

# **COIMBATORE INSTITUTE OF TECHNOLOGY**

**(Government Aided Autonomous Institution Affiliated to Anna University, Chennai)**

## **DEPARTMENT OF CHEMICAL ENGINEERING**

### **M.Tech. Chemical Engineering**

#### **VISION OF THE INSTITUTE**

The Institute strives to inculcate a sound knowledge in engineering along with realised social responsibilities to enable its students to combat the current and impending challenges faced by our country and extend their expertise to the global arena.

#### **MISSION OF THE INSTITUTE**

To impart high quality education and training to its students to make them World-class engineers with a foresight to the changes and problems, and pioneers to offer innovative solutions to benefit the nation and the world at large.

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## **DEPARTMENT OF CHEMICAL ENGINEERING**

### **M.Tech. Chemical Engineering**

#### **VISION OF THE DEPARTMENT**

The Department of Chemical Engineering strives for excellence in all aspects of teaching and research, to produce Chemical Engineers of quality required in Industries / academic / research organizations and serves the society at national and international standards.

#### **MISSION OF THE DEPARTMENT**

1. To educate the young minds by providing academic and research proficiency to pursue their successful career in industry, academic and research organization.
2. To evolve innovative technologies in the field of chemical engineering towards serving the profession and the community.
3. Nurture students to be dynamic, versatile in their profession and also in the humanism.

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(Government Aided Autonomous Institution Affiliated to Anna University, Chennai)

## DEPARTMENT OF CHEMICAL ENGINEERING

### M.Tech. Chemical Engineering

#### Programme Educational Objectives(PEOs)

- I. Experienced and technically competent engineers in the field of Chemical Engineering with a solid foundation in engineering and technology which will enable them to apply a range of different approaches to problem analysis and synthesis as well as different solution strategies in tackling complex technical problems in the industry
- II. Have a sound knowledge base and skill sets to develop and expand professional careers in fields related to Chemical processes, modeling and simulation, computer-based design of industrial processes.
- III. Technology pioneers and change agents as they apply their conceptual knowledge and engineering skills not only to design, develop and deploy state of the art chemical engineering related tools, techniques and technologies but also to catalyze change in the workplace and in the economy at large.
- IV. Lifelong learners who in a formal sense will go on to enroll in, and successfully graduate from, more advanced graduate and professional education and certification programs that are nationally and/or internationally recognized in engineering, science or business, and who, more informally, are and will remain wise enough to diagnose, analyze and remedy the gaps or deficits in their own knowledge bases over time by gleaning what they can from the environment on their own.

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## DEPARTMENT OF CHEMICAL ENGINEERING

### M.Tech. Chemical Engineering

#### Programme Outcomes (POs)

- a) The graduates have an ability to apply knowledge of advanced mathematics and engineering principles to practical problems in their respective professions.
- b) The graduates have an ability to improve the efficiency of processes and quality of products in chemical industry.
- c) The graduates have an ability to identify, formulate and solve chemical engineering problems.
- d) The graduates have an ability to design innovative processes and equipment suitable to the contemporary needs of the chemical industry and to promote the qualities of leadership and employability.
- e) The graduates have an ability to work in multidisciplinary teams consisting of professionals from various disciplines of Engineering.
- f) The graduates have an ability to be employed in software based jobs related to chemical engineering process control design and process simulation.
- g) The graduates have an ability to communicate effectively in multicultural environment and work with professional ethics and responsibility.
- h) The graduates have an ability to gather information and procreate effective technical reports and oral presentations.
- i) The graduates have an ability to design systems, components or processes to meet specified objectives within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability in the field of chemical engineering.

- j) The graduates have an ability to engage in lifelong research and to update technical know-how by self-learning besides learning a great deal by associating with professional bodies and alumni.
- k) The graduates have an ability to succeed in the graduate competitive examinations and pursue research in chemical engineering or lateral disciplines.

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## DEPARTMENT OF CHEMICAL ENGINEERING

Curriculum from the Academic Year 2015 – 2016 onwards

### M.Tech. CHEMICAL ENGINEERING

#### SUBJECTS OF STUDY

(For the students admitted from the Academic Year 2015 – 2016 onwards)

SEMESTER - I							
Course Code	Course Name	Contact Hours	L	T	P	C	Category
15MCH11	Linear Algebra, Numerical Methods and Calculus of Variations	4	4	0	0	4	FC
15MCH12	Momentum, Heat and Mass Transfer	4	4	0	0	4	PC
15MCH13	Digital Process Dynamics and Control	3	3	0	0	3	PC
15MCH14	Molecular Thermodynamics	4	4	0	0	4	PC
	Elective I	3	3	0	0	3	PE
15MCH15	Seminar and Technical Writing	2	0	0	2	1	EEC
15MCH16	Process Modeling, Dynamics and Control Laboratory	2	0	0	2	1	PC
	<b>Total</b>					<b>20</b>	
SEMESTER - II							
Course Code	Course Name	Contact Hours	L	T	P	C	Category
15MCH21	Reaction Engineering and Chemical Reactor Design	4	4	0	0	4	PC
15MCH22	Multiphase Flow	3	3	0	0	3	PC
15MCH23	Process Modeling, Simulation and Optimization	4	4	0	0	4	PC
15MCH24	New Separation Techniques	3	3	0	0	3	PC
	Elective II	3	3	0	0	3	PE
15MCH25	Professional Engineering Practices	2	0	0	2	1	EEC
15MCH26	Process Simulation Laboratory	2	0	0	2	1	PC
	<b>Total</b>					<b>19</b>	

<b>SEMESTER - III</b>							
<b>Course Code</b>	<b>Course Name</b>	<b>Contact Hours</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>	<b>Category</b>
	Elective III	3	3	0	0	3	PE
	Elective IV	3	3	0	0	3	PE
	Elective V	3	3	0	0	3	PE
	<b>Total</b>					<b>9</b>	

<b>SEMESTER - IV</b>							
<b>Course Code</b>	<b>Course Name</b>	<b>Contact Hours</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>	<b>Category</b>
15MCH41	Project Work and Viva-Voce	-	-	-	-	18	EEC
	<b>Total</b>					<b>18</b>	

*Minimum Number of credits to be earned for the award of degree: 66*

**LIST OF PROFESSIONAL ELECTIVES**

<b>SEMESTER - V</b>							
<b>CourseCode</b>	<b>Course Name</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>		
15MCHE01	Fluidization Engineering	3	0	0	3		
15MCHE02	Biomedical Engineering	3	0	0	3		
15MCHE03	Computer Aided Design of Chemical Equipments	3	0	0	3		
15MCHE04	Pilot Plants, Models and Scale up Methods in Chemical Engineering	3	0	0	3		
15MCHE05	Biochemical Engineering	3	0	0	3		
15MCHE06	Technology of Composites	3	0	0	3		
15MCHE07	Catalysis and Surface Phenomena	3	0	0	3		
15MCHE08	Solvent Extraction Engineering	3	0	0	3		
15MCHE09	Food Process Engineering and Technology	3	0	0	3		
15MCHE10	Safety Engineering	3	0	0	3		
15MCHE11	Statistical Thermodynamics	3	0	0	3		
15MCHE12	Operations Research	3	0	0	3		
15MCHE13	Research Methodology	3	0	0	3		
15MCHE14	Enzyme Engineering	3	0	0	3		
15MCHE15	Integrated Design of Chemical Processes	3	0	0	3		
15MCHE16	Design and Analysis of Experiments	3	0	0	3		
15MCHE17	Synthesis and Applications of Nanomaterials	3	0	0	3		
15MCHE18	Risk Analysis, Assessment and Management	3	0	0	3		
15MCHE19	Industrial Waste Water Treatment	3	0	0	3		

**L: Lecture, T: Tutorial, P: Practical, C: Credits**

- ❖ FC – Fundamental Course, PC – Professional Course, PE – Professional Elective, EEC – Employment Enhancement course
- ❖ Student can opt for a maximum of 2 professional elective subjects from other programmes during their entire programme of study

# 15MCH11 LINEAR ALGEBRA, NUMERICAL METHODS AND CALCULUS OF VARIATIONS

**ASSESSMENT: THEORY**

L	T	P	C
4	0	0	4

## **COURSE OBJECTIVE**

- ◆ To acquire the mathematical knowledge and skills needed in this course and to provide a basis for more advanced numerical techniques to solve complex engineering problems
- ◆ To interpret and solve a range of authentic engineering problems involving complex algebraic and differential equations.
- ◆ To learn number of standard and powerful algorithms, as well as demonstrating methodologies in graph techniques.

## **COURSE OUTCOME**

- CO1:** To utilize the various numerical techniques to solve system of linear and nonlinear equations
- CO2:** To solve simple optimal control problems using the concepts of classical and modern one dimensional calculus of variations
- CO3:** To solve isoperimetric problems involving extrema of integrals subject to integral constraints as side conditions
- CO4:** To able to obtain approximate values of definite integrals in one or two dimensions, as well as bound their error terms using Gaussian quadrature methods, and Adaptive methods.

## **LINEAR ALGEBRA-I**

System of Linear equations - Solution of linear system - Linear transformations - Matrix of linear transformation - Matrix operations - Inverse of a matrix - Matrix factorizations - Subspaces of  $R^n$  - Dimension and Rank - Determinants - Cramer's rule - Matrix factorization - Cholesky decomposition - QR factorization - Singular value decomposition - Toeplitz matrices and some applications. (12)

## **LINEAR ALGEBRA-II**

Vector spaces and subspaces - Null spaces and column spaces - Linearly independent sets - Basis - Coordinate systems - Dimension of a vector space - Rank - Eigenvector and Eigenvalues - Characteristic equation - Diagonalization - Eigenvectors and linear transformations - Orthogonal sets - Gram-Schmidt process - Least square problems - Inner products space. Vector spaces - subspaces - Linear dependence - Basis and Dimension - Inner product spaces - Gram - Schmidt Orthogonalization Procedure - Linear transformations - Kernels and Images - Matrix representation of linear transformation - Change of basis - Eigen values and Eigen vectors of linear operator - Quadratic form. (12)

## NUMERICAL DIFFERENTIATION AND INTEGRATION

Derivatives from difference tables - Divided differences and finite differences - Numerical integration by trapezoidal and Simpson's 1/3 and 3/8 rules - Romberg's method - Two and Three point Gaussian quadrature formulas - Double integrals using trapezoidal and Simpson's rules. (12)

## BOUNDARY VALUE PROBLEMS FOR ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS

Single step methods: Taylor series method - Euler and modified Euler methods - Fourth order Runge - Kutta method for solving first and second order equations - Multistep methods: Milne's and Adam's predictor and corrector methods. Finite difference solution of second order ordinary differential equation - Finite difference solution of one dimensional heat equation by explicit and implicit methods - One dimensional wave equation and two dimensional Laplace and Poisson equations. (12)

## CALCULUS OF VARIATIONS

Simple variation problems with fixed boundaries - Euler's equations - conditional extrema isoperimetric problems - approximate solutions - direct methods - Euler's finite difference method - Ritz method. (12)

**Total: 60**

## REFERENCES

1. *Hilder Brand F.B., "Method of Applied Mathematics", Prentice Hall Publications (Private Limited), 1965.*
2. *Venkataraman M.K., "Higher Engineering Mathematics for Engineering and Sciences", National publishing company, 2000.*
3. *Steven Chapra, Raymond P Cannle, " Numerical methods for Engineers", Tata McGrawHill Publications, 6th ed., 2010.*
4. *Vasistha A.R. and Gupta R.K, "Integral Transforms", Krishna Prakashan Media (Private Limited), Meerut(UP), 2000.*
5. *Elsgolts L "Differential equation and Calculus of variations", MIR Publication, Moscow, 1970.*
6. *Narayanan S., Manickavasagam Pillay T.K., Ramanaiah G., "Advanced Mathematics for Engineering students", Viswanathan Printers and Publishers Private Limited, 1986.*
7. *NarasimhaDeo, "Graph Theory with Applications to Engineering and Computer Science" Prentice-Hall 2008.*
8. *Kenneth Hoffman and Ray Kunze, Linear Algebra, 2nd ed., PHI, 1971.*

## 15MCH12 MOMENTUM, HEAT AND MASS TRANSFER

### ASSESSMENT: THEORY

L	T	P	C
4	0	0	4

### COURSE OBJECTIVE

- ◆ To develop physical understanding of principles of heat, mass and momentum transfer and with emphasis on chemical engineering applications.
- ◆ To introduce the concept of boundary layers and transition to turbulence.
- ◆ To learn how the resultant field equations is converted in dimensionless forms and to understand the physical meaning and significance of various dimensionless numbers.
- ◆ To understand the vector-tensor operations and differential calculus which describes various physical phenomena involved in chemical industries.
- ◆ To develop the governing equations for complex system in chemical engineering and solve the problem to describe the velocity, temperature and concentration field in such system.

### COURSE OUTCOME

- CO1:** Ability to set up shell balances for conservation of momentum, energy, and mass by microscopic and macroscopic view.
- CO2:** Ability to reduce and solve the appropriate equations of change to obtain desired profiles for velocity, temperature and concentration.
- CO3:** Recognize and apply analogies among momentum, heat and mass transfer.
- CO4:** Utilize information obtained from solutions of the balance equations to obtain engineering quantities of interest.
- CO5:** Appreciate relevance of transport principles in diverse applications of chemical, biological, materials science and engineering.

### REVIEW OF MATHEMATICS

Scalar, Vectors, Tensors, divergence, relation between rectangular coordinates and cylindrical coordinates, relation between rectangular coordinates and spherical coordinates, partial derivative, substantial derivative, total derivative, line integral, surface integral, integral theorems, frame of reference (Eularian and Lagrangian). Dimensional Analysis and its applications. (12)

### THE EQUATIONS OF CHANGE FOR ISOTHERMAL FLOW

Equations of continuity, equation of motion, equation of mechanical energy, application of Navier-Stokes equation to solve problems, equations of change for incompressible, Newtonian and Non-Newtonian fluids. (12)

## **THE EQUATIONS OF CHANGE FOR NON-ISOTHERMAL FLOW**

Equations of energy, the energy equation in curvilinear coordinates, use of equations of change to set up steady state and unsteady state heat transfer problems. (12)

## **THE EQUATIONS OF CHANGE FOR MULTI COMPONENT SYSTEMS**

The equations of continuity for a binary mixture, the equation of continuity of A in curvilinear coordinates, multicomponent equations of change in terms of flows, multi component fluxes in terms of transport properties, use of equations of change to setup diffusion problems. Velocity, temperature and concentration distributions with more than one independent variables, unsteady flow, stream function, potential flow, boundary layer theory, steady state two dimensional flow for momentum, heat and mass. (12)

## **TURBULENT FLOW**

Introduction, fluctuations and time smoothed equations for velocity, temperature and concentration, time smoothing of equation of change, equation of energy, equation of continuity, Reynolds stresses. (12)

**Total: 60**

## **TEXT BOOKS**

1. *Byron Bird R, Warren E. Stewart, Edwin N. Lightfoot, Transport Phenomena, Revised 2nd ed., John Wiley, (ISE), New York , 2007.*
2. *Brodkey R.S., Hershey H.C., Transport Phenomena, McGraw Hill (ISE), New York, 2003.*

## **REFERENCES**

1. *Welty J.R., Wicks C.E., Wilson, R.E., Fundamentals of Momentum, Heat and Mass Transfer, 5th ed., John Wiley (ISE), 2008.*
2. *Bennet C.O., Meyers J.E., Momentum, Heat and Mass Transfer, 3rd ed., Tata-McGraw Hill, New Delhi, 1983.*
3. *Geankopolis C.J., Transport Processes - Momentum, Heat and Mass, Allyn and bacon, Inc., Boston, USA, 2003.*

# 15MCH13 DIGITAL PROCESS DYNAMICS AND CONTROL

**ASSESSMENT : THEORY**

L	T	P	C
3	0	0	3

## **COURSE OBJECTIVE**

- ◆ To apply the various control methods employed in chemical engineering industries.
- ◆ To provide advanced course emphasizing digital control system and introduce the knowledge of Z - transforms.
- ◆ To provide the application of control structure formation, theory, tools to formulate the structure in MIMO system.
- ◆ To know the use of digital control systems, sampling effects on variables such as Temperature Pressure, etc.,

## **COURSE OUTCOME**

- CO1:** To understand the advanced control techniques, ratio, cascade and MPC systems.
- CO2:** Identify methods for various concepts and in industries to control the variables.
- CO3:** To understand the concepts of conversion of analog to digital and vice versa, hardware components of the control system.

## **OPEN AND CLOSED SYSTEM**

Review of first order and higher order systems, closed and open loop response to step, impulse and sinusoidal inputs. Design of control systems control valve, types - linear, equal percentage and quick opening valve. Block diagram - presentation of system. (9)

## **ADVANCED CONTROLLERS**

Advanced control techniques, cascade ratio, feed forward, Adaptive control, Selective control, computing relays, simple alarms, smith predictor, internal model control, theoretical analysis of computer process. (8)

## **MULTIVARIABLE CONTROLLER**

Multi loop system - level process, Stability of multi - variable systems, Non - linear systems. Decoupling of control loops and Relative Gain - Array. (8)

## **DIGITAL CONTROLLERS**

Digital computer, computer - process interface, computer control loops, new control design problems, Z - transforms, inversion of Z - transforms. Sampling of continuous signals, reconstruction - hold devices, conversion of continuous to discrete - time models. (12)

## **DYNAMIC SYSTEM AND STABILITY**

Discrete time response of dynamic systems, discrete time analysis of continuous systems, pulse transfer function, discrete time analysis of closed loop system, stability of discrete - time systems. Digital approximation of classical controllers, effect of samples, tuning and process identification. Zeigler - Nichols and Cohen - Coon tuning methods, ringing and placement of poles, Design of optimal regulatory control problems. (8)

**Total : 45**

### **TEXT BOOKS**

1. *Stephanopoulos G., Chemical Process Control: An Introduction To Theory And Practice, 6th ed., Prentice Hall of India Pvt.Ltd, New Delhi, 1998.*
2. *Luyben W.K., Luyben M.L., Essentials of process control, 2nd ed., McGraw hill, New York, 1997.*
3. *Cougnowr D., Steven Leblanc, Process Systems Analysis and Control, 3rd ed., McGraw Hill, New York, 2008.*

### **REFERENCES**

1. *Carlos A. Smith, Armando B. Corripio, Principles and Practice of Automative Process control, John Wiley, New York, 2005.*
2. *Karl Johan Astrom, Bjorn Witten mark, Computer controlled systems. Theory and design, 3rd ed., Prentice Hall of India Pvt. Ltd., New Delhi, 1996.*

## 15MCH14 MOLECULAR THERMODYNAMICS

ASSESSMENT : THEORY

L	T	P	C
4	0	0	4

### COURSE OBJECTIVE

- ◆ To apply the laws and tools of equilibrium thermodynamics to chemical engineering problems, including calculation of thermodynamic properties of pure fluids and mixtures.
- ◆ To provide advanced course emphasizing the conceptual structure of modern thermodynamics and its applications.
- ◆ To provide the application of non-ideal fluid-phase chemical potentials to problems in phase and chemical reaction equilibria.
- ◆ To know the use of fugacity, activity and chemical potential concepts for predicting the effect of such variables as temperature, pressure on equilibrium compositions.

### COURSE OUTCOME

- CO1:** Student will be able to explain thermodynamics of single-component fluid and binary mixtures, phase and chemical equilibria, surface and interface thermodynamics.
- CO2:** Define excess properties, fugacities, activity coefficients of multicomponent systems.
- CO3:** Identify methods for measuring and estimating thermodynamic properties important to equilibrium calculation in real systems.
- CO4:** Identify the relations of molecular structure and intermolecular forces to macroscopic thermodynamic properties.

### CLASSICAL THERMODYNAMICS OF PHASE EQUILIBRIA

Chemical thermodynamics of phase equilibria. Application of thermodynamics to phase equilibrium problems. Homogenous closed systems - open systems. Thermodynamic properties with independent variables. Phase equilibria from volumetric properties. (10)

### FUGACITIES IN GAS MIXTURES

Lewis fugacity rule. The virial equations of state. Fugacities from virial equations. Virial coefficients from corresponding states. Correlations. Chemical interpretation of deviations from gas-phase ideality. (14)

### FUGACITIES IN LIQUID MIXTURES: EXCESS FUNCTIONS

Activity coefficient from excess functions in binary mixtures. Applications of the Gibbs-Duhem equation. Testing equilibrium data for thermodynamic consistency. (14)

## **SOLUBILITY OF GASES AND SOLIDS IN LIQUIDS**

Ideal gas solubility. Effect of pressure and temperature on solubility in mixed solvents. Chemical effects on gas solubility. Solubility of solids in liquids. Ideal solubility.

(12)

## **HIGH PRESSURE EQUILIBRIA**

Phase behavior at high pressure. Calculation of high pressure vapor-liquid equilibria from a corresponding states correlation. Liquid-liquid and gas-gas equilibria.

(10)

**Total: 60**

## **TEXT BOOK**

1. *Prausnitz J.M., Lichtenthaler R.N., De Azevedo E.G., Molecular Thermodynamics of Fluid Phase Equilibria, 3rd ed., Prentice Hall, Inc. New Jersey, 2001.*

## **REFERENCE**

1. *Hougen O.A., Watson K.M., Chemical Process Principles, Part 2 - Thermodynamics, 2nd ed., John Wiley (ISE), 1954.*

## 15MCH15 SEMINAR AND TECHNICAL WRITING

L	T	P	C
0	0	2	1

### COURSE OBJECTIVE

- ◆ To develop the research skills using primary research to discover and employ technical information.
- ◆ To explore the correspondence skills by learning the generic conventions of technical fields
- ◆ To demonstrate promotional writing skills using primary research; to disseminate information in relevance with the research work.
- ◆ To familiarize with basic sources and methods of research and documentation on topics in technology, including online research. They will be able to synthesize and integrate material from primary and secondary sources with their own ideas in research papers.

### COURSE OUTCOME

- CO1:** Ability to participate actively in writing activities (individually and in collaboration) that model effective scientific and technical communication in the workplace.
- CO2:** Ability to recognize, explain, and use the rhetorical strategies and the formal elements of these the following the specific genres of technical communication such as technical abstracts, data based research reports, instructional manuals, and technical descriptions.
- CO3:** Ability to collect, analyze, document, and report research clearly, concisely, logically, and ethically; understand the standards for legitimate interpretations of research data within scientific and technical communities.

The students are expected to carry out fundamental theoretical and/or experimental studies, connected with physical properties or on process development studies or a design projects and an oral presentation on the work done. The students should maintain a record of the work done regularly and submit the same periodically for assessment. At the end of the semester, the students must submit a report of the work done in the standard format which will be evaluated by a team of senior faculty members and Head of the Department.

**Total : 30**

# 15MCH16 PROCESS MODELING, DYNAMICS AND CONTROL LABORATORY

## ASSESSMENT : PRACTICAL

L	T	P	C
0	0	2	1

## COURSE OBJECTIVE

- ◆ Ability to analyze process dynamics and various forms of mathematical models to express them, including differential equations, Laplace transfer functions, and frequency response plots.
- ◆ Develop realistic computer simulation case studies that exhibited nonlinear, high order dynamic behavior.
- ◆ Develop convenient graphical interface for students that allowed them to interact in real-time with the evolving virtual experiment.

## COURSE OUTCOME

- CO1:** Able to develop model for the dynamics of engineering systems using fundamental principles.
- CO2:** Able to explain the frequency response characteristics of linear systems and use them for stability analysis.
- CO3:** Able to demonstrate the principles of process control strategies in chemical process and develop the ability to design simple proportional-integral and other controllers.

## EXPERIMENTS

1. Studies on Indirect Heating (or) Cooling by Transfer of Heat from one fluid stream to another when separated by a Solid Wall.
2. Performance on Energy Balance across Shell and Tube Heat Exchanger.
3. Studies on the Effect of Heat Transfer, Temperature Efficiencies and Temperature Profile through a Shell and Tube Heat Exchanger.
4. Estimation of Overall Heat Transfer Coefficient for a Shell and Tube Heat Exchanger using LMTD Method.
5. Measurement of Hot and Cold Fluid Inlet and Outlet Temperature Using Lab VIEW.
6. Design of Closed Loop System of Heat Exchanger Using Lab VIEW.
7. To Study Tuning of PID Controller by Open Loop Method using Zeigler- Nichols Tuning rules in temperature control trainer.
8. To Study Tuning of PID Controller by Open Loop Method using Zeigler- Nichols Tuning rules in level control trainer.

9. To Study Tuning of PID Controller by Open Loop Method using Zeigler- Nichols Tuning rules in flow control trainer.
10. To Study Tuning of PID Controller by Open Loop Method using Zeigler- Nichols Tuning rules in pressure control trainer.
11. To study steady state and transient response of P+I control.
12. To study steady state and transient response of P+D control.
13. To study steady state and transient response of PID control using closed loop method.
14. To study stability of system by plotting bode plots.
15. Application of ANSYS in CFD problems - Flow problem - (laminar or turbulent flow Problems)
16. Application of ANSYS in Electrical problems RF Amplifier - Electrical field problems.
17. Simulation of industrial processes using Software packages like ANSYS, MATLAB,etc.

**Total : 30**

# 15MCH21 REACTION ENGINEERING AND CHEMICAL REACTOR DESIGN

**ASSESSMENT : THEORY**

L	T	P	C
4	0	0	4

## **COURSE OBJECTIVE**

- ◆ To explain the basic knowledge of catalyst preparation, characterization and poisoning of Catalyst and able to develop appropriate rate expressions for the design of heterogeneous reactors.
- ◆ To demonstrate the knowledge of the non-ideality creeping into the real systems, analyse the extent of deviation from ideal conditions and apply the same for calculating the conversion or size of a real system.
- ◆ To present the basic principles involved in multiphase reactor kinetics.

## **COURSE OUTCOME**

**CO1:** To choose appropriate catalyst preparation method and characterize the prepared catalyst and explain the possible catalyst deactivation route for the given reaction.

**CO2:** To develop the kinetics for a heterogeneous catalytic and non-catalytic reaction and design the reactor required for the given heterogeneous system.

**CO3:** To precisely analyze the extent of non-ideality in the real system.

**CO4:** To explain the underlying principles in multiphase reactors kinetics.

## **CATALYSIS**

Nature of catalysts - Their types, Preparation, testing and characterization. Factors affecting the choice of catalysts. Promoters and supports. Catalyst poisons. Adsorption isotherms - Determination of physical properties of catalysts. (9)

## **THEORY OF HETEROGENOUS SYSTEMS**

Rates of fluid - solid catalytic reactions - various controlling regimes. Rate expressions of various models for non catalytic fluid Solid systems - Determination of Rate controlling step - Application to design. (14)

## **DIFFUSION EFFECTS IN HETEROGENOUS REACTIONS**

External diffusion effects: Mass Transfer to a single particle, Mass transfer limited reactions in packed beds and on surfaces of metals. Internal diffusion effects - Diffusions and Reaction in Spherical catalyst pellets:- Thiele Modulus and Effectiveness factor - Mass Transfer and reaction in a packed bed. (14)

## **NON - IDEAL FLOW**

Residence Time distribution functions and their inter relationships, Moments of RTD - mean and variance. Reactor modeling with RTD - Micro mixing and the Segregation model. Dispersion and Tanks in series models. Multiparameter models. (14)

## **FLUID - FLUID REACTIONS**

Absorption systems with chemical reactions. Rate equations for instantaneous, Fast and slow reactions. Design of towers for fast and slow reactions. Slurry Reactors and Trickle bed reactors. (9)

**Total : 60**

## **TEXT BOOKS**

1. *Octave Levenspiel, Chemical Reaction Engineering, 3rd ed., John Wiley and sons, New Delhi, 2007.*
2. *Smith J.M., Chemical Engineering kinetics, 3rd ed., McGraw Hill, 1981.*

## **REFERENCES**

1. *Danckwerts P.V., Gas Liquid Reactions, McGraw-Hill, New York, 1970.*
2. *Scott Fogler H., Elements of Chemical Reaction Engineering, 3rd ed., Prentice Hall of India, Eastern Economy Edition, New Delhi, 2006.*

## 15MCH22 MULTIPHASE FLOW

**ASSESSMENT : THEORY**

L	T	P	C
3	0	0	3

### **COURSE OBJECTIVE**

- ◆ Analyses the basic techniques for one-dimensional multi-phase flows.
- ◆ To provide an understanding of homogeneous and separated flow.
- ◆ To provide knowledge on velocity profiles, one dimensional waves and interfacial phenomena.
- ◆ To provide an understanding of general theory of uniform steady flow. To acquire knowledge about various flow patterns.

### **COURSE OUTCOME**

- CO1:** Proficiency in the application of fundamental principles of multi-phase flows in wide variety of practical problems.
- CO2:** Simplest technique for analyzing two phase (or multiphase) flows using homogeneous and separated flow.
- CO3:** Identify various velocity profiles for multiphase flow and understand the interfacial phenomena. Understand the characteristics of particle suspensions in fluids.
- CO4:** Understand general theory, principles and applications of various flow patterns.

### **INTRODUCTION**

Methods of analysis, correlations, simple analytical methods, integral and differential analysis. Flow regimes, pressure drop and coordinates. (6)

### **HOMOGENEOUS AND SEPARATED FLOW**

Homogeneous flow - one dimensional steady homogeneous equilibrium flow, homogenous friction factor for laminar and turbulent flow. Separated flow - steady flow in which the phases are considered together but their velocities are allowed to differ. One dimensional separated flow in which the phases are considered separately. (9)

### **VELOCITY AND CONCENTRATION PROFILES, ONE DIMENSIONAL WAVES AND INTERFACIAL PHENOMENA**

Velocity profiles in single and two phase flow. One dimensional waves - continuity waves in single phase flow, incompressible two component flow and dynamic waves. Interfacial phenomena - velocity and stress boundary conditions. The effect of phase change on interfacial stresses. (10)

## **SUSPENSION OF PARTICLES IN FLUIDS**

General theory of uniform steady flow, terminal velocity of single particle, particulate fluidization and minimum fluidization velocity. Calculation procedures for particulate fluidized beds. Batch sedimentation. Shock waves. Friction characteristics of particle suspensions. Non uniform particle distributions. (10)

## **BUBBLE, SLUG, ANNULAR AND DROP FLOW**

Bubble formation, Taylor instability, rise velocity of single bubbles and the limits of bubble flow regime. Slug flow - general theory, bubble dynamics and velocity. Vertical and horizontal slug flow. Annular flow - horizontal and vertical flow. Drop flow - single-drop formation, atomization, flooding in drop flow and drop fluidization. Entrainment. (10)

**Total : 45**

## **TEXT BOOKS**

1. Wallis G.B., *One-dimensional Two Phase Flow*, McGraw Hill, 1969.
2. Govier G.W., Aziz K., *The Flow of Complex Mixtures in Pipes*, Krieger Pub Co., Van Nostrand, 1972.

## **REFERENCES**

1. Gad Hestroni (Ed. in chief)., *Handbook of Multiphase Systems*, 1st ed., Hemisphere publishing corporation, Washington, 1982.
2. Christopher E. Brennen, *Fundamentals of Multiphase Flow*, 1st ed., Cambridge University, 2005.

## 15MCH23 PROCESS MODELING, SIMULATION AND OPTIMIZATION

ASSESSMENT : THEORY

L	T	P	C
4	0	0	4

### COURSE OBJECTIVE

- ◆ To develop the mathematical modeling for chemical separation processes and reaction kinetics by using basic fundamental laws.
- ◆ To learn about linear regression analysis in matrix form, non-linear regression and design of experiments including factorial and optimal designs.
- ◆ To provide an overview of state-of-the-art for optimization algorithms, and their use for solving several types of practically relevant optimization problems arising in chemical process.
- ◆ To introduce various non-linear operation techniques involved in the optimization of chemical separation processes.

### COURSE OUTCOME

- CO1:** Ability to obtain mathematical model for flow processes like gravity flow tank, hydraulic transients and chemical separation processes like distillation and absorption column.
- CO2:** Ability to model any real system with the help of input-output data by using linear and non-linear regression analysis.
- CO3:** Ability to formulate and solve mathematical optimization problems for chemical reactor design and heat exchanger with and without constraints.
- CO4:** Ability to formulate Objective functions are based on economics or functional specifications.
- CO5:** Ability to solve non-linear optimization problems by using various numerical techniques.

### BASIC MODELING

Introduction to modeling, Application and scope of coverage, Formulation, Review of algebraic equations, Ordinary and partial differential equation. Analytical and numerical techniques, Smoothing techniques, Spline function approximations. (12)

### MODELING OF HEAT, MASS AND MOMENTUM TRANSFER OPERATIONS

Review of heat, mass and momentum transfer operations, Modeling of exchangers, Evaporators, Absorption columns, Extractors, Distillation columns, Membrane processes. (12)

## **MODEL DISCRIMINATION AND PARAMETER ESTIMATION**

Rate equations, Linear and non-linear regression analysis, Design of experiments, Factorial, Central, fractional design, Evolutionary operation techniques, Case studies. (12)

## **OPTIMIZATION TECHNIQUES**

Function, Analysis and numerical methods for single variable and multivariable system, constrained optimization problems. (12)

## **APPLICATION OF OPTIMIZATION**

Heat transfer and energy conservation, Separation techniques, Fluid flow systems, Chemical Reactor design. (12)

**Total : 60**

## **TEXT BOOKS**

1. *Thomas Edgar, David M. Himmelblau, Optimization of Chemical Processes, 2nd ed, McGraw Hill Book Co., New York, 2001.*
2. *William L. McCabe Luyben, Process Modeling, Simulation and Control for Chemical Engineers, 2nd ed, Tata McGraw Hill Book Co., New York, 1990.*
3. *Roger G.E. Franks, Modeling and Simulation in Chemical Engineering, Wiley-Interscience, New York, 1972.*

## **REFERENCES**

1. *Rao S.S., Engineering Optimization - Theory and Practice, New Age International (P) Ltd., 1999.*
2. *Chemical Engineering Tutorial Numerical methods, Chemical Engineering, August 17, October 26, 1987 Feb. 15, April 25, July 18, Nov. 21, 1988, July 14, 1989.*
3. *Chemical Engineering Tutorial Statistics for Chemical Engineers, Chemical Engineering. July 23, 1985, Feb. 3, April 14, June 23, Sept. 1, 1986.*

## 15MCH24 NEW SEPARATION TECHNIQUES

**ASSESSMENT : THEORY**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### **COURSE OBJECTIVE**

- ◆ In this optional course the principles of the most important separation techniques are discussed.
- ◆ The intention is to elucidate their usefulness in the framework of a chemical analysis.
- ◆ Introduction and survey of separations based on physical properties, phase equilibria, and rate processes.
- ◆ Most attention is devoted to the separations that precede the detection of inorganic components (cations and anions).

### **COURSE OUTCOME**

**CO1:** To amplify the student's understanding of basic concepts of modern separation processes.

**CO2:** To help the student to indicate the analytical separation.

**CO3:** To produce ability to differentiate the different separation process.

**CO4:** To impart ability to identify the process to be used for the given conditions.

**CO5:** To increase the ability to interpret and analyze new separation problems successfully.

### **MEMBRANE SEPARATIONS**

Types and choice of membranes, their merits, commercial, pilot plant polarization of membrane processes and laboratory membrane permeators, dialysis, reverse osmosis, ultra filtration, Concentration and economics of membrane operations, Design controlling factors. (9)

### **SEPARATION BY SORPTION TECHNIQUES**

Types and choice of adsorbents, chromatographic techniques, Types, Retention theory mechanism, Design controlling factors ion exchange chromatography equipment and commercial processes, recent advances and economics. (9)

### **IONIC SEPARATIONS**

Controlling factors, applications, Theory mechanism and - equipment for electrophoresis, di-electrophoresis and electro dialysis - commercial applications - Design considerations. (9)

## **THERMAL SEPARATION**

Thermal diffusion: Basic rate law, phenomenological theories of thermal diffusion for gas and liquid mixtures, Equipments design and applications. Zone melting: Equilibrium diagrams, Controlling factors, Apparatus and applications. (9)

## **OTHER TECHNIQUES**

Adductive crystallization molecular addition compounds, Clathrate compounds and adducts, Equipments, Applications, Economics and commercial processes. Foam Separation: Surface adsorption, Nature of foams, Apparatus, Applications, and Controlling factors. (9)

**Total : 45**

## **TEXT BOOKS**

1. *Schoen H.M., New Chemical Engineering Separation Techniques, Wiley Interscience, New York, 1972.*
2. *King C.J, Separation Processes, Tata McGraw Hill, New Delhi, 1982.*

## **REFERENCES**

1. *Sivasankar B, Bioseparations Principles and Techniques, Prentice Hall of India Pvt. Ltd, New Delhi, 2005.*
2. *Pratt H.R.C., Counter-Current Separation Processes, Elsevier, Amsterdam, 1967.*

## 15MCH25 PROFESSIONAL ENGINEERING PRACTICES

ASSESSMENT : PRACTICAL

L	T	P	C
0	0	2	1

### COURSE OBJECTIVE

- ◆ To prepare, to a professional standard, a technical written extended abstract, having good structure and format, high standards of spelling, grammar and punctuation, and appropriate and adequate technical content.
- ◆ To plan, prepare and deliver a verbal presentation in English, to a professional standard, on their own academic work, making effective use of presentation aids, in a professional forum.
- ◆ To present, defend and debate technical information, based on their own final year project and critically analyse the work of peers and to provide constructive feedback.

### COURSE OUTCOME

**CO1:** Able to recognise and debate the strengths and limitations of the academic component of the education of a professional engineer/surveyor.

**CO2:** Able to describe the need for a period of professional formation.

**CO3:** Able to categorize the various standards of simple Control system safety.

### CONTROL SYSTEM SAFETY

Understanding Safety: Personal, Office and Industrial Safety. Understanding safety impacts on business, Compliance and its implications, Cost advantages of being safe, Why safety should not be part of Safety department only? How Safety should be made as an Inclusive culture across all functions and departments? Case studies / Videos / Spot the unsafe hazards type engagements: Conducted thro' Internal and External speakers.

### ETHICS

**HUMAN VALUES :** Morals, Values and Ethics - Integrity - Work Ethics - Services Learning - Virtues - Respect for Others - Living Peacefully - Caring - Sharing - Honesty - Courage - Valuing Time - Co-operation - Commitment - Empathy - Self Confidence - Challenges in Work Place - Cyberspace - Impact of Cyberspace on Individuals.

**ENGINEERING ETHICS, RESPONSIBILITIES AND RIGHTS :** Senses of Engineering Ethics - Moral Issues - Inquiries - Moral Dilemma - Moral Autonomy - Profession and Responsible Professionalism - Social Responsibility - Collegiality, Loyalty and Confidentiality.

### ENTREPRENEURSHIP DEVELOPMENT

Entrepreneurship concept - Entrepreneurship as a Career - Entrepreneurial Personality - Characteristics of Successful, Entrepreneur - Knowledge and Skills of Entrepreneur. - Entrepreneurship Development Training and Other Support Organisational Services - Central and State Government Industrial Policies and Regulations - CASE STUDIES

## **COST ANALYSIS**

Understanding Cost analysis: Understanding process dynamic and its impact on bottomline, Showing the bigger picture, Connecting the linkage of process failures, lack of regular updations or non-following of process procedures to human and financial losses. Process audits and its advantages to bottomline, Supported by Case studies / On the spot impact on costs, gross margins discussions : Conducted thro' Internal and External speakers.

## **INTELLECTUAL PROPERTY RIGHTS (IPR)**

IPR policy of Government of India, Indian & International Patent laws, Indian Patent Act 1970; Recent Amendments; Types of patents; Patent application - forms and guidelines, fee structure, time frames; Filing of a patent application; Precautions before patenting - disclosure / non-disclosure; Patent application - forms and guidelines, fee structure, time frames; Types of patent applications; provisional and complete specifications; PCT and convention patent applications; International patenting - requirement, procedures and costs; Financial assistance for patenting - introduction to existing schemes.

## **REFERENCES:**

1. *BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007.*
2. *Kankanala C., Genetic Patent Law & Strategy, 1st ed., Manupatra, Information Solution Pvt. Ltd., 2007.*
3. *Hisrich, Entrepreneurship, Tata McGraw Hill, New Delhi, 2001.*
4. *S.S.Khanka, Entrepreneurial Development, S.Chand and Company Limited, New Delhi, 2001.*

## **NOTE:**

Quizzes, Seminars, presentations and test will be conducted periodically to evaluate the student performance in this subject. The students should maintain a record of their academic performance and submit the same periodically for assessment. At the end of the semester, the students must submit and present a report of their work on this subject in the standard format which will be evaluated by a team of senior faculty members and Head of the Department.

**Total : 30**

## 15MCH26 PROCESS SIMULATION LABORATORY

**ASSESSMENT : PRACTICAL**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>

### **COURSE OBJECTIVE**

- ◆ Solve complex chemical engineering problems by applying suitable numerical methods.
- ◆ Design and simulate the process equipment using MATLAB.
- ◆ Analyze and formulate a mathematical problem and solve the resulting system of linear set of equations, ODE, PDE using MATLAB.
- ◆ Develop the ability to use computer software to help describe and design Process systems.

### **COURSE OUTCOME**

- CO1:** Modeling of chemical engineering processes including mass transfer, momentum transfer and heat transfer from advanced engineering perspective.
- CO2:** Apply modern simulation tools to address the challenges faced in chemical and allied engineering industries.
- CO3:** Use modern software tools for design of processes and equipment like MATLAB.

### **LIST OF EXPERIMENTS**

1. MATLAB programming of numerical techniques applied in chemical engineering
2. Process simulation of Isothermal Batch reactor.
3. Mathematical modeling and simulation of a simple cooling tank system.
4. Develop and simulate a Mathematical model of Heat exchanger using simulink
5. Process simulation of a pressurized Isothermal Gas phase CSTR.
6. Simulation of one dimensional heat and mass flow equation.
7. Develop and simulate a Mathematical model of a simple distillation column using simulink.
8. Process simulation of two tanks in Interacting and Non Interacting fashion.
9. Develop Simulation algorithm of a PID controller for a first order time delay system.
10. Modeling a transient plug flow reactor.
11. Open and Closed loop simulation of process systems using P,PI and PID controllers.
12. Process simulation of a Non Isothermal CSTR with cooling jacket.

**Total : 32**

## 15MCH41 PROJECT WORK AND VIVA-VOCE

### ASSESSMENT : PRACTICAL

L	T	P	C
-	-	-	18

### COURSE OBJECTIVE

The objective of this course is to introduce students to demonstrate practical concepts, command and knowledge gained so far into some realistic project.

- ◆ To produce well - groomed engineers in the areas of Process Control Engineering who will be able to make contributions in design, implementations and execution of operation and process design and control projects.
- ◆ To develop practical skills needed to understand and modify any problems related to process design and implementation.
- ◆ To develop skills among chemical engineering professionals by which they can perform a variety of functions that ranges from installing applications to designing complex process.
- ◆ To provide an exposure to prominent cutting edge technologies, sufficient training & opportunities to work as teams on multidisciplinary projects with effective writing and communication skills.

### COURSE OUTCOME

The above exercise shall make the students competent in the following ways and will be able to learn following parameters at the end of the course.

- CO1:** Students should be able to design, analyse the data and interpretation of a chemical process system to meet desired needs.
- CO2:** Students are provided to work in multidisciplinary areas related to Process Control engineering.
- CO3:** Students should be able to work as Process Control Engineering Professionals, with portfolio ranging from process, data analysis, perform data management and software design, as well as management and administration of entire systems.

Every candidate individually shall undertake the project work during the fourth semester. Work can be undertaken in an industrial/research organization or in the Institute in consultation with the faculty guide and the Head of the Department. In case of Project Work at industrial/research organization, the same shall be jointly supervised by a faculty guide and an expert from the organization. The students should maintain a record of the work done regularly and submit them for assessment periodically. At the end of the semester, the students should submit a report of the work done in standard format which will be evaluated by the faculty and subject experts.

# 15MCHE01 FLUIDIZATION ENGINEERING

**ASSESSMENT : THEORY**

L	T	P	C
3	0	0	3

## **COURSE OBJECTIVE**

- ◆ To explain the applications of fluidization engineering in process industries.
- ◆ To provide students with the fundamental technical knowledge and skills in fluidization to recognize and solve problems in the area of design.
- ◆ To learn all the operations involved in fluidization and their heat and mass transfer studies.
- ◆ To utilize their expertise in engineering, identify, formulate, and solve engineering problems.
- ◆ To provide basic knowledge in types of fluidization, different modes of fluidization and various models.

## **COURSE OUTCOME**

**CO1:** Acquired the fundamental principles and operation of fluidization.

**CO2:** Ability to understand behavior of various models, heat and mass transfer studies.

**CO3:** Ability to solve problem in all modes of fluidization.

**CO4:** Ability to understand generalized fluidization in solid mixing and segregation.

**CO5:** Ability to apply design techniques to real time industrial systems.

## **INTRODUCTION**

The fluidized state, Nature of hydro dynamic suspension particle-particle forces, species of fluidization, regimization of the fluidized state, operating models for fluidizations systems, Application of fluidization systems. (9)

## **HYDRODYNAMICS OF FLUIDIZATION SYSTEMS**

General bed behavior pressure drop, Flow regimes, Incipient fluidization, pressure fluctuations, phase holdups, Measurement techniques, Empirical correlations for solids holdup, liquid holdup and gas holdup, Flow models -generalized wake model, structural wake model and other important models. (9)

## **SOLIDS MIXING AND SEGREGATION**

Mechanistic model, Reversal points, Degree of segregation, Mixing - segregation equilibrium, generalized fluidization of poly disperse systems, liquid phase mixing and gas phase mixing. (9)

## HEAT AND MASS TRANSFER IN FLUIDIZATION SYSTEMS

Mass transfer - gas-liquid mass transfer, Liquid solid mass transfer and wall to bed mass transfer, Heat transfer - column wall - to - bed heat transfer, Immersed vertical cylinder-to-bed heat transfer, Immersed horizontal cylinder to-bed heat transfer. (9)

## MISCELLANEOUS SYSTEMS

Conical fluidized bed, Moving bed, Slurry bubble columns, Turbulent bed contactor, Two phase and three phase inverse fluidized bed, Draft tube systems, Semi fluidized bed systems, Annular systems, typical applications, Geldart's classification for power assessment, Powder characterization and modeling by bed collapsing. (9)

**Total : 45**

## TEXT BOOKS

1. *Kunii D., Levenspiel O. Fluidization Engineering, John Wiley and Sons, New York, 1991.*
2. *Davidson J.F. and Harrison D. Fluidization, Academic Press, London, 1971.*

## REFERENCES

1. *Liang-Shih Fan, Gas-Liquid Solid fluidization Engineering, Butterworth, 1989.*
2. *Monsoon Kwauk, Fluidization Idealized and Bubble less, with Applications, Science Press, 1992.*

# 15MCHE02 BIOMEDICAL ENGINEERING

**ASSESSMENT : THEORY**

L	T	P	C
3	0	0	3

## **COURSE OBJECTIVE**

- ◆ To have an understanding of the basic functions of the various systems in a human body and the various signals associated with them.
- ◆ To prepare students for careers of useful service to society.
- ◆ To engage committed scholars in the productive application of the tools of engineering to the subject matter of biology and medicine across the spectrum of research and teaching.
- ◆ To provide opportunities for teamwork, open ended problem-solving and critical thinking.
- ◆ Work professionally in one or more of the following areas: biomedical electronics, medical instrumentation, medical imaging, biomedical signal processing, rehabilitation engineering.

## **COURSE OUTCOME**

- CO1:** To analyze and interpret the various signals associated with different systems in the humanbody.
- CO2:** Possible to identify and rectify the defects in the working of most of the bio medical instruments.
- CO3:** To understand the mathematical and physical foundations of biomedical engineering and how these are applied to the design of biomedical instruments.
- CO4:** To critically evaluate alternate assumptions, approaches, procedures, tradeoffs, and results related to engineering and biological problems.
- CO5:** To design a variety of electronic and / or computer - based devices and software for applications including biomedical instrumentation.

## **INTRODUCTION TO PHYSIOLOGY**

**CELL AND ITS FUNCTION :** Nervous system; Cardio vascular system. Respiratory system  
Renal physiology.

**BIOELECTRIC PHENOMENA :** Basics of biopotential; Properties of excitable membranes; Action potential; Principles of ECG, EGG, EMG. (9)

## **ANALYSIS OF SOME MONITORING DIAGNOSTIC THERAPEUTIC PROCEDURES**

Introduction Biomechanics; biodynamic models and their applications; Cardiac assist devices; Biomechanics of head injury.

**MEDICAL INSTRUMENTATION** : Amplifier constraints and specification; Recording systems; Electrical grounding and patient safety; Transducers; Electrodes for recording biopotential. (9)

### **ANALYSIS OF BIOELECTRIC SIGNALS**

Introduction; Data acquisition; Extraction of signals from noise; Introduction to pattern recognition.

**PHYSIOLOGICAL CONTROL SYSTEMS**: Regulation of body temperature. Regulation and control in the CV system.

**MEDICAL PHYSICS**: Rheology of blood; Radiation dosimetry; Neuron activation analysis; Safety procedures for radiation diagnostics; Ultrasound effects. (9)

### **BIOPOLYMERS**

**INTRODUCTION**: Nature and composition of polymers used as prosthetic devices with special to heart valves, artificial bones dentures, sutures etc.

**TRANSPORT PHENOMENA IN HUMAN BIOLOGY**: Introduction to renal and respiratory system; Lung oxygenator and their design characteristics; artificial kidney and their design features. (9)

### **MEDICAL ENZYMOLOGY**

Role of enzyme in clinical tests; their role as therapeutic agents; Role of enzyme electrodes in chemical testing; Extra corporeal shunts using immobilized enzymes.

**RECENT TRENDS IN MEDICAL FIELD**: Role computers in medical data logging and diagnosis; CAT and NMR Scanning; Transplants; Introduction to aviation and space medicine; Specialty drugs and their mode of action. (9)

**Total : 45**

### **TEXT BOOKS**

1. *Brown J.H.U., Jacobs J.E., Stark L: Biomedical Engineering, F.A.Davis Company, Philadelphia, 1971.*
2. *Kennedy R.M.: Advances in Biomedical Engineering, Vol.1, Academic Press, London & New York, 1971.*

### **REFERENCES**

1. *Wiley Encyclopedia of Biomedical Engineering, Metin Akay, John Wiley, 2006.*
2. *Bronzino, Joseph D, Biomedical Engineering Handbook, 2006.*

# 15MCHE03 COMPUTER AIDED DESIGN OF CHEMICAL PROCESS EQUIPMENTS

ASSESSMENT : THEORY

L	T	P	C
3	0	0	3

## COURSE OBJECTIVE

- ◆ To give the student an understanding of Computer aided steady state analysis, Flowsheeting, Methods of tearing, Simulation.
- ◆ To demonstrate the ability to read, understand, and use process flow diagrams.
- ◆ To demonstrate the ability to estimate investment costs for chemical process equipment, chemical plants and to estimate chemical manufacturing costs.
- ◆ To demonstrate the ability to use CAD tool for chemical process simulation.
- ◆ To demonstrate written documentation an ability to prepare a chemical process design report by using CAD tool very easily.

## COURSE OUTCOME

- CO1:** Ability to apply knowledge on different computing methods.
- CO2:** Ability to apply knowledge on different software for steady and dynamic simulation of chemical engineering systems like ASPEN PLUS, Fluent, DESIGN II, PRO II.
- CO3:** Ability to perform Computer aided design of chemical equipment like reaction vessels, storage vessels and pressure vessels.
- CO4:** Ability to analyze the profitability of chemical process investments and to occupy software related jobs in leading companies.
- CO5:** Ability to formulate and solve mathematical model problem with the help of computer programming.

## INTRODUCTION

Uses of computers in engineering design, General design considerations, Property estimation and Material and Energy balance, Introduction to special software for steady and dynamic simulation of chemical engineering systems, Aspen Plus, Fluent, Design II, PRO II (9)

## PRESSURE VESSELS

Computer aided design of reaction vessels, pressure vessels and storage vessels. Testing and inspection of vessels as per IS codes. (9)

## HEAT TRANSFER EQUIPMENTS

Design of heat exchangers, condensers, evaporators, reboilers and furnaces. Design of equipment using software packages. (9)

## MASS TRANSFER EQUIPMENTS

Computer aided design of distillation, extraction, absorption equipment, rotary driers and cooling towers. (9)

## FLUID-SOLID SEPARATIONS

Design of cyclone separators, thickeners, centrifuge, and filters. (9)

**Total : 45**

## TEXT BOOKS

1. Wells G.L., Hobson P.M, *Computation for process Engineers*, Leonard Hill, 1973.
2. Joshi M.V., *Process Equipment Design*, 3rd ed., Macmillan, India, 2000.
3. Brownell L.E., Young: *process Equipment Design*, John Wiley and Sons, New Delhi, 1959
4. Dawande S. D., *Process Equipment Design, Vol.1 and Vol.2*, 5th ed., Central Techno Publication, Nagpur, 1999

## REFERENCES

1. Bhattacharyya B.C., Narayanan C.M., *Computer Aided Design of Chemical Process Equipments 1st ed.*, New Central Book Agency (P) Ltd., New Delhi, 1992.
2. Prausnitz J.M. , Cheuh P.L., *Computer Calculation for High Pressure Vapor - Liquid Equilibria*, Prentice Hall, 1986.
3. Westerberg A.W., *Process Flow Sheeting*, Cambridge University Press, 1990.

## BOOKS PERMITTED FOR SEMESTER EXAMINATIONS:

1. Perry, R.H. , Green, D.W., *Perry's chemical Engineers' Handbook*, 8th ed., McGraw Hill international student edition, 2007.
2. *India Standard Codes:*
  - (a) IS : 2825 - 1969: Code for unfired Pressure Vessels.
  - (b) IS: 4049-1979: Specifications for formed ends for Tanks and pressure vessels.
  - (c) IS : 4179 - 1967: Sizes of process Vessels and their Leading Dimensions.
  - (d) IS: 4864 to 4870 - 1986: Specifications for Shell Flanges for Vessels and Equipment.
  - (e) IS: 4506 - 1967: Specifications for Shell and Tube Heat Exchangers.
  - (f) IS: 803 - 1962: Code of practice for Design, Fabrication and Erection of Mild Steel Cylindrical Welded Oil Storage Tanks. (Published by Bureau of Indian Standards, New Delhi).

## 15MCHE04 PILOT PLANTS, MODELS AND SCALE UP METHODS IN CHEMICAL ENGINEERING

ASSESSMENT : THEORY

L	T	P	C
3	0	0	3

### COURSE OBJECTIVE

- ◆ To learn how to create and conduct a pilot plant study, analyze and evaluate pilot plant results and apply process scale-up methods.
- ◆ To study proper designs, modeling and processing and the importance of the process geometry.
- ◆ To provide the different concepts of scale-up in mixing and contacting.
- ◆ To provide the knowledge on carrying out successful process translations from the laboratory to the plant.
- ◆ To learn how to create and conduct a pilot plant study, analyze and evaluate pilot plant results, and apply process scale-up methods.

### COURSE OUTCOME

- CO1:** Understand the techniques to solve problems relevant to the general practice of chemical engineering and engineering design.
- CO2:** Experience in the process of original chemical engineering design in the three areas of equipment design, process design, and plant design through the process of formulating a design solution to a perceived need and then executing the design and evaluating its performance including economic considerations and societal impacts.
- CO3:** Understand the effects of scale on the relative rates of mass, heat and momentum transfer, mixing effects, utility of various reactor operating modes and the acquisition of reliable kinetic, thermodynamic and transport data.
- CO4:** Ability to use different approaches for process scale - up and perform a power analysis and understand flow regimes basic to scale up.

### PRINCIPLES OF SIMILARITY, PILOT PLANTS AND MODELS

Introduction to scale up methods, pilot plants and models and principles of similarity.

(9)

### DIMENSIONAL ANALYSIS AND SCALE - UP CRITERION

Dimensional Analysis, Regime concept, similarity criterion and scale up methods used in chemical engineering.

(10)

### **SCALE - UP OF MIXING AND HEAT TRANSFER EQUIPMENT**

Typical problems in scale - up of mixing equipment and heat transfer equipment. (9)

### **SCALE - UP OF CHEMICAL REACTORS**

Kinetics, Reactor Development and scale - up techniques for chemical reactors. (9)

### **SCALE - UP OF DISTILLATION COLUMN AND PACKED TOWERS**

Scale - up of distillation columns and packed towers for continuous and batch process. (8)

**Total: 45**

### **TEXT BOOKS**

1. *John stone, Thring, Pilot plants models and scale - up methods in chemical Engineering, McGraw - Hill, New York, 1962.*
2. *Marko Zlokarnik, Dimensional Analysis and scale - up in Chemical Engineering, Springer - Verlag, Berlin, Germany, 1986.*

### **REFERENCE**

1. *Donald. G. Jordan. Chemical Process Development (Part 1 and 2), Interscience Publishers, 1988.*

# 15MCHE05 BIOCHEMICAL ENGINEERING

**ASSESSMENT : THEORY**

L	T	P	C
3	0	0	3

## **COURSE OBJECTIVE**

- ◆ To describe the basic structure and function of cells and provides certain skills in the areas of biochemical process and the fundamental background of biological systems.
- ◆ To understand and relate cell function to products and processes useful to man, and be able to explain the kinetics of these processes.
- ◆ To expose the students to the various separation procedures involved in the downstream processing of products, especially those of biological origin.
- ◆ To understand the principles and application of bioremediation processes, waste water treatment in particular.

## **COURSE OUTCOME**

- CO1:** To understand and use the basic principles of biology and biochemistry to successfully design and operate a biochemical process.
- CO2:** Students develop an understanding of the science and engineering principles underlying modern industrial practices in bioprocessing.
- CO3:** To understand the factors effecting cell growth and to design and operate various bioreactors.
- CO4:** Ability to apply knowledge of various unit operations for biochemical processes and in microbiological systems.

## **INTRODUCTION**

Structure of microbial cells - classes of microbes - Chemicals of life - cellular metabolism and energetic. (9)

## **KINETICS OF ENZYMES**

Kinetics of substrate - Product and Biomass yield. Kinetics of enzyme catalyzed reactions. (9)

## **SEPARATION OF ENZYMES**

Characteristics, isolation and uses of enzymes. Aeration and agitation in biochemical reactors, Media and Air sterilization. (9)

## **FERMENTATION PROCESSES**

Scale up of fermentation operation. Measurement, control and product recovery in fermentation processes. (9)

## **TRANSPORT IN MICROBIAL SYSTEM**

Transport phenomena in microbial systems: Gas - Liquid mass transfer in microbial systems. Mass transfer across free surfaces, scaling of mass transfer equipment, factors affecting mass transfer coefficients (9)

**Total: 45**

## **TEXT BOOKS**

1. *Bailey J.E., Ollis D.F, Biochemical Engineering Fundamentals, 2nd ed, McGraw Hill, international student edition, 1986.*
2. *Schuler, Kargi, Bioprocess Engineering, Prentice Hall of India Pvt. Ltd, New Delhi, 1992.*

## **REFERENCE**

1. *Aiba S., Humphrey A.E. and Millis N.F. Biochemical Engineering, 2nd ed., Academic Press, 1973.*

# 15MCHE06 TECHNOLOGY OF COMPOSITES

**ASSESSMENT : THEORY**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

## **COURSE OBJECTIVE**

- ◆ To introduce elementary concepts of composite technology, ethical aspects of engineering safety and environmental issues regarding the use of chemicals.
- ◆ To provide basic knowledge about fabrication methods, properties and applications of composites and molding methods.
- ◆ To provide general issues including flow of a product through a manufacturing firm and health issues.
- ◆ To provide applications of composites in general fields and real cases.
- ◆ To understand physical, chemical, mechanical and viscous-elastic properties of polymers and post processing methods.

## **COURSE OUTCOME**

- CO1:** An ability to gain knowledge about various composite production methods, application in real process.
- CO2:** An ability to identify, formulate new composite materials other than normal materials providing safety to the environment.
- CO3:** Effectively understands the reinforcement of thermosets and thermoplastics.
- CO4:** An ability to understand different molding process and application of plastics in fabrication process.
- CO5:** Effectively understanding the post processing methods and applying in projects.

## **INTRODUCTION**

Definition, classification constituents, function and requirements, reinforcements and matrix, properties of composite materials and applications. (8)

## **FIBRE REINFORCEMENT**

Glass, carbon, aramid and boron fibers, their production processes and properties, commercial forms of fiber, Whiskers and their applications. (9)

## **FUNDAMENTALS OF POLYMER COMPOSITES**

Types of composites reinforced thermoplastics, thermosets, reinforcement of elastomers, materials and types of reinforcements, Thermosetting and thermo plastic materials - their curing characteristics, FRTP pellets, their production, processing, fillers and additives.

Mechanical, electrical, thermal and viscoelastic properties of composites as determined by composition and its effect on processing. (10)

### **COMPOSITES AND FABRICATION PROCESSES**

Pressure bag/vacuum bag moulding, compression moulding, filament winding, autoclave moulding, centrifugal casting, pultrusion, injection moulding. Application of cellular plastics, effects on properties, methods of production, types of products and applications. (9)

### **POST PROCESSING METHODS**

Cutting, trimming, machining, water jet cutting, abrasive jet cutting, laser curing, joining, mechanical and adhesive points, painting, coating and other processes. (9)

**Total: 45**

### **TEXT BOOKS**

1. *Lubin G, Von Nostrand Rein Hold, Handbook of Composites, New York 1982.*
2. *Mohr J.G., SPI Handbook of Technology and Engineering of Reinforced Plastics/ Composites, 2nd ed., New York, Van Nostrand Rein - hold Company.1973.*

### **REFERENCE**

1. *Richardson M.D.W, Polymer Engineering Composites, Applied Science Publishers, London 1977.*

## 15MCHE07 CATALYSIS AND SURFACE PHENOMENA

ASSESSMENT : THEORY

L	T	P	C
3	0	0	3

### COURSE OBJECTIVE

- ◆ To give an introduction to the experimental and theoretical aspects of surface and interface science.
- ◆ To learn adsorption, the nature of the catalyst surface, kinetics of catalytic reactions, catalyst selections.
- ◆ To provide the knowledge of preparation, characterization and relevant applications of heterogeneous catalysts.
- ◆ To learn the fundamentals in physics, chemistry, material science with the static and dynamic behavior of catalyst.
- ◆ To learn physicochemical properties, surface activity and selectivity expression for the most important industrial catalytic processes.

### COURSE OUTCOME

- CO1:** An ability to gain knowledge about various catalytic methods, application in real process.
- CO2:** An ability to understand various methods involved in the catalytic and surface techniques.
- CO3:** Students will be able to simplify the general equations of change for specific applications.
- CO4:** An ability to understand the preparation, modification, and evaluation techniques involved in the catalytic process.
- CO5:** Ability to apply design techniques to real time industrial systems.

### PHYSICAL CHARACTERIZATION AND ANALYSIS

Physisorption, Chemisorption, Measurement of surface area, Pore volume, pore size distribution, Microscopy, Auger Electron Spectroscopy, X-photoelectron Spectroscopy, Electron Microprobe Analysis, X-Ray Diffraction, Calorimetry, Gravimetric Methods. (9)

### KINETICS OF CHEMICAL PROCESSES

Chemical kinetics of Elementary Steps, Transition State Theory, Thermodynamic Formulation of Rates, Collision Theory and Equation of Arrhenius, Steady State Approximation, Kinetic Treatment of Catalytic Sequences and Chain Reactions, Principle of Microscopic Reversibility, Simplified kinetics of sequences at the Steady State. (9)

## **CORRELATION IN HOMOGENEOUS AND HETEROGENEOUS CATALYSIS**

Polanyi Reaction, Bronsted Relation, Hammett Reaction, Compensation Effect, Acidity Function in Acid- Base catalysis, Catalysis on Non uniform surfaces, Activity and Selectivity, Principle of Sabatier, Kinetic comparison between homogeneous and heterogeneous Catalysis. (9)

## **THERMAL ANALYSIS, INFRA-RED SPECTROSCOPY AND X-RAY ANALYSIS**

Temperature programmed Reduction and Desorption, Surface analysis using thermal methods, Basic Concepts in IR, Dispersive versus FTIR spectroscopy, IR analysis of catalysts, Powder X-Ray Diffraction, Semi-quantitative analysis, XRF, XAFS. (9)

## **SYNTHESIS GAS AND ASSOCIATED PROCESSES**

Steam Reforming, Fischer - Tropsch Synthesis, Water-Gas shift Reaction, Methanol Synthesis and Ammonia synthesis. (9)

**Total: 45**

## **TEXT BOOKS**

1. *Boudart M., Kinetics of Chemical Processes, Prentice-Hall International Series in The Physical and Chemical Engineering Sciences, 1968.*
2. *Satterfield, Heterogeneous Catalysis in Practice, McGraw Hill. 2002.*

## **REFERENCE**

1. *Viswanathan B., Sivasanker S., Ramaswamy A. V., Catalysis: Principles and Applications, Narosa Publishers, 2002.*

## 15MCHE08 SOLVENT EXTRACTION ENGINEERING

ASSESSMENT : THEORY

L	T	P	C
3	0	0	3

### COURSE OBJECTIVE

- ◆ To provide students with the knowledge of solvent extraction, leaching and super critical extraction techniques.
- ◆ To acquaint the knowledge of the subject with modeling and calculation of such processes.
- ◆ To provide an understanding of the general principles of separation processes to allow students to make sensible options given a separation task.
- ◆ To give an awareness of multicomponent complications.
- ◆ To practice design of selected systems: Extractors and continuous tray fractionation columns.

### COURSE OUTCOME

- CO1:** To perform preliminary design calculations for multicomponent separation systems, including azeotropic and extractive cases.
- CO2:** Able to sketch composition profiles for operating multicomponent columns, and calculate these profiles for the infinite reflux case.
- CO3:** Students gain knowledge about equipment for solvent extraction.
- CO4:** Able to design liquid extraction columns and knowledge about calculations on cocurrent and countercurrent solvent extraction process.

### EQUILIBRIUM IN LIQUID - LIQUID SYSTEMS

Binary and ternary Liquid Equilibria, Tie-lines, Critical solution temperature, Tie line correlations, Contour/prism diagrams, Binary / Ternary prediction methods of activity coefficient, Theory and prediction of diffusion in Liquids, Theory of interphase mass transport, Estimation and prediction of mass transport coefficients. (9)

### DIFFERENTIAL/STAGE-WISE EQUILIBRIUM CONTACT OPERATIONS

Equilibrium stage-wise contact, Single and multiple contacts with cocurrent and countercurrent flow of phases for immiscible and partially miscible solvent phases, Calculation methods, Fractional extraction, Extraction with reflux of raffinate and extract. (9)

### DISPERSION AND COALESCENCE IN EXTRACTORS

Characteristics of dispersion involving single and multiple nozzle distributors, Drop size and formation and coalescence, Mean drop size at dispersions and their setting velocities/

relative characteristic velocities. Effect of drop oscillation, wobbling and internal circulation, Effect of surfactive agents, Prediction of drop size and characteristic velocity in spray, packed and mechanically agitated contactors as in RDC, pulsed columns, Solute transfer effects on drop dynamics. (9)

### **EXTRACTION EQUIPMENTS - CLASSIFICATION AND SELECTION**

Equipment for strategic and continuous contact. Construction and working principles of unagitated columns, spray columns, packed column, perforated plate towers, rotary agitated columns, pulse agitated extraction columns, mixer-settlers and other extractors. (9)

### **DESIGN OF EXTRACTION COLUMNS**

Design of Extractor height and diameter, Prediction of flow capacities in terms of flooding rates, Regime of operating envelopes, Hydrodynamic design variables such as holdup, characteristic velocity, pressure drop, Effect of direction of solute transfer on these variables and their prediction methods, Correction of mass transfer data. Axial mixing correction for column height, Interfacial area estimations, using slow, fast and instantaneous reactions and their application with models for mass transfer coefficients. (9)

**Total: 45**

### **TEXT BOOKS**

1. *Treybal, R.E. Liquid Extraction, McGraw - Hill, New York, 1963.*
2. *John Rydberg, Michael Cox, Solvent Extraction principles and practice, 2nd ed., 2005.*
3. *Manuel Aguilar, Joes Luis Cortina, Solvent Extraction and Liquid Membranes Fundamental and Applications in New Materials, CRC Press, 2008.*

### **REFERENCES**

1. *Kafarov V.V., Fundamentals of Mass Transfer, State publishing House, Moscow, 1962.*
2. *Laddha, G.S., T.E. Degaleesan, Transport Phenomena in Liquid Extraction, Tata McGraw Hill Publishing Company Limited, New Delhi, 1976.*

# 15MCHE09 FOOD PROCESS ENGINEERING AND TECHNOLOGY

ASSESSMENT : THEORY

L	T	P	C
3	0	0	3

## COURSE OBJECTIVE

- ◆ To provide basic information of food composition, nutrition, food spoilage and contamination.
- ◆ To understand the nature, properties, characteristics, quality and safety of food and conversion of food commodities into high quality product.
- ◆ To learn about the packaging material and packaging equipments used for food.
- ◆ To provide knowledge on the characteristics of some microbial groups that present positive and negative impacts in food.
- ◆ To learn about different methods for food preservation to improve chemical and physical properties of raw food.

## COURSE OUTCOME

**CO1:** To understand various operations involved in Food Processing.

**CO2:** To understand the concepts of material and energy balances in food processing systems.

**CO3:** To understand the fundamental chemical properties and reactions of food with the major chemical reactions.

**CO4:** To be able to identify typical problems found in food processing.

**CO5:** To be able to select the suitable dryers with considering technical point and economical point of view.

## CONSTITUENTS OF FOODS

Carbohydrates-proteins, Lipids, Vitamins, Additives, Preservatives, Solvents, Flavours, Agents, Food Engineering operations, Food sorting, Cleaning, Grading - harvesting - winnowing - drying - storage - prime processing. (9)

## FOOD ENGINEERING PROCESS OPERATIONS

Materials and Energy Balances - Fluid flow applications, Heat transfer applications - Drying Evaporation, Equilibrium stage process, Soxhlet extractions, Applications Mechanical separations, Mixing, Applications, Dairy, Meat Industry Oil and Flat Industry Cereal processing. (9)

## **PRESERVATION OPERATIONS**

Preservation methods and Strategies, Thermal Methods, Nabla Factor Sterilization Types Pasteurization, Dehydro - freezing, Irradiation, Dosimetry, Transport of food and Preservation strategies Cheap and applicable everywhere. (9)

## **PLANT HYGIENE**

Plant Hygiene Design Sterilization Process water quantity upkeep waste disposal Material handling, packaging of solid liquid foods, Food storage, special case studies. (8)

## **DEVELOPMENTS IN FOOD PROCESSING**

a) Developments in Food Processing Pruteen Food for future, Food constituents and processing, Food emulsions, Food Rheology, Advances in thermal Operation Extrusion, Cooking Spray dryer design, Energy expenditure and saving Food, for developing countries, Food Detoxification, Production of Sweeteners, starch, Microbial Polysaccharides, Aminoacid, Rice bran Tocopherols.

b) Quality control in food industry, Dose response relationship, Health problems, chemical and Microbiological aspects, Food analysis, Instruments and Enzymatic analysis, Food safety. (10)

**Total: 45**

## **TEXT BOOKS**

1. *Wilhelm L.R., Suter D.A., and Brusewitz G.H., Food Process Engineering and Technology, ASAE, 2005.*
2. *Earle R.L Unit operations in food processing, Pergemmon Press, Oxford, UK 1990.*

## **REFERENCES**

1. *Jowitt R, Hygienic Design and operation of food plant, AVI Pvt. Co., Westort, 1980.*
2. *Brennan J., Butters G.J.R., Cowell N.D. and AEV Lily, Food Engineering Operations, Applied Science Publishers, London, 1990.*
3. *Bourne E .M. Food Texture and Measurement of viscosity, Academic press, New York, 1982.*

## 15MCHE10 SAFETY ENGINEERING

### ASSESSMENT : THEORY

L	T	P	C
3	0	0	3

### COURSE OBJECTIVE

- ◆ Gain a better understanding of various hazards and its effects on health and environment.
- ◆ Ability to quantify risk analysis and control methods
- ◆ Provides a working knowledge of risk management which incorporates risk assessment, emergency handling, Standards, and Nil Risk Quantification methods
- ◆ Students should be able to function effectively in a lab team with safety precautions.

### COURSE OUTCOME

**CO1:** Gives standard limitation to dispose waste to prevent health and environmental effect and also quantifying risk analysis

**CO2:** To explore tools and techniques required for risk reduction.

**CO3:** To identify the sources causing hazard and gives the control methods, storage and handling of hazardous chemicals.

**CO4:** To apply hazard identification and assessment techniques for safe system design.

### GENERAL

Safety Total definition Hazard identification, General hazards of plant operation Toxic hazards, Fire and Explosions - Hazards Transport of Chemicals with safety Unforeseen deviations Emergency management, Planning for safety, Selecting a basics of safety Preventive and protective measures, Safety based on emergency, Relief systems, Safety based on containment Operational safety procedural instructions Sla-Routine checks, Process and product changes, Safety Checks, Checklist for safety, Leaks and detection. (9)

### HAZARDS AND EFFECTS

Hazards of plant operation, Toxic Hazards, Fire and explosion hazards, Reaction hazards, Literature calculations and Explosions Screening, Normal reaction, Gas evolution, Characterizing Runaways, Control and Mitigation of Gas emanations, Absorption with Chemical reaction, Health and environ effects. (7)

### SAFETY DISPOSAL METHODS

Special Problem of Developing countries, Safety gadgets, Dispersions, Degree of hazards, Disposals, Hierarchy of options, I.C.A. Application, Nil Hazards and Alternate methods, Threshold limits, Laws of safety, Accident Reporting. (6)

## **WASTE MANAGEMENT AND ECONOMICS**

Storage, Central handling safety, Unintentional spills, Runoff Emits, Containment economics, Waste disposal and environ projection, Incineration, Alternatives. (8)

## **RISK ANALYSIS**

Risk Analysis, Evaluation, Mitigation, Hazop, Hazan, Definition, Probability, Quantification-Risk, Engineering, Clean technology, Initiatives, Standards, Emergency Handling, Accident Investigation, Legislation, Nil Risk Quantification methods, Case histories of accidents, Examples of hazards assessment, Examples of use of Hazan, Explosion hazards in Batch units, Technical process, Documentation for Hazardous Chemicals, Format and methods. (15)

**Total: 45**

## **TEXT BOOKS**

1. *Wells G.L.,R.M.C. Seagrave-Flow sheeting for safety, Indian Institute of Chemical Engineering, London U.K,1977.*
2. *Trevur Kletz Butterworth, Learning from accidents, - London, 1988.*
3. *John Barton and Richard Rogers, Chemical reaction Hazards - A guide to safety, Institution of Chemical Engineering London,1997.*

## **REFERENCES**

1. *Rohatgi A.K, Safety handling of Hazardous Chemicals Enterprises, Bombay,1986.*
2. *Shukla S.K., Envirohazards and Techno Legal aspects, Shashi Publications, Jaipur India, 1993.*

# 15MCHE11 STATISTICAL THERMODYNAMICS

**ASSESSMENT : THEORY**

L	T	P	C
3	0	0	3

## **COURSE OBJECTIVE**

- ◆ To provide fundamental knowledge of statistical mechanics, concept of entropy and to overcome the discrepancy between a microscopic (statistical mechanics) and a macroscopic approach (thermodynamics), intermolecular interactions on different properties.
- ◆ Demonstrate a knowledge of atomic and nuclear physics.
- ◆ Statistical thermodynamics provides the analytical framework needed to determine important thermodynamic and transport properties associated with practical systems and processes.
- ◆ To provide basic concepts of particle transport. Applied thermodynamics and heat Transfer principles to the analysis of nuclear power components and systems.

## **COURSE OUTCOME**

**CO1:** Able to explain the basic terms and concepts involved in heat transfer.

**CO2:** Ability to calculate the heat capacity, internal energy, entropy, and the equilibrium constant at different temperatures.

**CO3:** Predict chemical processes basing on thermodynamic principles.

**CO4:** Relate the properties of a system to the energy transfers within individual particles.

**CO5:** Apply the laws of thermodynamics on a molecular level.

## **QUANTUM CONSIDERATIONS**

Introduction, Internal energy levels, Microstates, Macrostates and Probability, Case or repeated trials, Phase space, Combinatorial Problems with respect to particles and energy states.

(9)

## **ENTROPY AND PROBABILITY**

Thermodynamic probability, State of maximum Thermodynamic probability, Microscopic meaning of entropy, Use of Lagrangian multipliers, Stirling's approximation.

(9)

## **STATISTICAL MECHANICS**

The statistical laws, Maxwell - Boltzmaan statistics, Fermi-dirac and Bose - Einstein statistics, Partition functions, Translational, Rotational etc., Applications of physical models.

(9)

## STATISTICAL EVALUATION OF THERMODYNAMIC PROPERTIES

Ideal Monoatomic gas, Partition function, Calculation of the translational properties of an ideal monoatomic gas, Sector - Tetrode equation, Potential energy functions for a diatomic molecule, Rigid rotor harmonic - Oscillator approximation, Rotational and vibrational partition functions of ideal polyatomic gases. (10)

## THERMODYNAMICS OF IRREVERSIBLE PROCESSES

Irreversible processes, Phenomenological laws, Application of Onsager- reciprocal relations, Seebeck effect, Peltier effect, Thompson effect. (8)

**Total : 45**

## TEXT BOOKS

1. Normand M. Laurendeau, *Statistical Thermodynamics Fundamentals and Applications*, Cambridge University Press, 2005.
2. Terrell L. Hill, *An introduction to statistical Thermodynamics*, Dover Publications Inc., New edition, 1987.

## REFERENCES

1. Sonntag R.E., G.I. Van Wylen, *Fundamentals of statistical Thermodynamics*, John Wiley and sons, New York, 1996.
2. McQuarrie D.A. *Statistical Thermodynamics*, Harper and Row pub, New York, 1973.
3. Howerton M.T., *Engineering Thermodynamics*, D. Van Nostrand Co., New York, 1962.
4. Tien C.L, Lienhard J.H, *Statistical Thermodynamics*, Holt Rinhart and Winston Inc., New York, 1971.

## 15MCHE12 OPERATIONS RESEARCH

### ASSESSMENT : THEORY

L	T	P	C
3	0	0	3

### COURSE OBJECTIVE

- ◆ To learn the concepts of operations research by way of modeling real-world problems as Linear Programming (LP) or Integer Linear Programming (ILP) problem.
- ◆ To learn the geometry and mathematical analysis behind the theory of LPs and ILPs.
- ◆ To learn the connections between LPs, ILPs and combinatorial optimization problems on discrete graph structures.
- ◆ To be aware of the connections between operations research and other math - related courses.

### COURSE OUTCOME

- CO1:** Understand the characteristics of different types of decision-making environments and the appropriate decision making approaches and tools to be used in each type.
- CO2:** Identify and develop operational research models from the verbal description of the real system.
- CO3:** Understand the mathematical tools that are needed to solve optimisation problems.
- CO4:** Understand the connections between LPs, ILPs and combinatorial optimization problems on discrete graph structures.
- CO5:** Ability to solve the proposed models using mathematical software.

### INTRODUCTION AND LINEAR PROGRAMMING

Introduction to operations research - Art of operations research Modeling - Phases of operations research study - Computations of operations research - Linear programming formulation - Simplex method - Two phase technique, Primal and dual problems - Degeneracy - Unbounded solution - Infeasible solution. (9)

### TRANSPORTATION PROBLEM

Modeling - Basic feasible solution - N.W. Corner - Row minima - Column minima - Vogel's approximation method - MODI method - Optimality test - Degeneracy - Assignment and routing problems - Hungarian assignment method - Maximization and minimization - Unbalanced situation - Travelling salesman problem - Transshipment problem. (9)

### SEQUENCING AND GAME THEORY

Introduction - Johnson's rule - Processing jobs through 2 machines - 'n' jobs 3 machines - 2 jobs 'm' machines - [Gantt chart - Graphical method] - Game theory - Two

person zero sum games - Pure strategies and saddle points - Mixed strategies - Solution of games by dominance - Graphical solution - Linear programming model in game theory. (9)

### **PROJECT MANAGEMENT AND INVENTORY CONTROL**

Introduction to Network in project management. Fulkerson's rule - Comparison between Gantt chart and PERT Network - CPM Network - Crashing - Resource scheduling. Inventory control - Functions - Definition of terms and costs - EOQ Models for purchasing, Manufacturing [without and with shortages, price breaks] - Dynamic order quantity - ABC analysis - Lead time - Safety stock - Reorder level. (9)

### **QUEUING THEORY AND SYSTEM SIMULATION**

Definition of terms of queuing model - Derivation of single - channel infinite population model [Poisson arrival and exponential service]. Multichannel service model [No derivation - only problems]. Systems concepts - Types of systems and models - System simulation - Monte - Carlo method - Introduction to simulation languages. (9)

**Total: 45**

### **TEXT BOOKS**

1. *Dharani Venkatakrishnan, S, Operations Research Principles and Problems, Keerthi Publishing House, Coimbatore, 1996.*
2. *Taha, H.A, Operations Research An Introduction, Eighth Edition, Prentice hall of India, 2007.*

### **REFERENCES**

1. *Levin R.I., Kirkpatrick C.A., Rubin D.S., Quantitative Approaches to Management, McGraw Hill International, 8th ed., 1992.*
2. *Hiller F.S., Lieberman G.J., Operations Research An Introduction, 5th ed., Holden Day San Fransisco, 1997.*

## 15MCHE13 RESEARCH METHODOLOGY

### ASSESSMENT : THEORY

L	T	P	C
3	0	0	3

### COURSE OBJECTIVE

- ◆ To help in critical review of literature and assessing the research trends, quality and extension potential of research.
- ◆ To learn the basic statistics involved in data presentation.
- ◆ To provide the influencing factor or determinants of research parameters.
- ◆ To provide the knowledge and skills to undertake a research project, to present a conference paper and to write a scientific article.

### COURSE OUTCOME

- CO1:** Ability to critically evaluate current research and propose possible alternate directions for further work.
- CO2:** Ability to develop hypothesis and methodology for research.
- CO3:** Identify the influencing factor or determinants of research parameters.
- CO4:** Ability to comprehend and deal with complex research issues in order to communicate their scientific results clearly.

### DEFINING THE RESEARCH PROBLEM AND DATA COLLECTION METHODS

Research methodology - definition, mathematical tools for analysis, Types of research, exploratory research, conclusive research, modeling research, algorithmic research, Research process - steps. Data collection methods - Primary data - observation method, personal interview, telephonic interview, mail survey, questionnaire design. Secondary data - internal sources of data, external sources of data. (9)

### MEASUREMENT, SCALING TECHNIQUES AND SAMPLING FUNDAMENTALS

Scales - measurement, Types of scale - Thurstone's Case V scale model, Osgood's Semantic Differential scale, Likert scale, Q - sort scale. Sampling methods - Probability sampling methods - simple random sampling with replacement, simple random sampling without replacement, stratified sampling, cluster sampling. Non-probability sampling method - convenience sampling, judgment sampling, quota sampling. (9)

### TESTING OF HYPOTHESIS - I

Hypotheses testing - Testing of hypotheses concerning means (one mean and difference between two means - one tailed and two tailed tests), Concerning variance - one tailed Chi-square test. (9)

## TESTING OF HYPOTHESIS - II

Nonparametric tests- One sample tests - one sample sign test, Kolmogorov - Smirnov test, run test for randomness, Two sample tests - Two sample sign test, Mann - Whitney U test, K-sample test - Kruskal Wallis test (H-Test). (9)

## ANALYSIS OF DATA, INTERPRETATION AND REPORT WRITING

Introduction to Discriminant analysis, Factor analysis, cluster analysis, multidimensional scaling, conjoint analysis. Report writing - Types of report, guidelines to review report, typing instructions, oral presentation. (9)

**Total: 45**

## TEXT BOOK

1. *Kothari C.R., Research Methodology Methods and techniques, New Age Publications, New Delhi, 2009.*

## REFERENCES

1. *Panneerselvam R., Research Methodology, Prentice Hall of India, New Delhi, 2004.*
2. *Kidder L.H., Research Methods in Social Relations, Hall Saunders International, Japan, 1981.*
3. *Sedhu A.M., Singh A., Research Methodology in social Sciences, Himalaya Publishing House, Mumbai, 2nd ed., 2006.*

# 15MCHE14 ENZYME ENGINEERING

**ASSESSMENT : THEORY**

L	T	P	C
3	0	0	3

## **COURSE OBJECTIVE**

- ◆ To understand the concepts in enzymology and enzyme techniques in biological systems.
- ◆ To develop skills of the students in the area of enzyme engineering with emphasis on bioreactor operation and design.
- ◆ To understand the kinetic behavior of enzymes and its relation to enzyme activity and about inhibition and various types of inhibitors.
- ◆ To describe and characterize enzyme kinetics by using mathematical models.
- ◆ To study about the industrial applications of enzymes.

## **COURSE OUTCOME**

- CO1:** Students will have clear understanding in isolation, purification and characterization of enzymes.
- CO2:** Understand the enzyme engineering technologies.
- CO3:** Students will have knowledge about the classification of enzymes, immobilization and immobilization techniques.
- CO4:** Students will be able to develop kinetics for enzyme catalysed reactions.
- CO5:** Ability to apply knowledge of enzyme kinetics and describe a number of important technical, industrial enzyme applications and processes.

## **APPLICATION OF ENZYMES**

Classification of Enzymes, Commercial application of enzyme in Food, Pharmaceutical pulp and paper, leather and other industries. Enzyme for diagnostic and therapeutic applications. (9)

## **IMMOBILIZATION TECHNIQUES**

Merits and demerits : Carrier types; techniques of immobilization; fields of application - Immobilization of co-enzymes - Interaction - Chemical synthesis - Characterisation of co - enzyme - analogues exploitation of binding properties of coenzyme. Metalbsaed Enzyme Crosslinking and Stabilization. (9)

## **KINETICS AND MECHANISM OF ENZYME ACTION**

Kinetic Models; modelling of rate equations for single and multisubstrate reactions, types of inhibitions; inhibition kinetics; (9)

## **EFFECTS OF MASS TRANSFER IN IMMOBILIZED ENZYME ACTION**

Analysis of Film and pore Diffusion effects on Kinetics of Immobilised Enzyme Reactions;  
Calculation of Effectiveness Factors of IME systems. (9)

## **DESIGN OF ENZYME REACTORS**

Design and operation of Ideal Reactors - CSTR and PFR; Design of packedbed and  
Fluidized - Bed reactor Immobilized enzyme systems. (9)

**Total: 45**

## **TEXT BOOKS**

1. *Wiseman A., Blake borough N., Dunn ill P., Enzymic and non Enzymic catalysis, Ex. Volume-5 Ellis and Hardwood, UK1981.*
2. *Wiseman A., Topics in enzyme and fermentation Biotechnology, Ellis and Hardwood UK Vol.5, 1977.*

## **REFERENCES**

1. *Technological Applications of Biocatalysts, BIOTOL series, Butterworth, 1995.*
2. *Cornish A., Bowden, Analysis of enzyme kinetic Data, Oxford Univ.Press, 1996.*

# 15MCHE15 INTEGRATED DESIGN OF CHEMICAL PROCESSES

ASSESSMENT : THEORY

L	T	P	C
3	0	0	3

## COURSE OBJECTIVE

- ◆ To invent optimal and sustainable chemical processes by making use of systematic conceptual methods and computer simulation techniques.
- ◆ To process simulation; thermodynamic methods; process synthesis; process integration; and design project including case studies.
- ◆ To gain some knowledge in design project including case studies.
- ◆ To provides an introduction to the newest design methods.

## COURSE OUTCOME

- CO1:** Integrate the knowledge acquired in different chemical engineering courses in the design of a chemical plant.
- CO2:** Conduct preliminary feasibility study of the plant design assigned.
- CO3:** Function and work with others in teams.
- CO4:** Communicate effectively in English especially in presentations.
- CO5:** Apply modern process simulation software (such as HYSYS, ASPEN).

## REACTOR CONDITIONS AND CONFIGURATION

Hierarchy and approaches of Chemical process Design and Integration. Role of process economics, optimization.

Reactor Performance - Idealized reactor models and their choice. Reactor conditions - Reactor temperature, pressure and concentration. Reactor Configuration - temperature control, reactors for homogeneous and hetero reactions. (9)

## HOMOGENEOUS SEPARATORS

Separators for Heterogeneous mixtures. Settling and Sedimentation, Inertial and Centrifugal separation, Filtration, Scrubbing, Flotation and Drying. (9)

## HETEROGENEOUS SEPARATORS

Separator for Homogeneous fluid mixtures, Distillation, Absorption, stripping and Liquid-Liquid extraction, Adsorption, Membranes, Crystallization, Evaporation, Sequencing. (9)

## **NETWORKING**

Reaction, separation and Recycle systems for continuous processes and for batch processes. Heat exchanger networks - Heat transfer equipments, Energy capital and total cost targets, network Design. (9)

## **PROCESS INTEGRATION**

Heat Integration of reactions, Distillation columns, Evaporators, Dryers. Steam systems and Cogeneration, Cooling water networking design. (9)

**Total : 45**

## **TEXT BOOK**

1. *Robin Smith, Chemical Process Design and Integration, Wiley India Private Limited, New Delhi, 2009.*

## **REFERENCES**

1. *Alexandre C. Dimian, Costin Sorin Bildea, Chemical Process Design ComputerAided Case Studies, WILEY-VCH Verlag Gmbh and Co KgaA, Weinheim. 2008.*
2. *Anil Kumar, Chemical Process Synthesis and Engineering Design, McGraw Hill, 1982.*

# 15MCHE16 DESIGN AND ANALYSIS OF EXPERIMENTS

ASSESSMENT : THEORY

L	T	P	C
3	0	0	3

## COURSE OBJECTIVE

- ◆ An understanding of the non-deterministic behavior of manufacturing systems and other engineering processes.
- ◆ An ability to design control charts and monitor the process behavior overtime
- ◆ To design and analyze experiments statistically.
- ◆ To understand how to develop a well designed experiment that results in reliable and valid conclusions.

## COURSE OUTCOME

- CO1:** Given a set process data, characterize the process behavior using descriptive statistics.
- CO2:** Identify if the process in control. If not, identify special patterns that may exist.
- CO3:** Design experiments to identify the main effects, interaction effects and their significance.
- CO4:** Student well equipped in designing experiment.

## INTRODUCTION

Basic principles, guide lines for designing experiments, basic statistical concepts, inferences about the difference in mean, randomized, pair comparison designs, analysis of variance. (9)

## RANDOMIZED BLOCKS, LATIN SQUARES AND RELATED DESIGNS

Completely randomized, randomized Latin square, Graceo-Latin Square and crossover designs (9)

## FACTORIAL DESIGNS

Advantage of factorials, description, calculation of direct and interaction effects. 2k factorial designs. Blocking and confounding - principles and use of confounded designs. (9)

## FRACTIONAL FACTORIAL DESIGN

Two three and mixed level fractional designs and applications. (9)

## RESPONSE SURFACE DESIGN

Fitting regression model. Response Surfaces - First and Second order designs. (9)

**Total : 45**

## **TEXT BOOK**

1. *Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley and Sons inc., 5th ed, 2003.*

## **REFERENCES**

1. *Cochran W.G. , Cox G.M., Experimental Designs., Second Edition, John Wiley and Sons, 1957.*
2. *John Lawson, John Erjavee, Modern Statistics for Engineering and Quality Improvement, Duxbury, 2001.*
3. *Stephen R Schmidt and Robert G Launsby, Understanding Industrial Designed Experiments, Air Academy Press, 1992.*
4. *Davies O.L., The Design and Analysis of Experiments, Longman Group Ltd., 1978.*
5. *Andre I Khuri and John A Cornel, Response surfaces - Design and Analysis, New York Marcel Dekker, 1996.*

# 15MCHE17 SYNTHESIS AND APPLICATIONS OF NANOMATERIALS

**ASSESSMENT : THEORY**

L	T	P	C
3	0	0	3

## **COURSE OBJECTIVE**

- ◆ To provide knowledge on the synthesis and fabrication of nanostructures and nanomaterials.
- ◆ To provide an introduction to both combustion synthesis of functional nanomaterials and nanotechnology.
- ◆ The first part of the course will introduce basic principles, synthesis/fabrication techniques and application of nanoscience and nanotechnology.
- ◆ To The second part of the course will discuss combustion synthesis of nanostructures in zero-, one- two- and three- dimensions, and their characterization methods, physical and chemical properties.

## **COURSE OUTCOME**

- CO1:** Demonstrate a systematic knowledge of the range and breadth of application of nanomaterials.
- CO2:** Review critically the potential impact in all classes of materials of the control of nanostructure.
- CO3:** Describe the methods for the chemical and nanostructural characterization of such materials and select appropriate techniques for a range of situations.
- CO4:** Outline the nanotechnology production routes currently available.
- CO5:** Identify possible opportunities for nanomaterials in product development and enhancement.

## **BULK SYNTHESIS**

Synthesis of bulk nano-structured materials - sol gel processing - Mechanical alloying and mechanical milling - Inert gas condensation technique - Nanopolymers - Bulk and nano composite materials. (9)

## **CHEMICAL APPROACHES**

Self-assembly, self - assembled monolayers (SAMs). Langmuir - Blodgett (LB) films, clusters, colloids, zeolites, organic block copolymers, emulsion polymerization, templated synthesis, and confined nucleation and/or growth. Biomimetic Approaches: polymer matrix isolation, and surface - templated nucleation and / or crystallization. Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition. (9)

## **PHYSICAL APPROACHES**

Vapor deposition and different types of epitaxial growth techniques - pulsed laser deposition, Magnetron sputtering - Micro lithography (photolithography, soft lithography, micromachining, e-beam writing, and scanning probe patterning). (9)

## **NANOPOROUS MATERIALS**

Nanoporous Materials - Silicon - Zeolites, mesoporous materials - nanomembranes and carbon nanotubes - AgX photography, smart sunglasses, and transparent conducting oxides - molecular sieves - nanosponges. (9)

## **APPLICATION OF NANOMATERIALS**

Molecular Electronics and Nanoelectronics - Nanobots - Biological Applications - Quantum Devices - Nanomechanics - Carbon Nanotube - Photonic - Nano structures as single electron transistor - principle and design. (9)

**Total : 45**

## **TEXT BOOKS**

1. *Cao G. Nanostructures, Nanomaterials, Synthesis, Properties and Applications, Imperial College Press, 2004.*
2. *Gaddand, W., Brenner, D., Lysherski, S. and Infrate, G.F., Handbook of NanoScience, Engineering and Technology, CRC Press, 2002.*

## **REFERENCES**

1. *Gaponenko, S.P. Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.*
2. *Barriham, K., Wedensky, D.D. Low dimensional semiconductor structures, fundamental and device applications, Cambridge University Press, 2001.*
3. *George, J. Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.*

## 15MCHE18 RISK ANALYSIS, ASSESSMENT AND MANAGEMENT

### ASSESSMENT : THEORY

L	T	P	C
3	0	0	3

### COURSE OBJECTIVE

- ◆ To develop a working vocabulary of the common terms used in Risk Assessment.
- ◆ To become familiar with the framework of how a risk assessment is performed and used.
- ◆ To develop an understanding of the uses and limitations of risk analysis in chemical industries.
- ◆ To design, implement and execute process of risk management practices.

### COURSE OUTCOME

- CO1:** An ability to apply knowledge of mathematics, science and engineering to the assessment of risk.
- CO2:** An ability to identify, formulates, and solves engineering problems on the area risk management.
- CO3:** To have a sound knowledge to use the techniques, skills, and modern engineering tools necessary for risk management practice.
- CO4:** To utilize a range of popular risk analysis techniques innovatively to examine risk problems in chemical industries.

### GENERAL

Risk types, completion, Permitting, Resource, Operating, Environmental, Manageable, Insurable, Risk Analysis types clauses. (9)

### TECHNIQUES

General, Risk adjusted discounted rate method, Certainty Equivalent Coefficient method, Quantitative Sensitivity analysis, probability distribution, coefficient of variation method, Simulation method, Crude Procedures, Payback period, Expected monetary value method, Refined procedures, Shackle approach, Hiller's model, Hertz Model, Goal programming. (9)

### RISK MANAGEMENT

Emergency relief systems, Diers program, Bench scale experiments, Design of emergency relief systems, Internal emergency planning, Risk management pan, mandatory technology option analysis, Risk management alternatives, risk management tools, risk management plans, Risk index method, Dowfire and explosion method, Mond Index Method. (9)

## **RISK ASSURANCE AND ASSESSMENT**

Property Insurance, Transport insurance, liability insurance, Pecunious insurance, Risk Assessment, Scope convey study, Rijimond pilot study, Low probability high consequence events. Fault tree analysis, Event tree analysis, Zero infinity dilemma. (9)

## **RISK ANALYSIS IN CHEMICAL INDUSTRIES**

Handling and storage of chemicals, process plants, Personnel protection equipment. Environmental risk analysis, International environmental management system, Corporate management system, Environmental risk assessment, Total quality management, Paradigms and its convergence. (9)

**Total : 45**

## **TEXT BOOKS**

1. *Srivastava .S.K., Industrial Maintenance Management , Sultan Chand and Co., 2002.*
2. *Rao, P.C.K., Project Management and Control, Sultan Chand and Co., 1996.*
3. *Sincero, A.P., Sincero, G.A ., Environmental Engineering- A Desgin Approach, Prentice Hall of India, 1996.*

## **REFERENCES**

1. *Pandya, C.G., Risks in chemical units, Oxford and IBH Publishers 1992.*
2. *Fawcett, H.H., Safety and Accident Prevention in Chemical operations by John Wiley and Sons, 1982.*
3. *Kind, R.W., Industrial Hazard and Safety Handbook, Butterworth, 1982.*
4. *Steiner, H.M., Engineering Economic Principles, McGraw Hill Book Co., NewYork, 1996.*

# 15MCHE19 INDUSTRIAL WASTE WATER TREATMENT

**ASSESSMENT : THEORY**

L	T	P	C
3	0	0	3

## **COURSE OBJECTIVE**

- ◆ The study of the subject constitutes the sources, characteristics and treatment of wastewater.
- ◆ It imparts the knowledge of basic principles of science and engineering applied to the problem of water pollution.
- ◆ To provide an understanding of effluent characteristics and effects.
- ◆ The students will be able to understand various analysis and treatment methods of industrial effluents.

## **COURSE OUTCOME**

**CO1:** Recognize and define the quality parameters typically used to characterize wastewater. Identify the processes typically utilized in plants treating wastewater.

**CO2:** Describe various types of unit operation used for preliminary and primary treatment.

**CO3:** Describe and explain how biological wastewater treatment removes pollutants in general, nitrogen and phosphorus in particular. Explain the principles of the suspended and attached growth biological processes and the factors that influence and control these processes.

**CO4:** Recognize emerging technologies for advanced wastewater treatment and water recycling. Discuss wastewater treatment, sludge handling and disposal.

## **CLASSIFICATION AND CHARACTERISTICS OF WASTE WATER**

Sources of industrial wastes. Classification of industries - by Govt. of India. Tolerance limits for trade effluents. Ambient air quality standards in response of noise. Euro norms.

Wastewater characteristics - general, physical, chemical and organic pollution measurements. (9)

## **PHYSICAL UNIT OPERATIONS AND CHEMICAL UNIT PROCESSES**

Classification of wastewater treatment methods. Application of treatment methods. Physical unit operations and chemical unit processes. Design of facilities for physical and chemical treatment of wastewater. (9)

## **BIOLOGICAL UNIT PROCESSES**

Biological unit processes. Design of facilities for the biological treatment of wastewater. Advanced wastewater treatment. (9)

## **RESOURCE RECOVERY AND RECYCLING**

Waste utilization - overview of waste treatment for resource recovery. Recycling of Ferrous, non ferrous metals, glass, paper, plastics and rubber. Recovery of materials, conversion products and energy from solid wastes. (9)

## **STUDY OF VARIOUS INDUSTRIAL EFFLUENTS**

Characteristics, standards, treatment and disposal of pulp and paper, sugar, dye, petroleum, fertilizer, dairy, food, iron and steel industrial effluents. (9)

**Total : 45**

## **TEXT BOOKS**

1. *Metcalf, Eddy, Wastewater Engineering Treatment and Reuse, fourth edition, McGraw-Hill, 2002.*
2. *Hardam Singh Azad., Industrial Wastewater Management Handbook, McGraw-Hill 1976.*
3. *Howard.S.Peavy., Donald.R.Rowe., George Tchobanoglous., Environmental Engineering, 16th ed., McGraw-Hill Book Company 2001.*

## **REFERENCES**

1. *Manivasakam N., Physico-Chemical Examination of Water Sewage and Industrial Effluents, Pragati Prakashan, 2000.*
2. *William D., Robinson P.E., The Solid Waste Handbook, first edition, Wiley Interscience Publication, 1986.*
3. *Herbert F.Lund., Industrial Pollution Control Handbook, McGraw-Hill Company, 1971.*

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# **COIMBATORE INSTITUTE OF TECHNOLOGY**

(Government Aided Autonomous Institution Affiliated to Anna University, Chennai)

**COIMBATORE - 641 014, TAMILNADU, INDIA**

**DIAMOND JUBILEE  
1956 - 2016**



**M.Tech. Chemical Engineering**

**Curriculum and Syllabi  
under choice Based Credit System**

**DEPARTMENT OF CHEMICAL ENGINEERING**

(For the students admitted during the academic year 2015-2016 onwards)