

**New Scheme (CBCS) & Syllabus**  
of  
**Third and Fourth Year (Semester-V, VI, VII and VIII)**  
**Courses**  
in  
**B. Tech. (Chemical Engineering) Program**



**2020-21**

**CHEMICAL ENGINEERING DEPARTMENT**  
**NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR**  
**RAIPUR – 492010, CHHATTISGARH**

## **Department Academic Committee:**

- Chairperson: Dr. A. K. Poonia,  
Associate Professor & Head, Chemical Engineering  
Department, NIT Raipur
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Assistant Professor, Chemical Engineering Department,  
NIT Raipur
- Member: Dr. (Mrs.) A. B. Soni  
Professor, Chemical Engineering Department, NIT Raipur
- Member: Dr. Bidyut Mazumdar  
Associate Professor, Chemical Engineering Department,  
NIT Raipur
- Member: Dr. V. K. Singh  
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Dr. L. S. Bachan Upadhyay  
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Dr. B. C. Meikap  
Professor, Department of Chemical Engg, IIT Kharagpur
- External Member (Industry):  
Mr. Jaychand Chaudhari  
General Manager, SF complex, DRDO, Ministry of  
Defense, Jagdalpur (C.G.)

**Semester-V**  
**Scheme & Syllabus**

## National Institute of Technology Raipur

Course of Study and Scheme of Examination (CBCS Scheme)												B. Tech. V Semester				Branch: Chemical	
S. No.	Subject Type	Subject Code	Subject Name	Periods per Week				Examination Scheme				Total Marks	Credits				
				L	T	P	TA	MSE/MTR		ESE/ESVE							
								Theory	Practical	Theory	Practical						
1	Program Core	CH105101CH	Process Equipment Design -I	3	1	0	20	30		50		100	4				
2		CH105102CH	Chemical Reaction Engineering-II	3	1	0	20	30		50		100	4				
3		CH105103CH	Mass Transfer -II	3	1	0	20	30		50		100	4				
4	Program Elective-I	CH105201CH	Material Technology	3	0	0	20	30		50		100	3				
		CH105202CH	Fertilizer Technology														
		CH105203CH	Polymer Technology														
5	Open Elective-I	CH105301CH	Industrial Economics and Management	3	0	0	20	30		50		100	3				
6	Laboratory	CH105401CH	Chemical Reaction Engineering Lab	0	0	2	40		20		40	100	1				
7		CH105402CH	Mass Transfer Lab	0	0	2	40		20		40	100	1				
8	Summer Internship-I	CH105701CH	Summer Training I	0	0	2	-					-	1				
												<b>21</b>					

# Process Equipment Design-I



[V<sup>th</sup> Semester, Third Year]

## Course Description

### Offered by Department

Chemical Engineering

### Credits

3-1-0, (4)

### Status

Program Core

### Code

CH105101CH

[Pre-requisites: Material Technology, Engineering Mechanics]

## Course Objectives

1. To understand the basics of process and instrumentation diagram.
2. To apply the knowledge of codes and standard of vessel design
3. To design the mechanical aspect of vessels and support

## Course Content

### Unit-1: Introduction

General design considerations, load, theories of failure, process equipment and utilities symbol, PFD & P&ID, Line Sizing.

### Unit 2: Pressure Vessel Design

Mechanical aspect design of internal and external pressure vessel, head and closures, Designing of Flanges and Gasket.

### Unit 3: Support and Flanges

Design of skirt, saddle and bracket support. Designing of Flanges and Gasket.

### Unit 4: Tall Vessel

Design of tall vessel.

## Course Materials

### Required Text: Text books

1. S D Dawande, Process Design of Equipment, Central Techno Pub., Nagpur, 2000.
2. IS Code-2825 for Unfired Pressure Vessel & IS Code-803 for storage vessel

### Optional Materials: Reference Books

1. SJoshi, M. V. and Mahajani, V. V., "Process Equipment Design," 3rd ed., Macmillan, Delhi, 1996.
2. Bhattacharya, B. C., "Introduction to Chemical Equipment Design: Mechanical Aspects," 5th ed., CBS Pub., Delhi., 1991

# Chemical Reaction Engineering-II



[V<sup>th</sup>Semester, Third Year]

## Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, (4)	Program Core	CH105102CH

[Pre-requisites: Mathematics I and Mathematics II, Chemical Reaction Engineering-I, Heat transfer, Mass Transfer, Fluid mechanics]

## Course Objectives

1. To formulate a residence time distribution from tracer experiment results and use it to predict conversion in an ideal reactor
2. To identify the mechanisms involved in a heterogeneous reaction and formulate an effective rate equation
3. To calculate the impact of changing solid (or fluid) properties on the conversion of a heterogeneous reaction
4. To specify/design the configuration of a reactor to achieve optima fluid flow, mixing, heat transfer and mass transfer for a given reaction
5. To calculate the conversion for an ideal isothermal reactor starting from a general mass balance

## Course Content

### Unit 1:

Basics of Non-Ideal Flow: Exit age distribution of fluid, RTD, Mixing of fluids and degree of segregation, Conversion in non-ideal flow reactors, models for non-ideal flow- dispersion model, Chemical reaction and dispersion, tanks in series model.

### Unit 2:

Fluid particle reactions: Unreacted core model: diffusion through gas film control, diffusion through ash layer control, chemical reaction control. Rate of reaction for shrinking spherical particles, determination of rate controlling step.

### Unit 3:

Fluid – Fluid reactions: Kinetic regimes for mass transfer and reaction, rate equations for various regimes, film conversion parameter, application to design, reactive and extractive reactions.

### Unit 4:

Solid catalyzed reactions: film resistance, surface phenomenon and pore diffusion controls, heat effects, combination of resistances, experimental method for finding rate, determining controlling resistances and rate equations, application to design. Catalyst deactivation: mechanism, rate equation and design.

## Course Materials

### Required Text: Text books

1. J.M. Smith, Chemical Engineering Kinetics. McGraw-Hill, Inc., New York.
2. Octave Levenspiel, Chemical Reaction Engineering, John Wiley & Sons Inc

### Optional Materials: Reference Books

1. H.ScottFogler, Chemical Reaction Engineering, Pearson.
2. S.D. Dawande, Principles of Reaction Engineering, Central Techno Publications.
3. Coulson and Richardson, Chemical Engineering, Volume IV.



# Mass Transfer-II

[V<sup>th</sup> Semester, Third Year]

## Course Description

Offered by Department

Chemical Engineering

Credits

3-1-0, (4)

Status

Program Core

Code

CH105103CH

[Pre-requisites: Mass Transfer-I, Heat Transfer, Thermodynamics, Industrial Process Calculation]

## Course Objectives

1. To give a brief idea about the new separation technologies
2. To provide an understanding of liquid-liquid and solid-liquid equilibrium
3. To provide ability to carry out the mass and energy balance for mass transfer operations
4. To develop skill and ability to the basic design of the mass transfer units

## Course Content

### Unit-1 :Crystallization & Membrane separation

Equilibrium relationships, Mass balance and yield calculation, Equipment for crystallization, Crystal growth theories and design. Introduction to modern membrane separation techniques, theory and principle, and limitations.

### Unit 2: Humidification and drying

Equilibrium, Humidity chart and its use, wet bulb temperature- theory and it's use in measurement of humidity, Calculations in humidification operations, Adiabatic humidification, Equipment design.  
Drying: Equilibrium, Batch and continuous drying, Equipment for drying, Drying time calculations.

### Unit 3: Leaching

Liquid-solid equilibrium, Single-stage and multi-stage leaching, Equipment for leaching, Calculation of number of stages.

### Unit 4 :Liquid-Liquid Extraction

Liquid-liquid equilibrium, Principles of extraction, Single-stage and multi-stage extraction- cocurrent, cross-current and counter current modes, Calculation of number of stages, Equipment for extraction.

## Course Materials

### Required Text: Text books

1. Mass transfer operations by R. Treybal, McGraw hill, 1980.
2. Mass Transfer Operations for the Practicing Engineer by Louis Theodore, Francesco Ricci, Wiley, 2011.
3. Unit operations in chemical Engineering, Warren McCabe, Julian Smith, Peter Harriott, McGraw Hill Publications, 7th edition.
4. Mass Transfer in Chemical Engineering Processes, Hemming Lindberg, Scitus Academics LLC, 2016.
5. Transport Processes and Separation Process Principles by Christie Geankoplis, Prentice Hall Professional Technical Reference, 2003

### Optional Materials: Reference Books

1. Separation Process Engineering Includes Mass Transfer Analysis By Phillip C. Wankat, Prentice Hall, 2012.
2. Principles of mass transfer and separation processes by B.K. Dutta, PHI learning, 2007.
3. Mass Transfer Operations by AlapatiSuryanarayana, New Age International Publishers, 2002.
4. Transport Processes and Unit Operations by Christie J. Geankoplis, PTR Prentice Hall, 1993.
5. Coulson and Richardson's Chemical Engineering, 7th Edition, Volume 1B: Heat and Mass Transfer: Fundamentals and Applications, Butterworth-Heinemann

# Material Technology



[V<sup>th</sup>Semester, Third Year]

## Course Description

### Offered by Department

Chemical Engineering

[Pre-requisites: None]

### Credits

3-0-0, (3)

### Status

Program Elective-I

### Code

CH105201CH

## Course Objectives

1. To provide essential concepts of material science and technology
2. To learn fundamentals of material characteristics and its applications in chemical engineering.
3. To select suitable materials used in chemical industry

## Course Content

### Unit 1:

Properties and behavior of materials useful in structure, machines and equipment, atomic arrangements and imperfections elasticity, micro elasticity and phase transformation. Theories of corrosion and methods of corrosion control.

### Unit 2:

Theory of alloying, constitutional diagrams, their construction and applications. Cast iron as material of construction with reference to its application in chemical Engineering, selection of material, general criterion of selection of material of construction in process industries.

### Unit 3:

Materials of construction and their technology with reference to application in chemical industry: mild steel, high carbon steel, stainless steel, high silicon steel, molybdenum and tungsten steel. Heat treatment of plain steel, Nonferrous metals – copper, aluminum, lead, chromium, tin, brass, bronze and monel.

### Unit 4:

Non-metals – Glass, Enamels, graphite, wood, plastics, rubber, ebonite, lining materials. Composite materials: fiber reinforced plastic composite material, concrete, asphalt and asphalt mixture, ceramic mixture and silicates, structure and properties of polymeric materials high energy materials.

## Course Materials

### Required Text: Text books

1. Russel E Gackenbach, Materials selection for process plants. Literary Licensing, LLC, ISBN: 1258668920
2. Frank Ramford, Chemical Engineering materials. Nabu Press, ISBN: 1174906812
3. Lee Z.Z., Materials of construction for Chemical Process Industries. MC GRAW HILL

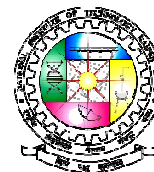
### Optional Materials: Reference Books

1. Agrawal B.K., Introduction to Engineering Materials. McGraw Hill. ISBN: 0074515055
2. Khurmi R.S., Materials Science. S. Chand.
3. Gupta K.M., Material Science & Engineering. Umesh Publication. ISBN: 9789380117249



# Fertilizer Technology

[V<sup>th</sup> Semester, Third Year]



## Course Description

Offered by Department  
Chemical Engineering  
[Pre-requisites: None]

Credits  
3-0-0, (3)

Status  
Program Elective-I

Code  
CH105202CH

## Course Objectives

1. To classify the fertilizers on the basis of its properties.
2. To explain manufacturing processes involved in production of fertilizers.
3. To identify the effect of fertilizers on the health, safety, and environment.
4. To Select appropriate fertilizer.

## Course Content

### Unit1:Introduction

Elements required for plants growth, Classification of fertilizers, Nutrient contents of fertilizer, Uses of fertilizers, Complex and blended fertilizers. N-P-K values and calculations.

### Unit2:Nitrogenous Fertilizer

Manufacturing of nitrogenous fertilizer, Physical and chemical properties, application, storage and transportation.

### Unit3:Phosphatic and Potassium Fertilizer

Availability and grinding of rock phosphate, Manufacturing of Phosphatic and Potassium fertilizer, Physical and chemical properties, application, Storage and transportation.

### Unit4:Bio Fertilizer

Biofertilizers and its types, Nitrogen fixing biofertilizers, Phosphate-solubilizing biofertilizers, Preparation of biofertilizers.

## Course Materials

### Required Text: Text books

1. Austin G T., Shreve's Chemical Process Industries, McGraw Hill Book Company, New Delhi, 5th Edition, 1986.
2. Sittig M., Gopala Rao M., Dryden's Outlines of Chemical Technology, 21st Century, 3rd Edition, WEP East West Press, 2010

### Optional Materials: Reference Books

1. Shukla S.D. and Pandey G.N, Textbook of Chemical Technology, Vol I & II, Vikas Publishing House Pvt. Ltd., New Delhi, 2000.
2. Slack,A.V., Chemistry and Technology of Fertilizers, Interscience, New York, 1966

# Polymer Technology

[V<sup>th</sup> Semester, Third Year]



## Course Description

### Offered by Department

Chemical Engineering  
[Pre-requisites: None]

### Credits

3-0-0, (3)

### Status

Program Elective-I

### Code

CH105203CH

## Course Objectives

1. To understand the basics of polymers
2. To understand the different reactions of polymers
3. To study various characterization methods and properties of the polymers
4. To gain the knowledge about various polymeric additive, blends and composites

## Course Content

### Unit 1:

Basic concepts and definitions, classification of polymers, polymer structure, molecular forces and chemical bonding in polymer, molecular weight and its distribution, chemical structure and thermal transition.

### Unit 2:

Step-reaction (condensation) polymerization, radical chain (addition) polymerization, ionic and coordination chain (addition) polymerization, copolymerization, polymerization conditions and polymer reactions. Various polymeric processing methods.

### Unit 3:

Characterization - Molecular weight and molecular size determination; Thermo-analytical methods: TGA, DTA, and DSC; Spectroscopy: IR, NMR, UV-visible; Properties: solution and mechanical properties, Viscoelasticity.

### Unit 4:

Additives – plasticizers, fillers, reinforcements and other important additives. Polymer blends and interpenetrating networks - polymer blends, toughened plastics and phase-separated blends, interpenetrating network. Introduction to polymer composites – Mechanical properties, composite fabrication. Manufacturing of polymers and recent scenarios in polymer industries.

## Course Materials

### Required Text: Text books

1. Joel R. Fried, "Polymer science and technology", 3rd Edition, Pearson Publisher, 2014.
2. R. R. Ebewele, "Polymer science and technology", CRC Press, Boca Raton, New York 2000.
3. F. W. Billmeyer, "Textbook of polymer science", 3rd Edition, A Wiley-Interscience Publication 1984

### Optional Materials: Reference Books

1. T. Meyer and J. Keurentjes, "Handbook of polymer reaction engineering", A Wiley-VCH Publication 2008.
2. Rodriguez, F., Cohen. C., Oberic.K and Arches, L.A., Principles of Polymer Systems, 5th edition, Taylor and Francis.
3. S. Palsule, "Polymer composites", New Age International 2008.
4. P. M.Ajayan, L. S Schadler., P. V Braun., "Nanocomposite science & technology", Wiley VCH 2003.
5. Seymour. R.B., and Carraher.C.E., Jr., Polymer Chemistry, 2nd Ed., Marcel Dekker, 1988.
6. Gowariker.V.T., Viswanathan.N.V., and Sreedar.J., Polymer Science, Wiley Eastern Ltd., 1988

# Industrial Economics and Management



[V<sup>th</sup> Semester, Third Year]

## Course Description

### Offered by Department

Chemical Engineering  
[Pre-requisites: None]

### Credits

3-0-0, (3)

### Status

Open Elective-I

### Code

CH105301CH

## Course Objectives

1. To provide the fundamentals of industrial economics
2. To provide information of various industrial Acts.

## Course Content

### Unit 1:

Various Terms in Economics, Time Value of Money, Taxation Concept, Tools of Engineering Economics. Investment Analysis.

### Unit 2:

Forms of Business Organization, Functions of Management, Organization Structure. Relationship & Scientific Management, Manpower Planning Techniques.

### Unit 3:

Work Study, Networking Techniques in Project Management: Gantt Charts, Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT).

### Unit 4:

Indian Factory Act, Indian electricity Act, Industrial Dispute Act, Boiler Act, Workmen's Compensation Act, ESI Act, Gratuity Act, Minimum Wages Act, Payment of wages Act, Trade Union Act, Payment of Gratuity Act.

## Course Materials

### Required Text: Text books

1. T. R. Banga, S.C. Sharma, Industrial organization & Engineering Economics, Khanna Publishers, 2006.
2. T. Chand, Engineering Economics, Nem Chand & Bros, 15th Edition, 2019R. M. Jones, Mechanics of Composite Materials, CRC Press

### Optional Materials: Reference Books

1. H. Koontz, C. O'Donnell, Principles of Management: An Analysis of Managerial Functions, McGraw-Hill, 1972.
2. R. H. Lansburgh, W. R. Sprigel, Industrial management, John Wiley & Sons: New York, 4th Edition, 1947

# Chemical Reaction Engineering Lab



[V<sup>th</sup> Semester, Third Year]

## Course Description

### Offered by Department

Chemical Engineering

### Credits

0-0-2, (1)

### Status

Laboratory

### Code

CH105401CH

[Pre-requisites: Mathematics I and Mathematics II, Heat transfer, Industrial Process Calculations, Chemical Reaction Engineering-I and II]

## Course Objectives

1. To determine the kinetics and reaction rate constant of the essentially irreversible reaction
2. To study residence time distribution (RTD) in a CSTR
3. To determine the specific rate of dissolution
4. To study the catalytic and non-catalytic homogeneous reaction

## Course Content

### List of Experiments:

1. To study physical dissolution of benzoic acid on water in Batch Reactor
2. To Study a Non-Catalytic Homogeneous reaction in an Isothermal Batch Reactor
3. To study a non-catalytic homogeneous reaction in a Straight type plug flow reactor under ambient conditions.
4. To study Residence Time Distribution (RTD) in a CSTR.
5. To study a non catalytic homogeneous second order liquid phase reaction in a CSTR
6. To study a non catalytic homogeneous reaction in a packed bed reactor.
7. To study a non catalytic homogeneous reaction in a coil tube plug flow reactor under ambient conditions
8. To determine the first order rate constant for photo-catalytic oxidation of formic acid
9. To study a second order Saponification reaction in a semi-batch reactor under isothermal condition
10. To study a catalytic homogenous reaction in a batch reactor under adiabatic condition.

## Course Materials

### Required Text: Text books

1. J.M. Smith, Chemical Engineering Kinetics. McGraw-Hill, Inc., New York.
2. Octave Levenspiel, Chemical Reaction Engineering, John Wiley & Sons Inc

### Optional Materials: Reference Books

1. H.ScottFogler, Chemical Reaction Engineering, Pearson.
2. S.D. Dawande, Principles of Reaction Engineering, Central Techno Publications.
3. Coulson and Richardson, Chemical Engineering, Volume IV.

# Mass Transfer Lab

[V<sup>th</sup> Semester, Third Year]



## Course Description

### Offered by Department

Chemical Engineering

[Pre-requisites: Mass Transfer]

### Credits

0-0-2, (1)

### Status

Laboratory

### Code

CH105402CH

## Course Objectives

1. To determine the time of drying
2. To determine the VLE curves
3. To determine crystallizer efficiency
4. To determine the distribution coefficient of liquid liquid extraction
5. To study a cooling tower and leaching setups

## Course Content

### List of Experiments:

1. To study the VLE of binary mixtures
2. Determination of the diffusion co-efficient of an organic vapour in air.
3. To study the performance of a Crystallizer and to determine the crystal yield and the efficiency of crystallizer.
4. To study the drying characteristics of a solid under forced draft condition and determine the critical moisture content.
5. To study the kinetics of dissolution of Benzoic acid in water.
6. To determine the liquid-liquid equilibrium for a system of three liquids with one pair only partially soluble
7. Extraction of a substance from solid mixture of sand and substance with water as solvent using simple single contact
8. To study the kinetics of homogeneous liquid-liquid mass transfer limited chemical reactions
9. To determine the gas film coefficient in a wetted wall column using air-water system.
10. Actual visualization of the cooling tower operation and to determine the mass transfer coefficient To study the behavior of beams with respect to the support conditions and loadings.

## Course Materials

### Required Text: Text books

1. Robert E. Treybal, Mass Transfer Operations, McGraw Hill Education; 3rd edition.
2. Binay K. Dutta, Mass Transfer- Separation Proceses, Prentice Hall India Learning Private Limited

### Optional Materials: Reference Books

1. Edward Cussler, Diffusion: Mass Transfer in Fluid Systems, Cambridge University Press; 3rd edition.
2. Francesco Ricci and Louis Theodore, Mass Transfer Operations for the Practicing Engineer, Wiley-AIChE; 1st edition

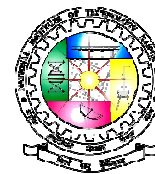
**Semester-VI**  
**Scheme & Syllabus**

**National Institute of Technology Raipur**

Course of Study and Scheme of Examination(CBCS Scheme)								B. Tech. VI Semester				Branch: Chemical	
S. No.	Subject Type	Subject Code	Subject Name	Periods per Week			TA	Examination Scheme				Total Marks	Credits
				L	T	P		MSE/MTR		ESE/ESVE			
								Theory	Practical	Theory	Practical		
1	Program Core	CH106101CH	Environmental Engineering	3	1	0	20	30		50		100	4
2		CH106102CH	Process Dynamics and Control	3	1	0	20	30		50		100	4
3		CH106103CH	Transport Phenomena	3	1	0	20	30		50		100	4
4	Program Elective-I	CH106201CH	Process Equipment Design -II	3	0	0	20	30		50		100	3
		CH106202CH	Biochemical Engineering										
		CH106203CH	Electrochemical Engineering										
		CH106204CH	Process Instrumentation										
5	Open Elective-I	CH106301CH	Non-Conventional Energy Sources	3	0	0	20	30		50		100	3
6	Laboratory	CH106401CH	Process Dynamics and Control Lab	0	0	2	40		20		40	100	1
7		CH106402CH	Environmental Engineering Lab	0	0	2	40		20		40	100	1
												20	

# Environmental Engineering

[VI<sup>th</sup> Semester, Third Year]



## Course Description

Offered by Department  
Chemical Engineering  
[Pre-requisites: None]

Credits  
3-1-0, (4)

Status  
Program Core

Code  
CH106101CH

## Course Objectives

1. To understand the importance of environment, pollutant, and its law.
2. To describe the causes and prevention of air pollution.
3. To describe the causes and prevention of water pollution.
4. To understand the management of solid waste

## Course Content

### Unit 1: Overview

Pollution control Acts and laws, Standards of pollution discharge, Effect of pollution on environment and human health, Various emission sources.

### Unit 2: Air Pollution

Introduction, Discharge standards, Classification of the pollutant, Meteorological aspects of air pollution, Control equipments, Methods of measurements and sampling of gaseous and particulate pollutants in ambient air and industrial emissions.

### Unit 3: Water Pollution

Introduction, Discharge standards, Source and Classification of wastewater from chemical industries, Selection of control equipment, Method of wastewater sampling and treatment methods.

### Unit 4: Solid Waste Management

Sources and Classification, Collection and Disposal methods, Land filling, Incineration, Composting, Solid waste as resource material.

## Course Materials

### Required Text: Text books

1. Peavy H.S. Rowe D.R., and George Tchobanoglous, Environmental Engineering, McGraw Hill Book Company, Ny, 1985.
2. Rao, C.S Environmental Pollution Control Engineering, Wiley- Eastern Ltd. 1991

### Optional Materials: Reference Books

1. Gilbert M. Masters, Introduction to Environmental Engineering and Science, Prentice – Hall of India, New Delhi, 1994.
2. “Pollution Control Acts, Rules, Notification issued there under” CPCB, Ministry of Environment and Forest G.O.I. 3rd Ed. 2006



# Process Dynamics & Control



[VI<sup>th</sup> Semester, Third Year]

## Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-1-0, (4)	Program Core	CH106102CH

[Pre-requisites: Mathematics I and Mathematics II, Heat Transfer, Mass Transfer, Reaction Engineering. CH103102CH, CH103101CH, CH104104CH]

## Course Objectives

1. To understand the applications of different controllers used in chemical plant
2. To understand the safety and stability of the process
3. To design a control system for a process in chemical industry

## Course Content

### Unit 1:

Laplace transform, Linear open loop system, The first and second order systems and their transient response Interacting and non-interacting systems, Linearization, Transportation lag.

### Unit 2:

Linear closed loop system-control system, block diagram, closed loop transfer function, Controllers, Transient response of closed loop systems.

### Unit 3:

Pneumatic controller mechanism, baffle nozzle, proportional controller mechanism, Proportional integral control, Proportional derivative control valve, PID control, Final control element, Control valve, Feed forward control, Controller tuning.

### Unit 4:

Stability concept, Routh stability criterion, Nyquists stability criterion, Root locus technique, introduction to frequency response, Bode diagram, Bode stability criterion, Gain and phase margins, Fuzzy Logic Control.

## Course Materials

### Required Text: Text books

1. LeBlanc CoughanowrCoughanowr and Koppel, Process Systems Analysis and Control, McGraw Hill Education; Third edition
2. G. Stephanopoulos, Chemical Process Control, Pearson Education India, 1stEdition

### Optional Materials: Reference Books

1. Donald P. Eckman, Automatic Process Control, Wiley India Pvt, Ltd.
2. Peter Harriot, Process Control, Krieger Publishing Company.
3. I.J. Nagrath and M. Gopal., Control Systems Engineering, New Age International Publishers.
4. Dale E. Seborg, Thomas F. Edgar and Dun can A. Mellichamp, Process Dynamics & Control, John Wiley& Sons Inc Pt. Ltd.

# Transport Phenomena



[VI<sup>th</sup> Semester, Third Year]

## Course Description

Offered by Department  
Chemical Engineering

Credits  
3-1-0, (4)

Status  
Program Core

Code  
CH106103CH

[ Pre-requisites: Heat Transfer, Mass Transfer, Chemical Reaction Engineering, Numerical Methods]

## Course Objectives

1. To apply the knowledge of mathematics in solutions of transport equations
2. To apply mass, heat and momentum transfer process in design of flow processes
3. To learn the solution of real world problems using transport equations
4. To apply computer knowledge in solution of complex engineering problems

## Course Content

### Unit 1: Principles of Momentum Transport

Shell Momentum Balance and its Applications, Flow of Falling Film, Flow Through Circular Pipe, Flow Through annulus, Couette flows, Flow in Viscometers.

### Unit 2: Principles of Steady State Heat Transport

Shell Energy Balance and its Applications Heat Conduction with Electrical Source, Heat Conduction with Chemical Heat Source, Natural Convection Heat Transfer Governing Equation, Analysis of Couette flow with heat transfer.

### Unit 3: Principles of Mass Transport

Mass Transport, Molecular Diffusion in Gases, Diffusion of component through Non-Diffusing component, Mass and Molar Transport by Convection, Counter diffusion and Diffusion through a 'stagnant' media, Steady State Mass diffusion with heterogeneous catalytic surface reaction, Steady State Mass diffusion with homogeneous chemical reactions.

### Unit 4: Equation of change

Derivation of Equation of continuity, Equation of Motion, Navier Stokes equation, Euler's equation for Cartesian coordinate system, nondimensional numbers, Application of equation of changes to solve flow problems.

## Course Materials

### Required Text: Text Books

1. R. B. Bird, W.E. Stewart, E.N. Lightfoot "Transport Phenomena", 2nd Edition, John Wiley & Sons (Asia) Pvt. Ltd.
2. C. J. Geankoplis, "Transport Processes and Separation Process Principles", 4th Edition, PHI Learning Private Limited., New Delhi
3. A. Keshav, B. Mazumdar, "Transport Phenomena", 1st edition, Wiley Indian Pvt. Ltd, New Delhi

### Optional Materials: Reference Books

1. Frank P. Incropera, David P. DeWitt "Fundamentals of Heat and Mass Transfer", 6th Edition, John Wiley & Sons (Asia) pvt. Ltd.
2. W.J. Thomson, "Introduction to Transport Phenomena", Pearson Education Asia, New Delhi, 2001



# Process Equipment Design-II

[VI<sup>th</sup> Semester, Third Year]

## Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-0-0, (3)	Program Elective-I	CH106201CH

[ Pre-requisites: Mass Transfer, Heat Transfer]

## Course Objectives

1. To learn about the design procedures of process equipment used in chemical process plants.
2. To apply the knowledge of heat transfer for design heat transfer equipment.
3. To design mass transfer equipment

## Course Content

### Unit 1: Design of Heat Exchanger Equipment

General design procedure, Double pipe heat exchanger, Shell and tube heat exchanger, pressure drop calculation. Condensers for single vapor, Vertical and horizontal condenser, desuperheater cum condenser, condenser cum subcooler, pressure drop in condenser.

### Unit 2: Design of Distillation Columns

Diameter and Height of tower, Plate efficiency, Tray spacing, downcomer, weir length, weeping and entrainment point, pressure drop calculations. Size and number of poles.

### Unit 3: Design of Absorption Column

No. of overall transfer Unit, Height of column, Design of packing support, Design of liquid distributor, Liquid hold up, pressure drop and diameter calculations.

### Unit 4: Design of Drier and Extraction Equipment

Designing of tunnel and tray drier. Design of plate and packed Extraction column.

## Course Materials

### Required Text: Text Books

1. Kern, D.Q., Process Heat Transfer, International Student Edition, McGraw Hill (2002).
2. Backhurst J. R., Harker J.H., Process Plant Design, Heinemann Educational Books, London.
3. Treybal R.E., Mass Transfer Operations, McGraw-Hill publication

### Optional Materials: Reference Books

1. Perry, R.H. and Green, D, Chemical Engineer's Handbook, Mc Graw Hill, NewYork. (2008).
2. Ullman - Chemical Engineering and Plant Design, Wiley-vch, John Wiley & Sons
3. Ludwig E.E., Applied Process Design in Chemical and Petrochemical Plants Vol II, Gulf Publishing Co. (1995)

# Biochemical Engineering



[VI<sup>th</sup> Semester, Third Year]

## Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-0-0, (3)	Program Elective-I	CH106202CH

[ Pre-requisites: CH106103CH, CH104104CH, CH105102CH]

## Course Objectives

1. To apply the fundamentals of chemical engineering in biological system.
2. To understand the basics of bioreactor design and analysis.
3. To learn the enzyme kinetics and immobilization

## Course Content

### Unit 1

**Basics of Biotechnology:** Concepts of Biology & Biotechnology, Diversity in microbial cells, Cell constituents.

**Bio-molecules:** Carbohydrates, Proteins, Amino acids, Nucleic acids, Enzymes and its types, Enzyme immobilization

### Unit 2

**Microbial growth and regulation:** Bioenergetics, Glucose metabolism, Krebs cycle, biosynthesis.

### Unit 3

**Kinetics of biochemical reaction:** Enzyme and its kinetics, Kinetics of substrate utilization, product formation and biomass production, Michaelis-Menten equation and its modification, Monod growth kinetics, Thermal death rate kinetics.

### Unit 4

**Bioreactor Design:** Bioreactor design and analysis, media formulation, Bio-product recovery and bio-separations.

**Industrial application:** SCP, High fructose corn syrup, Beer and wine manufacturing, Citric acid production, Penicillin production, Streptomycin production.

## Course Materials

### Required Text: Text Books

1. Shuler M., Kargi F., Bioprocess Engineering: Basic Concepts, PHI (2017)
2. Bailey, J.E. and Ollis, D.F, Biochemical Engineering Fundamentals, McGraw Hill, NewYork (2017)

### Optional Materials: Reference Books

1. Doran, P.M Bioprocess Engineering Principles, Academic Press (2013)
2. Stanbury P. F., Whittaker, A. and Hall, S. J., Principles of Fermentation Technology, Butterworth-Heinemann (2016).

# Electrochemical Engineering



[VI<sup>th</sup> Semester, Third Year]

## Course Description

<b>Offered by Department</b>	<b>Credits</b>	<b>Status</b>	<b>Code</b>
Chemical Engineering	3-0-0, (3)	Program Elective-I	CH106203CH

[ Pre-requisites: Basics knowledge in applied chemistry, corrosion and mass transfer]

## Course Objectives

1. To understand the basic principles of electrochemistry and mechanism involved in electrochemical systems
2. To understand the mass transfer and mechanism of corrosion.
3. To understand the concepts of electro process and design of batteries, fuel cell and electrochemical reactors

## Course Content

### Unit 1:

Faraday's law - Nernst potential – Galvanic cells – Polarography, The electrical double layer and its role in electrochemical processes –Electrocapillary curve – Helmholtz layer – Guoy –Steven's layer – fields at the interface.

### Unit 2:

Mass transfer in electrochemical systems: diffusion controlled electrochemical reaction – the importance of convention and the concept of limiting current. Over potential, primary-secondary current distribution – rotating disc electrode.

### Unit 3:

Corrosion- theories and current relations; diffusion-controlled corrosion process; pH diagram and forms of corrosion; factors and control methods; boiler corrosion control; protective coatings and vapor phase inhibitors; Cathodic protection and sacrificial anodes.

### Unit 4:

Electro deposition – electro refining – electroforming – electro polishing – anodizing – Selective solar coatings, Primary and secondary batteries – types of batteries, Fuel cells. Application of different electrodes: Metals- Graphite – Lead dioxide – Titanium substrate insoluble electrodes – Iron oxide – semi conducting type etc. Merits of different type of electrochemical reactors. Current electrochemical practices in industries.

## Course Materials

### Required Text: Text Books

1. Picket, "Electrochemical Engineering", Prentice Hall. 1977.
2. Newman, J. S., "Electrochemical systems", Prentice Hall, 1973

### Optional Materials: Reference Books

1. Barak, M. and Stevenge, U.K., "Electrochemical Power Sources - Primary and Secondary Batteries" 1980
2. Mantell, C., "Electrochemical Engineering", McGraw Hill, 1972

# Process Instrumentation



[VI<sup>th</sup> Semester, Third Year]

## Course Description

Offered by Department

Chemical Engineering

Credits

3-0-0, (3)

Status

Program Elective-I

Code

CH106204CH

[ Pre-requisites: None]

## Course Objectives

1. To impart the knowledge about the principles and practices of measurement of important chemical process variables such as temperature, pressure, flow, level, concentration, etc.
2. To introduce the field of Instrumentation and covers process variables and the various instruments used to sense, measure, transmit and control these variables

## Course Content

### Unit 1:

**General Concepts:** Functional Elements of an Instrument, Error Analysis, Static and Dynamic Characteristics.

**Temperature Measurement:** Thermometers, Bimetallic Thermometer, Pressure-spring Thermometer, Resistance Temperature Devices, Thermistors, Thermocouples, Thermopile, Pyrometers.

### Unit 2:

**Pressure Measurement:** Manometers, Diaphragms, Capsules, Bellows, Bourdon tubes, Barometers, Piezoelectric Pressure Gauge, Vacuum Instruments - Pirani Gauge, Ionization Gauge, McLeod Gauge

### Unit 3:

**Liquid Level Measurement:** Direct Level Sensing - Sight Glass, Conductive Probes, Capacitive Probes, Ultrasonic Probes, Indirect Level Sensing - Resistive Tapes, Load Cells, Bubbler Device.

**Other Measurement:** Hygrometers, Psychrometers, Hydrometers, Thermohydrometer, Viscometer, pH meter, Refractometer.

### Unit 4:

**Manipulation, Transmission and Recording of Data:** Bridge Circuits, Amplifiers, Filters, Analog-to-Digital Converters, Digital-to-Analog Converters, Fiber-Optic Data Transmission, Analog Voltmeters and Potentiometers, Digital Voltmeters and Multimeters, Active and Passive Transducers, Null and Deflection Methods, Magnetic Tape and Disk Recorders, Digital Printers and Plotters.

## Course Materials

### Required Text: Text Books

1. E. O. Doebelin, Measurement Systems: Application and Design, 4th Edition, McGraw-Hill Publishing Company, 1990.
2. Alan S. Morris, Measurement and Instrumentation Principles, Butterworth-Heinemann, 2001
3. B. C. Nakra and K. K. Chaudhry, Instrumentation Measurement and Analysis, 3rd Edition, Tata McGraw-Hill, 2009

### Optional Materials: Reference Books

1. C.D. Johnson, Process Control Instrumentation Technology, 8th Edition, Pearson Education Limited, 2014.
2. W.G. Andrew, Applied Instrumentation in the Process Industries, Vol. I, II & III Ed. Gulf Publication. 1993.
3. K. Robards, P.R. Haddad and P.E. Jackson, Principles and Practice of Modern Chromatographic Methods, Elsevier, 1994.
4. William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control, McGraw-Hill, 2005.
5. D. P. Eckman, Industrial Instrumentation, McGraw Hill Publications, 1975

# Non-Conventional Energy Sources



[VI<sup>th</sup> Semester, Third Year]

## Course Description

Offered by Department

Chemical Engineering

Credits

3-0-0, (3)

Status

Open Elective-I

Code

CH106301CH

[ Pre-requisites: None]

## Course Objectives

1. To know about world energy scenario and non-conventional energy sources.
2. To appreciate the advantages of energy production from renewable energy resources.
3. To learn the technology involved in the extraction/conversion of renewable energy sources into useful energy.
4. To get updated with alternative and new sources of energy

## Course Content

### Unit 1: Overview

Indian & global energy scenario potential and advantages of non-conventional energy resources, energy conservation, renewable energy.

### Unit 2: Solar Energy

Solar radiation and its measurement, Solar collectors – types, and constructional details. Solar water heating, applications of Solar Energy for heating, drying, space cooling, water desalination, solar concentrators, photovoltaic power generation using silicon cells.

### Unit 3:

**Wind Energy:** Principle of energy from wind, windmill construction and operational details and electricity generation and mechanical power production.

**Bio-Energy:** Combustion, pyrolysis and other thermo-chemical conversion of biomass to energy, biogas

### Unit 4:

Tidal Energy, Ocean thermal energy conversion (OTEC), Geothermal Energy, Hydrogen energy, other alternative & new sources of energy. Energy Storage and Distribution, Fuel cells.

## Course Materials

### Required Text: Text Books

1. Twiddle, J. Weir, T. "Renewable Energy Resources," Cambridge University Press, 1986.
2. Rai, G.D., "Non-Conventional Energy Sources," Khanna Publishers, New Delhi, 2001.
3. Sukhatme, S. P., "Solar Energy: Principles of Thermal Collection and Storage," 2nd ed., Tata McGraw-Hill, 2001

### Optional Materials: Reference Books

1. Sorenson, B, "Renewable Energy", 3rd ed., Elsevier Science, 2004.
2. Kreith, F. and Kreider, J. F., "Principles of Solar Engineering," McGraw Hill, 1978.
3. Duffie, J. A., Beckman, W. A., "Solar Engineering of Thermal Processes," John Wiley, 1980.
4. Veziroglu, N., "Alternative Energy Sources," Volume 5 & 6, McGraw-Hill, 1978.
5. Garg, H.P. and Prakash, J., "Solar Energy: Fundamentals and Applications," Tata McGraw-Hill, 2001.
6. S. Rao and Dr. B.B. Parulekar, Energy Technology, Nonconventional, Renewable and Conventional, Khanna Publishers
7. G.N. Tiwari, Fundamentals of Renewable Energy Sources, Narosa Publishing House

# Process Dynamics and Control Lab



[VI<sup>th</sup> Semester, Third Year]

## Course Description

Offered by Department

Chemical Engineering

Credits

0-0-2, (1)

Status

Laboratory

Code

CH106401CH

[ Pre-requisites: None]

## Course Objectives

1. To determine the time constant & dynamics of I and II order system
2. To determine the control valve coefficient of control valve
3. To identify the suitable parameters needed for PID controllers

## Course Content

### List of Experiments:

1. Study of Control Valve – Valve Coefficient, Hysteresis, Inherent Characteristics, Installed Characteristics, Rangeability
2. Time Constant of First Order System – Temperature Measurement Devices – Glass Thermometer, Bimetallic Thermometer, RTD, Thermistor, Thermocouple
3. Dynamic Response of U-Tube Manometer – Mercury, Water
4. Dynamic Response of Interacting and Non-Interacting System
5. Study of Controller – P, PI, PD, PID
6. Study of Cascade Control Trainer (SCADA)
7. Study of DCS Trainer
8. Study of Flapper Nozzle System
9. Study of Non-linear Level Control
10. Study of I/P and P/I Converter

## Course Materials

### Required Text: Text Books

1. D.R. Coughanowr and S.E. Leblanc, Process Systems Analysis and Control, McGraw Hill Education, 3rd Edition, 2017.
2. G. Stephanopoulos, Chemical Process Control, Pearson Education India, 1st Edition, 2015



# Environmental Engineering Laboratory



[VI<sup>th</sup> Semester, Third Year]

## Course Description

Offered by Department

Chemical Engineering

Credits

0-0-2, (1)

Status

Laboratory

Code

CH106402CH

[ Pre-requisites: None]

## Course Objectives

1. To understand the fundamentals of water as well as soil chemistry and their quality standards.
2. To learn various techniques and analytical methods available for wastewater treatment.
3. To understand different water, air, soil and noise quality parameters and their measurements

## Course Content

### List of Experiments(Any ten experiments):

1. Determination of pH and electrical conductivity of the given water sample.
2. Determination of the turbidity of the given water sample.
3. Determination of the optimum coagulant dosage of the given water sample.
4. Determination of the acidity and alkalinity of the given water sample.
5. Determination of the hardness of the given water sample.
6. Determination of various types of solids present in the given water sample.
7. Determination of sulphate and nitrate in the given water sample.
8. Determination of D.O in the given water sample.
9. Determination of B.O.D. in the given water sample.
10. Determination of C.O.D. in the given water sample.
11. Determination of chlorine in the given water sample.
12. Determination of coliforms using MPN Test in the given sample.
13. Determination of NO<sub>x</sub>, SO<sub>x</sub> and CO<sub>x</sub> in the air sample
14. Determination of noise profile in a multiple noise source situation
15. Determination of particulate matter in air sample.
16. Determination of specific gravity, bulk density and moisture content of a given soil sample.
17. Determination of organic carbon, NPK and CEC of a given soil sample

## Course Materials

### Required Text: Text Books

1. K. R. Aneja (2007), Experiments in Microbiology, Plant Pathology and Biotechnology; New Age International, New Delhi.
2. APHA, Standard Methods for the Examination of Water and Wastewater, 22nd Edition. American Public Health Association, Washington, DC.
3. J. G. Cappuccino, N. Sherman (2014) Microbiology, a laboratory Manual. Benjamin-Cummings Publishing Company, SF, USA.
4. CPCB guidelines

**Semester-VII**  
**Scheme & Syllabus**

National Institute of Technology Raipur													
Course of Study and Scheme of Examination(CBCS Scheme)								B. Tech. VII Semester				Branch: Chemical	
S. No.	Subject Type	Subject Code	Subject Name	Periods per Week			TA	Examination Scheme				Total Marks	Credits
				L	T	P		MSE/MTR		ESE/ESVE			
								Theory	Practical	Theory	Practical		
1	Program Core	CH107101CH	Process Modeling& Simulation	3	1	0	20	30		50		100	4
2	Program Elective-I	CH107201CH	Plant Design and Costing	3	0	0	20	30		50		100	3
		CH107202CH	Food Processing Technology										
		CH107203CH	Coal Processing Technology										
3	Program Elective-II	CH107251CH	Petroleum Refining Engineering	3	0	0	20	30		50		100	3
		CH107252CH	Heat Exchanger Network Design										
		CH107253CH	Membrane Science and Technology										
4	Open Elective-I	CH107301CH	Computational Fluid Dynamics	3	0	0	20	30		50		100	3
		CH107302CH	Introduction to Analytical Techniques										
5	Project Work	CH107501CH	Project Work	0	0	8	40		20		40	100	4
6	Laboratory	CH107401CH	Chemical Engineering Computational and Simulation Lab	0	0	2	40		20		40	100	1
7	Summer Internship	CH105801CH	Summer Internship -II				-					-	2
													20

# Process Modeling & Simulation



[VII<sup>th</sup>Semester, Fourth Year]

## Course Description

### Offered by Department

Chemical Engineering

### Credits

3-1-0, (4)

### Status

Program Core

### Code

CH107101CH

[Pre-requisites: Heat transfer, Mass transfer & CRE]

## Course Objectives

1. To understand the concept and importance of modeling and simulation.
2. To make aware with modeling of heat transfer and mass transfer processes etc.
3. To make aware about the use of computer programming/software in simulation of developed equations

## Course Content

### Unit 1:

Concept of modeling and simulation, Classification of models, uses of mathematical models, Principles of formulations. Introduction to C++, CFD, MATLAB and other computer languages & tools and their application in solving modeling problems.

### Unit 2:

Mathematical Modeling of Chemical Reactors: CSTR, PFR, batch reactor, Non isothermal CSTR, Bioreactor, Trickle bed reactor, Moving bed reactor. Simulation, Program development and numerical solutions of above processes.

### Unit 3:

Mathematical Modeling in Mass Transfer: distillation column, Liquid- liquid extraction, Reaction with mass transfer, Absorption, Adsorption. Simulation, program development and numerical solutions of above processes.

### Unit 4:

Mathematical Modeling in Heat transfer: Two heated tanks, Single component vaporizer, Multi component flash drum, Cooling towers. Simulation, program development and numerical solutions of above processes.

## Course Materials

### Required Text: Text books

1. Luyben W. L., Process Modeling and Simulation Control for Chemical Engineers, Mc Graw Hill International Edition.
2. Fogler H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India.
3. Holland C.D., Fundamental and Modelling of Separation Process, Prentice Hall

### Optional Materials: Reference Books

1. Edger T. F., Himmelblau D. M. and Lasdon L.S. Process Optimization in Chemical Process, McGraw Hill.
2. Gaikwad R.W. and Dhirendra, Process Modelling and Simulation, Denett and Co

# Plant Design and Costing



[VII<sup>th</sup>Semester, Fourth Year]

## Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-0-0, (3)	Program Elective-I	CH107201CH

[Pre-requisites: CH104103CH, CH105301CH]

## Course Objectives

1. To learn about the plant location and plant layout of a chemical industry.
2. To understand the basic concepts and design principles involved in piping, instrumentation, control, and power systems.
3. To study the procedures for the selection of process equipment and materials.
4. To understand the basic concepts and methods for calculation of depreciation, profitability analysis and estimation of different types of cost for a manufacturing unit

## Course Content

### Unit 1 :

Introduction to Plant Design, General Design Considerations, Process Design Development, Optimum Design and Design Strategy.

### Unit 2:

Location of the Chemical Plant, Plant Layout, Selection of Process Equipment and Materials.

### Unit 3:

Process Auxiliaries - Piping, Instrumentation, Control and Power Systems.

### Unit 4:

Analysis of Cost Estimation, Time value of Money, Evaluation of Profitability, Alternatives investment and Replacements, Depreciation and methods of its calculation.

## Course Materials

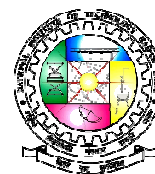
### Required Text: Text books

1. Peters Max S., Timmerhaus Klaus. D., West Ronald E.: Plant Design and Economics for Chemical Engineers, Fifth edition McGraw Hill Co., New York, 1991.
2. Vilbrandt Frank C, Dryden Charles E: Chemical Engineering Plant Design, Fourth edition, McGraw Hill book Co., New York

### Optional Materials: Reference Books

1. Towler G. and Sinnott R.K.: Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design". Butterworth-Heinemann. 2008
2. Mahajan M.S.: Industrial Engineering and Production Management, Dhanpat Rai Publication, First Edition 2000-01.
3. Kharbanda O.P.: Process Plant and Equipment Cost Estimation, Sevak Publication, Bombay

# Food Processing Technology



[VII<sup>th</sup> Semester, Fourth Year]

## Course Description

### Offered by Department

Chemical Engineering

### Credits

3-0-0, (3)

### Status

Program Elective-I

### Code

CH107202CH

[Pre-requisites: Heat Transfer, Mass Transfer, Thermodynamics]

## Course Objectives

1. To learn the basics of food processing and preservation
2. To understand the different food processing technologies
3. To understand the role of Nutraceuticals and functional food in health and disease
4. To familiarize with the current state of knowledge in food analysis.

## Course Content

### Unit 1: Basic considerations

Aims of preservation & processing of foods, Causes of quality deterioration and spoilage of perishable foods.

### Unit 2: Thermal and non-thermal methods of food preservation

Basic concepts in thermal destruction of microorganism, Cooking, Blanching, Pasteurization and Sterilization of foods. Drying, Dehydration of fruits, vegetables, milk, animal products etc.; osmotic methods.

### Unit 3: Methods of Food Analysis

Determination of Moisture in foods, ash content of foods, titratable acidity in foods, determination of dietary fiber and crude fiber, Spectroscopic and chromatographic techniques.

### Unit 4: Analysis of phytochemicals and assessment of antioxidant activity

Qualitative and quantitative methods, In vitro and In vivo methods for the assessment of antioxidant activity, Variation of Antioxidant Activity during food processing.

## Course Materials

### Required Text: Text books

1. Karnal, Marcus and D.B. Lund "Physical Principles of Food Preservation". Rutledge, 2003.
2. Tegge, G., Green, J. H., and A. Kramer. "Food Processing Waste Management". AVIPublishing, 1979.
3. VassoOreopoulou and Winfried Russ. "Utilization of by-products and Treatment of Waste in the Food Industry". Springer, 2007

### Optional Materials: Reference Books

1. Herzka, A. and Booth, R.G. "Food Industry and Trade: Recycling Waste". AppliedScience Publishers, 1981.
2. Gould, G.W. "New Methods in Food Preservation". Springer, 1995.
3. Adams, M.R and M.O. Moss. "Food Microbiology". New Age International, 2002

# Coal Processing Technology



[VII<sup>th</sup> Semester, Fourth Year]

## Course Description

### Offered by Department

Chemical Engineering

[Pre-requisites: None]

### Credits

3-0-0, (3)

### Status

Program Elective-I

### Code

CH107203CH

## Course Objectives

1. To provide overall idea about coal processing and utilization
2. To provide in-depth understanding of the efficiencies of coal washing processes
3. To understand the various unit operations, equipments and beneficiation techniques for processing of coal
4. To learn the characteristics of coal relevant to its preparation.

## Course Content

### Unit 1: Coal preparation

Scope, objectives and applications, Types and properties of coals in general, industrial uses, characteristics of coals, coking and non-coking coals, Washability studies, sink and float analysis of coals, Standard washability curves, washability index, Efficiency of coal washing.

### Unit 2: Crushing and Screening of Coal

Crushers for coal. Rotary breaker, Roll crushers, Impact group of crushers, Sizers, Pulveriser, Ball mill, Screening, Industrial Screens, Performance evaluation of crusher, mills and screens.

### Unit 3: Carbonization and Gravity Separation Process

Theory, types and advantages carbonization, Gasification of coal, smelter gasifier and corex gas, Standard metallurgical coke making process, Properties of coke, by-products of a coke oven, Waste heat and flue gas recovery, Heavy media Separation: Types, application and operation, Heavy Media cyclones-operating principles, applications, performance, efficiency and design calculations.

### Unit 4: Fine Coal Cleaning and Dewatering

Fine coal cleaning using Spirals, froth flotation, Dewatering - Centrifuges, thickeners, cyclones and filters, Typical flow-sheets for preparation of metallurgical (coking) and thermal (non-coking) coal, Coal washery equipments and its selection.

## Course Materials

### Required Text: Text books

1. Coal processing and utilization, D.V. Subba Rao, T. GouriCharan, CRC press, 2016.
2. Fuels and combustion by Samir Sarkar, 3rd edition, Universities Press, 2010.
3. Minerals and coal process calculations, D. V. Subba Rao, CRC Press, 2016

### Optional Materials: Reference Books

1. Coal production and processing technology, M.R. Riazi, R. Gupta, CRC Press, 2015
2. The Science and Technology of Coal utilization, Bernard R Cooper and Willim A Ellingson, 1st Edition, Springer, 1984

# Petroleum Refining Engineering



[VII<sup>th</sup> Semester, Fourth Year]

## Course Description

### Offered by Department

Chemical Engineering

[Pre-requisites: Chemical Technology]

### Credits

3-0-0, (3)

### Status

Program Elective-II

### Code

CH107251CH

## Course Objectives

1. To learn about crude reserves, consumption, composition, and evaluation.
2. To study various processes involved in petroleum refining.
3. To study sources of pollution in petroleum refining

## Course Content

### Unit 1:

Introduction to Petroleum Refinery, World reserves of petroleum crude, Production and consumption status of crude and its products in India, Composition, Classification and evaluation of crude oil, Common tests for petroleum crude and its products

### Unit 2:

Dehydration and desalting of crude, Distillation, temperature cuts and characteristics, Internals of distillation column, operation of distillation column. Various products: gasoline, kerosene, ATF, Diesel, lubricating oils and their characterization.

### Unit 3:

Cracking, hydro cracking, Coking, Reforming, Hydro treating, Isomerization, Alkylation, Polymerization, Gas to liquid Technology (GTL), Gasification of heavy petroleum feed stock, Reformulated gasoline.

### Unit 4:

Finishing operations (treatments of petroleum fractions), Pollution by refineries.

## Course Materials

### Required Text: Text books

1. W.L. Nelson, Petroleum Refining Engineering, McGraw-Hill Book Company, Inc., New York; International edition (January 1, 1941).
2. Hobson G.D, Modern petroleum Technology, 4th. Ed., Applied Science Publishers, Great Britain.
3. Bhaskara, Rao B.K., Modern Petroleum Refining Processes., 6th Ed., Oxford & IBH, New Delhi.

### Optional Materials: Reference Books

1. James H. Gary, Glen E. Handwerk, Mark J .Kaiser , Petroleum refining: Technology & Economics, 5th Ed., CRC Press, Taylor & Francis Group
2. James G. Speight, G.J and Ozum, B (2002) Petroleum Refining Processes. Marcel Dekker Inc, New York



# Heat Exchanger Network Design



[VII<sup>th</sup>Semester, Fourth Year]

## Course Description

Offered by Department

Chemical Engineering

[Pre-requisites:CH103102CH, CH104101CH]

Credits

3-0-0, (3)

Status

Program Elective -II

Code

CH107252CH

## Course Objectives

1. To introduce the concept of pinch technology for energy efficient heat exchanger network designs.
2. To understand the energy targets in design of processes.
3. To analyze and design heat exchanger networks

## Course Content

### Unit 1:Introduction to Pinch Technology:

Introduction, Basic concept, Role of thermodynamics in process design, Pinch technology applications.

### Unit 2:

**Key steps of Pinch Technology:** Concept of  $\Delta T_{\min}$ , Data Extraction, Targeting, Designing, Optimization-Super targeting.

**Basic Elements of Pinch Technology:** Grid Diagram, Composite curve, ProblemTable Algorithm, Grand Composite Curve.

### Unit 3:Targeting of Heat exchanger networks (HEN)

Energy targeting, Area targeting, Number of units targeting, Shell targeting and Cost targeting.

### Unit 4:Designing of Heat exchanger networks

Pinch design methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER), Design of multiple utilities and pinches, Design of threshold problem, Loops and Paths, Case study.

## Course Materials

### Required Text: Text books

1. U. V. Shenoy, Heat Exchanger Network Synthesis: Process Optimization by Energy and Resource Analysis, Gulf Publishing company, 1995.
2. M. M. El Halwagi, Process Integration, Academic Press, 7th Edition, 2006.
3. I. C. Kemp, Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy, Butterworth-Heinemann; 2nd edition, 2006

### Optional Materials: Reference Books

1. R. Smith, Chemical Process Design and Integration, John Wiley & Sons, 2nd edition, 2016
2. D.W. Linnhoff, User Guide on Process Integration for the Efficient Use of Energy, Institution of Chemical Engineers, 1994

# Membrane Science and Technology



[VII<sup>th</sup> Semester, Fourth Year]

## Course Description

Offered by Department	Credits	Status	Code
Chemical Engineering	3-0-0, (3)	Program Elective-II	CH107253CH

[Pre-requisites: Mass Transfer, Fluid Mechanics]

## Course Objectives

1. To understand the fundamentals of membrane separation process and its applications in various fields.
2. To understand the transport and fouling mechanisms of membranes
3. To gain the knowledge on membrane modules and flow patterns

## Course Content

### Unit 1:

Basics of membrane separation, Types of membranes, Membrane process classification, Synthesis and characterization of membranes.

### Unit 2:

Transport theory in membranes – Porous membrane: bulk flow, liquid diffusion in pores, Gas Diffusion. Non-Porous Membranes: solution diffusion for liquid mixtures and gas mixtures.

### Unit 3:

Membrane modules and applications, module flow patterns, control, polarization and fouling. Metal, ceramic and Liquid membranes.

### Unit 4:

Different Membrane Processes and their applications: Microfiltration, Ultrafiltration, Nanofiltration, Reverse Osmosis, Dialysis and Electro dialysis, Gas permeation, Pervaporation, Hybrid membrane processes, Current scenario in Industries.

## Course Materials

### Required Text: Text books

1. K. Nath, “Membrane separation processes”, PHI Learning Pvt. Ltd, New Delhi, 3rd Edition, 2012.
2. M. Mulder, “Basic principles of membrane technology”, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2nd Edition, 1996

### Optional Materials: Reference Books

1. J.D. Seader, E. J. Henley, “Separation process principles”, John Wiley & Sons, Inc, 2 nd Edition.
2. R. W. Baker, “Member technology and applications”, John Wiley & Sons Ltd, 2 nd Edition.
3. K. Pabby., S.S. H. Rizvi., A. M. Sastre, “Hand book of membrane separations: Chemical, Pharmaceutical, Food, and Biotechnological Applications”, CRC press, Taylor & Francis Group, 2009.
4. K. Scott, “Handbook of industrial membranes”, Published by Elsevier Advanced Technology, I st Edition, 2006

# Computational Fluid Dynamics

[VII<sup>th</sup>Semester, Fourth Year]



## Course Description

Offered by Department

Chemical Engineering

[Pre-requisites: None]

Credits

3-0-0, (3)

Status

Open Elective -I

Code

CH107301CH

## Course Objectives

1. To learn and apply the knowledge of mathematics in solutions of transport equations.
2. To apply numerical algorithms in making programs for solution of engineering modeling problems
3. To apply computer knowledge in solution of complex engineering problems
4. To engage in challenging problems of physical world

## Course Content

### Unit 1: Overview of CFD

Role, problem solving and components of CFD, Governing equations: Navier-Stokes Equations, Energy Equations, Mass conservation Equations. Structured and unstructured grids, Grid generation methods.

### Unit 2: Approximation of Governing Equations

Discretization of equations – Finite difference / volume methods/finite element methods, Convection and diffusion problems, Solution methods of discretized equations.

### Unit 3: Handling unknown pressure field

Pressure – velocity coupling, Staggered grid, SIMPLE, SIMPLEC and PISO, Unsteady flows- Explicit scheme, Crank Nicholson scheme, fully implicit scheme.

### Unit 4: CFD Solution Procedure and case studies

Problem setup – creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization, validation, Simulation of CFD problems by use of general CFD software.

## Course Materials

### Required Text: Text books

1. J. D. Anderson, Computational Fluid Dynamics, McGraw-Hill.
2. H. K. Versteeg, W. Malalasekera, An Introduction to Computational Fluid Dynamics - The finite volume method, Pearson Education Limited, 2nd Edition, 2007.
3. S. V. Patankar. Numerical Heat Transfer and Fluid Flow, Taylor and Francis, 1978

### Optional Materials: Reference Books

1. J.C. Tannehill, D.A. Anderson, R.H. Pletcher, Taylor and Francis. Computational Fluid Mechanics and Heat Transfer
2. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2nd Edition, 2010.
3. A. Keshav, B. Mazumdar, "Transport Phenomena", 1st edition, Wiley Indian Pvt. Ltd, New Delhi

# Introduction to Analytical Techniques



[VII<sup>th</sup> Semester, Fourth Year]

## Course Description

### Offered by Department

Chemical Engineering  
[Pre-requisites: None]

### Credits

3-0-0, (3)

### Status

Open Elective-I

### Code

CH107302CH

## Course Objectives

1. To determine the concentration of the solutes in a mixture.
2. To interpret the thermal stability.
3. To identify the structure of the organic compound

## Course Content

### Unit 1:

Introduction to Spectroscopy, Lambert Beer's law, limitations of Beer's law, Instrumentation, Applications in Qualitative and Quantitative analysis, Theory of electronic spectroscopy, Double beam spectrophotometer, Atomic absorption Spectroscopy (AAS).

### Unit 2:

Basic principles, Theory, Instrumentations, Vibrational frequency, - Number of fundamental vibrations, Hook's law Scanning of IR spectrum, Applications, difference between IR and Raman spectroscopy and its advantages, FTIR & NMR.

### Unit 3:

Principle, Instrumentation, analytical applications of HPLC, GC and GC-MS etc.

### Unit 4:

Thermogravimetry – TGA, DSC, BET and other advance analytical methods.

## Course Materials

### Required Text: Text books

1. Braun, R.D., Introduction to Instrumental Analysis, Pharma Med Press, 2016.
2. R.S. Khandpur, Handbook of Analytical Instruments, Tata McGraw Hill publishing Co. Ltd., 2nd edition, 2006.
3. Sharma B.K., Instrumental methods of chemical analysis, Eighteenth Edition, GOEL publishing House. 2002.
4. Donald L.P, Gary M.L., George A.K., James R.V., Introduction to Spectroscopy, Cengage Learning India Private Limited, 2015
5. Chatwal G.R., and Anand S.K., Instrumental Methods of Chemical Analysis, Seventh Edition, Himalaya Publishing House. 2005

### Optional Materials: Reference Books

1. Skoog D.A., - Principles of Instrumental Analysis, Sixth Edition, Saunders College Publication, 2007.
2. Bela G. Liptak, Analytical Instrumentation, CRC Press, 1994
3. C.N. Banwell and EM McCash, Fundamentals of molecular spectroscopy, Tata McGraw Hill publishing Co. Ltd, 2017
4. Cazes J., Ewing's Analytical Instrumentation Handbook, 3rd Edition, Marcel Dekker, New York, 2005
5. Hand book for Instrumental Techniques for Analytical Chemistry, Ed. Frank Settle Prentice Hall, New Jersey, USA (1997).

# Chemical Engineering Computational and Simulation Lab



[VII<sup>th</sup> Semester, Fourth Year]

## Course Description

Offered by Department

Chemical Engineering

[Pre-requisites: Numerical Methods, Transport Phenomena]

Credits

0-0-2, (1)

Status

Lab

Code

CH107401CH

## Course Objectives

1. To study the simulation of flow over flat plates and pipe lines
2. To model and simulate laminar and turbulent flows
3. To employ computational software to solve flow in elbows, over cylinders and air foils.
4. To determine the influence of roughness and vibrations in pipe in flow simulations

## Course Content

**List of Experiments** (Experiments will be conducted using Ansys/MATLAB/COMSOL/STAR CD/CCM etc.):

1. Flat plate boundary layer computational fluid dynamics
2. Laminar pipe flow computational fluid dynamics
3. Turbulent pipe flow computational fluid dynamics
4. Laminar convection computational fluid dynamics
5. Turbulent forced convection computational fluid dynamics
6. Computational fluid dynamics of flow over an Airfoil
7. Computational fluid dynamics steady flow past cylinder
8. Computational fluid dynamics of mixing elbow
9. Determination of effect of roughness on turbulent pipe flow using Computational fluid dynamics
10. Computational fluid dynamics for fluid flow through a vibrating pipe

## Course Materials

### Required Text: Text books

1. J.D. Anderson, Computational fluid dynamics: An introduction. 3rd Edition, Springer.
2. H.K. Versteeg and W. Malalasekera, An introduction to computational fluid dynamics: The finite volume method. 2nd Edition, Pearson

### Optional Materials: Reference Books

1. Joel J. Ferziger, Computational methods for fluid dynamics, Springer.
2. Chaoqun Liu, Guan Heng Yeoh and Jiyuan Tu., Computational fluid dynamics: A practical approach. 3rd edition, Butterworth-Heinemann

**Semester-VIII**  
**Scheme & Syllabus**

**National Institute of Technology Raipur**

Course of Study and Scheme of Examination(CBCS Scheme)							B. Tech. VIII-A Semester				Branch: Chemical		
S. No.	Subject Type	Subject Code	Subject Name	Periods per Week			TA	Examination Scheme				Total Marks	Credits
				L	T	P		MSE/MTR		ESE/ESVE			
								Theory	Practical	Theory	Practical		
1	Program Elective-I	CH108201CH	Process Safety and Hazard Management	3	0	0	20	30		50		100	3
		CH108202CH	Disaster Management in Chemical Industries										
		CH108203CH	Petrochemical Technology										
		CH108204CH	Nanotechnology										
2	Program Elective-II	CH108251CH	Fluidization Engineering	3	0	0	20	30		50		100	3
		CH108252CH	Process Intensification										
		CH108253CH	Colloidal and Interfacial Science and Engineering										
3	Open Elective-I	CH108301CH	Project Planning Evaluation and Management	3	0	0	20	30		50		100	3
		CH108302CH	Environmental Impact Assessment										
4	Open Elective-II	CH108351CH	Solid Waste Management	3	0	0	20	30		50		100	3
												12	

**National Institute of Technology Raipur**

National Institute of Technology Raipur														
Course of Study and Scheme of Examination(CBCS Scheme)								B. Tech. VIII-B Semester				Branch: Chemical		
S. No.	Subject Type	Subject Code	Subject Name	Periods per Week				TA	Examination Scheme				Total Marks	Credits
				L	T	P	MSE/MTR		ESE/ESVE					
							Theory		Prac.	Theory	Prac.			
1	#Open Elective-I	CH108326CH	Online courses/MOOCs approved by the DAC	3	0	0	20	30		50		100	3	
2	#Open Elective-II	CH108376CH		3	0	0	20	30		50		100	3	
3	Major Internship	CH108701CH	Major Internship									6 (4 <sup>^</sup> +2 <sup>^^</sup> )	12	

# Courses for Open Elective-I and II to be opted from online courses

^ Mid-Semester evaluation report and field evaluation report to be submitted by industry

^^ Report Submission and Presentation in the department



# Process Safety and Hazard Management



[VIII<sup>th</sup> Semester, Fourth Year]

## Course Description

Offered by Department

Chemical Engineering

[Pre-requisites: Chemical Technology, Environmental Engineering]

Credits

3-0-0, (3)

Status

Program Elective-I

Code

CH108201CH

## Course Objectives

1. To know about industrial safety programs and toxicology, industrial laws, regulations and source models
2. To understand about fire and explosion and preventive methods.
3. To study industrial hazards and its risk assessment.
4. To understand the methods of hazard identification and preventive measures

## Course Content

### Unit 1

Safety programs, engineering ethics, Accident and loss statistics, Acceptable risk, Public perceptions, Nature of accidents, disaster case studies. Toxicology: Effect of toxicants, Toxicological studies, Relative toxicity, Threshold limit values, Industrial hygiene: Government regulations, Identification, evaluation and control. Source models: Flow of liquids and vapors through pipes, flashing liquids, Liquid pool evaporation or boiling.

### Unit 2

Fires and explosions, Flammability characteristics of liquids and vapors, Minimum Oxygen Concentration (MOC), Inerting and Ignition energy. Designs to prevent fires and explosions: controlling static electricity, explosion proof equipments and instruments; Reliefs and rupture disks.

### Unit 3

Hazards identification, Process hazards checklists, Hazard surveys, Hazard and Operability studies (HAZOP), Safety reviews, Govt. Regulations for industrial safety – Indian and international scenario, MSDS.

### Unit 4

Investigations and learning from accidents, Investigation process, Case studies: static electricity, Chemical reactivity, Safety of Critical Equipment, Risk Register, Project Health, Safety and Environment Review (PHSER).

## Course Materials

### Required Text: Text books

1. D.A.Crowl and J.F. Louvar, Chemical Process Safety: Fundamentals with Applications, Prentice Hall PTR.
2. R.E.Sanders, Chemical Process Safety: Learning from Case Histories, Butterworth Heinemann

### Optional Materials: Reference Books

1. Ralph King and Ronald Hirst, King's Safety in the Process Industries, Wuerz Publishing Ltd., Canada

# Disaster Management in Chemical Industries



[VIII<sup>th</sup> Semester, Fourth Year]

## Course Description

### Offered by Department

Chemical Engineering  
[Pre-requisites: None]

### Credits

3-0-0, (3)

### Status

Program Elective-I

### Code

CH108202CH

## Course objectives

1. To provide overall idea about disasters and their effects in chemical industries
2. To provide in-depth understanding of the chemical industry related disasters with some case studies
3. To educate about chemical industry related disaster management
4. To educate the legal aspects of the disasters in chemical industries

## Course Content

### Unit 1 Introduction

Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life-case study, General aspects of industrial disaster: Due to fire, explosion, toxicity and radiation; Chemical hazards. Natural and man-made disasters, Classification of chemical hazards, Chemical as cause of occupational diseases –dust, fumes, gases and vapours.

### Unit 2 Hazard identification and assessment

Engineering control of chemical plant hazards, Hazard analysis techniques: Fault and Event tree analysis, General outline of DOW index, Risk estimation and management, Major hazard control.

### Unit 3: Disaster management

Legal framework for chemical disaster management in India, disaster management in industry and sensitive land, community awareness and preparedness, few case studies. Guidelines for chemical installations, storage, transport and road accidents.

### Unit 4: Planning for disaster management

Plant and companywide planning, Emergency shutdown procedures, building report form, implementation of guidelines, Institutional mechanisms and coordination at state and district levels.

## Course Materials

### Required Text: Text books

1. What Went Wrong? Case Histories of Process Plant Disasters and How They Could Have Been Avoided By Trevor Kletz , fifth edition, Elsevier, 2009
2. Resource book on chemical (industrial) disaster management, National institute of disaster management, India.
3. Safety and Accident Prevention in Chemical Operations, 2nd Edition, by Howard H. Fawcett (Editor), William S. Wood (Editor), Wiley International, 1982.
4. National disaster management guidelines- Chemical disasters (Industrial), National Disaster Management Authority -Government of India-2007

### Optional Materials: Reference Books

1. Emergency and Disaster Planning for Chemical and Allied Industries, By United States. Business and Defense Services Administration, 1954
2. Disaster Management by Harsh K. Gupta, Universities Press Publications, 2003.
3. Safety & Health Guide for the Chemical Industry, OSHA-1986.
4. Safety in Process Plant Design by Wells John Wiley and Sons, 1981.
5. Less, P. Frank, Loss Prevention in Process Industries.
6. J. Lolb& S. Roy Sterm, Product Safety and Liability

# Petrochemical Technology

[VIII<sup>th</sup> Semester, Fourth Year]



## Course Description

### Offered by Department

Chemical Engineering  
[Pre-requisites: None]

### Credits

3-0-0, (3)

### Status

Program Elective-I

### Code

CH108203CH

## Course Objectives

1. To learn about petrochemical industry
2. To study production methods of various petrochemicals

## Course Content

### Unit 1

Overview of Petrochemical Industry, Feedstock for Petrochemical Industries and their Preparation, Derivatives from Methane, Ethane, Propane and Butane.

### Unit 2

Derivatives of Ethylene and Acetylene, Polyethylene, Ethylene Oxide, Ethyl Alcohol and Ethyl Benzene. Vinyl Chloride, Acrylonitrile, Neoprene and Vinyl Acetate.

### Unit 3

Propylene and C<sub>4</sub> Hydrocarbon Derivatives, Polypropylene, Isoprene, Propylene Oxide, Iso-Propyl Alcohol, Cumene. Butadiene by Oxidative Dehydrogenation, Chemicals from Synthesis Gas and Olefins.

### Unit 4

Synthetic Rubber: Manufacture, General Characteristics, Raw Materials for Synthesis, PBR, SBR, NBR, Butyl Rubber. Field of Application of Surface-Active Agents.

## Course Materials

### Required Text: Text books

1. Dryden C. E., Outlines of Chemical Technology, East-West Press, 2008
2. Mall I. D; Petrochemical Process Technology. Macmillan India Ltd, 2007
3. Rao Bhaskar B.K.; A textbook on Petrochemicals, Khanna Publishers, New Delhi
4. Maiti Sukumar; Introduction to petrochemicals, Oxford & IBH Publishing CO. Pvt. Ltd.; New Delhi, Kolkata

### Optional Materials: Reference Books

1. James G. Speight; Handbook of Petrochemical Processes; CRC Press, Taylor & Francis Group.
2. P. Belov; Fundamentals of Petroleum Chemicals Technology; Central Books Ltd.(1971)

# Nanotechnology

[VIII<sup>th</sup> Semester, Fourth Year]



## Course Description

### Offered by Department

Chemical Engineering  
[Pre-requisites: None]

### Credits

3-0-0, (3)

### Status

Program Elective-I

### Code

CH108204CH

## Course Objectives

1. To provide an overview of nanostructures evincing their fascinating properties unseen otherwise.
2. To understand the hierarchical development from nano to macro length scale, and its adoption in nature.
3. To study the structural, phase, microstructural and mechanical characterization techniques in detail

## Course Content

### Unit 1

**Introduction to Physics of the Solid State:** Structure, Size Dependence of Properties, Crystal Structures, Energy Bands, Localized Particles.

**Method of Measuring Properties:** Structure, Atomic Structures, Crystallography, Particle Size Determination, Surface Structure, Transmission Electron Microscopy, Field Ion Microscopy, Scanning Microscopy, Infrared and Raman Spectroscopy, Photoemission and X-ray Spectroscopy, Magnetic Resonance Spectroscopy

### Unit 2

Properties of Individual Nanoparticles: Metal Nanoclusters, Semiconducting Nanoparticles, Rare Gas and Molecular Clusters, Methods of Synthesis. Self-Assembly and Catalysis, plasmonic nanoparticles

### Unit 3

**Bulk Nanostructured Materials:** Solid disordered nanostructures, nanostructured crystals.

**Nanostructured Ferromagnetism:** Basics of Ferromagnetism, Effect of Bulk Nanostructuring of Magnetic Properties, Dynamics of Nanomagnets, Nanopore Containment of Magnetic Particles, Nanocarbon, Ferromagnets, Giant and Colossal Magnetoresistance, Ferrofluids.

### Unit 4

**Optical and Vibrational Spectroscopy:** Introduction, Infrared Frequency Range, Luminescence, Nanostructures in Zeolite Cages.

**Quantum Wells, Wires and Dots:** Introduction, Preparation of Quantum Nanostructures, Size and Dimensionality Effects, Applications.

## Course Materials

### Required Text: Text books

1. Introduction to Nanotechnology, Charles P. Poole, Jr. Frank J. Owens, A John Wiley & Sons, Inc., Publication, 2007.
2. Nanotechnology: Basic Calculations for Engineers and Scientists, Louis Theodore, Wiley, 2011

### Optional Materials: Reference Books

1. Nanomaterials, Nanotechnologies and Design: An Introduction to Engineers and Architects, Michael F. Ashby, Paulo J. Ferreira, Daniel L. Schodek, Butterworth-Heinemann, 2009.
2. Introduction to Nanoscience and Nanotechnology, Chris Binns, Wiley-Blackwell, 2010

# Fluidization Engineering

[VIII<sup>th</sup> Semester, Fourth Year]



## Course Description

Offered by Department  
Chemical Engineering  
[Pre-requisites: None]

Credits  
3-0-0, (3)

Status  
Program Elective-II

Code  
CH108251CH

## Course Objectives

1. To understand the importance and applications of fluidization process
2. To study the types and stages of fluidization
3. To learn about the application in chemical reaction, heat and mass transfer processes

## Course Content

### Unit 1: Introduction

Importance of fluidization in process industry, Comparison of fluidized beds with other modes of contacting, Advantages and disadvantages, Industrial applications.

### Unit 2: Fluidization and Mapping of Regimes

Fixed bed of particles of one and mixed sizes, Fluidization with and without carryover of particles, Minimum fluidization, Terminal velocity of particles, Pneumatic transport of solids, Mapping of regimes, Classification of particles, Distributors for dense beds, types, and design.

### Unit 3: Bubble Behavior and Bed Properties

Single rising bubble models, Wake region and solids within bubbles, Interaction and coalescence of bubbles, Bubble formation, Slug flow. Bubbling Fluidized Beds: Emulsion phase, gas flow, Bubble properties, Effect of temperature and pressure on bed, Physical models, Flow models. Entrainment and Elutriation of Fluidized Beds: Free boards behavior, Gas outlet location, Entrainment from tall and short vessels.

### Unit 4: High Velocity Fluidization

Turbulent fluidized beds, Fast fluidization, Pressure drop in turbulent and fast fluidization. Solid movement: Vertical and horizontal movement of solids, Dispersion models. Gas dispersion and Gas Interchange in Bubble Bed: Dispersion of gas in beds, Gas interchange between bubble and emulsion, Estimation of gas interchange coefficients. Particle to Gas Heat and Mass Transfer: Interpretation of mass transfer coefficients and heat transfer coefficients and its determination.

## Course Materials

### Required Text: Text Books

1. Kunii D. and Levenspiel O., Fluidization Engineering, Butterworth-Heinemann.
2. Davidson D. and Harrison J.F., Fluidization Engineering, Academic Press

### Optional Materials: Reference Books

1. Perry J.H., Chemical Engineering Hand Book.
2. Mc Cabe and Smith, Unit operation of Chemical Engineering.
3. Yang W. C., Handbook of Fluidization and Fluid Particle Systems, CRC

# Process Intensification

[VIII<sup>th</sup> Semester, Fourth Year]



## Course Description

Offered by Department  
Chemical Engineering  
[Pre-requisites: None]

Credits  
3-0-0, (3)

Status  
Program Elective-II

Code  
CH108252CH

## Course Objectives

1. To understand the concept of process intensification.
2. To know the limitations of conventional chemical processes.
3. To apply the techniques of intensification to a range of chemical processes.
4. To develop and learn various process equipment used for intensifying the processes

## Course Content

### Unit 1:

Introduction to Process Intensification, History, Philosophy, principles; High Gravity Fields, Rotating Packed Bed, Spinning Disc Reactor, Compact multifunctional heat exchangers, Microreaction technology, Structured catalyst and reactors: monolithic reactors.

### Unit 2:

Inline and high-intensity mixers, combined heat exchanger and reactors, Reactive and hybrid separations, reactive distillation, membrane-based reactive separation hybrid separations, membrane chromatographic separation.

### Unit 3:

Multifunctional reactors, Process synthesis and integration, industrial studies.

### Unit 4:

Process intensification for industrial safety, Industrial practice, methodology and applications, commercial examples of process intensification.

## Course Materials

### Required Text: Text Books

1. Andrzej Stankiewicz, Jacob A. Moulijn, Re-engineering the chemical processing plant. CRC Press

### Optional Materials: Reference Books

1. Cornelis de Weerd, Process Intensification in Practice, John Wiley and Sons, 1 st edition, 2005
2. David Reay, Colin Ramshaw and Adam Harvey, Butterworth Heinemann, Engineering for Efficiency, Sustainability and Flexibility- Process Intensification, Elsevier Ltd., 2008

# Colloids and Interfacial Science and Engineering



[VIII<sup>th</sup> Semester, Fourth Year]

## Course Description

### Offered by Department

Chemical Engineering  
[Pre-requisites: None]

### Credits

3-0-0, (3)

### Status

Program Elective-II

### Code

CH108253CH

## Course Objectives

1. To understand the basic nomenclature and concepts of colloid and interface science and engineering.
2. To understand the differences between the surface and bulk dominated regimes.
3. To study the concepts and tools, translate into a variety of applications from processes to materials

## Course Content

### Unit 1:

**Nature of Colloidal Dispersions:** Introduction, Classification of Colloids, Brownian Motion, Diffusion, Electric Charge and Colloid Stability, Effect of Polymers on Colloid Stability.

**Thermodynamics of Surfaces:** Surface Energy and its Consequences, Thermodynamic Behavior of Small Particles, Equilibrium shape of a Crystal, Behavior of Liquids in Capillaries, Homogeneous Nucleation, Limits of Applicability of the Kelvin and Young-Laplace Equations, Contact Angle and Wetting Behavior.

### Unit 2:

**Transport Properties of Suspensions:** Mass Conservation Equation, Stress in a Moving Fluid, Stress and Velocity Field in a Fluid in Thermodynamic Equilibrium, Relationship Between the Stress Tensor and the Velocity Field, Navier-Stokes Equations, Methods for Measuring the Viscosity, Sedimentation of a Suspension, Flow Properties of Suspensions.

### Unit 3 :

**Particle Size and Shape:** Direct Microscopic Observation, Particle Size Distribution, Theoretical Distribution Functions, Sedimentation Methods of Determining Particle Size, Electrical Pulse Counters, Light Scattering Methods, Hydrodynamic Methods, Acoustic Methods.

### Unit 4 :

**Electrified Interfaces:** Electrical Double Layer, Electrostatic Potential of a Phase, Potential Distribution at a Flat Surface-Guoy-Chapman Model, Limitations of the Poisson-Boltzmann Equation, Mechanisms of Surface Charge Generation.

**Electrokinetics and the Zeta Potential:** Equilibrium Double Layer Theory of Electrokinetics, Measurement of Electrokinetic Properties, Standard Double Layer Model, Double Layer Dynamics.

## Course Materials

### Required Text: Text Books

1. Robert J. Hunter, Foundations of Colloid Science, Oxford, 2nd Edition, 2000.
2. Paul C. Hiemenz, R. Rajagopalan, Principles of Colloid and Surface Chemistry, CRC Press, 3rd Edition, 1997; Andrzej Stankiewicz, Jacob A. Moulijn, Re-engineering the chemical processing plant. CRC Press

### Optional Materials: Reference Books

1. Arthur W. Adamson, A. P. Gast, Physical Chemistry of Surfaces, Wiley India Pvt. Ltd, 6th Edition, 2011.
2. W.B. Russel, D.A. Saville, W.R. Schowalter, Colloidal Dispersions, Cambridge University Press, 1992.
3. Jacob N. Israelachvili, Intermolecular and Surface Forces, Academic Press, 3rd Edition, 2011.
4. Carel J. van Oss, Interfacial Forces in Aqueous Media, Taylor & Francis, 2nd Edition, 2006.

# Project Planning Evaluation and Management



[VIII<sup>th</sup> Semester, Fourth Year]

## Course Description

Offered by Department

Chemical Engineering

[Pre-requisites: None]

Credits

3-0-0, (3)

Status

Open Elective-I

Code

CH108301CH

## Course Objectives

1. To formulate and present a viable project idea with a realistic economic plan
2. To study the models and methods to lead, carry out, document and evaluate project
3. To critically review and evaluate the project plans

## Course Content

### Unit 1:

**Identification of projects:** Generation and screening of idea, monitoring corporate appraisal, preparing project profiles and project rating index.

### Unit 2:

**Feasibility studies:** Market and demand analysis, technical analysis, financial analysis and economic viability.

### Unit 3:

**Project appraisal:** Criteria, net present value, internal rate of return, payback period and accounting rate of return method.

### Unit 4:

**Project management and implementation:** Project planning, project control, prerequisites of Implementation. Network techniques of project management-Project evaluation and review technique (PERT) and critical path method (CPM), Project review and control: Initial review, performance evaluation, abandonment analysis and its behavioral issues.

## Course Materials

### Required Text: Text Books

1. Project planning, analysis, selection, implementation and review by Prasanna Chandra, TMH
2. Project management, Harold Kerzner, Wiley

### Optional Materials: Reference Books

1. Total Project management, P K Joy, Macmillan.
2. Project Management: The Managerial Process, Erik Larson, Clifford Gray, McGraw Hill



# Environmental Impact Assessment



[VIII<sup>th</sup> Semester, Fourth Year]

## Course Description

Offered by Department  
Chemical Engineering  
[Pre-requisites: None]

Credits  
3-0-0, (3)

Status  
Open Elective-I

Code  
CH108302CH

## Course Objectives

1. To understand the basic principles and steps of EIA and formulate objectives of the EIA.
2. To gain the knowledge about various policies, environmental acts and clearance related to EIA.
3. To understand the environmental attributes and guidelines for EIA report preparation

## Course Content

### Unit 1

Introduction to EIA; National & global policies; EIA on development activities; Impact prediction, evaluation and mitigation. Preparation of environmental base map; Public hearing; Classification of environmental parameters.

### Unit 2

Environmental Legislation Acts; Latest amendments; Rules; Regulations and notifications; Environmental standards; Criteria for standard setting. Environment audit: Audit legislations, Types of audit, Protocol, Data evaluation and Report preparation, Post audit activities.

### Unit 3

Environmental Clearance: Forest clearance; Consent to Establish & Operate; Environmental conservation plan for endangered flora and fauna. Framework for EIA, Screening, Scoping, Baseline studies, EIA Methodologies and selection criteria.

### Unit 4

Guidelines for preparation of project report and its evaluation, methods of clearance from the concerned authorities. Standards for Water, Air and Noise Quality - Environmental Management Plan-EIA- Case studies of EIA.

## Course Materials

### Required Text: Text Books

1. Larry W Canter, Environmental Impact Assessment, 2nd Ed, McGraw-Hill, 1997.
2. A Chadwick, Introduction to Environmental Impact Assessment, Taylor & Francis, 2007.
3. Ministry of Environment & Forests, Govt. of India 2006 EIA Notification, 2006
4. Barthwal, R. R. Environmental Impact Assessment, New Age International Publications

### Optional Materials: Reference Books

1. John G. Rau and David C. Wooten (Ed), Environmental Impact Analysis Handbook, McGraw Hill Book, 1990.
2. APHA, Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WPCF, Washington, D.C., 18th Ed, 1993.
3. R. Therirvel, E. Wilson, S. Thompson, D. Heaney, D. Pritchard, "Strategic Environmental Assessment", Earthscan publications, London, 1992
4. Paul, A Erickson, "A Practical Guide to Environmental Impact Assessment", Academic Press, 1994.
5. Wathern P, "Environmental Impact Assessment: Theory & Practice", Publishers Rutledge, London, 1992.
6. Howard S. Peavy, Donald R. Rowe and George Tchobanoglous, "Environmental Engineering", McGraw-Hill International Ed, 1985.
7. Richard K. Morgan., "Environmental Impact Assessment" Kluwer Academic Publications, London, 2002.
8. Judith Petts, "Handbook of Environmental Impact Assessment" Vol.I& II", Blackwell Science, 1999

# Solid Waste Management

[VIII<sup>th</sup> Semester, Fourth Year]



## Course Description

### Offered by Department

Chemical Engineering  
[Pre-requisites: None]

### Credits

3-0-0, (3)

### Status

Open Elective-II

### Code

CH108351CH

## Course Objectives

1. To learn solid waste disposal and management
2. To understand the characterization, segregation and disposal of wastes
3. To understand the nature of wastes and its management
4. To understand practical aspects of waste management through case studies

## Course Content

### Unit 1: Solid Waste Management Fundamental

Classification and sources of solid wastes, characteristics of solid wastes, problems associated with solid wastes, environmental and health impact of solid waste, solid waste reduction, recycling and reuse.

### Unit 2: Municipal Solid Waste (MSW)

Collection, transport, organization and management of municipal solid waste, composition of MSW, storage and handling of solid waste, future changes in waste composition, collection of MSW.

### Unit 3: Chemical and Biomedical wastes

Characterization and composition of chemical and biomedical solid wastes, evolution of chemical and biomedical waste, organization and management of chemical and biomedical waste, segregation, handling and storage of waste, treatment and disposal of chemical and biomedical waste.

### Unit 4: Electronic waste (E-waste)

Type of electronic wastes, electronic waste component average life, E-waste classification, composition and characterization of E-waste, organization and management of E-waste, E-waste management technologies.

## Course Materials

### Required Text: Text Books

1. Vesilind P.A., Worrell W and Reinhart, Solid Waste Engineering, 2nd Edition (2011), C L Engineering.
2. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, Integrated Solid Waste Management, (1993)Mc-Graw Hill International edition, New York

### Optional Materials: Reference Books

1. CPHEEO (2000), Manual on Municipal Solid waste management, Central Public Health and
2. Paul T Williams (2013), Waste Treatment and Disposal, 2nd Edition Wiley



**CHEMICAL ENGINEERING DEPARTMENT**  
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**CHHATTISGARH**