Dr. Vishwanath Karad
MIT WORLD PEACE UNIVERSITY | PUNE
TECHNOLOGY, RESEARCH, SOCIAL INNOVATION & PARTNERSHIPS

SYLLABUS

DR. VISHWANATH KARAD
MIT - WORLD PEACE UNIVERSITY

FACULTY OF ENGINEERING

TY B. TECH.
(CHEMICAL ENGINEEING)
(2017 Course)

w.e.f. 2019-2020

Dr. Kiran Patil
Chairman,
Board of Studies,
School of Petroleum, Polymer & Chemical Engineering

Dr. Shrihari Honwad
Provost and Dean,
Faculty of Engineering and Technology

B. Tech. Chemical Engineering (Third Year) (Batch 2019-20)

Trimester – VII

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	CH311	Numerical Methods in Chemical Engg.	PC	3	-	2	2	1	50	50	50	150
2	CH312	Mass Transfer-I	PC	3	-	2	2	1	50	50	50	150
3	CH313	Process Equipment Design	PC	3	-	2	2	1	50	50	50	150
4	CH314	Chemical Reaction Engineering-II	PC	3	-	2	2	1	50	50	50	150
5	OECH-I	Open Elective-I	OE	3	-	2	2	1	50	50	50	150
6	WPC5	Indian Tradition, Culture and Heritage	WP	3	-	-	2	-	50	-	50	100
Total :				**18**	**-**	**10**	**12**	**05**	**300**	**250**	**300**	**850**

Weekly Teaching Hours: 28 Hours

Total Credits: Third Year B. Tech. Trimester-I: 17

B. Tech. Chemical Engineering (Third Year) (Batch 2019-20)

Trimester – VIII

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	CH321	Mass Transfer-II	PC	3	-	2	2	1	50	50	50	150
2	CH322	Transport Phenomena	PC	3	-	2	2	1	50	50	50	150
3	CH 323	Environmental Engineering	PC	3	-	2	2	1	50	50	50	150
4	CH 324	Professional Elective –I	PE	3	-	2	2	1	50	50	50	150
5		Finance and Accounting	HSS	3	-	-	2	-	50	-	50	100
Total :				**15**	**-**	**8**	**10**	**04**	**250**	**200**	**250**	**700**

Weekly Teaching Hours: 23 Hours **Total Credits: Third Year B. Tech. Trimester-II: 14**

B. Tech. Chemical Engineering (Third Year) (Batch 2019-20)

Trimester – IX

Sr. No.	Course Code	Name of Course	Type	Weekly Workload, Hrs.			Credits		Assessment Marks**			
				Theory	Tutorial	Lab	Th.	Lab.	CCA*	LCA*	End Term Test	Total
1	CH331	Plant Design and Economics	PC	3	-	2	2	1	50	50	50	150
2	CH332	Process Dynamics and Control	PC	3	-	2	2	1	50	50	50	150
3	CH333	Process Safety and Management	PC	3	-	-	2	-	50	-	50	100
4	CH334	Professional Elective –II	PE	3	-	2	2	1	50	50	50	150
5		Seminar/ Mini Project	PR	-	-	2	-	1	-	50	-	50
6	WPC6	Humanities – Ethical, Moral and Social Science	WP	3	-	-	2	-	50	-	50	100
Total :				**15**	**-**	**8**	**10**	**04**	**250**	**200**	**250**	**700**

Weekly Teaching Hours: 23 Hours

Total Credits: Third Year B. Tech. Trimester-III: 14

Total Third Year B. Tech Credits: 17 + 14 + 14 = 45

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH311**				
Course Category	**Professional Core**				
Course Title	**Numerical Methods in Chemical Engg.**				
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**	
	03	**--**	**02**	**3**	

Pre-requisites: Engineering Mathematics

Course Objectives:

1. To understand, apply mathematical tools for chemical engineering problems
2. To use different numerical techniques
3. To learn mathematical computing tools like Matlab, Scilab, Python, R etc

Course Outcomes:

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

1. Solve different mathematical problems through effective application of various numerical methods.
2. Solve rigorous process models in mass transfer, heat transfer and other allied areas of chemical engineering using effective application of numerical methods.
3. Efficiently plan experiments, collect data, analyze and interpret the data, and understand how the observed data are related to the proposed model for the problem under study.

Course Contents:

Introduction to numerical methodology:
Need for numerical techniques, Chem. Engineering Application, Round-off and truncation errors.

Solving Linear Algebraic Equations:
Gauss Elimination, Matrix Inversion methods, LU Decomposition, Gauss-Jordon Elimination, and Gauss Seidel Method, Jacobi method, Eigen values and Eigen Vectors of Matrices.

Solving Non-Linear Algebraic Equations:
1-D root search using bracketing, Bracketing method: fixed point iteration, Bisection, False-Position. Open Method: Single variable Newton Raphson, Secant method.

Regression Analysis and Interpolation
Linear Regression, Polynomial Regression, Newton's Interpolation, Lagrangian Interpolation.

Numerical Integration, Differentiation and Difference formulas:
Newton-Cotes closed integration formulae, Finite divided differences for differentiation.

Solving Ordinary Differential Equation
Euler's method, Modified Euler's method, 2^{nd} order Runge-Kutta Method, 4^{th} order Runge-Kutta method, Multi-step (explicit and implicit) techniques, predictor-corrector algorithms, Boundary Value Problems.

List of Practicals:

Minimum 06 practicals based on applications of Numerical Methods in Chemical Engineering.

1. Eigen values and Eigen vector computations for Level Control Applications.
2. Numerical interpolation
3. Numerical integration.
4. Integration of ODE – Equation for Batch Reactions.
5. Numerical differentiation.
6. Root-finding method
7. Non-linear optimization methods
8. Regression Analysis.
9. Solving basic linear algebra involving matrix operations
10. Solving non-linear algebraic equation/s

Text Books:

1. S C Chapra and R P Canale, Numerical Methods for Engineers, McGraw Hill International Edition.
2. Edger, T. F.; Himmelblau, D. M., "Optimization of chemical processes", McGraw-Hill, 2nd Edition, 2001.

Reference Books:

1. Rice, R.G.; Do, D.D., "Applied Mathematics and Modeling for Chemical Engineers", John Wiley and Sons, 1995.
2. Jenson, V.G.; Jeffreys, G. V., "Mathematical Methods in Chemical Engineering", 2nd Edition, Academic Press, 1997.
3. Mickley, H. S.; Shewrwood, T. S.; Reed, C. E., "Applied Mathematics in Chemical Engineering", McGraw-Hill, 1957.
4. Riggs, James B., "An Introduction to Numerical Methods for Chemical Engineers", 2nd Edition, Texas Tech University Press, 1994.
5. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and sons, inc.
6. W.J. DeCoursey, Statistics and Probability for Engineering Applications with Microsoft Excel, Newnes.

7. Montgomery, D.C. and Runger, G.C. Applied Statistics and Probability for Engineers, John Wiley & Sons, 2011
8. J. D. Hoffmann, Numerical Methods for Engineers and Scientists, , Marcel Dekker Inc., 2nd ed., Indian Reprint, 2010.
9. S. K. Gupta, Numerical methods for Engineers, New Age Publishers, 2nd ed., 2009
10. Jaan Kiusalas, Numerical Methods in Engineering with MATLAB, Cambridge University Press, 2nd ed., 2009
11. Randall Leveque, Finite difference methods for ordinary differential equations, SIAM publications, 1st ed. 2007
12. Press et al., Numerical Recipes in Fortran/C, Cambridge University Press, 2nd ed.2000

Weblinks: ***https://nptel.ac.in/courses/103103035/1***
MOOCs: Courses by MIT Open course ware and NPTEL

Pedagogy:

- Co-teaching
- Power point presentations
- Videos

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Mid term	Presentations	Group Activity	MCQ	Oral	Any other
10 Marks	20 Marks		20 Marks			

Laboratory Continuous Assessment (LCA): 50 marks

Practical	Oral based on practical	Attendance	Mini Project	Problem based Learning	Any other
20 Marks	20 Marks	10 Marks			

Term End Examination: Programming Based Examination to be Conducted in Laboratory: 50 Marks **OR** Theory Question Paper OPEN BOOK: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	***Introduction to Numerical methodology and programming*** Need for numerical techniques, Chem. Engineering Applications Round-off and truncation errors	02	*02*	
2	***Solving Linear Algebraic Equations:*** Gauss Elimination, Matrix Inversion methods, LU Decomposition,Gauss-Jordon Elimination, and Gauss Seidel Method, Jacobi method, Eigen values and Eigen Vectors.	06	04	-
3	***Solving Non-Linear Algebraic Equations:*** 1-D root search using bracketing, Bracketing method: fixed point iteration, Bisection, False-Position. Open Method: Single variable Newton Raphson, Secant method	04	04	-
4	***Regression Analysis and Interpolation*** Linear Regression, Polynomial Regression, Newton's Interpolation, Newton's Divided Difference Interpolation, Lagrangian Interpolation.	06	04	
5	***Numerical Integration, Differentiation and Difference formulas:*** Newton-Cotes closed integration formulae, Finite divided differences for differentiation.	04	04	-
6	***Solving Ordinary Differential Equation:*** Euler's method, Modified Euler's method, 2nd order Runge-Kutta Method, 4th order Runge-Kutta method, Multi-step (explicit and implicit) techniques, predictor-corrector algorithms, Boundary Value Problems.	06	04	-

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH312**			
Course Category	**Professional Core**			
Course Title	**Mass Transfer-I**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**-**	**02**	**03**

Pre-requisites:

Course Objectives:

1. To acquaint the student with the fundamental concepts of mass transfer principles
2. To introduce equations describing molecular diffusion through gases, liquids, and solids.
3. To make the students conversant with techniques used to estimate mass transfer coefficients in laminar and turbulent flows.
4. To equip the student with the general approach for the design of continuous contact and stage wise operations.

Course Outcomes:

On successful completion of this course, student will be able to

1. Identify and formulate a mass transfer problem in diffusive and convective situations.
2. Formulate and solve interphase mass transfer problem encountered in real life
3. Identify, Formulate, and Solve single stage mass transfer problem
4. List and choose from the variety of gas-liquid contact equipment
5. Estimate mass transfer coefficient to be used in a real life application
6. Develop and Use Psychometric Chart for designing humidification/dehumidification tower
7. Estimate time and energy required for batch drying

Course Contents:

Introduction to Mass Transfer and Molecular Diffusion

Introduction, types of diffusion , Fick's first and second law of diffusion Molecular diffusion in gases and liquids, diffusivities of gases and liquids, diffusion in solids, methods to estimate diffusivities.

Interphase Mass Transfer

Concept of equilibrium, Diffusion between phases, Local and average phase /overall mass transfer coefficients

Mass Transfer Coefficients

Theories for mass transfer: Film Theory, Penetration theory, Surface renewal theory, Convective mass transfer, Dimensionless groups in mass transfer and their significance, Analogy between Momentum, Heat and Mass transfer.

Simultaneous Heat and Mass Transfer Operations: Humidification and Drying Operations:

Humidity, Relative, Percentage, Absolute humidity, Humidity Chart construction and use. Dry bulb, Wet bulb temperature and Dew point, Adiabatic saturation temperature, Lewis relation, simple problems on humidity chart.

Principles, equilibrium in drying, types of moisture content, mechanism of batch drying, continuous drying, and time required for drying, mechanism of moisture movement in solid, Classification and selection of industrial dryers.

List of Experiments: *(any 6 experiments)*

1. To determine diffusivity of acetone in air.
2. To determine drying characteristics of a wet solid material using tray dryer.
3. To determine mass transfer behavior of wetted wall tower.
4. To study equipment used for gas liquid operation- Gas dispersed.
5. To study equipment used for gas liquid operation- Liquid dispersed.
6. To evaluate performance of humidification/ de-humidification column.
7. To determine mass transfer coefficient for surface evaporation.
8. To determine liquid hold up in packed tower.

Reference Books:

1. Treybal, R.E., 'Mass Transfer Operations', 3rd edition, McGraw Hill, 1980.
2. Geankoplis, C.J, 'Transport Processes and Unit Operations', PHI, 3rd Edition, 1993
3. Coulson, J. M.; Richardson, J. F., 'Chemical Engineering – Vol. I & II', 6th edition, Butherworth-Heinemann, 1999.
4. Cussler E.L., 'Diffusion: Mass transfer in fluid Systems'; 2nd Edition, Cambridge University Press, 1998.

Weblinks: ***https://nptel.ac.in/courses/103103035/1***

MOOCs: Courses by MIT Open course ware and NPTEL

<u>Pedagogy</u>:

- Co-teaching
- Power point presentations
- Videos

Assessment Scheme:

Class Continuous Assessment (CCA): ***50 Marks***

Assignments	Mid term	Presentations	Group Activity	MCQ	Oral	Any other
10 Marks	20 Marks		20 Marks			

Laboratory Continuous Assessment (LCA)

Practical	Oral based on practical	Attendance	Mini Project	Problem based Learning	Any other
20 Marks	20 Marks	10 Marks			

Term End Examination : Theory Question Paper of 50 marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Introduction to Mass Transfer and Molecular Diffusion** Introduction, types of diffusion , Fick's first and second law of diffusion Molecular diffusion in gases and liquids, diffusivities of gases and liquids, diffusion in solids, methods to estimate diffusivities.	**6**	**2**	
2	**Interphase Mass Transfer** Concept of equilibrium, Diffusion between phases, Local and average phase /overall mass transfer coefficients	**6**	**2**	
3	**Mass Transfer Coefficients** Theories for mass transfer: Film Theory, Penetration theory, Surface renewal theory, Convective mass transfer, Dimensionless groups in mass transfer and their significance, Analogy between Momentum, Heat and Mass transfer	**6**	**2**	
4	**Simultaneous Heat and Mass Transfer Operations: Humidification and Drying Operations** Humidity, Relative, Percentage, Absolute humidity, Humidity Chart construction and use. Dry bulb, Wet bulb temperature and Dew point, Adiabatic saturation temperature, Lewis relation, simple problems on humidity chart.	**6**	**2**	
5	Principles, equilibrium in drying, types of moisture content, mechanism of batch drying, continuous drying, time required for drying, mechanism of moisture movement in solid, Classification and selection of industrial dryers.	**6**	**2**	

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	CH313			
Course Category	Engineering Core			
Course Title	Process Equipment Design			
Teaching Scheme and Credits Weekly load hrs	Theory	Tutorial	Laboratory	Credits
	03	-	02	03

Pre-requisites:

1. Strength of Materials 2. Engineering Drawing 3. Material Science 4. Heat Transfer

Course Objectives:

1. To learn about the design procedures of process equipments used in chemical process plants
2. To be familiar with process and mechanical aspects of equipment design.
3. To be exposed to various design codes and standards used in mechanical design of equipment.
4. To learn to draw various process equipments and mechanical components as per calculated design.
5. To test the equipment for safety against applied loads.

Course Outcomes:

On completion of this course, the students will be able to

1. Apply the role of design engineer in designing procedures
2. Design important components like flange couplings
3. To apply key criteria involved in the design of internal pressure vessels as per IS Code.
4. Design heat transfer equipments, understand heat exchanger sizing and develop a heat exchanger data sheet.
5. Design storage vessels and various parts of vessels (e.g. heads, Shell, bottom plate)
6. Demonstrate relationship between equipment design, safety and environment.

Course Contents:

Introduction To Design: General Design procedure, Design methodology, steps in design activity, process design and mechanical design, mechanical properties of material, factor of safety, material of construction, Selection, Equipment fabrication methods and testing, Codes and standards, IS, ASME and TEMA codes in design and their significance.

Design of mechanical component: protected and unprotected types of flange couplings.

Design of Pressure Vessel: A brief overview of process design aspects of pressure vessel (as a reactor for example), Codes and standards for pressure vessels design (IS: 2825: 1969) for unfired pressure vessel shell, design of head (Flat, hemispherical, torrispherical, elliptical & conical), flange joint, nozzle and supports. Selection of corrosion allowance and weld joint efficiency

Design of Storage Tank: Study of various types of storage vessels and applications, Atmospheric vessels, vessels for storing volatile and non-volatile liquids, storage of gases, Losses in storage vessels, Various types of roofs, Design of cylindrical storage vessels as per IS: 803- design of base plates, shell plates, roof plates, wind girders, curb angles for self-supporting and column supported roofs, stresses due to dead weight, wind load, Storage of gases (spherical vessels or hortonspheres).

Design of Heat Exchanger: Types of Heat Exchangers, Codes and standards for heat exchangers, Design of heat exchanger (U tube and fixed tube) i.e. shell, head, channel, channel cover, flanged joints, tubes, tube sheet, tie rods & baffles as per IS:4503 and TEMA standards. Fouling in heat exchanger, Fouling types.

List of Experiments:

Minimum *three* design assignments and respective drawings should be drawn (By hand or through AutoCAD) on full empirical drawing sheet from the following list.

1. Design of mechanical component such as protected / unprotected flange couplings.
2. Design of pressure / reaction vessel including shell, heads, supports, nozzles etc.
3. Design of storage tank including design of each course at different heights, rooftop, bottoms, vents etc.
4. Design of shell and tube heat exchanger including channels, baffles, tube sheets, and tie rods supports etc.
5. Design of distillation / absorption tower, including tall tower considerations, eccentrically loaded joints, supports, manholes reinforcement rings etc.
6. Optimum design of pressure vessel using design software such as Designer Desktop and IS Code 2825.

(At least one assignment should be drawn using design software)

Text Books:

1. Mahajani, V V and S.B.Umarji, ".Joshi's, Process Equipment Design", Trinity Press, New Delhi. (2014).
2. R. S. Khurmi, J. K. Gupta, "A Text Book on Machine Design", Eurasia Publishing House (Pvt.) Ltd., New Delhi.
3. S. D. Dawande, " Process Design of Equipments", Vol 1 & 2, Denett Publications, Nagpur (2007)

Reference Books:

1. Bhattacharya B. C., 'Introduction to Chemical Equipment Design Mechanical Aspects', CBS Publishers, Delhi, 1991.
2. E. Brownell and Edwin, H. Young, 'Process Equipment Design − Vessel Design', John Wiley, New York 1963.
3. J.M. Coulson, J.F. Richardson and R.K. Sinott, 'Chemical Engineering Vol.6', Pergamon Press, 2004
4. Walas S.,' Chemical Equipment Design', Butterworth-Heinemann, 1988.
5. Spolts M. F., 'Mechanical Design Analysis;', Prentice Hall, 1964
6. Moss Dennis R., 'Pressure Vessel Design Manual' 3rd Edition; Gulf Professional Publishing, 2003.
7. Indian Standards Institution, 'code for unfired pressure vessels', IS – 2825, 1969
8. Stanley M. Walas, "Chemical Process Equipment- Selection and Design", Butterworth-Heinemann Series in Chemical Engineering

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Group Activity
10	10	20	10

Laboratory Continuous Assessment (LCA): 50 marks

Practicals (Drawing Sheets)	Oral based on practical	Presentations	Any other
40	10	00	00

Term End Examination :

Theory Question Paper OPEN BOOK: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	***Lab***	***Assess***
1	General Design procedure, Design methodology, steps in design activity, process design and mechanical design, mechanical properties of material	**3**	**-**	**-**
2	Factor of safety, material of construction, Selection, Equipment fabrication methods and testing, Codes and standards, IS, ASME and TEMA codes in design and their significance.	**3**	**-**	**-**
3	Design of mechanical components such as protected and unprotected types of flange couplings.	**3**	**2**	**-**
4	A brief overview of process design aspects of pressure vessel (as a reactor for example), Codes and standards for pressure vessels design (IS: 2825: 1969) for unfired pressure vessel shell	**3**	**4**	**-**
5	Design of head (Flat, hemispherical, torrispherical, elliptical & conical), flange joint, nozzle and supports. Selection of corrosion allowance and weld joint efficiency	**3**	**-**	**-**
6	Study of various types of storage vessels and applications, Atmospheric vessels, vessels for storing volatile and non-volatile liquids, storage of gases, Losses in storage vessels, Various types of roofs	**3**	**2**	**-**
7	Design of cylindrical storage vessels as per IS: 803- design of base plates, shell plates, roof plates, wind girders, curb angles for self-supporting and column supported roofs, stresses due to dead weight, wind load, Storage of gases (spherical vessels or hortonspheres).	**3**	**-**	**-**
8	Types of Heat Exchangers, Codes and standards for heat exchangers	**3**	**-**	
9	Design of heat exchanger (U tube and fixed tube) i.e. shell, head, channel, channel cover, flanged joints, tubes, tube sheet, tie rods & baffles as per IS:4503 and TEMA standards.	**4**	**4**	
10	Fouling in heat exchanger, Fouling types.	**2**	**-**	

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	CH314			
Course Category	Professional Core			
Course Title	Chemical Reaction Engineering-II			
Teaching Scheme and Credits Weekly load hrs	Theory	Tutorial	Laboratory	Credits
	03	-	02	03

Pre-requisites: Reaction Engineering-I

Course Objectives:

1. To study the real reactors considering RTD in various reactors and obtain actual design parameters.
2. To learn catalytic phenomena with extensions to reactor design and catalyst characterization.
3. To get acquainted with the principles used in design of multiphase reactor.

Course Outcomes:

On successful completion of this course, student will be able to

1. Account for deviations from ideal mixing behavior
2. Identify critical parameters affecting the design and performance of catalytic reactors
3. Formulate the kinetics of fluid-solid non-catalytic reactions
4. Design equipment for handling fluid-fluid reactions
5. Characterize a given catalyst and formulate its deactivation kinetics
6. Do preliminary calculations involved in scale-up of a reactor

Course Contents:

Non-Ideal Flow and Mixing of Fluids

Review of basic concepts, Analysis of RTD from pulse input and step input, Models for predicting conversion from RTD data, Segregation and maximum mixedness model, One parameter: Dispersion model, Tank in series model, Early and late mixing of fluid, mixing of two miscible fluids.

Heterogeneous and Solid Catalyzed Reactions

Global rate of reaction, Complications of the rate equation and the contacting patterns for multiphase contact, Rate equation for surface kinetics, pore diffusion, Pore diffusion resistance combined with surface kinetics, Model of a single cylindrical pore, Effectiveness factor, Performance equations for reactions containing porous catalyst particles, Experimental methods for finding rates.

Types of deactivation, Mechanism of deactivation, Rate equation for deactivation, Models for Catalyst Deactivation, Regeneration of catalyst, Non-Isothermal reactor design.

Fluid-Particle Reactions (Non-catalytic Reactions)

Selection of a model for gas-solid reactions Un-reacted Shrinking core model, Rate controlling resistances, Determination of the rate controlling steps, Conversion-Time relationship.

List of Experiments: *(any 6 experiments)*

1. To study RTD Residence Time Distribution of a tubular reactor
2. To study RTD Residence Time Distribution of a mixed flow reactor
3. To study the reactive distillation (single stage)
4. To synthesize catalyst and study its characterization
5. To evaluate kinetics of liquid-solid catalytic reaction.
6. Mathematical modeling of fixed bed reactor
7. Simulation of Catalytic Reactor Using ASPEN

Reference Books:

1. Levenspiel O., "Chemical Reaction Engineering", Third Edition, John Wiley and Sons, 2003.
2. Scott Fogler H., "Elements of Chemical Reaction Engineering", Prentice-Hall of India, 1997.
3. Smith J. M., "Chemical Engineering Kinetics", McGraw-Hill, 1981.Seader J.D., Henley

Weblinks:

MOOCs: Courses by MIT Open course ware and NPTEL

Pedagogy:

- Co-teaching
- Power point presentations
- Videos

Assessment Scheme:

Class Continuous Assessment (CCA)*: 50 Marks*

Assignments	Test	Group Activity	Case study	MCQ	Oral	Any other
20 Marks	20 Marks	10 Marks				

Laboratory Continuous Assessment (LCA)

Practical	Oral based on practical	Attendance	Mini Project	Problem based Learning	Any other
20 Marks	20 Marks	10 Marks			

Term End Examination : Theory Question Paper of 50 marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Non-Ideal Flow and Mixing of Fluids** Review of basic concepts, Analysis of RTD from pulse input and step input, Models for predicting Conversion from RTD data, Segregation and maximum mixedness model, One parameter: Dispersion model, Tank in series model, Early and late mixing of fluid, mixing of two miscible fluids.	**8**	**-**	
2	**Heterogeneous and Solid Catalyzed Reactions** Global rate of reaction, Complications of the rate equation and the contacting patterns for multiphase contact, Rate equation for surface kinetics, pore diffusion, pore diffusion resistance combined with surface kinetics, Model of a single cylindrical pore, Effectiveness factor, Performance equations for reactions containing porous catalyst particles, Experimental methods for finding rates.	**8**	**-**	
3	**Fluid-Particle Reactions (Non-catalytic Reactions)** Selection of a model for gas-solid reactions Un-reacted core and Shrinking core model, Rate controlling resistances, Determination of the rate controlling steps, Application to fluidized bed design. Types of deactivation, Mechanism of deactivation, Rate equation for deactivation, Models for Catalyst Deactivation, Regeneration of catalyst, Non-Isothermal reactor design.	**8**	**-**	
4	**Fluid-Particle Reactions (Non-catalytic Reactions)** Selection of a model for gas-solid reactions Un-reacted Shrinking core model, Rate controlling resistances, Determination of the rate controlling steps, Conversion-Time relationship.	**6**	**-**	

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH321**			
Course Category	**Professional Core**			
Course Title	**Mass Transfer-II**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**-**	**02**	**03**

Pre-requisites:

Course Objectives:

1. Equip the student with principles underlying the design equations for basic mass transfer operations.
2. Equip the student to perform design calculations for equilibrium staged separation processes.
3. Provide an understanding of the general principles of separation processes to allow students to make sensible options given a separation task.
4. Prepare the student for a role as designer/operator of separation columns.

Course Outcomes:

On successful completion of this course, student will be able to

1. Set up material balances over and calculate minimum phase ratio required for a staged separation column.
2. Design a separation tower using 'equilibrium stages' approach
3. Design a separation tower using NTU-HTU approach
4. State the key factors affecting and their effect on performance of a separation tower
5. Design internals of tray and packed towers

Course Contents:

Gas Absorption

Mechanism of gas absorption, Henry's law, Choice of solvent.

Design approaches: Equilibrium approach and Rate approach

Equilibrium approach: No. of Equilibrium stages by Mc-Cabe Thile construction.

Rate approach: Number of transfer units (NTU), height of transfer units (HTU), Height Equivalent to Theoretical Plate (HETP), Packed and staged columns.

Distillation

Raoult's law, methods of distillation: Flash distillation, differential or simple distillation, steam distillation, multistage continuous rectification, Total reflux, minimum reflux ratio, optimum reflux ratio, Choice and effect of pressure in distillation column

Design calculations by McCabe-Thiele and Ponchon-Savarit methods, , Murphree stage and overall efficiency

Liquid-Liquid Extraction and Leaching Operations

Liquid -Liquid equilibrium, ternary diagrams, solvent characteristics, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter-current extraction

Adsorption and Ion Exchange: Types of adsorption, nature of adsorbents, adsorption equilibria, Adsorption isotherms, effect of pressure and temperature on adsorption isotherms, Freundlich equation, Langmuir equation, BET equation, break through curve, adsorption equipment for batch and continuous operation. Ion exchange – Principle of Ion exchange, techniques and applications, industrial equipment.

List of Experiments: *(any 6 experiments)*

1. To verify Rayleigh's equation for simple distillation
2. To compare single stage vs multistage countercurrent batch extraction performance.
3. To determine mass transfer coefficient in packed bed column
4. To determine the mass transfer coefficient and number of plates in a sieve plate absorption column.
5. To evaluate performance of packed column used for Liquid –Liquid Extraction.
6. To study plate column using sieve tray (Types of tray, tray layout, tray spacing, tray tower diameter etc.).
7. To study packed column (Types of packing, flooding chart and its use in design of packed tower).
8. To study the liquid- liquid extraction and solid-liquid leaching equipment (types, selection, and operation).
9. Determination of Break through curve of fixed bed reactor.
10. Modeling and simulation of separation process using process simulator

Reference Books:

1. Treybal, R.E., 'Mass Transfer Operations', 3rd edition, McGraw Hill, 1980.
2. Coulson, J. M.; Richardson, J. F., 'Chemical Engineering – Vol. I & II', 6th edition, Butherworth-Heinemann, 1999.
3. Philip Wankat, 'Equilibrium staged Operations', McGraw Hill; NJ, 1988
4. Seader J.D., Henley E.J, 'Separation Process Principles', John Wiley and sons, 1998.
5. Kister, Henry Z., 'Distillation Operation', 1st edition, McGraw-Hill, 1996.

Weblinks: ***https://nptel.ac.in/courses/103103035/1***

MOOCs: Courses by MIT Open course ware and NPTEL

Pedagogy:

- Co-teaching
- Power point presentations
- Videos

Assessment Scheme:

Class Continuous Assessment (CCA): *50 Marks*

Assignments	Mid Term	Group Activity	Case study	MCQ	Oral	Any other
20 Marks	20 Marks	10 Marks				

Laboratory Continuous Assessment (LCA)

Practical	Oral based on practical	Attendance	Mini Project	Problem based Learning	Any other
20 Marks	20 Marks	10 Marks			

Term End Examination : Theory Question Paper of 50 marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Gas Absorption** Mechanism of gas absorption, Henry's law, Choice of solvent, Design approaches: **Equilibrium approach and Rate approach**	**4**	-	
2	**Equilibrium approach:** No. of Equilibrium stages by Mc-cabe Thiele construction, **Rate approach:** Number of transfer units (NTU), height of transfer units (HTU), Height Equivalent to Theoretical Plate (HETP), Packed and staged columns.	**8**	-	
3	**Distillation** Raoult's law, methods of distillation: Flash distillation, differential or simple distillation, steam distillation, multistage continuous rectification, Total reflux, minimum reflux ratio, optimum reflux ratio, Choice and effect of pressure in distillation column Design calculations by McCabe-Thiele and Ponchon-Savarit methods, , Murphree stage and overall efficiency	**8**	-	
4	**Liquid-Liquid Extraction and Leaching Operations** Liquid -Liquid equilibrium, ternary diagrams, solvent characteristics, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter-current extraction	**4**	-	
5	**Adsorption and Ion Exchange:** Types of adsorption, nature of adsorbents, adsorption equilibria, Adsorption isotherms, effect of pressure and temperature on adsorption isotherms, Freundlich equation, Langmuir equation, BET equation, break through curve, adsorption equipment for batch and continuous operation. Ion exchange – Principle of Ion exchange, techniques and applications, industrial equipment.	**4**		

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH322**			
Course Category	**Professional Core**			
Course Title	**Transport Phenomena**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**-**	**02**	**03**

Pre-requisites: Engineering Mathematics, Numerical Techniques, Fluid Mechanics, Heat Transfer, Mass Transfer.

Course Objectives:

1. Develop an understanding of the conservation laws that govern mass momentum, and heat transfer.
2. Develop the ability to formulate and solve mathematical models for physical situations.

Course Outcomes:

On completion of this course, the students will be able to

1. Identify transport properties and analyze the mechanisms of molecular momentum, energy and mass transport.
2. Able to select appropriate coordinate systems for transport phenomena problems.
3. Formulate the differential forms of the equations of change for momentum, heat and mass transfer problems for steady-state and unsteady flows.
4. Create solutions to fluid flow, heat transfer and mass transfer complex problems.

Course Contents:

Transport by Molecular Motion: Viscosity and Stress Tensor, Thermal Conductivity and heat flux vector, Diffusivity and mass flux vector

Shell Balance Method: Shell Momentum, Energy, and Mass balance and distribution of velocity, temperature, and Concentration in one dimension.

Use of General Transport Equations: Equations of changes for isothermal, non-isothermal, and multicomponent mixtures.

Transport with two independent variables: Velocity, temperature, and concentration distributions with more than one independent variable;

Transport in Large Systems: Macroscopic balances and its applications in analysis and solution of process engineering problems.

List of Practicals:

Every student shall perform minimum Six experiments from the following list and submit a Journal which will form the term work.

1. Experiment based on transport phenomena in Momentum Transfer.
2. Experiment based on transport phenomena in Heat Transfer.
3. Experiment based on transport phenomena in Mass Transfer.
4. Solution of Differential Equations of Change using Numerical Methods.
5. COMSOL based assignments for Momentum Transfer.
6. COMSOL based assignments for Heat Transfer.
7. COMSOL based assignments for Mass Transfer.

Text Books:

1. Robert S Brodkey; Transport Phenomena: A Unified Approach, McGraw Hill,1988.
2. Bird R. W. Stewart and E. Lightfoot; Transport Phenomena, Second Edition; John Wiley and Sons Inc., 2002.
3. Geankoplis C. J.; Transport Processes and Separation Process Principles, Fourth Edition; Prentice Hall India, 2003.

Reference Books:

1. Brodkey, Robert S; 'Transport Phenomena: A Unified Approach', McGraw Hill,1988.
2. Tosun Ismail; 'Modeling in Transport Phenomena: A Conceptual Approach', Elsevier Science B. V., Amsterdam, Netherlands, 2002.
3. Versteeg H.K, Malalasekara W; 'An Introduction to Computational Fluid Dynamics: The Finite Volume Method', 2nd Edition, Pearson Education, 2007.

Web Resources:

NPTEL:

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
10	10	20	10

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Group Activity
30	--	10	10

Term End Examination : Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	***Lab***	***Assess***
1	**Transport by Molecular Motion:** Viscosity and Stress Tensor, Thermal Conductivity and heat flux vector, Diffusivity and mass flux vector	**6**		**-**
2	**Shell Balance Method:** Shell Momentum, Energy, and Mass balance and distribution of velocity, temperature, and Concentration in one dimension.	**6**		**-**
3	**Use of General Transport Equations:** Equations of changes for isothermal, non-isothermal, and multicomponent mixtures.	**8**		**-**
4	**Transport with two independent variables:** Velocity, temperature, and concentration distributions with more than one independent variable;	**6**		**-**
5	**Transport in Large Systems:** Macroscopic balances and its applications in analysis and solution of process engineering problems.	**4**		

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH323**			
Course Category	**Engineering Core**			
Course Title	**Environmental Engineering**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**--**	**02**	**03**

Pre-requisites:

1. Mechanical Operations 2. Mass Transfer Operations 3. Heat Transfer 4. Chemistry

Course Objectives:

1. To learn to appreciate interrelationship between various components of ecosystem.
2. To get acquainted with characterization of treatment methods for air and water pollution in process industry.
3. To know regulatory framework for pollution prevention.

Course Outcomes:

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

1. Understand key current environmental problems.
2. Identify and value the effect of the pollutants on the environment: atmosphere, water and soil.
3. Analyze an industrial activity and identify the environmental impact and problems.
4. Plan strategies to control, reduce and monitor pollution.
5. Select the most appropriate technique to purify and/or control the emission of pollutants.
6. Conversant with basic environmental legislation.

Course Contents:

Natural and man-made impacts on water, air and land, Impacts of Climatic change, Carbon Credit, Kyoto Protocol, Clean Development Mechanisms (CDM), Paris Climate Agreement, and Role of the environmental engineer. Role and norms of MPCB and CPCB.

Air Pollution: Sources and classification of air pollutants, Major emissions from global sources, Air pollution laws and standards, Air pollution sampling and measurements, Control methods, Cleaning of gaseous effluents, Particulate and Gaseous emission control, Control of specific gaseous pollutants such as SOx & NOx emission, carbon monoxide, Flaring of gases and its impact. Meteorological aspects of air pollution. Design of air pollution control equipments gravity settler, bag filter, ventury scrubber, cyclone separator etc.

Water Pollution: Origin of wastewater, General standards for quality of water for different purposes, Types of water pollutants and their effects, Water pollution laws and discharge standards, Waste water characteristics: physical characteristics and chemical characteristics

Design of Effluent Treatment Plant units (ETP): Preliminary, Primary and Secondary treatments, Activated Sludge Process (ASP), Trickling Filters (TF), Sludge treatment and disposal, Low cost waste treatment systems, Moving Bed Bio Reactor (MBBR), Anaerobic Digestion with biogas generation, Up flow anaerobic sludge blanket (UASB), Anaerobic Fluidized Bed Reactor (AFBR), H_2S & CO_2 removal from biogas with methane enrichment.

Advance Waste water treatments such as Ultrasonic Treatment, Wet Air Oxidation, Advanced processes like MBR (Membrane Bio Reactor).

Solid Waste Treatment: Solid waste collection, classification, treatment and disposals, waste recovery systems.

List of Experiments:

Every student should carry out minimum *Six* experiments from the following list and submit the journal, which will form the term work.

1. To analyze a given wastewater / water sample for Dissolved oxygen.
2. To analyze a given wastewater sample for Chemical Oxygen Demand (COD)
3. To analyze a given wastewater sample for Biological Oxygen Demand (BOD)
4. To analyze a given wastewater sample for Total solids: Suspended solids, Dissolved solids, volatile solids, settleable solids and non settleable solids
5. To calculate Sludge Volume Index (SVI) of given sample.
6. To analyze a given wastewater sample for Conductivity / Salt concentration.
7. To analyze a given hydrocarbon waste for Heavy metals (at least two).
8. To separate dust from gas using electrostatic precipitator.
9. To separate solids from gas using ventury scrubber.
10. To analyze a given gaseous effluent sample for SO_x, NO_x.
11. To analyze a gaseous sample for volatile organics using Gas Chromatograph.
12. To analyze a given hydrocarbon waste for Total organic carbon.

Text Books:

1. Rao C. S.; "Environmental Pollution Control Engineering"; Wiley Eastern Ltd., 1996.
2. Peavy H. S., Rowe D. R. and Tchobanoglous George; "Environmental Engineering"; McGraw Hill, 1985.
3. Rao M. N. and H. V. N. Rao; "Air Pollution"; Tata McGraw Hill Publishing Company Limited, New Delhi, 2001.

Reference Books:

1. George Technoglobus; Burton F. L.; “Wastewater Engineering: Treatment and Reuse”; Fourth Edition, Metcalf and Eddy, Inc.; Tata McGraw Hill, 2003.
2. De Nevers, “Air Pollution Control and Engineering”, McGraw Hills, 1993.
3. "Standard Methods for the Examination of Water and Wastewater", Twentieth Edition, American Public Health Association, Washington. D.C. 1998 of Hazardous waste treatment and disposal, Second Edition, McGraw-Hill, New York, 1997.

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
10	10	20	10

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Any other
40	10	--	--

Term End Examination : Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	Natural and man-made impacts on water, air and land, Impacts of Climatic change, Carbon Credit, Kyoto Protocol, Clean Development Mechanisms (CDM), Paris Climate Agreement,	**2**		-
2	Role of the environmental engineer. Role and norms of MPCB and CPCB.	**2**		-
3	Sources and classification of air pollutants, Major emissions from global sources, Air pollution laws and standards, Air pollution sampling and measurements, Control methods, Cleaning of gaseous effluents	**2**		-
4	Particulate and Gaseous emission control, Control of specific gaseous pollutants such as Sox & NOx emission	**2**		-
5	Flaring of gases and its impact.	**2**		-
6	Design of air pollution control equipments gravity settler, bag filter, ventury scrubber, cyclone separator etc.	**3**		-

7	***Water Pollution:*** Origin of wastewater, General standards for quality of water for different purposes, Types of water pollutants and their effects	**2**		
8	Water pollution laws and discharge standards, Waste water characteristics: physical characteristics and chemical characteristics	**2**		
9	***Design of Biological Treatment Processes***: Preliminary, Primary and Secondary treatments, Activated Sludge Process (ASP)	**2**		
10	Trickling Filters (TF), Sludge treatment and disposal, Low cost waste treatment systems, Advanced processes like MBR (Membrane Bio Reactor),	**3**		
11	Ultrasonic Treatment, Wet Air Oxidation, Anaerobic Digestion with biogas generation,	**3**		
12	Up flow anaerobic sludge blanket (UASB), Anaerobic Fluidized Bed Reactor (AFBR), H_2S & CO_2 removal from biogas with methane enrichment.	**3**		
13	Solid waste collection, classification, treatment and disposals, waste recovery systems.	**3**		

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH324**			
Course Category	**Professional Elective-I**			
Course Title	**Introduction to Computational Fluid Dynamics-I**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**-**	**02**	**03**

Pre-requisites: Engineering Mathematics I,II and III, Basic Sciences, Fluid Mechanics, Heat Transfer, Material and Energy Balance

Course Objectives:

To provide brief introduction of Computational Fluid Dynamics and its application to Fluid Mechanics, Heat Transfer related problems in Chemical Engineering

Course Outcomes:

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

1. Solve PDE
2. Use Finite Difference and Finite Volume Methods in CFD Modeling
3. Generate and Optimize the numerical mesh
4. Simulate Simple CFD Models and analyze its results.

Course Contents:

Introduction: Illustration of the CFD approach, CFD as an engineering analysis tool, Review of governing equations, Modeling in engineering, Partial differential equations- Parabolic, Hyperbolic and Elliptic equation, CFD application in Chemical Engineering, CFD software packages and tools.

Principles of Solution of the Governing Equations: Finite difference and Finite volume Methods, Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, CFD model formulation.

Mesh Generation: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation.

Solution Algorithms: Discretization schemes for pressure, momentum and energy equations - Explicit and implicit Schemes, First order upwind scheme, second order upwind scheme, QUICK scheme, SIMPLE, SIMPLER and MAC algorithm, pressure-velocity coupling algorithms, velocity-stream function approach, solution of Navier-Stokes equations.

CFD Solution Procedure: Problem setup – creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization.

List of Experiments:

Perform all experiments and to be submitted in journal format

1. Mesh Generation on Different Geometries with increasing complexities (3 Sesssions)
2. CFD Modeling of Turbulence
3. CFD Modeling of Heat Exchangers
4. CFD Modeling of Mixers
5. CFD Modeling of Reacting Systems

Text Books:

1. Computational Fluid Flow and Heat Transfer, Second Edition by K. Muralidhar, T. Sundararajan (Narosa), 2011.
2. Computer Simulation of Flow and Heat Transfer by P. S. Ghoshdastidar (4th Edition, Tata McGraw-Hill), 1998

Reference Books:

1. Numerical Heat Transfer and Fluid Flow by S. V. Patankar (Hemisphere Series on Computational Methods in Mechanics and Thermal Science)
2. Essential Computational Fluid Dynamics by Zikanov.O. Wiley 2010. Computational Fluid Dynamics by Chung T. J., Cambridge University Press, 2003
3. Niyogi, P. Chakrabarty, S.K. and Laha, M.K., Introduction to computational fluid dynamics, Pearson education (2006).
4. LI J., G. H. Yeoh, C Liu. A Computational Fluid Dynamics, ELSEVER (2008)
5. Suhas V. Patankar. Numerical Heat Transfer and Fluid Flow, Taylor and Francis (1978).
6. S K Gupta. Numerical Methods for Engineers, New Age Publishers, 2nd Edition (1995).
7. Anderson J.D. Computational Fluid Dynamics, Mc-Graw Hills (1995).
8. Ranade, V.V., Computational flow modeling for chemical reactor engineering, Academic Press (2002).
9. J H Ferziger and M Peric, Computational Methods for Fluid Dynamics, Springer (2002).

Web Resources:

NPTEL:

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
10	10	20	10

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Any other
20	20	--	10

Term End Examination : Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Introduction:** Illustration of the CFD approach, CFD as an engineering analysis tool, Review of governing equations, Modeling in engineering, Partial differential equations- Parabolic, Hyperbolic and Elliptic equation, CFD application in Chemical Engineering, CFD software packages and tools.	**8**	**4**	-
2	**Principles of Solution of the Governing Equations:** Finite difference and Finite volume Methods, Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, CFD model formulation	**6**	**6**	-
3	**Mesh Generation:** Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation	**6**	**4**	-
4	**Solution Algorithms:** Discretization schemes for pressure, momentum and energy equations - Explicit and implicit Schemes, First order upwind scheme, second order upwind scheme, QUICK scheme, SIMPLE, SIMPLER and MAC algorithm, pressure-velocity coupling algorithms, velocity-stream function approach, solution of Navier-Stokes equations.	**10**	**6**	-

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH324**			
Course Category	**Professional Elective-I**			
Course Title	**Refinery Operations**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**-**	**02**	**03**

Pre-requisites: Chemical Technology, Chemistry, Engineering Thermodynamics and Chemical Engineering Thermodynamics.

Course Objectives:

1. To illustrate the importance of crude oil as source of fuel and the size of refining industry.
2. To summarize the various refinery processes and the products along with their specifications.
3. To show the challenges involved in refining from viewpoint of economic considerations and environmental regulations.

Course Outcomes:

1. Outline the overall refinery flow.
2. Classify crude oil on the basis of its properties and characterization methods.
3. Identify the specifications required for good quality petroleum product.
4. Explain the process of purification and fractionation of crude oil.
5. Decide the proper conversion route to upgrade the products from ATU and VDU.
6. Apply chemical engineering principles to the analysis of safe and efficient refinery operations.

Course Contents:

Overview of Refining

Origin, formation, exploration and production of crude oil, Reserves and deposits in the world, Petroleum industry in India, Overall Refinery flow, Petroleum Products, Nelson complexity factor

Thermophysical properties of crude oil and petroleum products

Classification of crude oil, Composition of crude oil, Crude Assay, ASTM/TBP/EFV curves, Specifications and Test methods for: LPG, Naphtha, Gasoline, Kerosene, Diesel, Lube oil, Waxes, Bitumen and Coke.

Distillation and cracking of crude oil

Desalting of Crude, Preheating Train, Atmospheric Distillation of Crude oil, Vacuum Distillation, Catalytic Cracking,

Conversion processes

Hydrocracking, Catalytic Reforming, Alkylation, Isomerization, Hydro-processing, Coking

Lube oil and bitumen

Lube oil processing, Propane deasphalting, Solvent Extraction, Dewaxing, Finishing Processes, Methods of Manufacture of Bitumen

Supporting process

Product Blending, Hydrogen Production, Sulphur Recovery, Control of air and water pollution, solid waste management

List of Experiments:

1. To study ASTM Distillation of Petroleum Products
2. To characterize a given crude oil sample for water content
3. To characterize a given crude oil sample for Viscosity Gravity Constant
4. To determine the Conradson carbon residue for crude oil sample
5. To determine the softening point of bituminous material
6. To determine the melting point of petroleum wax
7. To determine the smoke point of given fuel sample
8. To determine the flash point of a given fuel sample
9. To aniline point and diesel index of diesel
10. To determine the cloud point and pour point of a given fuel sample
11. To determine the Reid Vapour Pressure of a gasoline sample
12. To determine the calorific value of a petroleum product using bomb calorimeter

Text books

1. Gary, J.H and Handework, G. E., (2001) *'Petroleum Refining Technology and Economics'*, Fourth Edition, Marcel Dekker, Inc.
2. Ram Prasad, (2013) 'Petroleum Refining Technology', First Edition, Khanna Publishers Bhaskararao, B.K, (2007) 'Modern Petroleum Refining Processes', Fifth Edition, Oxford and IBH Publishing Co. Pvt. Ltd.

Reference Books:

1. Fahim, M.A., Alsahhaf, T.A. and Elkilani, A. (2010) 'Fundamentals of Petroleum Refining', Elsevier
2. Nelson, N.L., (1985) *'Petroleum Refinery Engineering'*, McGraw Hill Book Co.

Weblinks:

http://nptel.ac.in/courses/103107081/

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
10 marks	10 marks	20 marks	10 marks

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Any other
20 marks	10 marks	10 marks	10 marks

Term End Examination : Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	***Lab***	***Assess***
1	**Overview of Refining** Origin, formation, exploration and production of crude oil, Reserves and deposits in the world, Petroleum industry in India, Overall Refinery flow, Petroleum Products, Nelson complexity factor	**4**	**2**	**-**
2	**Thermophysical properties of crude oil and petroleum products** Classification of crude oil, Composition of crude oil, Crude Assay, ASTM/TBP/EFV curves, Specifications and Test methods for: LPG, Naphtha, Gasoline, Kerosene, Diesel, Lube oil, Waxes, Bitumen and Coke.	**6**	**12**	**-**
3	**Distillation and cracking of crude oil** Desalting of Crude, Preheating Train, Atmospheric Distillation of Crude oil, Vacuum Distillation, Catalytic Cracking,	**5**	**2**	**-**
4	**Conversion processes** Hydrocracking, Catalytic Reforming, Alkylation, Isomerization, Hydro-processing, Coking	**6**	**-**	**-**
5	**Lube oil and bitumen** Lube oil processing, Propane deasphalting, Solvent Extraction, Dewaxing, Finishing Processes, Methods of Manufacture of Bitumen	**5**	**-**	**-**
6	**Supporting process** Product Blending, Hydrogen Production, Sulphur Recovery, Control of air and water pollution, solid waste management	**4**	**-**	**-**

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH324**			
Course Category	**Professional Elective-I**			
Course Title	**Introduction to Cell Biology**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**-**	**02**	**03**

Pre-requisites: School science subjects at SSC level

Course Objectives:

To provide overview of fundamental principles governing cell functions

Course Outcomes:

Student completing this course will be able to explain

1. Cell types and cell structure
2. Structure and function of basic biomolecules
3. Mechanisms of metabolism and catabolism
4. Stoichiometry of cell growth and product formation

Course Contents:

Biophysics and the Cell Doctrine. The Structure of Cells. Important Cell Types.

Chemical of Life. Lipids. Sugars and Polysaccharides. From Nucleotides to RNA and DNA Amino Acids into Proteins. Hybrid Bio chemicals. The Hierarchy of Cellular Organization.

Metabolic Stoichiometry and Energetics. Thermodynamics Principles. Metabolic Reaction Coupling: ATP and NAD. Carbon Catabolism. Respiration. Photosynthesis: Tapping the Ultimate Source.

Biosynthesis. Transport Across Cell Membranes. Metabolic Organization and Regulation. End Products of Metabolism. Stoichiometry of Cell Growth and Product Formation.

List of Experiments:

1. To measure length and breadth of the given cell sample by using micrometer
2. To study stages of cell division and its dynamics by observation of onion root-tip cells
3. To identify number of cells present in given one mL sample
4. To identify blood cell types in human blood smear
5. To identify blood cell types in the leaf cross section
6. To prepare permanent slides using the given sections like stem, root and leaf

Text Books:

1. "Biochemical Engineering Fundamentals", James Bailey and David Ollis ,2nd Ed, McGraw –Hill ,1986

Reference Books:

1. Lodish et. al. Molecular Cell Biology. Seventh Edition. Freeman Press.

Web Resources:

NPTEL:

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
10	10	20	10

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Any other
20	20	10	--

Term End Examination : Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	Biophysics and the Cell Doctrine. The Structure of Cells. Important Cell Type.			-
2	Chemical of Life. Lipids. Sugars and Polysaccharides. From Nucleotides to RNA and DNA, Amino Acids into Proteins. Hybrid Bio chemicals. The Hierarchy of Cellular Organization			-
3	Metabolic Stoichiometry and Energetics. Thermodynamics Principles. Metabolic Reaction Coupling: ATP and NAD. Carbon Catabolism. Respiration. Photosynthesis: Tapping the Ultimate Source.			-
4	Biosynthesis. Transport Across Cell Membranes. Metabolic Organization and Regulation. End Products of Metabolism. Stoichiometry of Cell Growth and Product Formation.			-

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	CH324			
Course Category	Professional Elective-1			
Course Title	Process Modelling and Simulation			
Teaching Scheme and Credits Weekly load hrs	Theory	Tutorial	Laboratory	Credits
	03	--	02	03

Pre-requisites: Mathematics, Process Calculations Basics

Course Objectives:

1. To get introduced to modelling and simulation of steady state and dynamic behaviour of chemical processes.
2. To understand physical and empirical modelling techniques.
3. To gain hands-on experience with commercial simulators.

Course Outcomes:

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

1. Understand the need and usefulness of Models
2. Develop Mathematical Models for Chemical Processes.
3. Know numerical simulation techniques.
4. Understand the principles of process simulators.
5. Understand the state space models and their usefulness.
6. Know of empirical models and their applications.

Course Contents:

Principles of Process Modelling

Introduction, definition of modelling and simulation, different types of models, application of mathematical modelling, scope of coverage. Fundamental Laws: Continuity equation, energy equation, and equation of motion, transport equation, equation of state, phase and chemical equilibrium, chemical kinetics.

Models in Fluid Flow Operations

The continuity equation, Laminar Flow in narrow Slit, Flow of Film on the outside of circular tube, Momentum fluxes for creeping flow in to slot.

Heat Transfer and other Equipments

Two heated tanks, double pipe heat exchanger, shell and tube heat exchanger, cooling towers

Single effect and multi effect evaporators, agitated vessels, mixing process, fluid – solid operations.

Mass Transfer Equipments

Flash distillation, differential distillation, and continuous binary distillation in tray and packed column, vaporizers, single phase and multiphase separation, multi-component separation, adsorption, absorbers and strippers. Liquid- liquid extraction, Mixer-Settler Extraction Cascades, Staged Extraction Columns.

Reaction Equipments

Batch reactor, Semi batch reactor, Continuous stirred tank reactor, Plug flow reactor, Slurry reactor, Trickle bed reactor, Bubble column reactor, Packed column reactor, Bioreactors, Reactors used in effluent treatments, Fluidized bed reactor.

List of Experiments:

Minimum 06 Practical Assignments must be completed using computational as well as simulation soft wares. Aspen plus, Mathcad, Mat lab, excel etc. can be used for solving practical assignments.

1. Computer program for plotting P-x-y and T-x-y diagram
2. Basic Modeling and Simulation: Hydraulic tank, Mixing vessel, Mixing with reaction, Simultaneous mass and energy balances, Continuous-flow system
3. Multicomponent Vapor-Liquid Equilibrium: Vapor-liquid equilibrium, Boiling operations, Batch distillation
4. Reaction Kinetics
5. Mathematical modeling and simulation of reactor systems.
6. Mathematical modeling and simulation of heat transfer equipments.
7. Mathematical modeling and simulation of Distillation column
8. Mathematical modeling and simulation of Compressor system (single stage and multistage)
9. Mathematical modeling and simulation of Absorption column
10. Mathematical modeling and simulation of Packed Columns
11. Mathematical modelling and simulation of multicomponent distillation column
12. Mathematical modelling and simulation of lumped parameter model of tray column

Text Books:

1. Luyben W. L., “Process Modelling, Simulation and Control for Chemical Engineering”, McGraw Hill Book Company, Singapore, 1990.
2. Finlayson, B. A., “Introduction to Chemical Engineering Computing”, John Wiley & Sons, New Jersey, 2006.

Reference Books:

1. Davis M.E., Numerical Methods and Modeling for Chemical Engineers, Wiley, New York, 1984
2. Mickley H.S., Sherwood T.K. and Reed C.E., Applied Mathematics in Chemical Engineering, McGraw Hill, New York, 1957
3. Denn, M. M., Process Modeling, Longman Sc. & Tech. (1987).
4. Himmelblau, D.M and Bischoff, K.B., Process Analysis and Simulation: Deterministic Systems, John Wiley (1968).
5. Holland, C. D., Fundamentals and Modeling of Separation Processes: Absorption, Distillation, Evaporation and Extraction, Englewood Cliffs, Prentice-Hall (1974)
6. Aris R.,"Mathematical Modeling, Vol. 1: A Chemical Engineering Perspective (Process System Engineering)", Academic Press, 1999.
7. Franks R.E.G., “Modeling and Simulation in Chemical Engineering”, Wiley Intrscience, NY
8. John Ingam, Irving J. Dunn., “Chemical Engineering Dynamic Modeling with PC Simulation”, VCH Publishers.
9. Kayode Coker A., “Chemical Process Design, Analysis and Simulation”, Gulf Publishing Company.
10. Himmelblau D., K.B. Bischoff, “Process Analysis and Simulation”, John Wiley & Sons.
11. Wayne Blackwell, “Chemical Process Design on a Programmable Calculator”, McGraw Hill,1992

Web Resources:
NPTEL

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
10	10	20	10

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Problem Based learning
10	20	10	10

Term End Examination : Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	***Lab***	***Assess***
1	***Principles of Process Modelling:*** Introduction, definition of modelling and simulation, different types of models, application of mathematical modelling, scope of coverage. Fundamental Laws: Continuity equation, energy equation, and equation of motion, transport equation, equation of state, phase and chemical equilibrium, chemical kinetics.	06	04	-
2	***Models in Fluid Flow Operations*** The continuity equation, Laminar Flow in narrow Slit, Flow of Film on the outside of circular tube, Momentum fluxes for creeping flow in to slot.	06	04	-
3	***Heat Transfer and other Equipments*** Two heated tanks, double pipe heat exchanger, shell and tube heat exchanger, cooling towers, Single effect and multi effect evaporators, agitated vessels, pressure change Equipments, mixing process, fluid – solid operations..	06	04	-
4	***Mass Transfer Equipments*** Flash distillation, differential distillation, and continuous binary distillation in tray and packed column, vaporizers, single phase and multiphase separation, multi-component separation, drying Equipments, adsorption, absorbers and strippers. Batch liquid- liquid extraction, continuous extraction, multistage counter current extraction, Mixer-Settler Extraction Cascades, Staged Extraction Columns.	06	04	-
5	***Reaction Equipments*** Batch reactor, Semi batch reactor, Continuous stirred tank reactor, Plug flow reactor, Slurry reactor, Trickle bed reactor, Bubble column reactor, Packed column reactor, Bioreactors, Reactors used in effluent treatments, Fluidized bed reactor	06	04	-

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH331**			
Course Category	**Professional Elective**			
Course Title	**Plant Design and Economics**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**-**	**02**	**03**

Pre-requisites:

Course Objectives:

1. To understand the concept of process plant design and economics
2. To understand the engineering drawings and interdisciplinary nature of a manufacturing process plant
3. To understand the importance of Health , Safety and Environment in Plant Design

Course Outcomes:

By the end of the course students should be able to

1. understand the stages involved in a development of a process plant
2. understand various flow diagrams, drawings, standards and codes
3. understand the HSE aspects involved in process design
4. perform cost estimation of a process plant
5. analyze the profitability of the process plant

Course Contents:

Process Engineering and Plant Design

General overall design considerations, Anatomy of chemical engineering projects, Process design codes, Standard sources of information, Environmental Protection, Plant location, Plant layout, Plant operation and control.

Process Development: Feasibility study, Development of design database, Process development and commercialization, Importance of laboratory development to pilot plant, scale up methods, Process creation, Process, process licensing, selection of contractor, scope and contract types, Plant, Erection and commissioning.

Engineering Flow Diagrams and Process Safety

Process Design, Diagrams / Documents: Introduction to block, process flow, Logic, Information flow diagrams. Preparation of PID, trip and interlock systems, MOC and valve selection, color code of pipeline, Equipment datasheets, Layout engineering (Plot Plan)

Safety In Process and Plant Design: Intrinsic / extrinsic safety, Safety of personnel, equipment and plant classification of plant areas, Fire protection systems, Flare systems, Safety relief valves, Flame arrestors, rupture disc and explosion venting etc., Health , Safety and Environmental hazards, Loss Prevention: Hazard Assessment Techniques: HAZOP, HAZAN, Fault Tree Analysis, etc

Plant Design, Process Safety Design Case Studies

Plant Design case studies for any one of the chemical, Petrochemical and Polymer products: Process synthesis, Development of process flow diagram, Mass and energy balance, P& ID diagram, Environmental and process safety analysis, Use of process design softwares Such as ASPEN HYSYS/ UniSim Design, Technical project report writing

Overview of Process Economics and Cost Estimations

Economic decision making in the CPI, Process plant components, elements of costing and principles of accounting, Total cost components, Types and methods of cost estimation, Interest, taxes and insurance, depreciations, Cost estimation for equipment and plant, Direct / indirect manufacturing costs, Various cost indices, William's sixth tenth rule, methods of estimation of fixed capital, product cost estimation

Equipment Design, Costing, Utility Costing and Optimum Design strategy

Materials transfer, handling, and treatment, Equipment-design and costs, Heat transfer equipment-design and costs, Mass transfer and reactor equipment-design and costs, Utility requirement estimations and costing Optimum design and design strategy

Profitability Analysis: Alternative Investments and Replacements

Profitability: Alternative investments and replacements, profitability standards, discounted cash flow, rate of return, capitalized cost, payment period, alternative investments, analysis with small investments, increments and replacements, Break Even Analysis.

Case studies of process plant design costing and economic analysis and estimation of payback period for any one of the chemical, Petrochemical and Polymer products.

Term Work:

Every student should carry out minimum eight experiments from the following list and submit the journal, which will form the term work and oral exam will be conducted on the same

List of Experiments:

Part A: Chemical Engineering Drawings

1. Standard symbols (IS code) for PFDS / P and ID etc.
2. Development of Block diagrams/ Process flow diagrams
3. Development of Piping and Instrumentation (P&ID) diagrams.
4. Development Trip and interlock systems / Logic diagrams.
5. Development of Layout drawings
6. Development of Process Design Basis Data Sheet, Equipment Specifications Data Sheet, Material Safety Data Sheet , Pump and Line sizing Data Sheet

Part B: Use of Softwares

1. Process flow sheet development and plant design using commercial process simulator such as Aspen Plus/Hysys/UniSim
2. MS-Excel Based Mass and Energy Balance Calculations on a complete process plant

Part C: Costing and Process Safety Analysis

1. Estimation of Utility Requirement for a given case study and costing, Equipment Costing
2. Total Cost Estimation and Breakeven Analysis for a plant design
3. Technical Analysis Presentation of Case Study of Actual Process Industry Accident
4. HAZAN, HAZOP Case study

Text Books:

1. Warren D. Seider, J. D. Seader, Daniel R. Lewin, Soemantri Widagdo, “ Product and Process Design Principles: Synthesis, Analysis and Design”, Third Edition, John Wiley & Sons, 2014
2. Guidelines for Engineering Design for Process Safety, Second Edition, Centre for Chemical Process Safety (CCPS), 2012

Reference Books:

1. M.S. Peters and K. D. Timmerhaus, “Plant Design and Economics for Chemical Engineers”, Fourth Edition, McGraw Hill International Book Co., 1991
2. James R. Cooper, “Process Engineering Economics”, Marcel Delkker Inc, New York, 2003
3. Coulson, J.M., Richardson J.E. and Sinnott R.K., “Chemical Engineering”, Vol. VI, Pergamon Press, 1991.
4. R. Turton, R. C. Bailie, W. B. Whiting, and J. A. Shaeiwitz, “ Analysis, Synthesis, and Design of Chemical Processes”, Prentice Hall, Upper Saddle River, New Jersey, 1998

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
10	10	20	10

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Any other
20	20		10

Term End Examination: Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	Process Engineering and Plant Design	5	2	-
2	Engineering Flow Diagrams and Process Safety	5	4	-
3	Plant Design, Process Safety Design Case Studies	5	4	-
4	Overview of Process Economics and Cost Estimations	5	4	-
5	Equipment Design, Costing, Utility Costing and Optimum Design strategy	5	4	-
6	Profitability Analysis: Alternative Investments and Replacements	5	6	-

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH332**			
Course Category	**Engineering Core**			
Course Title	**Process Dynamics and Control**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**-**	**02**	**03**

Pre-requisites: Chemical Technology, Chemistry, Engineering Thermodynamics and Chemical Engineering Thermodynamics.

Course Objectives:

1. To understand the importance of system dynamics and feedback control
2. To be able to design a control system to meet desired objectives
3. To be able to perform model-based design and tuning of controllers
4. To understand Advanced Process Control systems

Course Outcomes:

By the end of the course students should be able to

1. Model A Process System From Control Objective
2. Design A Control Strategy
3. Learn Advance And Multi Variable Process Control
4. Analyse The System Stability

Course Contents:

Introduction to Process Dynamics

Introduction to Process control and Process dynamics, Process control hardware, P&ID Diagram, codes and symbols, Review of Laplace Transform, Forcing functions, Partial fraction expansions, concept of poles and zeros.

Development of Process control models for First, second and higher order systems, interacting and Non-interacting systems, Transfer Functions, dynamic behaviour of pure gain, pure capacitive, first-order, second-order systems, dead- time systems, Degrees of freedom analysis, linearization of nonlinear ODEs

Design of Feedback Control Systems

Review of Feedback control system, its components and basic block diagram, Development and Reduction of Block diagram for a chemical process system, Closed loop transfer functions, overall transfer function for single and multi-loop systems, Transient response for servo and regulatory problems, Basic control modes PI – PD – PID – Integral wind- up and prevention- Auto/Manual transfer, Selection of control modes for processes involving temperature -pressure- level and flow.

Stability Analysis

Concept of stability, Stability criterion, Routh- Hurwitz test for stability, Concept of root locus, Plotting root locus diagrams.

The Bode stability criterion. Bode diagrams for various Gain and Phase margins, Nyquist stability criterion.

Controller tuning Methods: Evaluation criteria - IAE, ISE, ITAE. Process reaction curve method,-Ziegler –Nichol's tuning- damped oscillation method- Closed loop response of I & II order systems with and without valve –measuring element dynamics

Multivariable Process Control

Process control for large time-delay systems, inverse response systems, cascade, selective, split range control, feed forward, ratio, adaptive and inferential control systems.

List of Experiments:

1. Study of P,PI,PID Control actions on Temperature, Pressure Feedback control systems
2. Study of Cascade control strategy for a Shell and Tube Heat Exchanger
3. Study of Ratio Control of flow system
4. Study of dynamic response of a Flow and Level control system
5. Controller Tuning Using Zeigler Nichol Tuning Rules on a Temperature control system
6. Study of PLC and SCADA systems for different applications such as Level control, AC motor drive, alarm systems etc.

Text Books:

1. Donald K. Coughanowr; "Process System Analysis and Control"; McGraw Hill, Third Edition, New York, 2001
2. Seborg D. E., T. F. Edgar, D. A. Mellichamp; "Process Dynamics and Control"; Second Edition, John Wiley and Sons, New York, 2004.
3. Stephanopoulos G.; "Chemical Process Control: Introduction to Theory and Practice"; Prentice-Hall of India, 1995.

Reference Books:

1. Bella G Liptak, ‚Instrument Engineers' Handbook (Process Measurement), Third Edition, Elsevier, 2005
2. Thomas E. Marlin; "Process Control: Designing Processes and Control Systems for Dynamic Performance", Second Edition, McGraw-Hill, New York, 2000.
3. Ogunnaike B. A., W. H. Ray; "Process Dynamics, Modelling and Control", Oxford University Press, 1994.

Web Resources:

NPTEL:

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
10	10	20	10

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Group Activity
30	10	---	10

Term End Examination : Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	***Lab***	***Assess***
1	Introduction to Process Dynamics	7	2	-
2	Design of Feedback Control	7	6	-
3	Stability Analysis	7	6	-
4	Multivariable Control	9	6	-

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH333**			
Course Category	**Engineering Core**			
Course Title	**Process Safety and Management**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**--**	**--**	**02**

Pre-requisites: Basic Sciences, Chemical Principles, Chemical Engineering Applications

Course Objectives:

1. To familiarize Basics of Industrial Safety Management
2. Various aspects of Chemical plant safety
3. Various aspects of Industrial accidents and Fire safety
4. Hazard identification techniques
5. Various aspect of industrial hygiene and Occupational Health hazards, Safety legislation in chemical industries

Course Outcomes:

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

1. To familiarize Basics of Industrial Safety Management
2. Various aspects of Chemical plant safety
3. Various aspects of Industrial accidents and Fire safety
4. Hazard identification techniques
5. Various aspect of industrial hygiene and Occupational Health hazards, Safety legislation in chemical industries

Course Contents:

Introduction:

Concepts and definition, safety culture, storage of dangerous materials, plant layout safety systems, OSHA incidence rate, FAR, FR, The accident process: Initiation, propagation, and termination, toxicology: ingestion, inhalation, injection, dermal absorption, dose versus response curves, relative toxicity, threshold limit values.

Toxicology and Industrial Hygiene:

Concepts and definition, safety culture, storage of dangerous materials, plant layout safety systems, OSHA incidence rate, FAR, FR, The accident process: Initiation, propagation, and termination, toxicology: ingestion, inhalation, injection, dermal absorption, dose versus response curves, relative toxicity, threshold limit values.

Toxic Release and Dispersion Models:
Control of toxic chemicals, Storage and handling of flammable and toxic chemical, Runway reactions, Relief system risk and hazards management, Design to prevent Fires and Explosions: Inerting, static Electricity, Explosion proof equipment and Instrument, Ventilation, sprinkler systems and Miscellaneous Design for preventing Fires and Explosion

Fires and Explosions:
Technology and process selection, scale of disaster, fire triangle, distinction between fires and explosion, definitions of ignition, auto-ignition temperature, fire point, flammability limits, mechanical explosion deflagration and detonation, confined explosion, unconfined explosion, vapour cloud explosions, boiling liquid expanding vapour explosion (BLEVE), dust explosion, shock wave, flammability characteristics of liquids and vapours, minimum oxygen concentration (MOC).
Hazards Identification and Risk Assessment: process hazards checklists, hazard surveys, hazard and operability studies (HAZOP), safety reviews. Risk assessment: review of probability theory, interaction between process units, revealed and unrevealed failure, and probability of coincidence, event trees and fault trees.

Accident Investigations/Case Histories

Text Books:

1. D. A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 2011
2. Raghavan K. V. and Khan A. A., Methodologies in Hazard Identification and Risk Assessment, Manual by CLRI, 1990.
3. Marshal V. C., Major Chemical Hazards, Ellis Horwood Ltd., Chichester, United Kingdom, 1987.
4. Mannan S., Butterworth Heineman, Lees' Loss Prevention in the Process Industries, 4th Ed., Hazard Identification, Assessment and Control, 2012.
5. R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Vol. 6, Elsevier India, 2006.

Reference Books:

1. Sanders R.E., "Chemical Process Safety: Learning from case Histories", Oxford Butter Worth Publication
2. P. P. Leos, Loss prevention in process Industries, Vol 1 and 2 Butterworth, 1983
3. R. W. King and J. Magid, Industrial Hazards and Safety Handbook, Butterworth, 1982
4. Khulman, Introduction of Safety Science, TUV Rheinland, 1986
5. W. E. Baker, Explosion, hazards and Evaluation, Elsevier, Amsterdam, 1983
6. O. P. Kharbanda and E. A. Stallworthy, Management of Disasters and How to Prevent Them. Grower 1986
7. Sarma. A M "*Safety and Health in Industry"* -A Hand book, BS Publications, 2009.
8. Fulekar. M.H, "*Industrial Hygiene and Chemical Safety"*, I.K International Publishing house Pvt Ltd., 2006
9. Fawcett .H.H, and Wood .W.S, Safety and Accident Prevention in Chemical Operations, John Wiley & sons, U.S.A., 1965.
10. Willie Hammer &Dennis Price, Occupational safety management and Engineering, Prentice Hall, 2001.
11. William Handley, Industrial safety hand book, McGraw- Hill, 1969.

Web Resources:
NPTEL:

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
20	--	20	10

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Any other
1 0	20	20	--

Term End Examination : Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	***Lab***	***Assess***
1	**Introduction:** Concepts and definition, safety culture, storage of dangerous materials, plant layout safety systems, OSHA incidence rate, FAR, FR, The accident process: Initiation, propagation, and termination, toxicology: ingestion, inhalation, injection, dermal absorption, dose versus response curves, relative toxicity, threshold limit values.	**6**	-	-
2	**Toxicology and Industrial Hygiene:** Concepts and definition, safety culture, storage of dangerous materials, plant layout safety systems, OSHA incidence rate, FAR, FR, The accident process: Initiation, propagation, and termination, toxicology: ingestion, inhalation, injection, dermal absorption, dose versus response curves, relative toxicity, threshold limit values.	**6**	-	-
3	**Toxic Release and Dispersion Models:** Control of toxic chemicals, Storage and handling of flammable and toxic chemical, Runway reactions, Relief system risk and hazards management, Design to prevent Fires and Explosions: Inerting, static Electricity, Explosion proof equipment and Instrument, Ventilation, sprinkler systems and Miscellaneous Design for preventing Fires and Explosion	**6**	-	-
4	**Fires and Explosions:** Technology and process selection, scale of disaster, fire triangle, distinction between fires and explosion, definitions of ignition, auto-ignition temperature, fire point, flammability limits, mechanical explosion deflagration and detonation, confined explosion, unconfined explosion, vapour cloud explosions, boiling liquid expanding vapour explosion (BLEVE), dust explosion, shock wave, flammability characteristics of liquids and vapours, minimum oxygen concentration (MOC).	**6**	-	-
5	**Hazards Identification and Risk Assessment:** process hazards checklists, hazard surveys, hazard and operability studies (HAZOP), safety reviews. Risk assessment: review of probability theory, interaction between process units, revealed and unrevealed failure, and probability of coincidence, event trees and fault trees. **Accident Investigations/Case Histories**	**6**	-	-

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH334**			
Course Category	**Professional Elective-II**			
Course Title	**Petrochemical Processes**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**-**	**02**	**03**

Pre-requisites: Chemical Technology, Chemistry, Engineering Thermodynamics and Chemical Engineering Thermodynamics

Course Objectives:

1. To introduce the scientific and technological principles of organic synthesis and related unit processes.
2. To familiarize the student with the role of Petrochemical engineer in unit processes used for organic synthesis and polymerization processes.

Course Outcomes:

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

1. Outline the structure of petrochemical process industry
2. State production routes for major petrochemicals starting from basic feed-stocks
3. State principles underlying various unit processes used in organic synthesis
4. Explain engineering challenges involved in manufacture of bulk petrochemicals
5. Explain the processes and process parameters employed in manufacture of polymers in domestic and industrial use

Course Contents:

Introduction to Petrochemical Industry

Structure of Petrochemical Complexes, Profile of petrochemical industry, Feedstock: present and emerging, Petrochemical industries: Indian and worldwide

Production of olefins

Naphtha and gas cracking for production of olefins. Recovery of chemicals from FCC and steam cracking, Emerging technologies

Ethylene and Propylene derivatives

Ethylene Oxide, Ethylene glycol, Vinyl chloride, Propylene oxide, Isopropyl alcohol

Production of Aromatics

Aromatics separation train. Aromatics product profile-Benzene, Toluene, Xylene, Nitrobenzene, Aniline, Ethyl benzene, Styrene, Phenol

Polymers and Elastomers

Polymers: Polystyrene, Polycarbonate, Thermoset Resins: Phenol formaldehyde, Urea formaldehyde and melamine formaldehyde, Elastomers: Styrene Butadiene Rubber (SBR), Nitrile rubber

Intermediates for Synthetic Fibers

Cyclohexane, Caprolactam, Adipic Acid, Terephthalic acid and Dimethyl Terephthalate, Acrylonitrile

List of Experiments:

1. Simulation of flowsheets for manufacture of petrochemicals on commercial simulators.
2. Conversion of Phenol to Anisole
3. Nitration of Benzene
4. Conversion of Nitrobenzene to Aniline
5. Conversion of Aldehyde to Carboxylic Acid
6. Conversion of Anhydride to Amide
7. Conversion of 2-Naphthol to Nerolene
8. Oxidation of Side Chain of an Aromatic Substrate
9. Synthesis of Oxalic Acid from Cane Sugar
10. To synthesize polymer by suspension polymerization technique.
11. To synthesize polymer by emulsion polymerization technique
12. Synthesis of epoxy resin.
13. Synthesis of styrene-maleic anhydride copolymer

Text Books:

1. Mall I.D., ‘Petrochemical Process Technology’, Macmillan India Ltd, 2007
2. Chauvel A. and Lefebvre G., ‘Petrochemical Processes - I’, Gulf Publications, I Edition, 1989
3. Rao M G, Marshall S, ‘Dryden’s Outlines of Chemical Technology’, East West Press; III Edition, 1997.

Reference Books:

1. Groggins PH, ‘Unit Processes in Organic Synthesis’, Tata McGraw Hill, 5thEdition, 1995.
2. Wiseman P., ‘Petrochemicals,’ Ellis Horwood Ltd.,1986

Web Resources:

NPTEL: https://nptel.ac.in/courses/103103029/

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
10 marks	10 marks	20 marks	10 marks

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Any other
20 marks	10 marks	10 marks	10 marks

Term End Examination : Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	*Lab*	*Assess*
1	**Introduction to Petrochemical Industry** Structure of Petrochemical Complexes, Profile of petrochemical industry, Feedstock: present and emerging, Petrochemical industries: Indian and worldwide	4	-	-
2	**Production of olefins** Naphtha and gas cracking for production of olefins. Recovery of chemicals from FCC and steam cracking, Emerging technologies	6	-	-
3	**Ethylene and Propylene derivatives** Ethylene Oxide, Ethylene glycol, Vinyl chloride, Propylene oxide, Isopropyl alcohol	5	4	-
4	**Production of Aromatics** Aromatics separation train. Aromatics product profile-Benzene, Toluene, Xylene, Nitrobenzene, Aniline, Ethyl benzene, Styrene, Phenol	6	6	-
5	**Polymers and Elastomers** Polymers: Polystyrene, Polycarbonate, Thermoset Resins: Phenol formaldehyde, Urea formaldehyde and melamine formaldehyde, Elastomers: Styrene Butadiene Rubber (SBR), Nitrile rubber	5	4	-
6	**Intermediates for Synthetic Fibers** Cyclohexane, Caprolactam, Adipic Acid, Terephthalic acid and Dimethyl Terephthalate, Acrylonitrile	4	2	-

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH334**			
Course Category	**Professional Elective-II**			
Course Title	**Bio-catalysis**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**--**	**02**	**03**

Pre-requisites: School Science subjects at SSC level. Reaction engineering fundamentals.

Course Objectives:

To provide overview of enzyme catalysis and its applications

Course Outcomes:

Student completing this course will be able to

1. Interpret laboratory kinetic data obtained using enzyme catalysis
2. Explain factors governing enzyme activity and deactivation
3. Discuss industrial applications of biocatalysis
4. Interpret laboratory kinetic data on biomass production
5. Model product formation kinetics in biocatalysed reactions

Course Contents:

The Kinetics of Enzyme-Catalyzed Reactions. The Enzyme-Substrate Complex and Enzyme Action. Simple Enzyme Kinetics with One and Two Substrates. Determination of Elementary-Step Rate Constants. Other Patterns of Substrate Concentration Dependence. Modulation and Regulation of Enzymatic Activity. Other Influences of Enzyme Activity. Enzyme Deactivation. Enzyme Reactions in Heterogeneous Systems.

Applied Enzyme Catalysis. Applications of Hydrolytic Enzymes. Other Applications of Enzymes in Solution. Immobilized-Enzyme Technology. Immobilized Enzyme Kinetics.

Kinetics of Substrate Utilization, Product Formation, and Biomass Production in Cell Cultures Ideal Reactors for Kinetics Measurements. Kinetics of Balanced Growth. Transient Growth Kinetics.

Structured Kinetic Models. Product Formation Kinetics. Segregated Kinetics Models of Growth and Product Formation. Thermal-Death Kinetics of Cells and Spores.

List of Experiments:

1. To estimate Michaelis –Menten parameters for a given Biocatalytic process
2. To study effect of temperature on enzyme activity
3. To study effect of pH on enzyme activity
4. To study effect of metal ions on enzyme activity
5. To study kinetics of enzyme inhibition
6. To study effect of temperature on enzyme stability
7. To study effect of pH on enzyme stability

Text Books:

1. "Biochemical Engineering Fundamentals", James Bailey and David Ollis ,2nd Ed,McGraw-Hill ,1986

Reference Books:

1. "Biocatalysis: From Discovery to Application (Springer Desktop Editions in Chemistry)" by W D Fessner
2. "Biocatalysis: From Discovery to Application (Springer Desktop Editions in Chemistry)" by W D Fessner

Web Resources:
NPTEL:

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
10	10	20	10

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Any other
20	20		10

Term End Examination: Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	***Lab***	***Assess***
1	The Kinetics of Enzyme-Catalyzed Reactions. The Enzyme-Substrate Complex and Enzyme Action. Simple Enzyme.	6	4	-
2	Kinetics with One and Two Substrates. Determination of Elementary-Step Rate Constants. Other Patterns of Substrate Concentration Dependence. Modulation and Regulation of Enzymatic Activity. Other Influences of Enzyme Activity. Enzyme Deactivation. Enzyme Reactions in Heterogeneous Systems.	6	4	-
3	Applied Enzyme Catalysis. Applications of Hydrolytic Enzymes. Other Applications of Enzymes in Solution. Immobilized-Enzyme Technology. Immobilized Enzyme Kinetics.	6	4	-
4	Kinetics of Substrate Utilization, Product Formation, and Biomass Production in Cell Cultures Ideal Reactors for Kinetics Measurements. Kinetics of Balanced Growth. Transient Growth Kinetics	6	4	-
5	Structured Kinetic Models. Product Formation Kinetics. Segregated Kinetics Models of Growth and Product Formation. Thermal-Death Kinetics of Cells and Spores	6	4	-

Third Year B. Tech. (Chemical Engineering) Syllabus

Course Code	**CH334**			
Course Category	**Professional Elective-II**			
Course Title	**Process Simulation Principles**			
Teaching Scheme and Credits Weekly load hrs	**Theory**	**Tutorial**	**Laboratory**	**Credits**
	03	**--**	**02**	**03**

Pre-requisites: Basic knowledge of Courses on Material & Energy Balance; Transport Phenomena and Numerical methods.

Course Objectives:

1. To get introduced to modelling and simulation of steady state behaviour of chemical operations.
2. To understand different process simulation techniques.
3. To gain hands-on experience with commercial simulators.

Course Outcomes:

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

1. Know numerical simulation techniques.
2. Understand the principles of process simulators.
3. Understand the state space models and their usefulness.
4. Know of empirical models and their applications

Course Contents:

Introduction to Process Simulation:

Introduction to process modelling and simulation, tools of simulation, approaches of simulation, planning of calculation in a plant simulation.

Process Simulation

Process simulation, Scope of process simulation, Steady state and dynamic simulation, Formation of problem, Pressure – Flow relations, Process simulation approaches for steady state and dynamic simulation, Process simulator, Structure of process simulator, Integral process simulation, Simulation tools.

Process Simulation based on process calculation and thermodynamics

Registration of new components, Physical properties estimation Role of Process calculation in simulation, importance of thermodynamics in simulation, selection of thermodynamic models for simulation, simulation of recycle streams, concept of hypothetical components in simulation

Simulation of Chemical Engineering System based on mathematical modelling

Input-output models, Degrees of freedom analysis, MBEB based modelling and simulation, Process models of representative chemical engineering processes like pumps, compressors, evaporators, binary distillation column, Heat Exchanger, CSTR, Gas Absorber, Flash vaporizer etc.

Steady State Process Models Simulation

Development of process models from process systems, Plant wide steady state simulation, Introduction to petrochemical process simulation, oil environments. Introduction to IoT, VS with cases.

List of Experiments:

Minimum *06 Practical Assignments* must be completed using computational as well as simulation soft wares. Aspen plus, Mathcad, Mat lab, excel etc. can be used for solving practical assignments.

1. Calculation of bubble point / dew point for multicomponent hydrocarbon mixture
2. Flash calculations for a multicomponent hydrocarbon mixture
3. Steady state simulation of pumps
4. Steady state simulation of compressors
5. Steady state simulation of heat exchangers
6. Steady state simulation of Multi-component Flash Drum
7. Steady state simulation of Multi-component cyclone separator
8. Modeling and simulation of batch reactor
9. Steady state simulation of CSTR
10. Steady state simulation of separators
11. Steady state mathematical modeling and simulation of Separation Train
12. Mathematical modeling and simulation of chemical processes
13. Solution of under specified and over specified systems.

Text Books:

1. Luyben W. L., "Process Modelling, Simulation and Control for Chemical Engineering", McGraw Hill Book Company, Singapore, 1990.
2. Finlayson, B. A., "Introduction to Chemical Engineering Computing", John Wiley & Sons, New Jersey, 2006.

Reference Books:

1. Denn, M. M., Process Modeling, Longman Sc & Tech. (1987).
2. Himmelblau, D.M and Bischoff, K.B., Process Analysis and Simulation: Deterministic Systems, John Wiley (1968).
3. Dimian A. C. Integrated Design and Simulation of Chemical Processes, Elsevier (2003)
4. Foo D.C., Chemical Engineering Process Simulation, Elsevier (2017)

Web Resources:

NPTEL:

CACHE

AIChE

Assessment Scheme:

Class Continuous Assessment (CCA): 50 marks

Assignments	Test	Mid Term exam	Attendance
10	10	20	10

Laboratory Continuous Assessment (LCA): 50 marks

Practicals	Oral based on practical	Presentations	Problem Based learning
10	20	10	10

Term End Examination : Theory Question Paper: 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Theory	***Lab***	***Assess***
1	***Introduction to Process Simulation:*** Introduction to process modelling and simulation, tools of simulation, approaches of simulation, planning of calculation in a plant simulation	06	04	-
2	***Process Simulation*** Process simulation, Scope of process simulation, Steady state and dynamic simulation, Formation of problem, Pressure – Flow relations, Process simulation approaches for steady state and dynamic simulation, Process simulator, Structure of process simulator, Integral process simulation, Simulation tools	06	04	-
3	***Process Simulation based on process calculation and thermodynamics*** Registration of new components, Physical properties estimation Role of Process calculation in simulation, importance of thermodynamics in simulation, selection of thermodynamic models for simulation, simulation of recycle streams, concept of hypothetical components in simulation	06	04	-
4	***Simulation of Chemical Engineering System based on mathematical modelling*** Input-output models, Degrees of freedom analysis, MBEB based modelling and simulation, Process models of representative chemical engineering processes like pumps, compressors, evaporators, binary distillation column, Heat Exchanger, CSTR, Gas Absorber, Flash vaporizer etc. .	06	04	-
5	***Steady State Process Models Simulation*** Development of process models from process systems, Plant wide steady state simulation, Introduction to petrochemical process simulation, oil environments. Introduction to IoT, VS with cases	06	04	-

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