Bansilal Ramnath Agarwal Charitable Trust's

Vishwakarma Institute of Technology

(An Autonomous Institute affiliated to University of Pune)

Structure & Syllabus of

B.Tech. (Chemical Engineering)

Pattern 'F11'
Effective from Academic Year 2012-13

Prepared by: - Board of Studies in Chemical Engineering

Approved by: - Academic Board, Vishwakarma Institute of Technology, Pune

Signed by

Chairman – BOS **Chairman – Academic Board**

Contents

Notes:

1. **For the following courses refer to Academic Information : Mini Project, Comprehensive Viva Voce, Seminar, Project – I**
2. **For F.E. Course structure and syllabi (Modules I and II): Refer to 'F.E. Structure and Syllabi Booklet'**
3. **For General Proficiency, Professional Development and Open Elective: Refer to 'GP-PD-OE Structure and Syllabi Booklet'**

FF No. : 654

Program Educational Objectives

B.E. (Chemical Engineering)

PEO No.	Description of the Objective
1	To prepare the students for successful industrial careers and postgraduate education in a global environment.
2	To provide the students with a solid foundation in chemistry, physics and mathematics, necessary to address a wide range of chemical engineering problems from conventional chemical engineering design to novel areas such as nanotechnology and biotechnology.
3	To train the students in the chemical engineering principles of equipment design, process design and plant design.
4	To provide learning opportunity in a broad spectrum of multidisciplinary fields such as nanotechnology, biotechnology, advanced materials, energy engineering, environmental enginering, product design etc.
5	To train the students in conducting and planning experiments on physical systems and computer simulation tools, analyzing data and preparing technical reports with the aid of computer tools.
6	To promote awareness of life-long learning and to prepare the students for teamwork, leadership and ethical conduct.

Programme Outcomes

(a) The graduates will demonstrate ability to apply knowledge of mathematics, science and engineering.
(b) The graduates will demonstrate ability to formulate requirements for and design a chemical engineering system taking into account constraints such as economic, environmental, social, safety, manufacturability and sustainability.
(c) The graduates will demonstrate ability to design and conduct experiments, interpret and analyze data and prepare a technical report of the results.
(d) The graduates will be exposed to the state-of-the-art in one of more fields of their choice from amongst a broad spectrum of fields such as nanotechnology, biotechnology, advanced materials, energy engineering, environmental engineering, product design etc.
(e) The graduates will demonstrate ability to use modern software tools and equipments necessary for engineering practice.
(f) The graduates will possess necessary foundation to pursue higher education and careers in research and academics.
(g) The graduates will demonstrate ability to work in multi-disciplinary teams.
(h) The graduates will demonstrate an awareness of professional and ethical responsibilities.
(i) The graduates will demonstrate effective communication and leadership skills.
(j) The graduates will possess an attitude of life-long learning.
(k) The graduates will be exposed to opportunities to pursue recreational activities of their choice.

FF No. : 654

Module VI, T.E. Chemical Engineering

(FF 653, Issue No. 3, Rev 01 Dated 02/04/2011)

Subject No.	Subject Code	Subject Name	Teaching Scheme (Hrs/week)			Credits
			Lect.	Tutorial	Practical	
S5	CH30102	Process Equipment Design	3	0	0	3
S6	CH30104	Chemical Reaction Kinetics	3	0	0	3
S7	CH30106	Chemical Technology	3	0	0	3
S8	CH30108	Separation Techniques	3	0	0	3
T3	CH30202	Process Equipment Design (Tutorial)	0	1	0	1
T4	CH30204	Chemical Reaction Kinetics (Tutorial)	0	1	0	1
P3	CH30304	Chemical Reaction Kinetics Laboratory	0	0	2	1
P4	CH30308	Separation Techniques Laboratory	0	0	2	1
MP6	CH37402	Mini Project	0	0	2	2
PD2		Institute Level Elective	0	0	2	1
CVV4	CH30402	Comprehensive Viva Voce	Based on courses S5,S7			1
Following course to be offered in Semester I only						
SM1	CH37301	Seminar	0	0	1	2
Following course to be offered in Semester II only						
PS1	CH37302	Project Stage I	0	0	1	2
		Total	12	2	9	22

CH30102 :: PROCESS EQUIPMENT DESIGN

Credits: 03 **Teaching Scheme: -** Theory 3 Hrs/Week

Prerequisites: NIL

Objectives:

1. To introduce the students to design of various types of equipments like heat exchangers, plate and packed towers, filtrations equipments and auxiliary equipments, etc.
2. Mapping with PEOs : 3 (b)

Unit I **(8 Hrs)**

Heat Exchangers

Introduction, process heat transfer, types of heat exchangers, codes and standards for heat exchangers, materials of construction, API scale, forced convection equation, mean metal temperature, LMTD, caloric temperatures, countercurrent & concurrent exchangers, temperature approach & cross, , counter-flow: double pipe exchangers, baffles and tie rods, tube joining methods, design of shell and tube heat exchangers as per IS: 4503 and TEMA standards i.e. shell, tube sheets, channel, channel cover, flanged joints. Condensers & reboilers. Awareness on commercial software for thermal design.

Unit II **(6 Hrs)**

Evaporators & Crystallizers

Classification of vaporizing equipment, evaporators (including different types such as kettle, thermosiphon, vertical, horizontal etc.) Chemical evaporators, natural circulation & forced circulation evaporators, the calculation of chemical evaporators, crystallizers, types of crystallizers, design considerations.

Unit III **(7 Hrs)**

Tray Column Design

Design of plate column- distillation columns, design variables in distillation, design methods for binary systems, plate efficiency, approximate column sizing, plate contactors, plate hydraulic design.

Unit IV **(7 Hrs)**

Packed Column Design

Choices of packing, types of packing, packed bed height (distillation and absorption), HETP, HTU, NTU, Cornell's method, Onda's method, column diameter, column internals, column auxiliaries.

Unit V **(7 Hrs)**

Filters & Dryers

Study of various types of filters like vacuum filters, pressure filters, centrifuges and rotary drum filters, design of rotary drum filters including design of drum, shaft, bearing and drive system. Types of dryers, batch type dryers, continuous dryers.

FF No. : 654

Unit VI **(5 Hrs)**

Self Study- Auxiliary Process Vessels

Study of auxiliary process vessels such as reflux drum, knockout drum, liquid-liquid and gas-liquid separators, entrainment separators, oil water separator, Decanter, gravity separator. Safety devices used in process industries, Introduction to design and engineering software.

Text Books

1. "Process Heat Transfer", D. Q. Kern, Tata McGraw Hill Publications, 2009
2. "Coulson & Richardson's Chemical Engineering, Volume-6", R. K. Sinnott, Elsevier Butterworth Heinemann, MA, 2005.
3. "Joshi's Process Equipment Design", V. V. Mahajani, Fourth Edition, Macmillan Publishers India ltd, 2009.

Reference Books

1. 'Chemical process equipment: selection and design',Walas, S. M., Butterworth-Heinemann, 1990.
2. 'Applied Process Design for Chemical and Petrochemical Plants, Vol. 1 and 2', Ludwig, E.E., 3rd Ed., Gulf Publishing Co., 1997.

CH30104 :: CHEMICAL REACTION KINETICS

Credits: 03 **Teaching Scheme: -** Theory 3 Hrs/Week

Prerequisite: Nil

Objectives:

1. Demonstrate the ability to quantitatively predict the performance of common chemical reactors using simplified engineering models
2. Demonstrate the ability to design a set of experiments from which they determine the kinetic model of a multi-reaction system and use this information to design a commercial reactor
3. Write a rate law and define reaction order and activation energy
4. Mapping with PEOs : 3 (b)

Unit I **(8 Hrs)**

Unit 1: Kinetics of homogeneous reactions

A. Irreversible and reversible reactions, Equilibrium; Order and molecularity of reaction. Elementary and non elementary reactions; Stoichiometry, Fractional conversion. Rate of reaction based on all components of the reaction and their interrelation. Law of mass action, Rate Constant-Based on thermodynamic activity, partial pressure, mole fraction and concentration of the reaction components and their interrelation,

B. Temperature dependency of rate Constant -Arrhenious law, Transition state theory and collision theory. Temperature and conversion profiles for exothermic and endothermic reactions, Stable operating condition in reactors

Unit II **(8 Hrs)**

Unit 2: Interpretation of batch reactor data

A. Batch reactor concept, Constant volume Batch reactor system; Design equation for zero, first, Second irreversible and reversible reactions, graphical interpretation of these equations and their limitations, Variable volume Batch reactors. Design equation for first and second order irreversible and reversible reactions, Graphical interpretation of their limitations, Multiple reactions-stoichiometry and Rate equations for series and parallel reactions

B. Multiple reactions-stoichiometry and Rate equations for series and parallel reactions; Non elementary single reactions Development of rate expression; Chain reactions development of rate expressions

Unit III Ideal flow reactors **(8 Hrs)**

A. Concept of ideality, Types of flow reactors and their differences, Space-time and Space velocity, Design equation for plug flow reactor and CSTR; Design equations for first and second order reversible and irreversible constant volume and variable volume reactor

B. Graphical interpretation of these equations; Mean holding time; Development of rate expression for mean holding time for a plug flow reactor.

Unit IV

Single and multiple reactor system **(8 Hrs)**

A. Size comparison of single reactors; Optimum size determination; Staging of reactors, Reactors in series and parallel; Performance of infinite number of back mix reactors in series, Back mix and plug flow reactors of different sizes in series and their optimum way of staging; Recycle reactors, Optimum recycle ratio for auto-catalytic (recycle) reactors Yield and selectivity, Parallel reactions Requirements for high yield, best operating condition for mixed and plug flow reactors, Series reactions

B. Multiple reactions in CSTR and PFR reactors. Maximization of desired product rate in a plug flow reactor and back mixed reactor, product distribution in multiple reactions.

Unit V **(7+1 Hrs)**

Temperature and Pressure Effects

A. Equilibrium Conversion, Optimum temperature progression, Adiabatic and non adiabatic operations, Temperature and conversion profiles for exothermic and endothermic reactions,

B Solving problems based on POLYMATHS, ODE, Interpretation of Batch Reactor data, Series and Parallel Reactions, Sizing of Reactor Finding Tau Optimum Etc

Text Books

1. Levenspeil, O., 'Chemical Reaction Engineering', 3rd. edition, John Wiley & Sons, 2001.
2. Fogler, H. S., 'Elements of Chemical Reaction Engineering', 3rd Ed., PHI, 2002.

Reference Books

1. Walas, S. M., 'Reaction Kinetics for Chemical Engineers', McGraw Hill, 1959.
2. Smith, J.M., 'Chemical Engineering Kinetics', 3rd ed., McGraw Hill, 1987.

CH30106 :: CHEMICAL TECHNOLOGY

Credits: 03 **Teaching Scheme: -** Theory 3 Hrs/Week

Prerequisites: NIL

Objectives:

1. To understand how to prepare process flow sheet for a given reaction chemistry.
2. To learn to study scope and basic principles of various unit operations used in chemical process industry and used in plants.
3. To learn about unit process, yield and process economics to study a chemical process technology.
4. Mapping with PEOs : 3 (b)

Unit I **(8 Hrs)**

Basic Concepts

A. Theory of Unit operations and industrial equipment and systems used in large scale plants; Unit processes, Development of flow diagram, schematic representation and application for unit operations and unit processes.

B. Study the selection and process specific applications knowing available industrial equipment and plant accessories

Unit II **(8 Hrs)**

Chlor-Alkali Industry

A. Chlor-alkali chart and importance of chlor-alkali industry, manufacturing processes process economics, and plants in India and a few examples of latest technology used in other nations; Manufacturing of soda ash, caustic soda, chlorine and engineering problems.

B. Membrane cell, mercury cell diaphragm cell processes and electrolytic cell processes and flowsheets

Unit III **(8 Hrs)**

Nitrogen industry

A. Role of nitrogen in fertilizers, manufacturing of ammonia, nitric acid, urea, the above study must involves different routes adopted, limitations, advantages and disadvantages of the process; steam-reforming process technology.

B. Coal gasification technologies (Fixed bed (Lurgi Process)
Fluidised bed (Winkler Process)

Unit IV **(8 Hrs)**

Sulfur and Sugar Industry

A. Importance, manufacturing of sulfur by Frasch process, technology for the manufacturing of sulfuric acid.

Sugar Industry: Manufacture of sugar and engineering problems associated, Dextrin and starch derivatives.

B. detailed study and comparison between chamber and DCDA processes; process economics.

Unit V **(8 Hrs)**

Phosphorus and Paper Pulp Industry

A. Importance, manufacturing of super phosphate, triple super phosphate, phosphoric acid, electro thermal processes and NPK fertilizers, production of pulp, engineering problems involved, paper manufacturing from pulp, and comparison of methods of manufacturing.

B. Flow sheet and process for manufacture of sulfuric acid and 'phosphate rock'

Textbooks:

1. 'Dryden Outline of Chemical. Technology', Rao, M. Gopala, , 3rd Edition, East West Publishers, 1997.
2. 'Shreve's Chemical Process Industries', Austin, George T., 5th Edition, McGraw-Hill, 1984.

Reference Books:

1. 'Chemical Process Design and Integration', Smith, R., 3rd Edition, Wiley, 2005.
2. 'Unit Processes in Organic Synthesis', Groggins, P.H., 3rd Edition, McGraw-Hill Book Co., 1958.

CH30108 :: SEPARATION TECHNIQUES

Credits: 03 **Teaching Scheme: -** Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:

1. To present the principles of mass transfer and their application to separation and purification processes.
2. To cover graphical methods of design of Distillation columns, liquid-liquid and solid-liquid extraction.
3. Mapping with PEOs : 3 (b)

Unit I **(8+1 Hrs)**

Distillation -I

A**.** Vapour – liquid equilibria for ideal and non-ideal systems, relative volatility, methods of distillation - differential, flash, low pressure, batch rectification. Continuous rectification for binary system, multistage (tray) towers, Lewis Sorrel, McCabe Thiele, and tray efficiencies, concept of reflux, Fenske's equation, Fenske-Underwood equation, use of open steam. Partial and total Condensers, reboilers.

B. Packed towers for distillation, NTU, HTU, HETP concept and calculations, distillation column internals.

Unit II **(8 Hrs)**

Distillation-II

Ponchon Savarit method for multistage operations, tray efficiencies, concept of multi component distillation. Numerical problems on multi component distillation, steam distillation, positive and negative deviations from ideality, Non ideal distillation-extractive and azeotropic distillation. Numerical problems based on multi component distillation and Ponchon Savarit method.

Unit III **(8 Hrs)**

Liquid – Liquid Extraction

A: Ternary liquid equilibria, single stage extraction, multistage crosscurrent, countercurrent and cocurrent extraction, calculations based on triangular diagrams, x – y co – ordinates and solvent free basis. Continuous countercurrent extraction with reflux, total reflux, stage efficiency

B., Continuous contact extraction in packed towers, HTU and NTU concept

B: Types of extractors – stage type and differential type

Unit IV **(8 Hrs)**

Solid – Liquid Extraction (Leaching)

A. continuous counter current leaching, ideal stage equilibrium, operating time, constant and variable underflow, number of ideal stages, stage efficiencies. Problem based on Calculation of single stage and multistage leaching processes.

B: Leaching equipments,

Unit V **(8 Hrs)**

Adsorption and Ion Exchange

A: Adsorption – Basic Principle and Equilibria in adsorption. Single gases and vapors – Adsorption of liquids. Types of adsorption – Physical and Chemical Adsorption Isotherms- Langmuir and Freundlich. Introduction to pressure Swing Adsorption (PSA), and Temperature Swing Adsorption (TSA). Ion Exchange- Principles of Ion Exchange Equilibria and rate of ion exchange

B. Equipments: Continuous Contact steady state –moving bed adsorber. Techniques and applications, equipments.

Textbooks

1. "Mass Transfer Operations", Treybal, R.E., 3rd edition, McGraw Hill, 1980.
2. "Chemical Engineering – Vol. I & II", Coulson J.M., Richardson, J. F., 6th edition, Butterworth-Heinemann, 1999
3. "Multi component distillation ", D. D. Holland, Prantic Hall India.
4. "Principles of Unit Operations", A.S. Foust, L.A.Wenzel, John Wiley &sons

Reference Books

1. "Unit Operations of Chemical Engineering", McCabe, W. L.; Smith, J. C.; Harriett, P. 4th ed., McGraw-Hill, 1985.
2. "Perry's Chemical Engineer's Handbook", Perry, Robert H.; Green, Don W., 6th Edition, McGraw-Hill, 1984.

CH30202 :: Process Equipment DesigN (Tutorial)

Credits: 01 **Teaching Scheme: -** Tutorial 1 Hr/Week

Prerequisites: NIL

Objectives:

1. To introduce the students to design of various types of equipments like heat exchangers, plate and packed towers, filtrations equipments and auxiliary equipments, etc.
2. Mapping with PEOs : 3 (b)

List of Contents

A TERM-WORK containing the record of the following:

Assignments (Any three of the following)

1. Problems on calculation of heat exchangers
2. Problems on design of evaporators.
3. Problems on tray column design.
4. Problems on design of packed columns.

Half Imperial Size Drawing Sheets (Any two of the following)

1. Design of heat exchangers.
2. Design of tray tower.
3. Design of packed tower.
4. Design of auxiliary vessels.

Text Books

1. "Process Heat Transfer", D. Q. Kern, Tata McGraw Hill Publications, 2009
2. "Coulson & Richardson's Chemical Engineering, Volume-6", R. K. Sinnott, Elsevier Butterworth Heinemann, MA, 2005.
3. "Joshi's Process Equipment Design", V. V. Mahajani, Fourth Edition, Macmillan Publishers India ltd, 2009.

Reference Books

1. 'Chemical process equipment: selection and design',Walas, S. M., Butterworth-Heinemann, 1990.
2. 'Applied Process Design for Chemical and Petrochemical Plants, Vol. 1 and 2', Ludwig, E.E., 3rd Ed., Gulf Publishing Co., 1997.

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CH 30204 :: CHEMICAL REACTION KINETICS (Tutorial)

Credits: 01 **Teaching Scheme: -** Tutorial 1 Hr/Week

Prerequisites: Nil

Objectives:

1. Write a rate law and define reaction order and activation energy
2. Demonstrate the ability to quantitatively predict the performance of common chemical reactors using simplified engineering models
3. Demonstrate the ability to regress the experimental data from which they determine the kinetic model of a multi-reaction system and use this information to design a commercial reactor.
4. Mapping with PEOs : 3 (b)

Contents

A TERM-WORK containing the record of the following:

Assignments:

1. Preparation of reaction mechanism for the non elementary reaction
2. Preparation of reaction mechanism for the biochemical reaction derive Michelis Menton kinetics mechanism
3. Find the overall order of the irreversible reaction using half life period data
4. Two problems based on best arrangement of in set of series reactors

Polymaths program :

1. Solving problem based on series of reaction, considering differential equationConcentration Profile of a Series Reaction
2. Polymath Semibatch production distribution profile

Text Books

1. "Chemical Reaction Engineering", Levenspile O. 3rd Edition, John Wiley & Sons, 2001.
2. "Elements of Chemical Reaction Engineering" Fogler H. S., 3rd Edition PHI, 2002.

Reference Books

1. "Reaction Kinetics for Chemical Engineers", Walas, S. M.McGraw Hill, 1959.
2. "Chemical Engineering Kinetics" Smith J. M. , 3rd Edition, McGraw Hill, 1987.

CH30304 :: CHEMICAL REACTION KINETICS LABORATORY

Credits: 01 **Teaching Scheme: -** Laboratory 2 Hrs/Week

Prerequisites: Nil

Objectives:

1. Write a rate law and define reaction order and activation energy
2. Demonstrate the ability to quantitatively predict the performance of common chemical reactors using simplified engineering models
3. Demonstrate the ability to regress the experimental data from which they determine the kinetic model of a multi-reaction system and use this information to design a commercial reactor.
4. Mapping with PEOs : 3,5 (b,c)

List of Practical

1. To calculate value of rate constant 'k' for the saponificaton of ethyl acetate with NaOH in batch reactor – I (Where M=1)
2. To calculate value of rate constant 'k' for the saponificaton of ethyl acetate with NaOH in batch reactor – II (Where M=2)
3. To calculate value of rate constant 'k' for the saponificaton of ethyl acetate with NaOH in straight tube, coli Bent Tube reactor and CSTR and PFR
4. To calculate value of rate constant 'k' for the saponificaton of ethyl acetate with NaOH in mixed flow reactor.
5. To calculate value of rate constant 'k' for the saponificaton of ethyl acetate with NaOH in mixed flow reactors in series.
6. Verification of Arrhenius law.
7. Autoclave reactor: Reaction CO_2 Carbonization in the reactor
8. Residence time Distribution in PFR and CSTR, Finding Dispersion Number
9. Semibatch Reactor Addition of NaOH in Ethyl acetate, Utilization of POLYMATHS for finding Behavior of products with respective of time
10. Finding τ optimum using polymaths for parallel Reactions
11. Finding conversion and rate of polymerization reactions using gravimetric method

Text Books

1. "Chemical Reaction Engineering", Levenspile O. 3rd Edition, John Wiley & Sons, 2001.
2. "Elements of Chemical Reaction Engineering" Fogler H. S. , 3rd Edition PHI, 2002.

Reference Books

1. "Reaction Kinetics for Chemical Engineers", Walas, S. M.McGraw Hill, 1959.
2. "Chemical Engineering Kinetics" Smith J. M. , 3rd Edition, McGraw Hill, 1987.

CH30308 :: SEPARATION TECHNIQUES LABORATORY

Credits: 01 **Teaching Scheme: -** Laboratory 2 Hrs/Week

Prerequisites: Nil

Objectives:

1. Apply mass transfer fundamentals to study the performance of various separation devices in practical situations.
2. Analyze the performance of columns with different types of packing (e.g. Raschig rings, berl saddles, structured packings)
3. Support the separation techniques theory course by practical experience.
4. Mapping with PEOs : 3,5 (b,c)

List of Practicals

1. Simple Distillation
2. Total Reflux
3. Steam Distillation
4. Equilibrium Diagram for Liquid – Liquid Extraction
5. Characterization of Spray Extraction Column
6. Distillation using Sieve Plate, Bubble Cap Column
7. Batch/ Continuous Leaching
8. Adsorption and Ion Exchange
9. Two assignments based on multi component distillation using ASPEN software.

Text Books

1. "Mass Transfer Operations", Treybal, R.E., 3rd edition, McGraw Hill, 1980.
2. "Chemical Engineering – Vol. I & II", Coulson J. M.; Richardson, J. F., 6th edition, Butterworth-Heinemann, 1999.
3. "Introduction to ASPEN "Departmental manual.

Reference Books

1. "Unit Operations of Chemical Engineering", McCabe, W. L.; Smith, J. C.; Harriott, P., 4th ed., McGraw-Hill, 1985.
2. "Perry's Chemical Engineer's Handbook", Perry, Robert H.; Green, Don W., 6th Edition, McGraw-Hill, 1984.

Semester – II, T.E.Chemical Engineering: Module-Independent Courses:

CH37302 :: PROJECT – I

Credits: 02 **Teaching Scheme: -** Laboratory 2 Hrs/Week

Prerequisites: Nil

Objectives:

1. Student should be able to apply Chemical Engineering knowledge.
2. They should learn How to Work in Team.
3. They should be learn to take task (problem) and execute it.
4. The aim of the project work is to carry out research and development work.
5. Mapping with PEOs : 1,4,5,6 (a-e,g,i,j)

Contents:

This stage will include a report consisting of synopsis, the plan for experimental/theoretical work and the summary of the literature survey carried out till this stage.

Students may undertake studies in application chemical engineering knowledge for manufacturing project, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of this work. The group of students is required to choose the topic in consultation with the Guide.

A technical report of 15 pages is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation.

Text Books

1. "Project Writing Manual" B.A. Bhanvase, Chemical Engineering Department, VIT, Pune

Reference Books: Nil