process Design for Chemical and Petrochemical Plants, Vol. 1 and 2, 3rd Ed., Gulf Publishing Co. 1997.
4. Indian Standards Institution, Code for Unfired Pressure Vessels, IS – 2825.
5. Bhattacharya, B.C, Introduction to Chemical Equipment Design, CBS Publications, 1985.
6. Perry's Chemical Engineers Handbook.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Design Heat Transfer Equipment's as per standard procedure. (PO- 2, 3, PSO-1, 2)
2. Design Mass Transfer Equipment's. (PO- 2, 3, PSO-1, 2)
3. Design pressure vessels and other equipment's with reference to IS Standards. (PO- 2, 3, PSO-1, 2)

PROCESS CONTROL

Course Code: CH62 **Credits**: 3:1:0
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 derivatives, solution of differential equations, inversion by partial fractions, partial fractions.
First and second order systems: Thermometer, level, mixing tank, STR: Linearization: I order systems in series. Response for various input forcing functions. Second order transfer functions. Characteristics. Response for various input forcing functions. Transportation lag.

Unit II

Control Systems and Controllers: Basic components, Servo and Regulator control. P.I.D and on-off modes. Controller combinations.
Close Loop: Block diagrams. Closed loop transfer function.
Transient response of servo and regulator control systems with various controller modes and their characteristics**.**

Unit III

Final Control Elements: Valves, actuators, valve positioners, valve characteristics.
Stability of loops: Stability of open and closed loop linear control systems. Routh Test, Root locus plotting.
FOPTD Models: Skogestad's half rule for approximate first order plus dead time models

Unit IV

Frequency Response – Amplitude ratios, phase lags, Gain and Phase Margins. Bode diagrams, Bode criterion.
Control system Design: Ziegler – Nichols tuning by frequency response. Cohen-Coon tuning by process reaction curve.

Unit V

Advanced Control Strategies: Cascade Control, Feed Forward Control. Ratio Control. Introduction to digital control, analysis of basic transfer functions in z-domain.

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 and II order systems. (PO-1, 2, PSO-1)
2. Analyze control system and controllers & analyze the transient response of feedback systems. (PO-1,2,3, PSO-1)
3. Design stable control systems for processes. (PO-1,2, PSO-1)
4. Understand Frequency Response and tune controllers. (PO-1,2,3, PSO-1)
5. Learn different advanced control strategies (PO-1,5, PSO-1)

NATURAL GAS ENGINEERING AND TRANSPORTATION

Course Code: CHE631 **Credits:** 3:0:0
Prerequisites: Petroleum Technology **Contact Hours:** 42L
Chemical Engineering Thermodynamics
Course Coordinator/s: Chemical Engineering Faculty

Course content

Unit I

Introduction: Overview of the gas industry and gas processing, Field operations and inlet receiving.
Gas Compression: Methods of gas compression, thermodynamic considerations.

Unit II

Fundamentals of vapour-liquid equilibrium and distillation, Gas hydrates, Gas dehydration.

Unit III

Cryogenic extraction of natural gas liquids (NGL). Minor component (nitrogen, helium, mercury, and BTEX) recovery or removal. Acid Gas (hydrogen sulfide and carbon dioxide) removal.

Unit IV

Sweetening and dehydration of condensate and natural gas liquids (NGL).
Sulfur recovers with the Claus process, Tail gas clean-up.

Unit V

Acid gas injection. Liquefied natural gas (LNG), production, storage, transportation, and regasification.

Text Books:

1. Katz, D. L. and Lee, R.L., Natural Gas Engineering, McGraw Hill, 1990.

Reference Books:

1. Kidnay, A.J., Parnish, W.R., Dekker, Fundamentals of Natural Gas Processing, McGraw Hill.
2. Mokhatab, S., Handbook of Natural Gas Transmission and Processing.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Explain the basic principles of gas compression. (PO-1, 2, 3, 7, PSO-1)
2. Understand various methods of gas dehydration. (PO-1, 2, 3, 7, PSO-1)
3. Explain gas treatment processes and impurity removal methods. (PO-1, 2, 3, 7, PSO-1)
4. Design to the gas processing and transportation system. (PO-1, 2, 3, 7, PSO-1)
5. Understand LNG production and processing. (PO-1, 2, 3, 7, PSO-1)

MOLECULAR BIOLOGY

Course Code: CHE632 **Credits**: 3:0:0
Pre-requisites*:* Biological Chemistry **Contact Hours**: 42L
Course coordinator: Chemical Engineering Faculty

Course Content

Unit-I

Introduction to Molecular Biology and DNA Replication: Scope of molecular biology. Genomes- genetic material, gene structure and functions. Concept of central dogma of molecular biology. Replication: origin and site and structure DNA polymerases, composition and features, replication factors.

Unit-II

The mechanism of replication, leading strand and lagging strand synthesis, Termination replication. Eukaryotic-replication origins, DNA polymerases and their composition, replication initiation complexes and their assembly, licensing factors, telomerase and mode of action, replication factors, Replication fidelity.

Unit-III

Prokaryotic Transcript: Promotor and their structure, *E. coli* RNA polymerase, Initiation, functions of σ factors, elongation, and termination. Eukaryotic transcription: types of RNA polymerases and promoters. RNA Pol II structure and subunit functions. General transcription factors, mechanism of Initiation, elongation, termination, rRNAs; Structural features of rRNAs- prokaryotic and eukaryotic. tRNAs: structural features, their anticodon feature. mRNAs- prokaryotic and eukaryotic mRNAs, structural feature.

Unit-IV

RNA Processing: exons & introns, splicing, spliceosomes, snRNPs, self-splicing introns, Alternative splicing, capping, polyadenylation. RNA editing, Trans splicing.
Translation: Ribosome structure & function, mechanism of prokaryotic and eukaryotic translation, role of initiation elongation and termination factors, genetic code. Protein folding: molecular chaperon, HSP 70 and Gro EL/Groes complex. Post translational modification:

Unit-V

Regulation of prokaryotic genes expression: Operons and their types, Regulation of Lac operon, Tryptophan operon. Genetic regulation of sporulation in *B. subtilis*, role of sigma factors in sporulation. Role of sigma factor in Regulation of lytic and lysogenic pathway in phage, Expression and regulation of early and late genes, Role of upstream activating sequences and regulatory proteins.

Regulation of eukaryotic gene expression: Levels of gene regulation, DNA binding proteins. Chromatin remodelling. Translational control of gene expression. Gene silencing- anti-sense RNA, RNAi. Protein degradation and turnover

Text book:

1. Watson JD. et al. (2014) Molecular Biology of the Gene, Pearson Education, Inc USA
2. Bruce A. et al (2007) Molecular Biology of the Cell, 5th edition, Garland science, New York, USA**.**

References book:

1. Verma P.S. and Agarwal VK (2005) Cell Biology, Genetics, Molecular Biology, Evolution and Ecology S. Chand & company Ltd. New Delhi India.
2. Hardin J et al. (2012) Becker's World of the Cell VIII edn. Pearson Benjamin Cummings, San Francisco, USA
3. Genes IX. 9th ed. B. Lewin. Jones and Bartlett Publishers, 2007.
4. Robert F. Weaver, Molecular Biology 3rd Edition, McGraw-Hill, 2003.

Course Outcomes (COs):

After the completion of the course student will be able:

1. To understand about molecular biology and DNA replication
2. To acquire knowledge of DNA replication and differentiate various steps and mechanism involved replication of prokaryotic and eukaryotic DNA. (PO-1 and PO-2 PSO- 1 and PSO-2)
3. To compare and analyse mechanism of prokaryotic and eukaryotic transcription and translation. (PO-1 PSO- 1 and PSO-2)
4. To compare and analyse mechanism of prokaryotic and eukaryotic translation. (PO-1 PSO- 1 and PSO-2)
5. To describe various levels of gene expression regulation and compare and contrast the mechanism involved in regulation prokaryotic and eukaryotic gene expression (PO 1 and PO-4 PSO- 1 and PSO-2)

MODELING OF CHEMICAL PROCESSES

Course Code: CHE633 **Credits**: 3:0:0
Pre-requisites*:* Engineering Mathematics I and II, Momentum Transfer, Process Heat Transfer, Chemical Reaction Engineering-I, Chemical Process Calculations **Contact Hours**: 42L
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)

OPERATIONS RESEARCH

Course Code: CHE634 **Credits:** 3:0:0
Prerequisites: Engineering Mathematics I and II **Contact Hours:** 42L
Course Coordinator/s: Chemical Engineering Faculty

Course content

Unit I

Introduction: Definition. Scope of Operations Research (OR). Approach and limitations of O.R. Models. Characteristics and phases of O.R.

Linear Programming Problems: Mathematical formulation of L.P. Problems. Graphical solution method.

The Simplex Method: 1 & 2 – slack, surplus and artificial variables. Dual simplex method. Degeneracy and procedure for resolving degenerate cases.

Unit II

Assignment problems: Balanced and Unbalanced assignment problems. Maximization assignment problems. Travelling salesman problems.

Transportation Problem: Basic feasible solutions by different methods. Finding optimal solution. MODI method. Degeneracy. Unbalanced transportation problems. Maximization Problems.

Unit III

Sequencing: Johnson's algorithm. n jobs - 2 machines, n jobs -3 machines, and n jobs-n machines without passing sequence. 2 jobs-n machines. Graphical solutions.

Deterministic Models: Inventory, EOQ Models. With and without shortages. Ordering cost. Carrying cost.

Unit IV

PERT-CPM Techniques: Network construction. Determining critical path. Variance and probability of completing the project. Calculation of different floats. Project duration. Crashing of simple networks.

Unit V

Replacement model: Replacement of items which fails completely-individual replacement, group replacement. Replacement of items where maintenance cost increases with time and the value of money changes with time.

Text Books:

1. Srinath, L. S., Introduction to Pert and CPM, 3rd Edition, East West, 1998.
2. Kantiswaroop, Gupta, P. K. and Manmohan, Operation Research, 9th Edition, S Chand & Co., 1999.

Reference books:

1. Sharma, S. D., Operation Research, 8th Edition, Kedarnath & Co, 2003.

Course Outcomes (COs):

On successful completion of the course students will be able to

1. Develop the linear mathematical models for and solve them for their maximization and minimization using graphical and analytical methods. (PO-1, 2, 11, PSO-3)
2. Solve Balanced and Unbalanced Assignment problems and Transportation problems for Maximization and Minimization. (PO-2, 11, PSO-3)
3. Solve problems on Sequencing of jobs in n machines and Inventory for cost analysis. (PO-2, 11, PSO-3)
4. Develop Network construction and determining critical path, Variance and probability of completing the project by PERT-CPM method. (PO-2, 11, PSO-3)
5. Develop model for replacement of individual items, group replacement and maintenance cost analysis. (PO-2, 11, PSO-3)

AIR POLLUTION CONTROL

Course Code: CHE635 **Credits:** 3:0:0
Prerequisites: Industrial Waste Water Treatment **Contact Hours:** 42L
Course Coordinator/s: Chemical Engineering Faculty

Course Content

Unit I

Introduction, Sources, Classification, Meteorology and air pollution, industrial plant location, Effects of air pollution on health, animals, plants, economic effects. Air Pollution Standards - Air quality and emission standards, Legislation and regulations.

Unit II

Air Pollutants, Chemical kinetics, Mass and Heat Transfer, Elements of Probability Theory, Turbulent mixing.

Unit III

Sampling procedures, Analytical techniques, Pollution due to automobile, photochemical air pollution. Aerosols.

Unit IV

Equipments for removal of particles from gas streams, smoke and its control, process changes.

Unit V

Removal of gaseous pollutants from effluent streams – Interfacial mass transfer, absorption of gases, absorption of gases on solids, SO_2 removal, NOx removal.

Text Book:

1. Richard C. Flagan, John H. Seinfeld, Fundamentals of Air Pollution Engineering, Prentice Hall
2. MN Rao, HVN Rao, Air Pollution, TMH, 1999.

SEPARATION TECHNIQUES

Course Code: CHE636 **Credits:** 3:0:0
Pre-requisites*:* Mass Transfer I and II **Contact Hours**: 42L
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, 5th 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)

POLYMER PROCESSING TECHNOLOGY

Course Code: CHE641 **Credits**: 3:0:0
Pre-requisites: Nil **Contact Hours**: 42L
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: CHE642 **Credits**:3:0:0
Pre-requisites: Chemical Engineering Thermodynamics **Contact Hours**: 42L
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)

PRINCIPLES OF FOOD PROCESSING AND PRESERVATION

Course Code: CHE643 **Credits:** 3:0:0
Pre-requisites: Nil **Contact Hours**: 42L
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, NewAge International, 2008.
2. Subbulakshmi, G., and Udupi, S.A., Food Processing and Preservation, 1st Edition**,** NewAge 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)

ELECTROCHEMICAL TECHNOLOGY	
Course Code: CHE644	**Credits:** 3:0:0
Pre-requisites*:* Engineering Chemistry	**Contact Hours:** 42L
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: Potentiometer 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, Cleaverhume 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)

INTRODUCTION TO NANOTECHNOLOGY

Course Code:CHE645 **Credits:**3:0:0
Pre-requisites*:* Material Science, Chemical Engineering Thermodynamics **Contact Hours**: 42L
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 nanomaterials, 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 Nanomanufacturing, 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: CHE646 **Credits**: 3:0:0
Pre-requisites*:* Engineering Mathematics IV **Contact Hours**: 42L
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, 2nd 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)

DESIGN PROJECT / MINI PROJECT/NPTEL COURSE

Course Code:CH65 **Credits:** 0:0:4
Prerequisites: Chemical Process Calculations, Process Equipment Design and Drawing **Contact Hours:** 8
Course Coordinator/s: Chemical Engineering Faculty

Course content

A group of students will be assigned a 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 will be allocated in the beginning of the sixth semester and the problem on design of a process is identified. The project group should complete design project and use software ASPEN PLUS or HYSYS for process simulation studies and submit the report at the end of the semester. The project will be evaluated by the guide and a project co-ordination committee to award the CIE marks as per the rubrics designed by the committee.

Student who is unable to register for Design Project or fails to clear design project can take up a 04 credit NPTEL course approved by the project coordinator of design project and HoD. The student must write the examination and produce the result certificate for the course.

Course Outcomes (COs):

The student should be able to

1. Carry out literature review on selected product and process. (PO- 2, PSO-1)
2. Write material balance, energy balance and thermodynamics for selected process. (PO- 1,2,3, PSO-1)
3. Design and select various equipment's for the process. (PO- 1,2,3,7 PSO-1, 2)
4. Carry out computational and economic analysis (PO- 1, 2, 3, 11, 12, PSO-1, 2, 3)
5. Contribute as team member and prepare precise project report with appropriate reference. (PO-8, 9, 10, 11, 12, PSO-3)

POLLUTION CONTROL LABORATORY

Course Code: CHL66 **Credits:** 0:0:1
Prerequisites: Nil **Contact Hours:** 14P
Course Coordinator/s: Dr. J Koteswararao

Course content

List of experiments:

1. Determination of pH, alkalinity of samples.
2. Determination of turbidity of sample using Nephelo turbidometer.
3. Determination of dissolved, suspended and volatile solids.
4. Optimum coagulant dosage using Jar test.
5. Settle able and suspended particulate matter in air using high volume sampler.
6. Determine of chloride, iodide, nitrate ions in water samples using Ion selective electrode.
7. Determination of BOD.
8. Determination of COD.
9. Dissolved oxygen determination using DO meter.
10. Estimation of Copper in mining leachate using photo-colorimeter
11. MPN count.
12. Determination concentration of Sodium, Potassium, Calcium using flame photometer.
13. Determination of concentration of COx, SOx, NOx in air sample.
14. Analysis using FTIR
15. Estimation of Chromium using UV Vis Spectrophotometer.

Course Outcome (COs):

On successful completion of the laboratory course, the student will be able to

1. Characterize water in terms of the pollutants present in it and determine its quality. (PO- 2, 3, 4, 6, 7, 8, 12, PSO-1, 3)
2. Determine pollutants in air. (PO- 2, 3, 4, 6, 7, 8, 12, PSO-1, 3)
3. Use instruments to determine pollutant compositions. (PO- 2, 3, 4, 6, 7, 8, 12, PSO-1, 3)

MASS TRANSFER LABORATORY

Course Code: CHL67 **Credits:** 0:0:1
Prerequisites: Mass Transfer **Contact Hours:** 14P
Course Coordinator/s: Dr. Sravanthi

Course content

List of experiments suggested:

1. Diffusion of organic vapour in air
2. Simple Distillation
3. Packed column/ plate column distillation
4. Steam distillation
5. Solid – liquid leaching
6. Surface evaporation
7. Tray dryer
8. Adsorption studies
9. Liquid - Liquid /Vapour –Liquid equilibrium
10. Liquid extraction – (cross current: 1 and 2 or 3 stage)
11. Hold up studies in packed columns
12. Rotary/ vacuum dryers
13. Wetted wall column
14. Cooling tower
15. Solid dissolution

Course Outcome (COs):

The student will be able to

1. Understand the working principles of mass transfer equipment's. (PO-1, 2, 3, PSO-1, 3)
2. Evaluate the performance of mass transfer equipment's. (PO-1, 2, 3, PSO-1, 3)
3. Select and design mass transfer equipment's. (PO-1, 2, 3, PSO-1, 3)

SIMULATION LABORATORY

Course Code: CHL68 **Credits:** 0:0:1
Prerequisites: Nil **Contact Hours:** 14P
Course Coordinator/s: Dr.Rama Sivakiran reddy

Course content

List of simulations suggested:

1. Introduction to suggested software available (flow sheeting)
2. Simulations Studies of flash drum, Distillation Column, CSTR, PFR, Heat Exchanger.
3. Simulation Studies of pump, compressor, cyclone, heater.
4. Process simulation study involving mixing, reactor, distillation, heat exchanger for any of the following;
   a. Ethylene Glycol from Ethylene oxide
   b. Propylene Glycol from Propylene oxide
   c. Aromatic stripper with recycle stream (Benzene, Toluene, Xylene)
   d. Cyclohexane
   e. Ethanol Amine

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

Course Outcome (COs):

On successful completion of the course students will be able to

1. Apply 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)

OPEN ELECTIVE OFFERED BY THE DEPARTMENT

GREEN TECHNOLOGY

Course Code:CHOE01	**Credits**: 3:0:0
Pre-requisites*:* Engineering Chemistry	**Contact Hours:** 42L
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)