AC 26/02/2015 Item no. 4.62

UNIVERSITY OF MUMBAI

Revised Syllabus
Program – **Bachelor of Engineering**
Course – **Chemical Engineering**
(Final Year – Sem VII and VIII)

under
Faculty of Technology
(As per Credit Based Semester and Grading System from 2015-16)

General Guidelines

Tutorials

- The number of tutorial batches can be decided based on facilities available in the institution.
- Tutorials can be creative assignments in the form of models, charts, projects, etc.

Term Work

- Term work will be an evaluation of the tutorial work done over the entire semester.
- It is suggested that each tutorial be graded immediately and an average be taken at the end.
- A minimum of ten, or as specified in syllabus, tutorials will form the basis for final evaluation.
- The total marks for term work(except project and seminar) will be awarded as follows:

Assignments etc.	20
Attendance	05

Further, while calculating marks for attendance, the following guidelines shall be adhered to:

75 % – 80%.	03
81% – 90%	04
91% onwards	05

Theory Examination

- In general all theory examinations will be of 3 hours duration.
- Question paper will comprise of total six questions, each of 20 Marks.
- Only four questions need to be solved.
- Question one will be compulsory and based on as much of the syllabus as possible.

Note: In question paper, weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus as far as possible.

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Project & Seminar Guidelines

- Project Groups: Students can form groups with not more than 3(Three) per group.
- The load for projects may be calculated as below,

  Sem VII: $\frac{1}{2}$hr for teacher per group.

  Sem VIII: 1 hr for teacher per group.

- Maximum of four groups can be allotted to a faculty.
- Seminar topics will be the consensus of the project guide and the students. Each student will work on a unique topic.
- The load for seminar will be calculated as one hour per week irrespective of the number of students.
- Students should spend considerable time in applying all the concepts studied, into the project. Hence, eight hours each were allotted in Project A,B and three hours for Seminar to the students.

University of Mumbai

Scheme for BE: Semester-VII

Subject Code	Subject Name	Teaching Scheme			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CHC701	Process Equipment Design (PED)	03	–	01	3.0	–	1.0	4.0
CHC702	Process Engineering	03	–	01	3.0	–	1.0	4.0
CHC703	Process Dynamics & Control (PDC)	03	–	01	3.0	–	1.0	4.0
CHE704	Elective – II	04	–	–	4.0	–	–	4.0
CHP705	Project – A	–	–	08	–	–	3.0	3.0
CHS706	Seminar	–	–	03	–	–	3.0	3.0
CHL707	Chemical Engg Lab (PED)	–	03	–	–	1.5	–	1.5
CHL708	Chemical Engg Lab (PDC)	–	03	–	–	1.5	–	1.5
	Total	13	06	14	13.0	3.0	9.0	25.0

Examination Scheme

Subject Code	Subject Name	Examination Scheme							
		Theory marks				Term Work	Pract.	Oral	Total
		Internal Assessment			End Sem. Exam				
		Test 1 (A)	Test 2 (B)	Avg.of (A) & (B)					
CHC701	Process Equipment Design (PED)	20	20	20	80	25	–	–	125
CHC702	Process Engineering	20	20	20	80	25	–	–	125
CHC703	Process Dynamics & Control (PDC)	20	20	20	80	25	–	–	125
CHE704	Elective – II	20	20	20	80	–	–	–	100
CHP705	Project – A	–	–	–	–	100	–	50	150
CHS706	Seminar	–	–	–	–	50	–	–	50
CHL707	Chemical Engg Lab (PED)	–	–	–	–	–	–	25	25
CHL708	Chemical Engg Lab (PDC)	–	–	–	–	–	25	25	50
			Total	80	320	225	25	100	750

Elective Streams(CHE704)

Sem.	**Management Stream**	**Technology Stream**	**Process System Engineering Stream**
VII	High Performance Leadership	• Polymer Technology • Petroleum Refining Technology	• Advanced Process Simulation

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHC701	Process Equipment Design	3.0	1.0	4.0

Prerequisites

Fundamentals of units. Elementary theory of engineering mechanics. Engineering drawing. Knowledge of Heat Transfer, Mass Transfer, Mechanical Operations and Mechanical Equipment Design.

Course Objectives

- To understand the basics for design as per the codes & standards for the mechanical design of equipments used in the process industry.
- Selection of material of construction and stress analysis by determining values of stresses arising out of different loading conditions.

Course Outcomes

- Student will demonstrate ability to carry out complete chemical engineering project.
- Students will demonstrate ability to design process equipments as heat exchanger, distillation column, high pressure vessels etc.

Detail syllabus

Module	Contents	No. of hrs
1	**Introduction:** The organisation of a chemical engineering project. Flow sheet presentation i) Block diagram ii) Pictorial representation iii) Presentation of stream flowrates. iv) Information to be included. v) Plant layout. The P & I diagram i) Symbols and layout. ii) Basic symbols. Computer Aided Design Softwares. Material safety data sheet.	03
2	**Heat Exchangers:** Introduction. Codes and Standards for heat exchangers. Material of construction. Design of shell and tube heat exchanger (U-tube and fixed tube) as per IS: 4503 & TEMA standards i.e. shell, tube, tube sheets, channel and channel cover, flanged joints. Complete fabrication drawing for designed heat exchanger to a recommended scale. Design of standard vertical evaporator with design of calendria and tube, flange, evaporator drum & heads.	12
3	**Design of Tall Columns:** Stresses in column shell. Shell thickness determination at various heights. Elastic stability under compression stresses. Complete fabrication drawing for designed column to a recommended scale.	08

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Module	Contents	No. of hrs
4	**High Pressure Vessels:** Stress analysis for thick walled cylinders. Theories of elastic failure. Prestressing of thick walled vessels. Design of monoblock high pressure vessels. Multilayer high pressure vessel design and construction. Materials of construction for high pressure vessels.	12
5	**Introduction to Design of Crystallizers, Filters and Dryers:** Design considerations for Crystallizers, filters, absorption column, extractor and dryers (No numerical problems).	03
6	**Piping Design and Layout:** Pipe sizing for gases and liquids. Piping for high temperature. Piping layout and its factors under consideration. Design of buried and overhead pipeline.	02

TUTORIALS:

- Design procedure or example based on heat exchanger.
- Design procedure or example based on short tube vertical evaporator.
- Design procedure or example based on distillation column.
- Design procedure or example based on monoblock high pressure vessel.
- Design procedure or example based on multilayer high pressure vessel.

References

1. Process Equipment Design- Vessel Design by E. Brownell and Edwin, H. Young, John Wiley, New York 1963.

2. Chemical Engineering Vol 6-Design by J.M. Coulson, J.F.Richardson and P.K Sinnot, Pregamon press, International edition 1989.

3. Introduction to Chemical Equipment Design- Mechanical Aspects by B.C Bhattacharya, CBS Publications.

4. Process Equipment Design by M.V. Joshi, Macmillan India.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHC702	Process Engineering	3.0	1.0	4.0

Prerequisites

- The students should have knowledge of Heat transfer and Mass Transfer to carry out Mass and Energy balance around process.
- They should be aware about basic principles of economics to evaluate cost and profit of process.
- They should be familiar with process and mechanical design of Process equipments.
- They should be familiar with various types of plant utilities.

Course Objectives

- To provide training to solve problems relevant to the general practice of chemical engineering and design
- To provide students experience in conducting and in planning experiments in the modern engineering laboratory including interfacing experiments with computers as well as interpreting the significance of resulting data and properly reporting results in well written technical reports.
- To provide experience in the process of original chemical engineering design in the areas of equipment design, process design and plant design through the process of formulating a design solution to a perceived need and then executing the design and evaluating its performance including economic considerations and societal impacts if any, along with other related constraints, and culminating in both written and oral presentation of results.
- To provide students familiarity with professional issues in chemical engineering including ethics, issues related to the global economy and to emerging technologies ,and fostering of important job related skills such as improved oral and written communications and experience in working in teams at a number of levels.

Course Outcomes

- The graduates are expected to have ability to apply knowledge of mathematics, science and engineering.
- The graduates are expected to have ability to design a system, a component, or a process to meet the desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability and sustainability.
- The graduates are expected to possess ability to function on multi disciplinary teams.
- The graduates are expected to possess ability to identify, formulate and solve engineering problems.
- The graduates are expected to have an understanding of professional and ethical responsibility.
- The graduates are expected to engage themselves in lifelong learning.
- The graduates are expected to posses ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Detail syllabus

Module	Contents	No. of hrs
1	**An Overview of Process Engineering:** Process engineering and Chemical Engineering, Basic functions of Process Engineering: understanding and transferring licensor's know-how, development of P&ID, equipment selection and specifications, input to other engineering disciplines. Activities of Process engineering: Material and Energy balance, gathering data, establishing design basis, P&I diagram, control strategy, equipment specifications, deciding requirements of interlock shut down arrangement, piping requirement, civil and electrical requirements, acquiring knowledge of codes and standards, statutory requirements, safety study, preparing operating manuals, commissioning, interaction with other engineering disciplines, interaction with external agencies	01
2	**Preliminary Process Selection:** Economic evaluation of process: fixed and variable costs. Analysis of environmental concerns of process: rules & regulations of pollution control board, handling hazardous materials, etc. Safety analysis of process, Analysis of control structure of process, Flexibility analysis of process	01
3	**Selection of Process Steps:** Various types of diagrams to represent the process: block diagram, process flow diagram(PFD) , process and instrumentation diagram (P&ID), utilities line diagram. Basic steps in PFD synthesis: gathering information, representing alternatives, criteria for assessing preliminary design. PFD: objective, way of presentation, essential constituents (equipment symbols, numbers, names, process stream flow lines, utility designation, operating conditions, etc), optional constituents (energy exchange rates, physical properties of streams, etc) Way of presenting major equipments in PFD: vessels, heat exchangers, pumps, compressors, distillation columns, process lines, instruments, Common characteristics of PFD	02

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Module	Contents	No. of hrs
4	**Flowsheet Synthesis Based on Design Heuristics:** Input information to the process for flow sheet synthesis: reactions, side reactions, maximum yield, catalyst deactivation rate, production rate, product purity, raw material, process constraints, plant & site data, cost data, physical properties. Level 1 decision in flow sheet synthesis: batch v/s continuous process (production rates, market forces, operational problems, single unit for multiple operations). Level 2 decision in flow sheet synthesis: input output structure of flow sheet (feed purification, recover or recycle reversible by-products, gas recycle & purge stream, reactants not to recover or recycle, number of output streams). Level 3 decision in flow sheet synthesis: Recycle structure of flow sheet (number of reactor systems, recycle streams, excess reactants, heat effects & equilibrium limitations, reversible by-products, reactor heat effects). Level 4 decision in flow sheet synthesis: separation system for process (phase of reactor effluent and separation system, vapor recovery system (VRS), liquid recovery system (LRS), types of VRS and LRS. Level 5 decision in flow sheet synthesis: heat integration in flow sheet. Reactor trains: options & selection criteria, CSTR, PFR, reactors similar to CSTR, application of different reactor geometries and associated heuristics.	06
5	**Mass & Energy Balances around Major Equipments in Flow Sheet:** Physico-chemical specification of each process stream in flow sheet. Detailed mass and energy balance around major equipments in flow sheet using thumb rules: reactors, mixers, splitters, flash columns, distillation columns, absorption column, stripping column, evaporator, dryer	07

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Module	Contents	No. of hrs
6	**Sizing and Costing of Major Equipments in Flow Sheet:** Sizing of equipments using short cut designing methods and design heuristics: reactors, heat exchangers, distillation columns, pumps, compressors, evaporators. Costing of equipments: evaluation of updated bare module cost of above process equipments using Guthries costing modules	08
7	**Utility Selection for Process:** Plant utilities: concept, Major types of plant utilities: heating utilities, cooling utilities, compressed air, nitrogen, vacuum, water, electricity. Heating utilities and their operating T & P ranges: steam, pressurized hot water, thermal fluids dowtherm A, E, inorganic salt mixtures, mineral oils, silicon compounds. Cooling utilities and their operating T & P ranges: cooling tower water, chilled water, chilled brine system. Utility Hook-ups. Evaluating minimum utility requirement for process using pinch analysis	05
8	**Control Strategy for Process**: To suggest control strategies for various process parameters to be controlled. Degree of Freedom analysis for suggested controlled strategy. Alternate control strategies for various process parameters	03
9	**Safety and Hazard Analysis for Process:** Major types of accidents in chemical industries: fire, explosion, toxic release. Fire: probability of occurrence, potential for fatalities and economic losses, fuel-oxidants-ignition source for fire to occur, fire triangle, types of fire. Explosion: probability of occurrence, potential for fatalities and economic losses, types of explosion Toxic release: probability of occurrence, potential for fatalities and economic losses, entry route-entry organ-method of control, various models to analyse toxic release. Multiple Redundancy System: Risk assessment and its different methods – event tree analysis, fault tree analysis, quantitative risk analysis, layer of protection analysis, HAZOP	03

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Module	Contents	No. of hrs
10	**Basic Chemical Processes:** Common Features and Preliminary Process System (PPS) for Basic Chemical Processes: Nitration, Chlorination, Oxidation, Sulfonation, Liquid Phase Catalytic Reduction	04

References

1. Systematic Methods Of Chemical Process Design, Loren T Biegler, Grossman E.I., Westberg, A.W. Prentice Hall Intl ed., 1997

2. Conceptual Design of Chemical Processes, J.M.Douglas, McGraw Hill International Editions, 1988

3. Chemical Process Equipment: selection & design, Walas, S.M., Butterworth, London, 1980

4. Strategy of Process Engineering, John D.F.Rudd & C.C. Watson, Wiley & Sons International, 1968

5. Process Design Principles: synthesis analysis & evaluation, Sieder, W.D., Seader J.D. & Lewin D.R., John Wiley & Sons, 1998.

6. Analysis, Synthesis, and Design of Chemical Processes, Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz, PHI Learning Private Limited, New Delhi, 2011

7. Introduction to Process Engineering and Design, S B Thakore, B I Bhatt, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2011

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHC703	Process Dynamics & Control	3.0	1.0	4.0

Prerequisites

Linear Algebra, Differential Equations, Laplace Transforms.

Course Objectives

- To understand dynamic behaviour of process systems and equipments.
- To understand frequency response of dynamic systems.
- To understand and analyse stability charecteristics of dynamic systems.
- To design controllers.

Course Outcomes

- The student will be able to model dynamical systems and study their responses in Time ,Laplace and Frequency domains.
- The student will be able to design stable controllers, for important chemical processes

Detail syllabus

Module	Contents	No. of hrs
1	**Introduction To Process Control:** Typical Control Problems, A Blending Process Example, Control Strategies, Hierarchy of Control Activities, An Overview of Control System Design.	04
2	**Dynamic Models of Processes:** The Rationale for Dynamic Process Models, General Modelling Principles, Degrees of Freedom Analysis, Typical Dynamic Models.	06
3	**Transfer Function Models:** Transfer Functions of Typical Systems, First and Second Order Systems, Properties of Transfer Functions, Transfer Functions of Systems in Series, Time Delay Processes, Linearisation of Non-linear Systems, State Space and Transfer Function Matrix Models.	03
4	**Dynamic Behaviour of Processes:** Standard Process inputs, Response of First Order Processes, Response of Second Order Processes, REsponse of Integrating Processes.	06

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Module	Contents	No. of hrs
5	**Development of Empirical Models From Process Data:** Fitting First and Second Order Models Using Step Tests, Development of Discrete Time Dynamic Models, Identifying Discrete Time Models From Experimental Data.	04
6	**Feedback and Feedforward Control:** Basic Control Modes, Features of PID and On-off Control, Conntrol Valve Characteristics, Response of Feedback Control Systems, Digital Verions of PID Controllers.	02
7	**Closed-Loop Response and Stability:** Closed-Loop Transfer Functions, Closed-Loop Response, Stability, Root Locus.	04
8	**Controller Design and Tuning:** Performance Criteria, Model-Based Design Methods, Controller Tuning, Controllers with Two Degrees of Freedom, On-Line Tuning.	04
9	**Control Strategies:** Degrees of Freedom Analysis, Selection of Variables, Typical Applications.	02
10	**Frequency Response:** Frequency Response of Typical Systems, Bode Stability Criterion, Nyquist Stability Criterion, Gain and Phase Margins.	05

References

1. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle III, Process Dynamics and Control,3 Ed., John Wiley & Sons (Asia) Pvt. Ltd., New Delhi.
2. William L. Luyben, Process Modeling Simulation and Control For Chemical Engineers,2nd Ed., Mc-Graw Hill Publishing Co.
3. Stephanopoulos, Chemical Process Control, PHI Learning Pvt. Ltd.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHE704	Elective – II : High Performance Leadership	4.0	–	4.0

Prerequisites

This course is designed to enhance your leadership to improve your ability to lead with purpose, to communicate effectively, and to work well with others. The course will be a combination of learning about leadership through the review of literature. Students will further develop and apply various skills and techniques deemed to be essential for successful leadership in organizations. The course also explores leadership challenges and opportunities in relation to individual and team performance.

Course Objectives

- To become aware of strengths and weaknesses in one's leadership behaviour.
- Analyse the numerous approaches of leadership development and critically evaluate how they may be applied in practice.
- To understand how the most successful leaders are able to influence followers through effective communication of well-reasoned ideas, proposals and values.
- To systematically train and improve one's leadership effectiveness.

Course Outcomes

- Improve one's self leadership skills through effective emotion regulation and emotional intelligence.
- Apply concepts of leadership and effective communication to individuals, groups, and organizations

Detail syllabus

Module	Contents	No. of hrs
1	**Leadership:** Theories of Leadership, Leadership Styles and Leadership, Leadership Skills, Objectives for personal development.	05
2	**Leadership Skills:** Leadership Skills and Leadership, Developing competencies, The Business Related Inventory of Personality (strengths and weaknesses), Changing behaviour in critical situations.	07
3	**Team work & Positive thinking:** Team work & Team building, Positive thinking Martin Seligmans theory of Learned, Helplessness, Learned Optimism Lessons through Literature Positive thinking, Attitudes, Beliefs, Lateral Thinking.	07

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Module	Contents	No. of hrs
4	**Interpersonal skills:** Interpersonal skills Conversation, Feedback, Feed forward, Transformational Leadership: analysis and consequences from the 360° feedback Interpersonal skills, Delegation, Humour, Trust, Expectations, Values, Status, Compatibility.	06
5	**Effective Leadership Communication:** Principles of effective communication: authenticity, clarity, credibility, and empathy. Persuasion including body language, posture, facial expressions, gestures, creating a personal relationship (message-audience-speaker), Impact speech: effective and convincing lines of argument.	08
6	**Conflict Management:** Types of conflicts, Coping strategies and Conflict Management Styles. Creative problem Solving Techniques.	06

References

1. Jeff Grimshaw & Gregg Baron, Leadership Without Excuses : How to Create Accountability and High-Performance, Tata McGraw - Hill Education, 1st Ed., 2010.

2. Harrison Owen, Wave Rider: Leadership for High Performance in a Self-organizing World, Berrett-koehler Publishers, 2008.

3. Daniel Goleman, Richard E. Boyatzis, Annie McKee, Primal Leadership: Realizing the Power of Emotional Intelligence, Harvard Business Review Press, 2002.

4. John Baldoni, Great Communication Secrets of Great Leaders, Primento Digital Publication, 2012.

5. Paul Glen, Leading Geeks: How To Manage And Lead The People Who Deliver Technology, Wiley Publication, 2002.

6. Shel Holtz, Corporate Conversations : A Guide To Crafting Effective And Appropriate Internal Communications, Phi Learning Pvt Ltd, 1st Ed., 2007.

7. Garber, J. and Seligman, M.E.P., Human Helplessness: Theory and Applications, New York Academic Press.,1980.

8. Bass, Bernard. M., The Bass Handbook of Leadership, Theory, Research & Managerial Applications, 4th edition, New York, 2008

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHE704	Elective – II: Polymer Technology	4.0	–	4.0

Prerequisites

Chemistry, physics, Chemical reaction engineering.

Course Objectives

- To understand thermodynamics of polymer structure.
- To select polymerization reactor for a polymer product.
- To characterize polymers and state polymer additives, blends and composites.

Course Outcomes

At the end of the course students will be able to

- Understand thermodynamics of polymer structure.
- Select polymerization reactor for a polymer product.
- Characterize polymers and state polymer additives, blends and composites.

Detail syllabus

Module	Contents	No. of hrs
1	**Introduction:** Introduction and Classification of Polymers. Thermosets, Factors influencing the polymer properties, Glass Transition Temperature Monomers used for polymer synthesis, Thermoplastics, Linear Branch, Cross Linked Polymers. **Addition and Condensation Polymerisation:** Mechanism, kinetics, synthesis and reactions.	06
2	**Natural Polymers:** Chemical & Physical structure, properties, source, important chemical modifications, applications of polymers such as cellulose, lignin, starch, rosin, shellac, latexes, vegetable oils and gums, proteins etc. **Polymerization Techniques:** Bulk polymerization, Solution polymerization, Emulsion polymerization and Suspension polymerization, Interfacial Polymerization with their merits Comparison of the various processes Advantages and disadvantages.	12

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Module	Contents	No. of hrs
3	**Molecular Weight and Molecular Weight Distribution:** Molecular Weights, Polydispersity Index, Different Methods of determination of Molecular weight, Effect of Molecular weight on Engineering Properties of Polymers. **Co-Polymerization:** Basic concept, Technical significance, steady state assumptions in free radical copolymerization, The copolymer equation, Instantaneous molar composition of copolymer formed; Monomer reactivity ratios; Significance and method of determination, Types of copolymers.	08
4	**Polymerization Reactor:** Polymerization reactors types and mode of operation, Polymerization reactor design, control of polymerization, Post polymerization unit operations and unit processes Polymer Degradation.	06
5	**Polymer Processing:** High Performance and Specialty Polymers, Polymer additives, compounding. Fillers plastisizers lubricants colourants UV stabilizers, fire retardants, antioxidants, Different moulding methods of polymers. Injection moulding , blow moulding, thermoforming, film blowing etc.	08
6	**Manufacturing Processes:** Manufacturing of typical polymers with flow-sheet diagrams properties & application: PE, PP, PS, Polyesters, Nylons, ABS, PC. Manufacturing of thermoset polymers such as Phenolic resins.	12

References

1. Fried J R, Polymer Science and Technology, Prentice Hall of India Pvt. Ltd., New Delhi, Eastern Economy Edition, 2000.
2. Premamoy Ghosh, Polymer Science and Technology, 3rd Edition, Tata Mc. Graw-Hill Publishing Company, New Delhi, 2010.
3. R. Sinha, Outlines of Polymer Technology: Manufacture of Polymers, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
4. Gowarikar V.R. et.al., Polymer Science Wiley Eastern 1984.
5. Ghosh P, Polymer Science & Technology of Plastics & Rubbers Tata McGraw Hill, 1990.
6. Encyclopedia of Polymer Science & Engineering., Wiley 1988.
7. Rosen S.L. Fundamental Principles of Polymeric materials, 2nd e.d., John Wiley & Sons Inc, 1993.

8. McCrum N.G et.al. ,Principles of Polymer Engineering , 2nd ed., Oxford Sciences, 1997.

9. Bhatnagar M.S., a Textbook of Polymers Vol.I & Vol.II, S.Chand & Co. Ltd.,New Delhi, 2004.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHE704	Elective – II: Petroleum Refining Technology	4.0	–	4.0

Prerequisites

Knowledge about Formation and origin of petroleum, composition and testing methods,Basic treatment Techniques.

Course Objectives

- To understand petroleum refinery products, its evaluation techniques, and treatment techniques.
- To understand various cracking processes, and its applications in chemical industries.

Course Outcomes

Students will be able to understand petroleum refinery products, its evaluation techniques, and treatment techniques,various cracking processes, and its applications in chemical industries.

Detail syllabus

Module	Contents	No. of hrs
1	**Origin formation and composition of petroleum:** Origin theory, Reserves and deposits of world. Types of crude and Indian crude types. Exploration Reserves.	06
2	**Refinery products and feedstock:** Overall refinery flow.Low boiling products. Gasoline Specifications. **Fuels:** Jet fuels, automotive diesel fuels. Oils:-Heating Oils, Residual fuel Oils, Crude Oil properties, Composition of petroleum, Crude suitable for asphalt manufacture. Crude distillation curves. Distillation characteristics. Petrochemical Feedstock.	10
3	**Fractionation of Petroleum:** Dehydration and desalting of crude, Heating of Crude Pipe still Heaters. Multi-component Fractionation of Petroleum including pump-around and side-stripping.Blending of gasoline. Over lead corrosion in distillation unit.	12
4	**Treatment Techniques and product specifications:** Fraction impurities treatment of gasoline, Treatment of kerosene, Treatment of Lubes. Wax and purification.	08

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Module	Contents	No. of hrs
5	**Catalytic Cracking and thermal process:** Fluidised bed catalytic cracking, Catalytic reforming, Coking, Hydrogen Process Hydro cracking, Hydrodesulphurization, Hydro-Treatment. Alkalyation process, Isomerisation Proccess, Polymer gasoline.	10
6	**Asphalt Technology:** Source of Asphalt. Air Blowing of Bitumen up-gradation of heavy crude.Brief review about bio-refinery	06

References

1. B.K Bhaskara Rao, Modern Petroleum Refining Process .
2. W.L Nelson, Petroleum Refinery Engineering 4th ed, McGraw Hill.
3. Petroleum Chemistry and Refining Edited by James G. Speight,Taylor and Francies .
4. Chemical Process Industries, Austin, G.T Shreves.
5. Encyclopedia of chemical processing and design by john J. McKhetta; Marcel Deckker, Inc.
6. Chemial Weakly for supply and demand figures and current prices and price trends.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHE704	Elective – II: Advanced Process Simulation	4.0	–	4.0

Prerequisites

Process Calculations, Computer Programming.

Course Objectives

To understand the tools of process integration.

Course Outcomes

The student will be able to design integrated processes.

Detail syllabus

Module	Contents	No. of hrs
1	**Introduction:** Introduction to Process Integration, Alternative Processes, Process Synthesis, Process Analysis, Process Integration.	02
2	**Overall Mass Targeting:** Targeting for Minimum Discharge of Waste, Targeting for Minimum Fresh Material Utilities, Mass-Integration Strategies for Attaining Targets.	04
3	**Graphical Techniques for Direct-Recycle Strategies:** Introduction, Source-Sink Mapping Diagram and Lever-Arm Rule, Selection of Sources, Sinks, and Recycle Routes, Direct REcycle Targets Through Material Recycle Pinch Diagram, Multi-component Source-Sink Mapping Diagram.	08
4	**Synthesis of Mass Exchange Networks (A Graphical Approach):** Design of Individual Mass Exchangers, Cost Optimization of Mass Exchangers, Synthesis of Mass Exchange Networks, Mass Exchange Pinch Diagram, Screening of Multiple External MSAs.	08
5	**Mass Integration Strategies:** Low/No Cost Strategies, Most Changes in Operating Conditions and Process Variables, medium-Cost Strategies and Main Technology Changes.	06
6	**Algebraic Approach to Targeting Direct Recycle:** Algebraic Targeting Approach, Algebraic Targeting Procedure, The Composition Interval Diagram, Table of Exchangeable Loads, Mass Exchange Cascade Diagram, Example of Cleaning of Aqueous Waste.	06

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Module	Contents	No. of hrs
7	Recycle Strategies Using Property Integration Contents: Property Based Material Recycle Pinch Diagram, Process Modification, Clustering Techniques for Multiple Properties, Cluster Based Source Sink Mapping, Design Rules, Multiplicity, Clusters and Mass Fractions, Examples.	10
8	**Mathematical Approach:** Problem Statement and Representation, Formulation of Optimization Models, Interaction between Direct Recycle and the Process, Synthesis of MENs.	08

References

1. Mahmoud M. El-Halwagi, Process Integration, Academic Press

Course Code	Course/ Subject Name	Credits
CHP705	Project – A	3.0

Details

- Project Groups: Students can form groups with not more than 3(Three).
- Students should spend considerable time in applying all the concepts studied, into the project. Hence, eight hours each were allotted in Project A,B to the students.
- Students are advised to take up industrial/ experimental oriented/ simulation and/or optimization based topics for their projects.

Course Code	Course/ Subject Name	Credits
CHS706	Seminar	3.0

Details

- Seminar topics will be the consensus of the project guide and the students. Each student will work on a unique topic.
- The load for seminar will be calculated as one hour per week irrespective of the number of students.

Course Code	Course/ Subject Name	Credits
CHL707	Chemical Engg Lab (PED)	1.5

Concepts for experiments:

Includes drawing sheets based on

- Process flow diagram and piping and instrument diagram.
- Fabrication drawing of problem based on heat exchanger.
- Fabrication drawing of problem based on short tube vertical evaporator.
- Fabrication drawing of problem based on distillation column.
- Fabrication drawing of problem based on monoblock high pressure vessel.
- Fabrication drawing of problem based on multilayer high pressure vessel.

Course Code	Course/ Subject Name	Credits
CHL708	Chemical Engg Lab (PDC)	1.5

Concepts for experiments:

Objective for experiments

- To correlate the theoretical understanding of the dynamics of systems with actual observations.
- To calculate system parameters from observed data.
- To validate system models.
- To study closed-loop behaviour of control systems

At least eight experiments should be carried out in this lab course based on the following concepts:

- Dynamic behaviour of typical first and second-order systems.
- Dynamic behaviour of systems in series.
- Response of closed loop systems with different control configurations.
- Tuning of Controllers.

Scheme for BE: Semester-VIII

Subject Code	Subject Name	Teaching Scheme			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CHC801	Modelling, Simulation & Optimization (MSO)	03	–	01	3.0	–	1.0	4.0
CHC802	Project Engineering & Entrepreneurship Management	03	–	01	3.0	–	1.0	4.0
CHC803	Environmental Engineering (EE)	04	–	–	4.0	–	–	4.0
CHC804	Energy System Design	03	–	01	3.0	–	1.0	4.0
CHE805	Elective – III	04	–	–	4.0	–	–	4.0
CHP806	Project – B	–	–	08	–	–	6.0	6.0
CHL807	Chemical Engineering Lab (EE)	–	02	–	–	1.0	–	1.0
CHL808	Chemical Engg Lab (MSO)	–	02	–	–	1.0	–	1.0
	Total	17	04	11	17.0	2.0	9.0	28.0

Examination Scheme

Subject Code	Subject Name	Examination Scheme							
		Theory marks				Term Work	Pract.	Oral	Total
		Internal Assessment			End Sem. Exam				
		Test 1 (A)	Test 2 (B)	Avg.of (A) & (B)					
CHC801	Modelling, Simulation & Optimization (MSO)	20	20	20	80	25	–	–	125
CHC802	Project Engineering & Entrepreneurship Management	20	20	20	80	25	–	–	125
CHC803	Environmental Engineering (EE)	20	20	20	80	–	–	–	100
CHC804	Energy System Design	20	20	20	80	25	–	–	125
CHE805	Elective – III	20	20	20	80	–	–	–	100
CHP806	Project – B	–	–	–	–	100	–	50	150
CHL807	Chemical Engineering Lab (EE)	–	–	–	–	–	25	25	50
CHL808	Chemical Engg Lab (MSO)	–	–	–	–	–	25	–	25
				Total	100	400	175	50	75	800

Elective Streams(CHE805)

Sem.	Management Stream	Technology Stream	Process System Engineering Stream
VIII	Total Quality Management	• Advanced Separation Technology • Biotechnology • Nanotechnology	• Advanced Process Control • Advanced Transport Phenomenon

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHC801	Modelling, Simulation & Optimization (MSO)	3.0	1.0	4.0

Prerequisites

Linear Algebra, Process Calculations, Computer Programming.

Course Objectives

- To understand writing and solving linear balance equations for single units as well as complete flowsheets.
- To understand writing and solving systems of non-linear equations for single and multiple units.
- To understand simulation of complete flowsheets.
- To understand optimization of single and multiple units.

Course Outcomes

- The student will be able to write and solve linear and non-linear mass and energy balance equations for individual as well as multiple units.
- The student will be able to carry out sequential and equation oriented simulation of complete flowsheets.
- The student will be able to optimize typical chemical processes.

Detail syllabus

Module	Contents	No. of hrs
1	**Mass and Energy Balances:** Introduction, Developing Unit Models for Linear Mass Balances, Linear Mass Balances, Setting Temperature or Pressure Levels from Mass Balances, Energy Balances.	10
2	**Unit Equation Models:** Introduction, Thermodynamic Options for Process Simulation, Flash Calculation, Distillation Calculations, Other Unit Operations.	10
3	**Simulation:** Introduction, Process Simulation Modes, Methods for Solving Systems of NLE, Recycle Partitioning and Tearing, Simulation Examples.	10
4	**Process Flowsheet Optimization:** Introduction, Constrained Non-Linear Programming, SQP, EO based Process Optimization.	10

References

1. Lorenz T. Beigler, Ignacio E.Grossman, Arthur W. Westburg, Systematic Methods of Chemical Process Design, Prentice Hall

2. Thomas Edgar, David M. Himmelbleau, Optimization of Chemical Processes, 2nd Ed., John Wiley.

3. A. W. Westerberg, H. P. Hutchison, R. L. Motard, P. Winter, Process Flowsheeting, Cambridge University Press; 1 edition (June 9, 2011).

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHC802	Project Engineering & Entrepreneurship Management	3.0	1.0	4.0

Prerequisites

- Employment and Corporate Skills.

Course Objectives

- Project management demands the judicious mix of science, arts and technology, so the objective is to project the scientific aspects of project management.
- To amidst real life constraints for the benefit of the individual, project and society.
- To learn entrepreneurship for the improvement of technology, product and the society for the economical growth.

Course Outcomes

- To prepare students for an exciting, challenging and rewarding managerial career.
- To insight students in identifying opportunities, creating and starting a venture, financing and managing the venture.

Detail syllabus

Module	Contents	No. of hrs
1	**Introduction:** Definition of project, project management, project life cycle, project types, Project over runs, Role, responsibilities demands on project manager.	04
2	**Project initiation:** Feasibility reports of various types project selection criteria, project licensing, Basic and detailed engineering, Guarantees, Liabilities, Risk insurance, types of estimates.	06
3	**Project clearances:** Various laws & regulations, List of various clearances, Intellectual property rights, Patents, need for clearances and influences on project, management, LOI. **Project organization:** Various forms of pure project, matrix and mixed type. Project team, responsibilities of various members.	08
. . . cont.	**Project planning:** WBS, responsibility charts, contracts, types, role of contractor, sub-contractor consultant, selection criteria and appointment procedure	

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Module	Contents	No. of hrs
4	**Project Scheduling and execution:** CPM and PERT, GANTT charts, LOB , Resource allocation, ABC and VED Analysis , Economic Order Quantity (EOQ), CAT vs RAT. (Numericals included)	08
5	**Project monitoring and control:** Time and cost control tools and techniques, fund flow control, Project quality control, Importance of environmental and safety aspects. **Project termination:** Commissioning, start up, stabilization, close out.	06
6	**Entrepreneurship:** Definition of entrepreneurship, Concept of entrepreneur and entrepreneurship, Characteristics, aspects of entrepreneurship, factors affecting entrepreneurship. Classification and types of entrepreneurship based on business, technology, motivation, growth and stages of development.	06

References

1. Choudhary, S., Project Management.
2. Joy, P. K., Total Project Management.
3. Jack Meredith and Samuel, Project management a Managerial approach.
4. Vasant Desai, Dynamics of entrepreneurial development and management.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHC803	Environmental Engineering (EE)	4.0	–	4.0

Prerequisites

Basic concepts of Fluid Flow Operations, Solid Fluid Mechanical Operations, Mass Transfer Operations and Chemical Reaction Engineering.

Course Objectives

- Students should be able to understand the scope of subjects in Chemical Industry.
- Students should learn to apply the Environmental Engineering concepts to control and management of various types of pollutants.

Course Outcomes

Students should be able to apply the Environmental Engineering concepts to control and management of various types of pollutants.

Detail syllabus

Module	Contents	No. of hrs
1	**Introduction:** Environmental pollution, Importance of environmental pollution control, Concept of ecological balance, Role of environmental engineer, Hydrological & nutrient cycles, Environmental Legislation & Regulations, Industrial pollution emissions & Indian standards, Water (prevention & control of pollution) act, Air (prevention & control of pollution) act.	06
2	**Water Pollution:** Classification, sources and effect of water pollutant on human being and ecology, Sampling, measurement and standards of water quality, Determination of organic matters: DO, BOD, COD, TOC. **Determination of inorganic substances:** nitrogen, phosphorus, trace elements, alkalinity. **Physical characteristics:** suspended solids, dissolved solids, colour and odour, Bacteriological measurements.	08
3	**Waste Water Treatment:** **Primary treatment:** pretreatment, settling tanks and their sizing. **Secondary treatment:** micro-organisms growth kinetics, aerobic biological treatment, activated sludge process, evaluation of bio-kinetic parameters, trickling filters, sludge treatment and disposal.	12

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Module	Contents	No. of hrs
...cont.	**Tertiary treatment:** advanced methods for removal of nutrients, suspended and dissolved solids, Advanced biological systems, Chemical oxidation, Recovery of materials from process effluents.	
4	**Air Pollution:** Air pollutants, sources and effect on man and environment, acid rain, smog, greenhouse effect, Ozone depletion, global warming, Temperature lapse rate and stability, Plume behaviour, Dispersion of air pollutants, Gaussian plume model, Estimation of plume rise, Air pollution sampling and measurement, Analysis of air pollutants.	08
5	**Air Pollution Control Methods and Equipment:** Source correction methods for air pollution control, Cleaning of gaseous effluents, Particulate emission control, Equipment, system and processes for... – **Particulate pollutants:** gravity settler, cyclones, filters, ESP, scrubbers etc. – **Gaseous pollutants:** scrubbing, absorption, adsorption, catalytic conversion.	12
6	**Solid Waste Management:** Solid waste including plastic, nuclear and hazardous waste management.	03
7	**Noise Pollution:** Noise pollution: measurement and control, effect on man and environment.	03

References

1. Rao, C.S., Environmental Pollution Control Engineering, New Age International (P) Limited.
2. Peavy, H. S., Rowe, D.R., Tchobanoglous, G., Environmental Engineering, McGraw-Hill Book Company Limited
3. Metcalf et al., Waste Water Treatment, Disposal & Reuse, Tata McGraw Hill Publishing Company Limited.
4. Mahajan, S.P., Pollution Control in Process Industries, Tata McGraw Hill Publishing Company Limited.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHC804	Energy System Design	3.0	1.0	4.0

Prerequisites

- The students should have knowledge of Heat transfer to carry out Energy balance and Heat Exchanger Networking.
- They should be aware about basic principles of economics to evaluate cost and profit of energy efficient operations/modifications/techniques.
- They should be familiar with various types of plant utilities.
- They should be familiar with basic Industrial systems/operations like, HVAC, Lighting, Steam, Refrigeration, etc.

Course Objectives

- To provide training to solve problems relevant to the energy conservation.
- To provide students the knowledge in planning conducting energy audit, energy survey, and evaluate energy conservation opportunities.
- To provide knowledge to design and evaluate energy efficient technologies such as heat exchanger networks, multiple effect evaporators, co-generation, etc.

Course Outcomes

- The graduates are expected to have ability to design a energy system to meet the desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability and sustainability.
- The graduates are expected to possess ability to function on multi disciplinary teams, identify, formulate and solve engineering problems.
- The graduates are expected to have an understanding of professional and ethical responsibility.
- The graduates are expected to posses ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Detail syllabus

Module	Contents	No. of hrs
1	**Global Energy Scenario:** Broad classification of energy sources: primary, secondary, commercial, non-commercial, renewable, non-renewable. Global primary energy reserves and energy consumption, Ratio of energy demand to GDP: significance. Indian energy scenario: w.r.t above points.	02

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Module	Contents	No. of hrs
. . . cont.	Energy policies, regulations, consumption and production, installed capacity, energy intensive sectors in India. Energy management:aim, key principles, steps to be taken to improve energy efficiency of systems. Energy conservation act (India). Energy and environment, Causes of high energy intensity and energy demand in developing countries: technological, managerial, economic, structural causes	
2	**Energy Audit:** Definition, need and steps of energy audit. **Energy audit methodology:** interview with key facility personal, facility tour, document review, facility inspection, staff interviews, utility analysis, identifying energy conservation opportunities/measures, economic analysis, preparing audit report, review and recommendations. **Types of energy audit:** preliminary (walk-through) audit, general (mini) audit, investment grade (maxi/detailed) audit. **Energy profiles:** energy profile by use, cost, function. **Energy sub-audits:** envelope, functional, process, transportation and utility audit. **Instrumentation part of energy audit:** equipments for measuring light intensity, electrical performance, temperature, pressure, humidity, performance of combustion system and HVAC system during energy audit; energy auditors tool box and its contents. **Preparing for energy audit visit:** to study the facility in view of energy use data, energy rate structure, physical and operational data. **Safety considerations during energy audit:** related to electrical, respiratory, hearing, etc. **Post audit analysis:** identifying ECOs, evaluate feasibility of ECOs with help of simple pay back period analysis, preparing summarized energy audit report	04
3	**Energy Efficient Technologies:** Basic energy consuming systems in chemical industries and energy efficient modifications in those systems: lighting system; motors, belt and drives system; fans and pumps system; compressed air system; steam system; refrigeration system; material handling system; hydraulic system; drying system. Examples of energy efficient technologies: pressure swing adsorption purification; ethylene by thermal cracking.	03

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Module	Contents	No. of hrs
4	**Energy Integration in The Process Industries:** Energy integration in process: concept. Pinch analysis: evaluation of minimum utility requirement by temperature interval method and composite curve method. Design of Heat Exchanger Network (HEN) for process system: minimum approach temperature difference (ΔT_{min}); Linnhoff rules for HEN design; pinch decomposition diagram; concept of minimum number of heat exchangers ($NH_{x,min}$); design of HEN with $NH_{x,min}$ using breaking loop method and stream splitting method. Concept of Threshold approach temperature difference (ΔT_{thresh}) and Optimum approach temperature difference (ΔT_{opt}) during HEN. Determining annualized cost of HEN	10
5	**Heat Integration in Process Units:** **Multiple effect evaporators (MEE):** types forward feed, backward feed, parallel feed; advantage of MEE over single effect evaporator in terms of energy saving. Effect of process variables on evaporator operation: feed temperature, operating pressure, steam pressure, Boiling point rise. Heat integration of Multiple effect evaporators (MEE) with background process. Heat integration MEE with and without vapour re-compression: mechanical vapour re-compression, thermal vapour re-compression. **Distillation column:** heat integration in distillation column – multiple effect distillation, heat pumping, vapour re-compression, Reboiler flashing. Different arrangements of heat integration of columns with background process.	12
6	**Co-generation:** Introduction and basic concepts related to co-generation: advantages of co-generation over conventional power plants; basic terms related to co-generation like, process heat, process returns, net heat to process, heat to power ratio, prime mover, etc. Basic thermodynamic cycles supporting working of co-generation plant: Brayton cycle, Rankine cycle. Basic types of co-generation systems: topping cycle, bottoming cycle, combined cycle. Different types of co-generation power plants: steam turbine system, gas turbine system, combined gas steam turbine system, diesel engine system. Distributed generation (DG) co-generation technologies: reciprocating engine system, micro turbines, fuel cells, photovoltaic cells, Co-generation design procedure, Applications of co-generation	06

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Module	Contents	No. of hrs
7	**Waste Heat Recovery (WHR):** Classification and applications of WHR: waste heat sources, quality of waste heat and its application; high temperature WHR, medium temperature WHR, low temperature WHR . Benefits of WHR: direct and indirect benefits. Different techniques used for WHR / Commercial devices used for WHR: recuperators, radiation/convective hybrid recuperator, ceramic recuperator, regenerator, heat wheel, heat pipe, waste heat boiler, economizer, heat pumps	03

References

1. Seider W. D., and Seader J. D. and Lewin D. R., Process Design Principles, John Wiley and Sons Inc., 1988.
2. Douglas J. M. .Conceptual Design of Chemical Process., McGraw Hill Book Co.,1988.
3. G. D. Rai, Non-Conventional Energy Sources, Khanna Publishers.
4. Larmine James, .Fuel Cells Explained., John Wiley and Sons, 2000.
5. Kreith F., .Principles of Solar Energy., McGraw Hill Book Co., 1978.
6. Freris L. L., .Wind Energy Conversion System., Prentice Hall, 1990.
7. Wayne C. Turner, Steve Doty (Ed.), Energy Management Hand Book., John Wiley and Sons, 2000
8. Biegler L. T., Grossman E. I. and Westerberg A. W., .Systematic Methods of Chemical Process Design., Prentice Hall International Ltd., 1997.
9. P K Nag, Power Plant Engineering, The McGraw-Hill Publishing Company Limited.
10. H.M.Robert, J.H.Collins, Handbook of Energy Conservation-Volume 1, CBS Publishers & Distributors.
11. Robin Smith, Chemical Process Design and Integration, Wiley India, 2005.
12. Serth, Robert W., Process Heat Transfer Principles and Applications, Elsevier Science & Technology Books, 2007.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHE805	Elective – III: Total Quality Management	4.0	–	4.0

Prerequisites

Course Objectives

- To acquaint with the significance and features of TQM philosophy
- To familiarize with various quality tools and their uses in problem solving.
- To appraise on the modern productivity improvement approaches and their interface with TQM
- To familiarize with various quality standards, quality auditing and certification methodologies.
- To give and an insight into the ongoing global trends in quality approach and practices with specific forms to the customer relationship.

Course Outcomes

Learner will be able to:

- Appreciate the importance of quality and its dimensions in striving for excellence.
- Understand the conscious compromise between cost and quality.
- Develop competency in the selection and use of appropriate quality tools in various manufacturing and service functions.
- Integrate quality approaches for productivity improvement.
- Acquire knowledge base and develop skills for conducting quality audits.

Detail syllabus

Module	Contents	No. of hrs
1	**Introduction:** Definition of Quality, principles and dimensions of TQM. Quality in manufacturing and service segments. Approach in implementation of TQM, barriers in implementation. Cost of quality – prevention, appraisal and failure costs, hidden costs, trade-off between quality and cost.	06
2	**Planning for quality and Quality improvement:** **Planning for quality:** Need for quality policies and objectives. Significance of top management commitment, strategic planning for quality. **Quality improvement:** Management of controllable defects, operator controllable defects, sporadic and chronic problems of quality, Pareto's principle. **Bench marking:** Definition and significance, data collection for bench marking and its use.	08

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Module	Contents	No. of hrs
3	**Customer relations:** Customers, user and consumers, product awareness, types of customers, customer perception and expectations. Quality feedback and redressal. **Basic principles of reliability:** quality and reliability, product life cycle, trade-off between maintainability.	05
4	**Vendor relations:** Vendor as a partner, vendor selection, vendor evaluation. Push-Pull view of supply chain and cycle view of chain management.	05
5	**SQC Tool:** Histograms, Pie charts, Scatter diagrams, Cause and effect diagram. Statistical Process Control: **Process variability:** Variables and process variation, measures of accuracy and centring, precision or spread, normal distribution. **Process Control:** Control charts for variables ($\bar{X}$-chart, R-chart, σ-chart) and attributes (np-charts, p-chart, c-charts, U-charts). **Process capability:** OC curve, acceptance sampling, single and double sampling – producer's and consumer's risk.	14
6	**Quality System:** **Quality standards:** • ISO 9001:2000 Quality management system. • ISO 14001:2004 Environmental management system. • ISO 27001:2005 Information security management system. **Quality assurance:** Nature of assurance, reports on quality, measuring performance, internal audit, surveillance audit, quality certification methodology and implications. **Productivity improvement Tools/ Approaches/ Techniques:** Principles of Six-Sigma, approaches like JIT, Lean manufacturing zero defect concept, KANBAN, QFD, FMEA, Basics of DOE and Shainin concepts of quality. Productivity improvement techniques like 5S, POKAYOKE, SMED, KAIZEN and Concurrent Engineering.	14

Note: Seminar/Case study presentation with report by individual or in groups comprising of not more than **three** students should be considered for tutorials.

References

1. Juran, J. M., Gryana, F. M., Quality planning and analysis, TMH.
2. Bester Fidd, D. H., et.al., Total quality management, Prentice Hall.
3. Erossbly, Pillip b., Quality is free, Mentor/New Americal Library.

4. Ishikawa, K., What is total quality control? The Japanese way, Prentice Hall.
5. Fergenbaum, Armand V., Total quality control.
6. Logothetis, N., Managing for total quality, Prentice Hall.
7. Aurora, K. C., Total Quality Management, S. K. Kataria and Sons.
8. Haldar, U. K., Total Quality Management, Dhanpatrai and Co.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHE805	Elective – III: Advanced Separation Technology	4.0	–	4.0

Prerequisites

Basic knowledge regarding fundamental separation processes and its applications in chemical industries.

Course Objectives

The students completing this course are expected to understand . . .

- the various separation principles like Adsorption process, the types and designs,
- foam fractionation process with equipments and application in waste water treatment,
- liquid chromatography – types and separation and of enzymes using it,
- Types of membranes, membrane characterization, membrane material, membrane molecules, membrane applications in biotechnology.

Course Outcomes

- The graduates are expected to have ability to apply knowledge of mathematics, science and engineering
- The graduates are expected to have ability to design a system, a component, or a process to meet the desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability and sustainability
- The graduates are expected to possess ability to identify, formulate and solve engineering problems
- The graduates are expected to posses ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Detail syllabus

Module	Contents	No. of hrs
1	**Adsorption Process:** Modern absorbent such as Activated carbon, molecular sieves of various types, Activated Alumina. Their characteristics and applications. Regeneration & Activation of absorbents. Thermal & pressure swing process. Fixed bed, Moving bed, stimulated moving bed and other processing schemes. Design of adsorption process for separation and purification. Industrial Examples	13

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Module	Contents	No. of hrs
2	**Foam Fractionation Process:** Foam Formation, coalescence, collapse and drainage phenomena Adsorption properties of foams. Modes of operation of foam fraction equipment. Principal of froth flotation, properties of foam relevant to the flotation equipment. Application of froth flotation to mineral processing, protein and enzyme separation, waste water treatment.	13
3	**Liquid Chromatographic Process:** Basic concept of chromatography, phenomena and characterization. Various chromatography options. Typical Chromatographic separation systems for preparative chromatography. Equipment characteristics of solids, their selection for various applications. Column design and filling. Applications of chromatography in separation of enzymes and proteins. Industrial Examples	13
4	**Membrane process:** Introduction to the membrane process,definition of membrane, importance, process. **Characterization of membranes:** Characterization of porous membranes, characterization of ionic membranes, characterization of non-ionic membranes.Preparation of synthetic membranes. Preparation of phase inversion membranes. Preparation techniques for immersion precipitation, preparation techniques for composite membranes, influence of various parameters on membrane morphology, preparation of inorganic membranes.Transport process in membrane driving force, transport through porous membranes, transport through non- porous membranes and transport in ion-exchange membranes.Polarization phenomenon and fouling concentration polarization, characteristic flux behaviour in pressure driven membrane preparation, various models, temperature polarization, membrane fouling, methods to reduce fouling. Modules and process design plate, and frame, spiral wound, tubular, capillary, hollow fibre modules and their comparison, system design.	13

References

1. Ruthven, D.M., Principal Adsorption & Adsorption Process, Wiley,1984.
2. Lemlich, R., Adsorptive Bubble Separation Techniques, Academic Press,1972.
3. Coulson, Richardson, Chemical Engineering, Vol.3, Pergamon.
4. Terybal, R.E, Mass Transfer Operations, McGraw Hill.
5. Ruthven, Faruqh, Knalbal, Pressure Swing Adsorption, VCH, 1994.
6. Snyder, Kirl, Introduction To Liquid Chromatography, 2 ed., 1979.

7. Scott RTW, Liquid Chromatography Column Theory, Wiley, 1992.

8. Marcel Mulder, Basic Concepts Of Membrane Technology, Kluwer Academic Publishers (1997).

9. E.J. Hoffman, Membrane Separation Technology, Gulf Professional Publishing.

10. Nath, Membrane Separation Process, Prentice Hall of India.

11. Membrane Handbook - Editors W.S. Winston Ho, K.K. Sirkar, Van Nostrand Reinhold Publication.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHE805	Elective – III: Biotechnology	4.0	–	4.0

Prerequisites

Knowledge of biology, chemistry, chemical engineering

Course Objectives

- At the end of the course the students should understand the basic concept of biotechnology. They should be able to classify micro-organisms, understand cell structure and basic metabolism.
- They should be able to understand basic knowledge about biological polymers.
- They should be able to understand basic knowledge about enzyme technology.
- They should understand role of biotechnology in medical field and industrial genetics.
- They should know importance of biotechnology in agricultural, food and beverage industries, environment, energy and chemical industries.
- They should understand to how to recover biological products.

Course Outcomes

- Students will demonstrate the knowledge of biotechnology in various fields.
- Students will know cell and metabolism.
- Students will have deep knowledge of biological polymers.
- Students will have deep knowledge of enzymes.
- Students will able to know about other uses of biotechnology in medical field and industrial genetics.
- Students will be able to understand how biotechnology helps in agricultural, food and beverage industry, chemical industries, environment and energy sectors.
- Students will be able to understand how biological products are recovered.

Detail syllabus

Module	Contents	No. of hrs
1	**Introduction:** Traditional and modern applications of biotechnology. Classification of micro-organisms. Structure of cells, types of cells. Basic metabolism of cells. Growth media. Microbial growth kinetics.	10
2	**Biological polymers:** Lipids, Proteins, Amino acids, Nucleic acids, Carbohydrates, Macronutrients and micronutrients.	06

continued . . .

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Module	Contents	No. of hrs
3	**Enzyme Technology:** Nomenclature and classification of enzymes. Enzyme kinetics. Immobilization of enzymes. Industrial applications of enzymes.	10
4	**Biotechnology in health care and genetics:** Pharmaceuticals and bio-pharmaceuticals, antibiotics, vaccines and monoclonal antibodies, gene therapy. Industrial genetics, protoplast and cell fusion technologies, genetic engineering, Introduction to Bio-informatics. Potential lab biohazards of genetic engineering. Bioethics.	06
5	**Applications of biotechnology:** Biotechnology in agriculture, food and beverage industries, chemical industries, environment and energy sectors.	10
6	**Product recovery operations:** Dialysis, Reverse osmosis, ultrafiltration, microfiltration, chromatography, electrophoresis, elecrodialysis, crystallization and drying.	10

References

1. Shuller M.L. and F. Kargi. 1992. Bioprocess Engineering, Prentice-Hall, Englewood Cliffs, NJ.
2. Bailey. J.E. and Ollis D.F. 1986, Biochemical Engineering Fundamentals, 2 nd Edition, McGraw-Hill, NewYork.
3. Kumar H.D., Modern Concepts of Biotechnology, Vikas Publishing House Pvt. Ltd.
4. Gupta P.K., Elements of Biotechnology, Rastogi Publications
5. Inamdar , Biochemical Engineering, Prentice Hall of India.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHE805	Elective – III: Nanotechnology	4.0	–	4.0

Prerequisites

Basic concept of electron, atom, ions, molecules & molecular rearrangements, Basic knowledge of fluid flow, thermodynamics and heat transfer, Various types of material and metals, Basic knowledge of particle size measurement, Students are expected to have an understanding of basic chemical and physical concepts.

Course Objectives

- Understand the basic scientific concepts nanoscience and nanotechnology.
- Understand the properties of materials and biomaterials at the atomic/molecular level and the scaling laws governing these properties.
- To facilitate skills transfer from another relevant area of engineering or science and technology to the study of nanotechnology.
- Understand what nanotechnology is about and how to use it.

Course Outcomes

- Understand the essential concepts used in nanotechnology.
- Appreciate the development of modern nanotechnology.
- Understand the application of nanotechnology in major scientific fields.
- Understand the challenges nanotechnology poses to our environment.
- Gain knowledge of structure, properties, manufacturing and applications of silicon and carbon materials.
- Gain knowledge of fabrication methods in nanotechnology and characterization methods in nanotechnology.

Detail syllabus

Module	Contents	No. of hrs
1	**Fundamentals of Science behind Nanotechnology:** Electron , Atom and Ions, Molecules, Metals, Biosystems, Molecular Recognisation, Electrical Conduction and Ohms Law ,Quantum Mechanics and Quantum Ideas,Optics	06
2	**Fullerenes:** Combustion Flame Synthesis, Crystal Formation, Sintering, Organic Synthesis Method Super Critical Oligomerization, Solar Process, Electric Arc Process.	07

continued . . .

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Module	Contents	No. of hrs
3	**Carbon NanoTubes (CNT):** Synthesis of CNT, Electric Arc Discharge Process, Laser Ablation Process, CVD, HIPCO Process, Surface Mediated growth of Vertically Aligned Tubes, Physical Properties of CNTs, Morphology of CNT.	08
4	**Nanostructuring Methods:** Vacuum Synthesis, Gas Evaporation Tech, Condensed Phase Synthesis, Sol Gel Processing, Polymer Thin Film, Atomic Lithography, Electro deposition, Plasma Compaction. **Characterization of Nanostructures:** Transmission Electron Microscope, Scanning Electron Microscope, Microwave Spectroscopy, Raman Microscopy, X ray Diffraction.	12
5	**Calculations in Nanotechnology:** Particle Size Distribution, Particle Size & Measurement Methods, Fluid Particle Dynamics, Particle Collection Mechanisms, Particle Collection Efficiency.	12
6	**NanoBiology:** Interaction between Biomolecules & Nanoparticle Surface, Influence of Electrostatic Interactions in the binding of Proteins with Nanoparticles, The Electronic effects of bimolecule - Nanoparticle Interaction, Different Types of Inorganic materials used for the synthesis of Hybrid Nano-bio assemblies, Application.	07

Note: A minimum of 08 Tutorials involving a report based on literature survey and an oral presentation to the class on topic from any one Tutorial during tutorial session is envisaged. In addition numerical problems on various topics as included above. The performance of the students should be evaluated based on report and presentations.

References

1. Nano-structuring Operations in Nanoscale Science and Engineering- Kal Ranganathan Sharma, McGraw-Hill Companies
2. Nanotechnology: Basic Calculations for Engineers and Scientists - Louis Theodore, A John Willy & Sons
3. Nanotechnology: A Gentle Introduction to the Next Big Idea-By Mark Ratner, Daniel Ratner
4. Nano-The Essentials, Understanding Nanoscience and Nanotechnology, T. Pradeep
5. Introduction to Nanotechnology- Charles P. Poole, Jr. and Frank J. Owens, John Wiley & Sons, 2003

6. Nanotechnology: Basic and Emerging technologies, - Michael Wilson, Chapman & Hall

7. Principal of Nanotechnology-Molecular Based Study of Condensed Matter in Small Systems, - G .Ali Mansoori

8. Nanotechnology Assessment and Prospective - Schmid et al., Springer

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHE805	Elective – III: Advanced Process Control	4.0	–	4.0

Prerequisites

Linear Algebra, Differential Equations, Difference Equations, Laplace Transforms.

Course Objectives

- To understand dynamics of MIMO processes.
- To understand Batch Process Control.
- To understand Model Predictive Control.
- To design digital controllers.

Course Outcomes

- The student will be able to analyse multi-loop and multi-variable control systems.
- The student will be able to design batch controllers.
- The student will be able to design MIMO controllers.
- The student will be able to design Model Predictive Controllers.

Detail syllabus

Module	Contents	No. of hrs
1	**Advanced SISO Control Strategies:** Cascade Control, Time Delay Compensation, Inferential Control, Selective Control/Override Systems, Nonlinear Control Systems, Adaptive control Systems	06
2	**Digital Sampling Filtering and Control:** Sampling and Signal Reconstruction, Signal Processing and Data Filtering, z-Transform Analysis for Digital Control, Tuning of Digital PID Controllers, Direct Synthesis for Design of Digital Controllers, Minimum Variance Control	08
3	**Multiloop and Multivariable Control:** Process and Control Loop Interactions, Pairing of Control and Manipulated Variables, Singular Value Analysis, Tuning of Multi-loop PID Control Systems, Decoupling and Multivariable Strategies, Strategies for Reducing Control Loop Interactions	06
4	Model Predictive Control: Overview of Model Predictive Control, Predictions for SISO Models, Predictions for MIMO Models, Model Predictive Control Calculations, Set Point Calculations, Selection of Design and Tuning Parameters, Implementation of MPC	08

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Module	Contents	No. of hrs
5	**Batch Process Control:** Batch Control Systems, Sequential and Logic Control, Control During The Batch, Run-to-Run Control	06
6	**Introduction To Plantwide Control:** Plantwide Control Issues, Hypothetical Plant for Plantwide Control Studies, Internal Feedback of Material and Energy, Interaction of Plant and Control System Design	06
7	**Plantwide Control System Design:** Procedures for the Design of Plantwide Control Systems. A Systematic Procedure for Plantwide Control System Design. **Case Study:** The Reactor/Flash Unit Plant, Effect of Control Structure on Closed Loop Performance	06
8	**Optimal Control:** Introduction to Optimal Control, Batch Process Optimisation	06

References

1. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle III, Process Dynamics and Control, 3 Ed., John Wiley & Sons (Asia) Pvt. Ltd., New Delhi.

2. William L. Luyben, Process Modeling Simulation and Control For Chemical Engineers,2 Ed., McGraw Hill Publishing Co.

3. Stephanopoulos, Chemical Process Control, PHI Learning Pvt. Ltd.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
CHE805	Elective – III: Advanced Transport Phenomenon	4.0	–	4.0

Prerequisites

Continuity equation, equation motion covered in Fluid Mechanics, Diffusion and absorption from Mass Transfer and Conduction, convection and radiation from Heat Transfer. Knowledge of numerical methods to solve ODE and PDE.

Course Objectives

- Students will get in depth knowledge of momentum, heat and mass transport.
- Applications of fundamental subjects learned, towards chemical engineering problems.
- Students will learn the modelling of engineering operations and structured approach towards engineering problems.

Course Outcomes

- Students will get useful base from which to start for analysing given chemical engineering problem.
- Students will able to apply conservation principles, along with the flux expressions from mass and heat transfer to frame a model for any chemical engineering problem.
- By applying boundary conditions students can approach to structured solution to a given chemical engineering problem.

Detail syllabus

Module	Contents	No. of hrs
1	Differential equations of heat transfer (Conduction), mass transfer (molecular diffusion) with application like CVD reactors.	06
2	**Shell balance :** velocity distribution in laminar flow, temperature distribution in solids and laminar flow, concentration distributions in solids and in laminar flow.	08
3	Convective momentum transport in boundary layer. Convective heat transport in boundary layer. Convective Mass transport in boundary layer. Formulation of differential equations for wetted wall column, thin film evaporator (only model formulation, solution not expected).	10
4	Simplification of continuity equation and equation of motion in Cartesian, cylindrical and spherical coordinates for different steady state engineering problems e.g. flow through trough, pipes and ducts, conical sections, etc for Newtonian and Power law fluids.	10

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Module	Contents	No. of hrs
5	Simplification of equation of energy with and without viscous dissipation for steady state chemical engineering problems. Applications should be limited to Newtonian and Power law fluids. Simplification of continuity equation for multicomponent system with applications to chemical engineering problems like absorption, absorption with reaction, adsorption, diffusion, extraction, etc.	10
6	Unsteady state microscopic balances with and without generation: laminar flow in a tube, conduction with/without heat generation, gas absorption in liquid droplets with/without reaction. Solution to partial differential equations developed in earlier modules using various numerical methods like finite element method, Crank-Nicholson method, Laplace equation. Emphasis should be given to write the computer programs and analysis of simulated values using SciLab/MATLAB for home/class assignments.	08

References

1. Bird, R.B., W.E. Stewart and E.N. Lightfoot, Transport Phenomena, Wiley, New York, 2nd ed., 2002.
2. Welty, James R., Wicks, C. E., Wilson, R. E., Rorrer, Gregory L., Fundamental of Momentum, Heat, and Mass Transfer, Wiley India (P.) Ltd., 5th ed., 2008.
3. Ismail Tosun, Modelling in Transport Phenomena A Conceptual Approach, ELSEVIER SCIENCE B.V, Amsterdam, 2002.
4. Slattery, J.C., Advanced Transport Phenomena, Cambridge University Press, Cambridge, 1999.
5. Brodkey, R.S. and H.C. Hershey, 1988, Transport Phenomena: A Unified Approach, McGraw-Hill, New York.
6. Fahien, R.W., 1983, Fundamentals of Transport Phenomena, McGraw-Hill, New York.
7. Santosh K. Gupta, Numerical Methods for Engineers, New Age Publishers, 2nd ed., 2010.
8. L. Gary Leal, Advanced Transport Phenomena, Cambridge University Press, Cambridge, 2007.
9. Yang, Cao, Chung, and Morris, Applied Numerical Methods Using MATLAB, John Wiley & Sons, Inc., New York, 2005.
10. G. R. Liu, S. S. Quek, The Finite Element Method: A Practical Course, Butterworth-Heinemann, Oxford, 2003.

Course Code	Course/ Subject Name	Credits
CHP806	Project – B	6.0

Details

- Project Groups: Students can form groups with not more than 3(Three).
- Students should spend considerable time in applying all the concepts studied, into the project. Hence, eight hours each were allotted in Project A,B to the students.
- Students are advised to take up industrial/ experimental oriented/ simulation and/or optimization based topics for their projects.

Course Code	Course/Subject Name	Credits
CHL807	Chemical Engineering Lab (EE)	1.0

Concepts for experiments:

Students should be able to apply the Environmental Engineering concepts to control and management of various types of pollutants. A minimum of eight experiments must be performed on following concepts,

- Physical characterization (TDS /turbidity measurement) of waste water.
- Chemical characterization (chloride ion, sulphate ion etc.) of waste water.
- Determination of organic matters (dissolved oxygen) in waste water.
- Sampling measurement and standard of water quality (determination of BOD).
- Sampling measurement and standard of water quality (determination of COD).
- Determination of toxic matters (phenol, chromium etc.) in waste water.
- Determination of inorganic matters (heavy metal) in waste water.
- Measurement of particulate matter in air.
- Measurement of gaseous pollutant (any one) in air.
- Measurement of various types of residues or solids in the given sample.
- Measurement of sound level.

Course Code	Course/Subject Name	Credits
CHL808	Chemical Engg Lab (MSO)	1.5

Concepts for experiments:

The following are suggestions for experiments using using any available computing software:

- Simulation of multi-component flash calculations in ideal and non-ideal systems.
- Simulation of Pipe and pump network flows.
- Simulation of operation of batch, semi-batch and continuous reactors.
- Simulation of unit operations.
- Simulation of flowsheet calculations.
- Optimization of chemical processes.