Bansilal Ramnath Agarwal Charitable Trust's

Vishwakarma Institute of Technology

(An Autonomous Institute affiliated to University of Pune)

Structure & Syllabus of

M.E. (Chemical Engineering)

Pattern 'B13'

Effective from Academic Year 2014-15

Prepared by: - Board of Studies in Chemical Engineering

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

Signed by,

Chairman – BOS   Chairman – Academic Board

Contents

M.E. Chemical Engineering: Structure (Pattern B13, 2014-16)

Semester I Structure

Code	Subject	Type	Teaching Scheme		Assessment Scheme					Credits
			L	P	ISA				ESA	
					CT*	MSE	HA*	CA	ESE	
CH50101	Mathematical Methods in Chemical Engineering	Theory	3	0	10	30	10	_	50	3
CH50103	Advanced Transport Phenomena	Theory	3	0	10	30	10	_	50	3
CH50105	Advanced Separation Techniques	Theory	3	0	10	30	10	_	50	3
	Elective I	Theory	3	0	10	30	10	_	50	3
	Elective II	Theory	3	0	10	30	10	_	50	3
CH50301	Postgraduate Laboratory - I	Lab	_	4				100	_	4
HS56301	Communication and Soft Skills	Lab		2				_	100	2
CH50401	Comprehensive Viva Voce - I	Oral	_	_	_		_	_	100	2
CH57701	Semester Project – I	Project	_	6	_	_	_	_	100	2
			15	12						25

***** CT (Unit 1) 1 hour 30 marks converted to 10 marks + HA (minimum 3) – Total 30 marks converted to 10 marks = 20 marks
MSE – 2 hours 60 marks converted to 30 marks (Unit 2 & 3)
ESE – 3 hours 100 marks converted to 50 marks (Unit 1 to 6)

$ L- Lecture, P-Practical, ISA – In Semester Assessment, ESA – End Semester Assessment, CT- Class Test, MSE – Mid Semester Examination, HA- Home Assignment, CA – Continuous Assessment, ESE – End Semester Examination

Semester II Structure

Code	Subject	Type	Teaching Scheme		Assessment Scheme					Credits
			L	P	ISA				ESA	
					CT *	MSE	HA *	CA	ESE	
CH50102	Advanced Reaction Engineering	Theory	3	0	10	30	10	_	50	3
CH50104	Advanced Thermodynamics	Theory	3	0	10	30	10	_	50	3
CH50106	Chemical Process Simulation	Theory	3	0	10	30	10	_	50	3
	Elective III	Theory	3	0	10	30	10	_	50	3
	Elective IV	Theory	3	0	10	30	10	_	50	3
CH50302	Postgraduate Laboratory II	Lab	_	4				100	_	4
CH50702	Technical Seminar - I	Seminar		2				_	100	4
CH50402	Comprehensive Viva Voce II	Lab	_	_	_		_	_	100	2
CH57702	Semester Project – II	Project	_	6	_	_	_	_	100	2
			15	12						27

Semester III Structure

Code	Subject	Type	Teaching Scheme		Assessment Scheme					Credits
			L	P	ISA				ESA	
					CT	MSE	HA	CA	ESE	
	Institute level Open Elective	Theory	2	-	10	30	10	-	50	2
	Department level Open Elective	Theory	2	-	10	30	10	-	50	2
CH60701	Dissertation Stage I	Lab	-	4#	-	-	-	-	100	15
CH60703	Technical Seminar II	Lab	-	2	-	-	-	-	100	4
			4	6						23

 # - Student is expected to work around 40 hours per week as Self Study

Semester IV Structure

Code	Subject	Type	Teaching Scheme		Assessment Scheme					Credits
			L	P	ISA				ESA	
					CT	MSE	HA	CA	ESE	
CH60702	Dissertation Stage II	Lab	-	8#	-	-	-	-	100	25

 # - Student is expected to work around 40 hours per week as Self Study

M. E. Chemical Engineering: Syllabus

Semester I

CH50101: Mathematical Methods In Chemical Engineering

Course Objectives:
To cover mathematical methods – both analytical and numerical – required to address complex mathematical models of chemical engineering systems.

Course Outcomes:
At the end of the course the student should be able to
1. Use linear algebraic methods to solve algebraic and ordinary differential equations
2. Use tensor expressions in orthogonal curvilinear coordinate systems to simplify mathematical models
3. Solve mathematical models of chemical engineering systems involving algebraic, ordinary and partial differential equations analytically and numerically

Unit 1: Tensors, Matrices and Their Applications: (7 Hrs)
Tensor Algebra and Elements of Tensor Calculus, Numerical Linear Algebra: Solution of Systems of Linear and Nonlinear Algebraic Equations and the Algebraic Eigen value Problem

Unit 2: Advanced Topics in ODEs: (7 Hrs)
General Results for Systems of Linear First Order ODEs, Phase Portraits of multi-dimensional Linear Systems, Nonlinear Systems, Elementary Stability and Bifurcation Analysis, Green's Function, Series Solutions and Special Functions, Orthogonal Polynomials, Differential Eigen value Problems, Sturm-Liouville Problems

Unit 3: PDEs: (7 Hrs)
Classification and General Results including the Maximum Principle, Detailed discussion of Laplace's, Wave and Diffusion Equations (class notes and handouts); Boundary Conditions; External vs. Internal Problems; Finite, Semi-Infinite and Infinite Spatial Domains; Solution in Different Coordinate Systems

Unit 4: Analytical Methods for Partial Differential Equations: (7 Hrs)
PDEs arising from models for Reaction-Diffusion-Convection Phenomena, Instability and Pattern Formation in Systems Governed by PDEs.

Unit 5: Numerical Solution to ODEs and PDEs: (7 Hrs)
Finite Difference Method, Method of Weighted Residuals, Pseudo-Spectral Methods, Introduction to Finite Element Method

Unit 6: Perturbation Methods: (7 Hrs)
Regular and Singular Perturbation, Method of Multiple Scales, Homogenization

Introduction to Lattice Methods, Stochastic Simulation Techniques

Total Contact Hours: 42

Textbooks / Reference Books:

1. Strang, G. 'Linear Algebra and its Applications', 4th edition, Thomson, 2006.
2. Pushpavanam, S. 'Mathematical Methods in Chemical Engineering', Prentice Hall of India, 2001.
3. Kreyszig, E. 'Advanced Engineering Mathematics', 8^{th} edition, Wiley, 2008.
4. Beers, K.J. 'Numerical Methods in Chemical Engineering: Applications in Matlab', Cambridge University Press, 2006.
5. Varma, A., Morbidelli, M. 'Mathematical Methods in Chemical Engineering', Oxford University Press, 1999.
6. Bird, R., Stewart, W.E. And Lightfoot, E.N. 'Transport Phenomena', 2^{nd} ed, Wiley, 2006.

CH50103 : Advanced Transport Phenomena

Prerequisites:
Basic concept and review of classical flow problems using shell balances.

Course Objectives:

1. To introduce the student to art of mathematical modeling of current process systems, when transport processes give rise to systems of partial differential equations, integral equations.
2. To teach the student the applications of momentum heat and mass transport principles that lead to design of reactors, separation systems, as well as, instruments and equipment design.
3. To teach the student about the analysis of characteristic time and scales lead to multi-scale models and scale-up practices.

Course Outcomes:

At the end of the course the student should be able to model a complex multiphase – multicomponent chemical system.

Unit 1: Review of mathematics: (7 Hrs)
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).

Unit 2: The equations of change for isothermal flow: (7 Hrs)
Equations of continuity, equation of motion, the equation of mechanical energy, application of Navier-Stokes equation to solve problems, the equations of change for incompressible non-Newtonian fluids.

Unit 3: The equations of change for non-isothermal flow: (7 Hrs)
Equations of energy, the energy equation in curvilinear coordinates, use of equations of change to set up steady state heat transfer for problems.

Unit 4: The equations of change for multi component systems: (7 Hrs)
The equations of continuity for a binary mixture, the equation of continuity of A in curvilinear coordinates, the multicomponent equations of change in terms of the flows, the multi component fluxes in terms of the 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.

Unit 5: Turbulent flow: (7 Hrs)
Introduction, fluctuations and time smoothened equations for velocity, temperature and concentration, time smoothing of equation of change, equation of energy, equation of continuity of A, Reynolds stresses.

Unit 6: Dimensional Analysis: **(7 Hrs)**
Introduction, momentum, heat and mass transfer.

Total Contact Hours: 42

Text Books:

1. R.B. Bird, W. E. Stewart and E. N. Light foot Transport Phenomena Wiley international Edition, New York 2002.
2. C.M. Bender and S.A. Orszag, Advanced Mathematical Methods for Scientists and Engineers, Springer 1999.

Reference Books:

1. L.A. Glasgow, Transport Phenomena (An Introduction to Advanced Topics), Wiley 2010.
2. G.K.Batchelor An introduction to fluid dynamics, Cambridge university press, Cambridge, 1967.
3. J.C. Slaterry momentum Energy and mass transfer in continua Robert e. Kridger publishing company. New York 1981.
4. James R.Welty, Charles E. Wicks and Robert E. Wilson, Fundamentals of momentum, heat and mass transfer, John Wiley & sons, Inc New York.

CH50105 : Advanced Separation Techniques

Course Objectives:

1. Introduce novel separation techniques.
2. Create awareness of industrial applications and economics.
3. Teach method of designing.

Course Outcomes:

1. The students will be aware of new separation techniques and their industrial applications.
2. They should able to compare various techniques and choose correct one.
3. Using mathematical model they should able to size a unit for particular separation problem.

Unit 1 :Introduction: (7 Hrs)

Reveiw of conventional processes, Recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances, Process concept. Separation from solid mixtures, zone melting, Phann theory, equipment used and mathematical model.

Unit 2 : Advanced distillation techniques: (7 Hrs)

Extractive distillation with liquid solvents, with solid salts, and with mixture of liquid solvents and solid salts. Extractive distillation with ionic liquids. Molecular distillation. Mathematical modeling of molecular distillation, comparison of different distillation processes.

Unit 3 : Advanced extraction processes: (7 Hrs)

Liquid Emulsion Membrane Processes, applications, mathematical modeling. Supercritical fluid extraction, design and modeling of the process, industrial examples. Extraction using ionic liquids.

Unit 4 : Membrane Separation: (7 Hrs)

Types and choice of membranes, Plate and frame, tubular, spiral wound and hollow fiber membrane reactors and their relative merits, Commercial, pilot plant and laboratory membranes permeators involving dialysis, reverse osmosis, Nanofiltration, ultrafiltration, microfiltration and dialysis, Economics of membrane operations, Ceramic membranes.

Unit 5 : Separation By Adsorption Techniques: (7 Hrs)

Mechanism, Types and choice of adsorbents, Normal adsorption techniques, Affinity chromatography and immuno chromatography. Types of equipment and commercial processes, Recent advances and process economics.

Unit 6 :Ionic Separations: (7 Hrs)

Controlling factors, Applications, Types of equipment employed for electrophoresis, Di-electrophoresis, Ion exchange chromatography and electro dialysis, Commercial Processes

Total Contact Hours: 42

Text Books:

1. King, C.J. " Separation Processes ", Tata McGraw - Hill Publishing Co., Ltd., 1982.
2. Ramaswamy S., Huang H., Ramarao B., “Separation and Purification Technologies in Biorefineries”, Wiley Publication, 2013.

Reference Books :

1. Lacey, R.E. and S.Loaeb - " Industrial Processing with Membranes ", Wiley -Inter Science, New York, 1972.
2. Ronald W.Roussel - " Handbook of Separation Process Technology ", John Wiley, New York, 1987.
3. Schoew, H.M. - " New Chemical Engineering Separation Techniques ", Interscience Publishers, 1972.

Elective I and Elective II

Please see the syllabi of the elective courses given at the end.

CH50301: Postgraduate Laboratory - I

Course Objectives:

i. To develop analytical mind in day to day life.
ii. To get an acquaintance with classical and advanced analytical techniques.
iii. To apply the knowledge of fluid mechanics, reaction engineering and advanced separation techniques.

Course Outcomes:

i. Students will become conversant with different analytical techniques which they will use in their research projects.
ii. Student will learn to apply the knowledge of fluid mechanics, reaction engineering and advanced separation techniques.

Experiments should be performed based on but not limited to the following List of Experiments.

List of Experiments:

1. Experiment on fluidization (gas-solid and liquid-solid)
2. Hydrodynamics of packed bed
3. Batch Reactor, Plug Flow Reactor, Single Continuous Stirred Tank Reactor
4. Rectors in combination (Two CSTR's in series, CSTR followed by PFR)
5. Residence time distribution in CSTR, PFR
6. Examples actual Mass transfer with Chemical Reaction (Carbonization of $CaCO_3$ synthesis)
7. Synthesis of Metal Nanoparticles.
8. Heat transfer characteristics of nanofluids.
9. Emulsion polymerization PMMA synthesis
10. Adsorption Isotherm and Cyclic Adsorption Process
11. Pressure activated Membrane Process
12. Nano Filtration, Ultra Filtration, Micro Filtration
13. Counter-Current Multistage Extraction
14. Electrolysis and Ion-Exchange
15. Residue Curve Mapping
16. Reactive Distillation
17. To detect, separate and quantitate solitary component system OR components of complex mixtures using High Performance Liquid Chromatography (HPLC).
18. To justify Beer Lambert's law and to determine concentration of a given compound from unknown sample using UV-Visible Spectrophotometer.
19. To detect, separate and quantitate solitary component system using Gas Chromatography (GC).
20. To test water samples for the presence of ionic moieties and to quantitate them by using Ion Chromatography (IC).

Total Contact Hours: 4 Hrs/ Week

Text Books:

1. Fogler, H. S., ‘Elements of Chemical Reaction Engineering’, 2nd ed., Prentice-Hall, 1992.
2. Perry, R. H., D. W. Green, J. D. Malorey, “Perry’s Chemical Engineers Handbook”, McGraw-Hill, 1984.
3. Douglas A. S., “Fundamentals of Analytical Chemistry”, Brooks/Cole, 2004.
4. King, C.J., “Separation Processes", Tata McGraw - Hill Publishing Co., Ltd., 1982.
5. Lacey, R. E., S. Loaeb, “Industrial Processing with Membranes", Wiley -Inter Science, New York, 1972.

Reference Books:

1. Dean, A. (Ed.), ‘Lange’s Handbook of Chemistry’, McGraw-Hill, 1973.
2. John Kenkel, ‘Analytical Chemistry for Technicians, Third Edition, CRC Press, 2002
3. Ho W. S., K. K. Sirkar, “Membrane Handbook”, VNR New York, 1992.
4. Belfort G., “Synthetic membrane Processes”, Academic Press New York, 1984.
5. Cheryan M., “Ultrafilteration Handbook”, Technomic Publication, Lancaster, 1986.
6. Levenspiel O., D. Kunii, “Fluidization Engineering”, John Wiley, 1972.
7. Ronald W. Roussel, “Handbook of Separation Process Technology”, John Wiley, New York, 1987.

HS56301: Communication and Soft Skills

CH50401: Comprehensive Viva Voce - I

CH57701: Semester Project - I

Semester II

CH50102:Advanced Reaction Engineering

Course Objectives:
The focus of the course is on heterogeneous reactions with coverage of the following topics:
1. Non-ideal flow in reacting systems,
2. Fluid-particle non-catalytic reactions
3. Fluid-fluid reactions
4. Catalysis and solid catalyzed reactions
5. Recent trends in chemical reaction engineering

Course Outcomes:
1. Analysis of solid catalyzed heterogeneous reactions
2. Modelleing of non-ideal reactors
3. Use of regression methods for kinetic model discrimination
4. Modelling of Gas-Liquid-Solid heterogeneous reactions

Unit 1: Kinetics Of Heterogeneous Reactions: (7 Hrs)
Catalytic Reactions, Rate controlling steps**,** Langmuir - Hinshelwood model, Rideal - Eiley Mechanism, Steady State approximation, Noncatalytic fluid - solid reactions, Shrinking and unreacted core model.

Unit 2: Population Balance Models: (7 Hrs)
Mixing concepts, Residence Time Distribution, Response measurements, Segregated flow model, Dispersion model, Series of stirred tanks model, Recycle reactor model, Analysis of non-ideal reactors.

Unit 3: External Diffusion Effects In Heterogeneous Reactions: (7 Hrs)
Mass and heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects, Modeling diffusion with and without reaction.

Unit 4: Internal Transport Processes In Porous Catalysts: (7 Hrs)
Intra pellet mass and heat transfer, Evaluation of effectiveness factor, mass and heat transfer with reaction.

Unit 5: Design Of Heterogeneous Catalytic Reactors: (7 Hrs)
Isothermal and adiabatic fixed bed reactors, Non-isothermal and non-adiabatic fixed bed reactors. Introduction to multiphase reactor design, Two phase fluidized bed model, slurry reactor model, Trickle bed reactor model.

Unit 6: Introduction to multiphase reactor design: (7 Hrs)
Two phase fluidized bed model, slurry reactor model, Trickle bed reactor model. Photocatalytic reactor, Sonochemical reactors.

Total Contact Hours: 42

Text Books:

1. Smith J.M. - " Chemical Engineering Kinetics ", McGraw-Hill, 1981.
2. Fogler H.S - " Elements of Chemical Reaction Engineering ", Prentice - Hall 1986.

Reference Books:

1. Walas, S. M; ‘Reaction Kinetics for Chemical Engineers’, McGraw Hill, New York 1989.
2. Bischoff and Froment - " Chemical Reactor Design and Analysis ", Addision - Wesley, 1982.
3. Chaudhari and Ramachandran – “ Three Phase Catalytic Reactors” , Gordan – Breach, 1983.

CH50104: Advanced Thermodynamics

Course Objectives:
This course will address
1. Molecular and statistical thermodynamics, states of matter and their properties, with emphasis on only equilibrium aspects.
2. Phase transitions and stability from a macroscopic thermodynamics viewpoint.
3. Introduction to Statistical Mechanics.
4. Thermodynamic of Irreversible Processes

Course Outcomes:
At the end of the course the student should be able to understand the molecular and statistical thermodynamics, states of matter and their properties.

Unit 1: Quantum Considerations: (7 Hrs)
Introduction, Internal energy levels, Microstates, Macrostates and Probability, Case or repeated trials, Phase space, combinatorial problems with respects to particles and energy states.

Unit 2: Entropy and Probability: (7 Hrs)
Thermodynamic probability, State of maximum Thermodynamic probability, Microscopic meaning of entroy, Use of Lagrangion multipliers, Stirling's approximation.

Unit 3: Statistical Mechanics: (7 Hrs)
The statistical distribution laws, Maxwell - Boltzmann statistics, The Fermi-Dirac and Bose -Einstein Statistics, Partition functions, Transnational, Rotational etc., Applications of physical models.

Unit 4: Statistical Evaluation Of Thermodynamic Properties 1: (7 Hrs)
Ideal Monatomic gas, Partition function, Calculation of the translational properties of an ideal monatomic gas, Sackur - Tetrode equation

Unit 5: Statistical Evaluation Of Thermodynamic Properties 2: (7 Hrs)
Potential energy function for a diatomic molecule, Rigid rotor harmonic – oscillator approximation, Rotational and vibrational partition functions of ideal polyatomic gases.

Unit 6: Thermodynamic Of Irreversible Processes: (7 Hrs)
Irreversible processes, Phenomenological laws, Application of onsager - reciprocal relations, Seebeek effect, Peltier effect, Thompson effect.

Total Contact Hours: 42

Reference Books:

1. Sonntag R.E. and G.I. Van wylen - " Fundamental of Statistical Thermodynamics", John wiley and Sons, New York, 1966.

2. McQuarric D.A. - " Statistical Thermodynamics ", Harper and row Pub. New York, 1973.
3. Howerton M.T. - " Engineering Thermodynamics ", D. Van Nostrand Co., Inc., New York, 1962.
4. Tien C.L. and J.H. Lienhard - " Statistical Thermodynamics ", Halt Rinhart and Winston Inc., New York, 1971.
5. Otto Beran J., JulianaBoerio-Gates Vol I & II, “Chemical Thermodynamics: Advanced Applications”, Academic press, 2000.
6. Reid, Prausnitz and Poling, “The Properties of Gases and Liquids”,McGraw Hill Publication

CH50106: Chemical Process Simulation

Course Objectives:

i. To provide basic concepts of modeling and simulation of chemical engineering systems.
ii. To acquire abilities to propose and solve simple chemical process, and unit operation models in the chemical industry

Course Outcomes

i. Apply the strategies of scientific methodology: analysis of problem situation qualitatively and quantitatively, propose hypotheses and solutions to solve chemical engineering problems
ii. Ability to carry out the analysis, design, modeling and simulation of processes and products.
iii. Ability to design, manage and troubleshoot chemical processes.

Unit 1: Basic concepts (06 Hrs)

Introduction to process modeling and simulation, uses of models, fundamental laws, general modeling procedure, simulation tools, process analysis, model based on transport phenomena principle, planning of calculation in a plant simulation

Unit 2: Parameter Estimation and Models (07 Hrs)

Parameter estimation techniques in theoretical as well as numerical models, Models, need of models and their classification, models based on transport phenomena principles, alternate classification of models, population balance, stochastic, and empirical models, unit models.

Unit 3: Modeling and Simulation in Mass Transfer (07 Hrs)

Introduction, vapor-liquid equilibria, bubble point of gas mixtures, dew point calculations, equilibrium flash calculations, tower sizing for valve trays, packed tower design, determination of plate in fractionating columns, multi-component distribution and minimum trays in distillation column. Single and multi-component batch and continuous, extraction, stage-wise absorption

Unit 4: Modeling and Simulation in Heat Transfer and Fluid Flow (06 Hrs)

LMTD in shell and tube heat exchanger, double pipe heat exchangers, air cooler, condensation, evaporation, steady-state and unsteady-state heat exchanger, jacketed reactor, gas flow system, hydraulic transients

Unit 5: Modeling and Simulation of Chemical Reactors (07 Hrs)

Modeling scheme, liquid phase CSTR, heterogeneous kinetics, particle age distribution in CSTR, tubular chemical reactor, reactor with axial dispersion, Modeling and simulation of batch reactor, CSTR, PFR, Classification of fixed bed reactor models, one dimensional and two dimensional fixed bed reactor models, fluidized bed reactor models, bioreactor models

Unit 6: Numerical Methods for Modeling and Simulation (07 Hrs)

Newton-Raphson method, Secant method, system of nonlinear equations, roots of polynomials, Mueller's method, Gauss-Seidel method, Curve fitting: Least square regression, interpolation, Numerical differentiation and Integration, Partial differential equations: Finite difference method, elliptical and parabolic equations, Laplace equation, solution techniques, boundary conditions, explicit method, Introduction and use of different softwares for modeling and simulation

Total Contact Hours: 40

Text Books:

1. Franks R.E.G., "Modeling and Simulation in Chemical Engineering", Wiely Intr-science, NY
2. John Ingam, Irving J. Dunn., "Chemical Engineering Dynamic Modeling with PC simulation", VCH Publishers.
3. Chapra S.C., R.P. Canale, "Numerical Methods for Engineers", Tata-McGraw Hill Publications

Reference Books:

1. Kayode Coker A., "Chemical Process Design, Analysis and Simulation", Gulf Publishing Company.
2. Wayne Blackwell, "Chemical Process Design on a Programmable Calculator", McGraw Hill.
3. Wayne Bequette, " Process Dynamics, Modeling, Analysis and Simulation", Prantice Hall
4. Teukolsky S.A., W.H. Press, "Numerical Recipes in 'C' ", Cambridge University press
5. Constantinides A., "Applied Numerical Methods with Personal Computer", Mc-Graw Hill publishers
6. Himmelblau D., K.B. Bischoff, "Process Analysis and Simulation", John wiely & Sons.

Elective III and Elective IV

Please see the syllabi of the elective courses given at the end.

CH50302: Postgraduate Laboratory - II

Course Objectives:

i. To provide introduction to systematic problem solving methods.
ii. To introduce programming languages as a powerful, broad-based tool which can be used to analyze and solve many Chemical Engineering problems.
iii. To solve Example problems and laboratory projects drawn from the Chemical Engineering field whereby the student learns to apply appropriate software or numerical methods

Course Outcomes:

i. Students will learn different simulation tools which will help them for solving many Chemical Engineering Problems.
ii. Student will learn simulation software's such as ASPEN PLUS, HYSYS, MATLAB and others software's which are useful in process engineering.
iii. Students should be able to apply advanced computational techniques to Chemical Engineering systems

Experiments should be performed based on but not limited to the following List of Experiments

List of Experiments:

1. Dynamics of a Stirred Tank Heater with variable Volume
2. Modeling and Dynamics of a Quadruple Tank System.
3. Decoupled SISO control of the Quadruple Tank System.
4. Multi-variable Control of the Quadruple Tank System.
5. Dynamic Matrix Control of the Stirred Tank System.
6. Experiment on Programmed Adaptive Control System
7. Experiment on Time-delay compensation (Smith-Predictor)
8. Experiment on Inverse Response compensation
9. Experiment on multiple outputs controlled by a single input
10. Experiment on a single output controlled by multiple input
11. Introduction to process simulators and CFD software- ASPEN PLUS, HYSYS.
12. Simulation of steady state and Dynamic processes using ASPEN PLUS
13. Simulation of a batch reactor, CSTR, Tubular Reactor, multiphase reactor systems
14. Simulation of a shell and tube heat exchanger
15. Simulation of a condenser
16. Simulation of a pump/compressor
17. Simulation of a fixed bed absorber
18. Simulation of a staged distillation column
19. Simulation of flow in channels and pipes
20. Simulation of flow in sudden expansion/contraction systems
21. Simulation of flow in a square cavity, cylindrical venturi, slit venturi and orifice plate.
22. Process simulation study (flow sheeting)- Production of hydrogen by stream reforming

23. Process simulation study (flow sheeting)- Production of vinyl chloride monomer flowsheet
24. Process simulation study (flow sheeting)- Production of nitric acid from anhydrous ammonia

In the Practical Examination students must be able to simulate any of the above Processes/Process Equipment using Computer Programs or Simulation Packages such as ASPEN PLUS/CHEMCAD/HYSYS (UNISIM)/gPROMS etc.

Total Contact Hours: 4 Hrs/ Week

Text Books:

1. Froment G.F., K. B. Bischoff, "Chemical Reactor Analysis and Design", 2nd Ed., Wiley, 1990
2. Franks R.E.G., "Modeling and Simulation in Chemical Engineering", Wiely Intrscience, NY
3. John Ingam, Irving J. Dunn., "Chemical Engineering Dynamic Modeling with PC simulation", VCH Publishers.
4. Chapra S.C., R.P. Canale, "Numerical Methods for Engineers", Tata-McGraw Hill Publications

Reference Books:

1. Lewin D.R., "Using Process Simulators in Chemical Engineering – A Multimedia Guide for Core Curriculum", 2nd Ed., Wiley, 2003
2. Finlayson B.A., "Introduction to Chemical Engineering Computing", Wiley 2006
3. Jana A.K., "Process Simulation and Control using ASPEN" Prentice Hall, 2009
4. Jana A.K., "Chemical Process Modelling and Computer Simulation" Prentice Hall, 2008
5. Aris R., "Mathematical Modeling, Vol. 1: A Chemical Engineering Perspective (Process System Engineering)", Academic Press, 1999
6. Ogunaike B. A.; Ray W.H., Process Dynamics, Modeling and Control, Oxford University Press, NY, 1994
7. Bequette B. W., Process Dynamics: Modeling, Analysis and Simulation", Prentice Hall International Series, 1998

CH50702: Technical Seminar - I

Course Objectives:

1. Deeper exposure to a chosen topic.
2. To learn to compile information about the chosen topic from various sources with emphasis on literature survey based on peer-reviewed journal articles
3. Exposure to report writing skills

Course Outcomes:

At the end of the course the student should be able to

1. Compile and organize information about a chosen topic.
2. Present the information in the form of a compact technical report.
3. Make an oral presentation of the report by using appropriate presentation tools.

The Seminar work will involve the following:

1. Selection of a topic and compilation of information about the same from various sources such as reasearch journals, books, online literature, interaction with industry / research institutions.
2. Submission of a report in the following format: 15-20 pages of A-4 size paper, 1.5 spaced typed material, and appropriately bound.
3. A presentation on the seminar topic by the student

CH50401: Comprehensive Viva Voce – II

CH57702: Semester Project – II

Semester III

Institute level Open Elective

Department Level Open Elective

Please see the syllabi of the elective courses given at the end.

CH60701: Dissertation Stage I

Course Objectives:

i. The objective of the dissertation work is to carry out research and development work.

ii. Student will be required to choose the topic of dissertation in consultation with the faculty guide cad carry out detailed literature survey.

Course Outcomes:

i. Students will have topic for dissertation. They will have extensive literature survey on the selected topic of dissertation.

ii. Student will have their plan of the work and experimental setup ready for further work.

This stage will include a report consisting of synopsis, the plan for experimental/theoretical work and the summary of the literature survey carried out till this stage. This stage will include comprehensive report on literature survey, design and fabrication of experimental set up and/or development of model, relevant computer programs and the plan for stage II.

The Project examinations for Stage I will be based on the report submitted and (orally) presented.
Report for stage I should be submitted in a format provided by the department.

Total Contact Hours: 4 Hrs/ Week

Text Books:

1. Jeff Wu C. F., M. S. Hamada, “Experiments Planning, Analysis, and Optimization”, Second Edition, John Wiley & Sons, New Jersey, 2009.
2. Srinagesh K., “The Principles of Experimental Research”, Butterworth-Heinemann, Burlington, 2011.
3. Zivorad R. Lazic, “Design of Experiments in Chemical Engineering”, Wiley-VCH Verlag GmbH, Weinheim, 2004.

Reference Books:

1. Cochran W. G., W. G. Cochran, G. M. Cox, “Experimental Designs”, Wiley-Interscience publication, 1992
2. Ryan T. P., “Modern Experimental Design”, John Wiley & Sons, New Jersey, 2007.
3. Diamond W. J., “Practical Experiment Designs: For Engineers and Scientists”, Third Edition, John Wiley & Sons, 2001.

CH60703: Technical Seminar - II

Course Objectives:

1. Deeper exposure to a chosen topic.
2. To learn to compile information about the chosen topic from various sources with emphasis on literature survey based on peer-reviewed journal articles
3. Exposure to report writing skills

Course Outcomes:

At the end of the course the student should be able to

1. Compile and organize information about a chosen topic.
2. Present the information in the form of a compact technical report.
3. Make an oral presentation of the report by using appropriate presentation tools.

The Seminar work will involve the following:

1. Selection of a topic and compilation of information about the same from various sources such as reasearch journals, books, online literature, interaction with industry / research institutions.
2. Submission of a report in the following format: 15-20 pages of A-4 size paper, 1.5 spaced typed material, and appropriately bound.
3. A presentation on the seminar topic by the student

Semester IV

CH60702: Dissertation Stage II

Course Objectives:

i. The objective of the dissertation work is to carry out research and development work.
i. To apply knowledge of mathematics, science, and engineering to design and conduct experiments, as well as to analyze and interpret data.
ii. To design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

Course Outcomes:

i. The diversity of research activities in the department will help placement of students and admissions in reputed institution for higher studies.
ii. Students will learn to apply knowledge of mathematics, science, and engineering to design and conduct experiments, as well as to analyze and interpret data.
iii. Students will learn to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
iv. Students will learn to work on multidisciplinary engineering problems.
v. Students will understand the professional and ethical responsibility and they will understand the need for, and to engage in, life-long learning.

This is the final stage in the dissertation work. This stage will include comprehensive report on the work carried out at this stage and relevant portions from stage I, including experimental studies, analysis and/or verification of theoretical model, conclusions. The student is required to publish at least one national/international paper based on the dissertation work. The publication/ accepted paper for publication shall be included in the report.

The Project examinations for Stage II will be based on the report submitted and (orally) presented.

Report for stage II should be submitted in a format provided by the department.

Guidelines for M.E. Chemical Dissertation

1. Research Adviser (Guide):

- Students should have at least one research advisor in the M.E. Chemical Engineering Department.
- To select a research advisor, the student should give their preference of faculty members in potential areas of research interest then department will allot the guide (advisor).

- If the research topic is of an interdisciplinary nature, the student can choose to have two research advisors as long as at least one advisor is from Chemical Engineering Department.

2. Recommendations and tips about finding a research advisor:

- Talk to senior graduate students about their advisors. Share your interests and ask them for suggestions about whom you should meet.
- Make a list of faculty to contact who are involved in research areas that interest you.
- Read about faculty research in journals, conference proceedings and visit their labs.
- Schedule meetings with faculty members. Be knowledgeable about their work in order to have an active discussion about their previous and ongoing research.
- Sometimes working in their lab for academic reasons only will provide you with the opportunity to prove your researching capabilities.
- If possible, enroll in classes being taught by faculty whose work interests you and do well in classes relevant to your research interest and get to know the faculty.

3. Dissertation Proposal Presentation (DPE) and Review of Research Progress:

The DPE is a presentation on the dissertation topic that provides an early assessment of the feasibility of a student's proposed research topic for his/her dissertation. In particular, the presentation is intended to assess the suitability of the topic and the student's academic background for carrying out the proposed research. The presentation is administered by a student's Dissertation Committee (DC). After successful presentation and positive report of DC student is allowed to register for the given topic as his/her Dissertation Topic. **DC should be made of THREE ELIGIBLE FACULTY MEMBERS of chemical engineering department. Same DC members** will track the student's progress and provides feedback and guidance. At each of Dc meetings the student presents his research and responds to the committee members' questions. The purpose of the committee is to provide an outside perspective on the student's research – helping the student to structure his work and identify opportunities. The committee is responsible for approving the student's research plan and signing off on the final dissertation and examination. The research advisor will become the chair of the student's DC except in rare circumstances. The chair will work with the student to assemble a committee consisting of appropriate faculty regarding their experience and research.

Once the DC is formed, the DPE is scheduled as the first meeting of this committee. The student will prepare a written thesis proposal for the committee to review and give an oral presentation to the committee.

4. Pre-Dissertation Submission Presentation:

In this stage student has to present his/her complete work in front of DC. This will be conducted after research adviser's approval of the work carried by the student. After the preliminary approval of the DC to of the work presented by the students, he/she is allowed for writing of the dissertation report.

5. Dissertation Writing:

The dissertation is the most important aspect of the students M.E. program experience, since it documents the original contributions made by the student as a result of independent research. After the preliminary approval of the DC, students are allowed for writing dissertation report. The final draft of the dissertation, it must be formatted to meet the standards of Chemical Engineering Department. Support for dissertation report formatting is available in Chemical Engineering Department, which template assistance, guides, and resources for dissertation preparation. The rough draft of the dissertation report must be approved by the research advisor. Students must submit the final dissertation report the Chemical Engineering Department at least 10 days before the final examination.

6. Final Dissertation Examination (Oral):

The final dissertation examination will be given after the final dissertation report submission. This examination will be a defence of the dissertation report and a test of the candidate's knowledge in the specialized field of research. The format of the examination will be a public seminar presented by the student, with an open question period, followed by an examination by the External Examiner and DC. During this examination student must defend a dissertation and complete all degree requirements as set forth by Chemical Engineering Department and Vishwakarma Institute of Technology, Pune.

Total Contact Hours: 8 Hrs/ Week

Text Books:

1. Jeff Wu C. F., M. S. Hamada, “Experiments Planning, Analysis, and Optimization”, Second Edition, John Wiley & Sons, New Jersey, 2009.
2. Srinagesh K., “The Principles of Experimental Research”, Butterworth-Heinemann, Burlington, 2011.
3. Zivorad R. Lazic, “Design of Experiments in Chemical Engineering”, Wiley-VCH Verlag GmbH, Weinheim, 2004.

Reference Books:

1. Cochran W. G., W. G. Cochran, G. M. Cox, “Experimental Designs”, Wiley-Interscience publication, 1992
2. Ryan T. P., “Modern Experimental Design”, John Wiley & Sons, New Jersey, 2007.
3. Diamond W. J., “Practical Experiment Designs: For Engineers and Scientists”, Third Edition, John Wiley & Sons, 2001.

Departmental Electives: Electives I, II, III and IV

CH52101: Advanced Process Control (Elective)

Course Objectives:

i. The purpose of this course is to provide an advanced treatment of the theory and practice of chemical process modeling and control.
ii. To familiarize the students with various types of controllers and control strategies in complex control and multivariable process control scheme.
iii. To familiarize the students with z transforms and computer process control strategies.

Course Outcomes:

i. Students should be able to develop structured, logical control schemes for complex processes.
ii. Students should be able to choose control configurations for standard operations.
iii. Students should be able to estimate controller parameter settings and to study dynamics of process and control behaviour.

Unit 1: Process Identification and Non-Linear Systems (07 Hrs)

Introduction and motivation, principles of empirical modeling, step response, impulse response, Frequency response identification

Non-linear behavior, Non-linear model and method of dynamic analysis, Linearization, linear system analysis, generalization

Unit 2: Design of More Complex Control Structure (07 Hrs)

Process with significant disturbance, antireset windup, adaptive control principle, variable transformation, Control design for time-delay system, inverse response system, open loop unstable system, Control design for non-linear system, model based control

Unit 3: Multivariable Control System (07 Hrs)

Introduction, multivariable process model, open loop dynamic analysis in state space, multivariable transfer function, open loop- dynamic analysis and Closed loop dynamic analysis, Interaction analysis and loop pairing, RGA and loop pairing, pure integrated model, decoupling, decoupler design

Unit 4: Computer Process Control (07 Hrs)

Introduction to sampled data system, discrete time system, tools for discrete time system analysis, Z-transform, pulse transfer function, Dynamic analysis of discrete time system

Unit 5: Model predictive control (06 Hrs)

General Principles of Model Predictive Control, dynamic matrix control, Model Algorithmic Control, Commercial Model Predictive Control Schemes, statistical process control

Unit 6: Process Control System Synthesis- Case Studies (06 Hrs)

Control of Distillation Columns, Control of Catalytic Packed Bed Reactors, Control of a Solution Polymerization Process, Control of an Industrial Terpolymerization Reactor, Guidelines for Characterizing Process Control Problems

Total Contact Hours: 40

Text Books:

1. Ogunaike B. A., W. H. Ray, "Process Dynamics, Modeling and Control", Oxford University Press, NY, 1994
2. Bequette B. W., "Process Dynamics: Modeling, Analysis and Simulation", Prentice Hall International Series, 1998

Reference Books :

1. Seborg D. E.; D. A. Mellichamp, T. F. Edgar, F. J. Doyle III, "Process Dynamics and Control", 3rd Edition, Wiley.
2. Stephanopoulos G., "Chemical Process Control", Prentice-Hall, Englewood Cliffs, NJ, 1984
3. Marlin T., "Process Control", 2nd Edition, McGraw Hill Inc, US, 2000.

CH52102: Industrial Pollution Control (Elective)

Course Objectives:

1. To study different types of pollutions and pollutant analysis techniques
2. To study the techniques for removal of industrial gaseous and liquid pollutants
3. To Study of environment pollution from process industries and their abatement

Course Outcomes:

This course will enable students to understand different types of pollutions, its causes and effects on the environment. At the end of the course the student should be able to understand the analysis of different gaseous and liquid pollutants and the abetment techniques.

Unit 1: Pollution and its measurement **(7 Hrs)**

Types of pollutions, pollution control aspects, industrial emissions of liquids and gaseous pollutants, environmental legislations, Industrial waste water analysis, industrial gaseous effluent analysis, particle size distribution

Unit 2: **(7 Hrs)**

Removal of organic matter: Biological oxidation, bacterial population dynamics, kinetics of biological growth and its applications to biological treatment, biological oxidation units, anaerobic treatment

Removal of chromium: Control methods, reduction precipitation, lime coagulation, adsorption

Removal of mercury: Removal of mercury from gaseous streams, removal of mercury from liquid streams

Unit 3: **(7 Hrs)**

Removal of particulate matter: particulate dynamics, separation of particulate matter from effluent gases, preliminary methods of separation

Removal of phenolic effluents: sources of phenol, treatment, removal

Unit 4: **(7 Hrs)**

Removal of sulphur dioxide: effects of sulphur dioxide, control methods, reduction of sulphur dioxide concentration, wet process.

Removal of oxides of nitrogen: analysis of NOx, control measures.

Unit 5: Waster water treatment processes: **(7 Hrs)**

Design concepts for primary treatment, grid chambers and primary sedimentation basins, biological treatment

Bacterial population dynamics, kinetics of biological growth and its applications to biological treatment, process design relationships and analysis, determination of kinetic coefficients, activated sludge process.

Design, trickling filter design considerations, advanced treatment processes.

Unit 6: Pollution Control in Process Industries **(7 Hrs)**

Study of environment pollution from process industries and their abatement. Fertilizer, paper and pulp, petroleum and petrochemicals, tanning industries, sugar industries etc

Reference Books:

1. S.P. Mahajan Pollution control in process industries.
2. C. S. Rao Environmental pollution control engineering, 2nd edition
3. N.L.Nemerow, “Liquid waste of industry- theories, Practices and Treatment”, Addison Wesley, New York, 1971.
4. W.J.Weber, “Physico-Chemical Processes for water quality control”, Wiley Interscience,. New York, 1969.
5. W.Strauss, “Industrial gas cleaning”, Pergamon, London, 1975.
6. A.C.Stern, “Air pollution”, Volumes I to VI, academic Press, New York

CH52103: Catalysis and Surface Phenomena (Elective)

Course Objectives:

To learn

1. Catalyst types, synthesis methods
2. Catalyst characterization
3. Therories of catalysis
4. Detailed modeling of industrial catalytic systems

Course Outcomes:

1. The student should able to select correct catalyst for particular reaction.
2. The student should able to determine temperature and conversion for given scheme of reaction and condition.
3. The student should able to design reactor for given industrial catalytic scheme.

Unit 1: Introduction to Catalysis: (7 Hrs)

Classification of Catalysis - Homogeneous, Heterogeneous, Biocatalysts, Preparation of catalysis - Laboratory Techniques, Industrial methods, Transition models, Dual functional catalysts, Zeolites, Enzymes, Solid Catalysts, Powder Catalysts, Pellets, Composition, Active ingredients, Supportive materials, Catalysts activation.

Unit 2: Catalysts Characterization: (7 Hrs)

Surface area measurements, BET Theory, Pore size distribution, Porosimetry Chemisorption techniques, Static and dynamic methods, Crystallography and surface analysis techniques, XRD, XPS, ESCA, ESR, NMR, Raman and Masbauar spectroscopies, Surface acidity and toxicity, Activity, Life time, Bulk density, Thermal stability etc.

Unit 3: Theories of Catalysts: (7 Hrs)

Crystal structure and its defects, Geometric and electronic factors, Analysis of transition model catalysis, Chemistry and thermodynamics of adsorption, Adsorption isotherms – Langmuir model, Tempkin model, Freundich model, Elovich equation, Langmiur Hinshel - wood model, Rideal - Eely mechanism, Reversible - irreversible mono and bimolecular reactions with and without inerts, Determination of rate controlling steps, Inhibition, parameter estimation.

Unit 4: Mass and Heat Transport in Porous Catalysts: (7 Hrs)

Internal and external transport, fixed bed, Fluidized bed reactors, Effect of internal transport on selectivity. Effectiveness factor and Thiele modulus.

Unit 5: Catalyst Deactivation: (7 Hrs)

Poisons, sintering of catalysts, Pore mouth plugging and uniform poisoning models, Kinetics of deactivation, Catalyst regeneration.

Unit 6: Industrial Catalysis: (7 Hrs)

Industrial catalysts preparation methods, Typical industrial catalytic processes, Case studies, Catalytic deactivation prevention methods, New techniques for catalyst characterization, Overall study.

Total Contact Hours: 42

Text Books:

1. Satterfield, C.N. 'Heterogeneous Catalysis in Industrial Practice', 2ed, Krieger Pub. Co., 1996.
2. Emmett, P.H., 'Catalysis Vol. I and II, Reinhold Corp.', New York, 1954.

Reference Books:

1. Smith, J.M., 'Chemical Engineering Kinetics '', McGraw Hill, 1971.
2. Thomas and Thomas, 'Introduction to Heterogeneous Catalysts ', Academic Press, London 1967.

CH52104: Membrane Technology (Elective)

Course Objectives:

1. To learn the fundaments of the different membrane processes and membrane technology to use according to the characteristics of the species to be separated.
2. To learn the selection of the right material and membrane structure according to the properties of the involved compounds.
3. To study the design and applications of different membrane process

Outcomes:

At the end of the course students will be able to understand and solve membrane-based separation/reaction problems by acquiring in-depth knowledge in the area of membrane separation mechanisms, transport models, membrane permeability computations, membrane types and modules etc.

Unit 1: Gas Permeation: (7 Hrs)

Definition, theory and design of gas permeation, applications and economics.

Unit 2: Pervaporation: (7 Hrs)

Definition and background, theory and design of pervaporation, applications and economics.

Unit 3: Dialysis and Electrodialysis: (7 Hrs)

Definition of dialysis and electrodialysis, ion-exchange membranes, design and cost estimates.

Unit 4: Reverse Osmosis: (7 Hrs)

Definition, theory and design of reverse osmosis, mechanistic concept, selected applications and economics.

Unit 5: Ultrafiltration: (7 Hrs)

Definition, theory and mechanistic concepts, membranes, modules and process configurations, applications and economics.

Unit 6: Microfiltration: (7 Hrs)

Definition, theory for deadend microfiltration, theory for cross flow microfilteration, applications design and cost.

Total Contact Hours: 42

Reference Books:

1. Membrane Handbook, by W. S. Ho and K.K.Sirkar VNR New York (1992)
2. Synthetic membrane Processes, Belfort G., Academic Press New York (1984)
3. Ultrafilteration Handbook, Cheryan M., Technomic Publication, Lancaster (1986)

CH52105: Nano Science and Nanotechnology (Elective)

Course Objectives:
Obtain an overview of the various facets of nanotechnology including:
1. historical development
2. characterisation techniques
3. physics and chemistry
4. synthesis / fabrication
5. Applications, with focus on electronic properties

Course Outcomes:
At the end of the course the students should be able to carry out preliminary design of nanotechnology-based products.

Unit 1: Introduction to nano science and nanotechnology: (7 Hrs)
The nanoscale dimension and paradigm, definitions, history and current practice, Overview of current industry applications, Nanoscale science and engineering principles Self-assembly of nano particles and nano structural molecular materials, nanoscale molecular self assembly and self organization of surfactant solutions, Polymers, biological system and liquid crystals. Different structures anisotropic, asymmetric, symmetric particles, clay materials platelets structures, dendrimers, colloid structures

Unit 2: Fundamentals of nano science: (7 Hrs)
Overview of chemistry fundamentals for nanotechnology, Engineering principles for nanotechnology materials and applications Principles of surfaces / colloid chemistry Role of surfaces in nanotechnology devices ,Colloid chemistry and particles in nanotechnology Surface Tension and Interfacial Tension Surfaces at Equilibrium Surface Tension Measurement, Contact Angles, Colloidal Stability, Electrical Phenomena at Interfaces Van der Waals Forces between Colloidal Particles, Intrinsic semiconductors, Band gaps, Law of mass action, Mobility of charge carriers Extrinsic semiconductors The p-n junction, de Broglie's hypothesis

Unit 3: Instrumentation for nanoscale characterization: (7 Hrs)
Instrumentation required for characterization of properties on the nanometer scale. The measurable properties and resolution limits of each technique, with an emphasis on measurements in the nanometer range. Zeta Potential, XRD,TEM,SEM,XPS,DSC, Particle size distribution analysis methods and applications, Cryo TEM for material analysis. Contact angle, surface tension. Gel Permission Chromatography Atomic Force Microscopy, Focus on emerging applications.

Unit 4: Synthesis of nanomaterials: (7 Hrs)
Methods of synthesis of nanomaterials Top down approach, Bottom up approaches, Bottom-up vs. top-down, Insitu Deposition Method, Colloidal Methods, Plasma Technique, Layer by Layer technique Different types of Surfactants, Use of Surfactants Self-assembly, Nanotubes Carbon arc bulk synthesis in presence and absence of catalysts graphite High-pressure CO conversion (HIPCO Chemical Vapor

Deposition (CVD), Micro fluidics and Micro reactors Focus on emerging applications. CdSe. Mini emulsion synthesis

Unit 5: Properties of nanomaterials: (7 Hrs)

Mechanical properties: Strength of nano crystalline, Preparation for strength measurements, Mechanical properties, Magnetic properties, Electrical properties: electronic conduction with nano particles Optical properties: Optical properties. Polymer nanocomposites. Hiding powder improvement coating. New advancement reported in current literature. Population balance Quantum dots properties, dendrimer properties

Unit 6: Applications of nanomaterials : (7 Hrs)

Catalysis : Using nanometal colloids as catalysts, Catalysts, Using, Other Types of Catalysts Made From Nanomaterials, Separations nanofiltration membranes, Magnetic Fluids - Processing Methods and Potential Applications Remediation : TiO_2 photocatalysis, disinfections, advance waste water treatments using metal oxides Drug delivery system, Introduction to industries which produces commercial nanomaterials.

Total Contact Hours: 42

Text Book:

1. Introduction to NanoScience, (CRC Press of Taylor and Francis Group LLC), by G. Louis Hornyak, Joydeep Dutta, Harry F. Tibbals and Anil K. Rao May 2008, 856pp, ISBN-13: 9781420048056

Reference Books:

1. M. Di Ventra, S. Evoy and J. R. Heflin, Jr. (Eds.), Introduction to Nanoscale Science and Technology, Springer, 2004.
2. "Nano science and technology: novel structures and phenomena", Tang, Zikang and Sheng, Ping, Taylor and Francis, 2003
3. "Nano-Engineering in Science and Technology: An Introduction to the World of Nano design", Michael Rieth, World Scientific, 2003
4. R. Kelsall, I. Hamley and M. Geoghegan (Eds.), "Nanoscale Science and Technology",Wiley, 2005.
5. C. P. Poole, Jr., F. J. Owens, Introduction to Nanotechnology, Wiley, 2003.
6. S. A. Campbell, The Science and Engineering of Microelectronic Fabrication, Oxford, 2001.

CH52106: Advanced Food Technology (Elective)

Course Objectives:
1. To understand India's situation in food Industry, compare it with world situation.
2. Find out challenges in food processing industry.
3. Learn chemical and nature of food, food properties, and how to use them in design of equipments need for food processing.
4. Learn about food processing equipments and procedures of preservation and packaging of natural and process food.

Course Outcomes:
1. The student will understand importance of food processing.
2. The student will understand different equipments and the process conditions in food processing.
3. The student will able to design major equipments required in foof processing.

Unit 1: Introduction and Basic Principles: (7 Hrs)
Importance of food Industry in India, Current status of various food products from cereals, dairy, edible oil, fruits, vegetables and beverages. Physical properties determination using modern technology. Properties for taste.

Unit 2: Post Harvesting operations and storage: (7 Hrs)
Use of modern technology for post harvesting operations. Mechanism of degradation of food, water activity.

Unit 3: Treatment of milk: (7 Hrs)
Treatment of milk before storage, effect of pasteurization, heat sterilization, In-container sterilization, storage of oils, filtration, free fatty acids removal, foots and other impurities.

Unit 4: Processing of fruits: (7 Hrs)
Principle involved in Processing of fruits for manufacture of Jams, Jellies, operations and equipments involved. Preservatives involved in it.

Unit 5: Processing of food grains: (7 Hrs)
Theory of size reduction equipments and effect of size reduction on foods, evaporation extrusion, hot air dehydration, baking, roasting and hot oil frying Theory, equipments, applications and effect on food materials for Freezing / Freeze drying and Freeze concentration

Unit 6: Post Processing operations: (7 Hrs)
Coating or enrobing operations, equipment and applications, theory of food packaging, types of packaging materials and packaging operations, filing and sealing of rigid and semi-rigid containers. Materials for handling the food items. Temper evident containers.

Total Contact Hours: 42

Text Books:

1. Matz S. A. : Bakery Technology & Engineering, AVI Publishing, 1960.
2. Charm S. E. Fundamentals of food Engineering, AVI, 1963.

Reference Books:

1. Hall, Farral, Rippen, Encyclopedia of food Engineering, AVI 1970.
2. Shapton & Shapton, Safe Processing of Foods
3. Weiser, Mountney, Gould, Practical Food Microbiology and Technology.
4. Mirajkar M, Menon- Food Science and Processing Technology Vol I & II New Delhi, Kanishka Publishers.
5. Fellows P. , Ellis H., 1990 – Food Processing Technology Principles and Practice –New York
6. Considine D. M., Food and Food Production Encyclopedia, VNR New York 1982.

CH52107: Advanced Materials (Elective)

Course Objectives:

1. Learn advanced materials systems involving metals, ceramics, polymers and composites
2. Learn advances in electronic, optical, magnetic, superconducting materials etc
3. Learn advances in nanotechnology
4. Have an understanding of the correlation between structure and properties of the materials

Course Outcomes:

At the end of the course the students should be able to

1. describe state-of-the-art and future trends in advanced materials systems
2. explain how a specific property is imparted to a material in terms of the material structure

Unit 1: Nanotechnology I: (7 Hrs)

Introduction to quantum mechanics, solid state physics etc (in the context of nanotechnology).Introduction to nanotechnology. Characterization. Nanostructured materials.

Unit 2: Nanotechnology II: (7 Hrs)

Nanoelectronics, biological nanomaterials, nanomachines and nanodevices etc.

Unit 3: Electrical, optical, magnetic properties of materials – I: (7 Hrs)

Electrical conduction. Intrinsic & extrinsic semiconductors. Semiconductor devices. Fabrication of microelectronics integrated circuits-I

Unit 4: Electrical, optical, magnetic properties of materials – II: (7 Hrs)

Fabrication of microelectronics integrated circuits-II. Optical properties of materials, magentic properties of materials, superconductive materials

Unit 5: Advanced Metallic, Polymeric,Ceramic and Composite Materials:(7 Hrs)

Superalloy steels. Superalloys. Engineering polymers s.a. polyamide, polycarbonates etc. Specialty polymers s.a liquid-crystal polymers, conductive polymers etc. Applications. Engineering ceramics s.a. silicaon carbide, silicon nitride, alumina, zirconia.

Unit 6: Topics in materials science and engineering: (7 Hrs)

Open-ended material to be decided by the instructor.

Total Contact Hours: 40

Text Books:

1. Poole, C.P. Jr; Owens, F.J. 'Introduction to Nanotechnology', Wiley India, 2006
2. Campbell, S.A. 'The Science and Engineering of Microelectronic Fabrication', 2nd ed, Oxford University Press, 2001
3. Smith, W.F. 'Foundations of Materials Science and Engineering', 3rd ed, McGraw Hill, 2004

4. Matthews, F.L.; Rawlings, R.D. 'Composite Materials: Engineering and Science', CRC Press, 2005

Reference Books:

1. Fried, J.R. 'Polymer Science and Technology', Prentice-Hall, 1995.
2. Budinski,K.G.; Budinski, M.K. 'Engineering Materials: Properties And Selection', Prentice Hall, 2002.
3. Lee, H.H. 'Fundamentals of Microelectronic Processing', McGraw-Hill, 1990
4. Middleman, S.; Hochberg,A.K. 'Process Engineering Analysis in Semiconductor Device Fabrication', McGraw-Hill Chemical Engineering Series, McGraw-Hill, 1993

CH52108 : Bio-reaction Engineering

Course Objectives:

1. To understand fundamentals of bioreaction engineering and biotechnology for designing and evaluating bioprocesses
2. To understand principles for design of a bioreactor and its mathematical modeling.

Course Outcomes:

1. Able to perform mathematical modeling of bioreactors for various fermentation process and optimal design can be achieved.
2. Able to perform calculations on complex enzyme catalyzed reactions for various industrial applications.

Unit 1 : Advanced Enzyme Kinetics: **(6 Hrs)**

Models for complex enzyme kinetics, modeling of effect of pH and temperature, models for insoluble substrate, models for immobilized enzyme systems, diffusion limitations in immobilized enzyme system, electrostatic and steric effects.

Unit 2 : How cell work **(7 Hrs)**

The central dogma, DNA replications, sending the messages, genetic code, translation, posttranslational processing, sensing of extra cellular environment, roll of cell receptors.

Unit 3 : Major metabolic pathways **(7 Hrs)**

Bioenergetics, Glucose metabolism, metabolism of nitrogenous compounds, respiration, metabolism of hydrocarbons, anaerobic metabolism, autotrophic metabolism.

Unit 4 : Bioreactors **(7 Hrs)**

Modifications of batch and continuous reactors, chemostat with recycle, multistage chemostat, fed-batch operation, perfusion system, active and passive immobilization of cells, diffusional limitations in the immobilized system, solid state fomenters.

Unit 5 : Homogeneous and heterogeneous reactions in bioprocesses **(7 Hrs)**

Reaction thermodynamics, growth kinetics with Plasmid instability, The Thiele Modulus and effectiveness factor, diffusion and reaction in waste treatment lagoon. Reactors and choice of reactors.

Unit 6 : Biological waste water treatment **(6 Hrs)**

Microbial participation in natural cycle of matter, activated sludge process, design and modeling of activated sludge process, Nitrification, anaerobic digestion, mathematical modeling of anaerobic digester, anaerobic denitrification, phosphate removal.

Total Contact Hours: 40

Text Books:

1. Biochemical Engineering Fundamentals – J. E. Bailey and D. F. Ollis – McGraw-Hill
2. Bioprocess Engineering – M. L. Shuler, F. Kargi , Prentice -Hall

Reference Books :

1. Bioprocess Engineering Principles – P. M. Doran – Academic Press

CH52109: Water Treatment and Engineering

Course Objectives:

1. To understand water pollutants, problems and remedies.
2. To learn about optimum utilization and recycle.
3. To learn about rain water harvesting

Course Outcomes:

At the end of the course the student

1. will understand the pollutants, problems and remedies.
2. Will able to take decision about treatment technology.

Unit 1 : Water consumption : (7 Hrs)

Water consumption for domestic applications in world and in India, water consumption by Industrial in the world and in India, analysis of water requirement for various chemical industries, quality of water for boiler, cleaning and process.

Unit 2 : Analysis of water : (7 Hrs)

COD, BOD measurement, TDS measurement, colour, pH, toxicity, needs and standards for various requirement, measurement and determination techniques.

Unit 3: Treatment technology for recycle and reuse for Industrial scale: (7 Hrs)

Methods of treatment for recycle such as adsorption, membrane technique, filtration and other techniques.

Unit 4: Economics of recycle: (7 Hrs)

Cost of treatment technology, cost of water and processing, economic feasibility of above technologies.

Unit 5: Reduction in water requirement of various chemical industries: (7 Hrs)

Case studies with alternative technologies. Cost involved and feasibility of alternating techniques being used in some unit operations and processes.

Unit 6: Rain water harvesting: (7 Hrs)

Techniques of rain water harvesting, water table and its effects.

Total Contact Hours: 42

Text Books:

1. Water Reuse: Issues Technologies and applications: Takashi Asano, Franklin Burton et al. Metcalf and Eddy Inc. an AECOM Company. McGrow Hill NewYork, 1st Ed. 2006
2. Water Treatment : Principles and Design : John Crittenden, R. R. Trucell, D. W. Hand, K. J. Howe, G. Techobanogus, 2nd Edition, John Wiley and Sons, Inc., 2005.

Reference Books:

1. Water and waste water calculations manual : 2nd Edition, Shun Dar Lin, McGraw Hill, 2007.

2. Rain water harvesting for dry lands and beyond: Volume I and II, Brad Lancaster, Rainsource Press (2008)

CH52110: Advanced Optimization Techniques (Elective)

Course Objectives:
The focus of the course is on advanced optimization techniques with coverage of the following topics:

1. Unconstrained optimization
2. Constrained multivariable optimization
3. Gradient based search methods
4. Advanced evolutionary algorithms

Course Outcomes:
Students are equipped with ability to solve problems related to

1. Unconstrained optimization
2. Constrained multivariable optimization
3. Use of spreadsheet and advanced optimization software

Unit 1 :Introduction (6Hrs)
Introduction to process optimization; formulation of various process optimization problems and their classification, basic concepts of optimization-convex and concave functions, necessary and sufficient conditions for stationary points.

Unit 2 :UnconstrainedOptimization (8Hrs)
Optimization of one dimensional functions, unconstrained multivariable optimization-direct search methods. Bracketing methods: Exhaustive search method, Bounding phase method Region elimination methods: Interval halving method, Fibonacci search method, Golden section search method. Point-Estimation method: Successive quadratic estimation method.

Unit 3 :Gradient Based Optimization Algorithms (8Hrs)
Indirect first order and second order method. Gradient-based methods: Newton-Raphson method, Bisection method, Secant method, Cubic search method. Root-finding using optimization techniques.

Unit 4 :Multivariable Optimization Algorithms (7Hrs)
Optimality criteria, Unidirectional search, direct search methods: Evolutionary optimization method, simplex search method, Powell’s conjugate direction method. Gradient-based methods: Cauchy’s (steepest descent) method, Newton’s method.

Unit 5 :Constrained Optimization Algorithms (7Hrs)
Kuhn-Tucker conditions, Transformation methods: Penalty function method, method of multipliers, Sensitivity analysis, Direct search for constraint minimization: Variable elimination method, complex search method.

Unit 6 :Quadratic Programming and Evolutionary Optimization (6Hrs)
Successive linear and quadratic programming, optimization of staged and discrete processes, Genetic Algorithms: Working principles, differences between GAs and

traditional methods, similarities between GAs and traditional methods, GAs for constrained optimization

Total Contact Hours: 42

Text Books:

1. T.F.Edgar and D.M.Himmelblau, optimization of chemical processes, McGraw Hill International editions, chemical engineering series, 1989.
2. Kalyanmoy Deb ,Optimization for engineering design, , Prentice Hall of India

Reference Books :

1. G.S. Beveridge and R.S. Schechter, Optimization theory and practice, McGraw Hill, Newyork, 1970.
2. Rekllitis, G.V., Ravindran, A., and Ragdell, K.M., Engineering Optimization- Methods and Applications, John Wiley, New York, 1983.
3. S.S. Rao, Optimization Theory and Applications, Associated Press, 2009.

CH52111: Computer Aided Design (Elective)

Course Objectives:

1. Introduction to fundamental concepts and principles of process synthesis and design
2. Use of flow sheet simulators to assist in process design.

Course Outcomes:

1. After learning this course students will be able to do the process flow sheet models and life cycle assessment of the process
2. They would be able to do the synthesis of heat exchanger, ideal-non ideal distillation systems and use the flow sheet simulators for the same

Unit 1 : Process Flow sheet Models (7 Hrs)

An Introduction to Design, Chemical process synthesis, analysis and optimization. Product design and developments, Process engineering economics and project evaluation

Unit 2 : Life Cycle Assessments of process (7 Hrs)

From design to product development, Project costing and performance analysis, Environmental concerns, green engineering, engineering ethics, and health and safety. Introduction to commercial process design and costing software such as HYSYS, Aspen plus etc., Chemical Process (reactor, heat exchanger, distillation etc) analysis using commercial software

Unit 3 : Heat Exchanger Network Synthesis (7 Hrs)

Introduction & problem highlights, HENS basics & graphics, The pinch point approach, Performance targets, trade-off & utilities, Heat & power integration, HENS as mathematical programming

Unit 4 : Ideal Distillation (7 Hrs)

Column and sequence fundamentals, Sharp splits & sequencing Phase diagrams for 2, 3 and 4 components, Feasibility and vapor rates for single columns, Residue curve basics

Unit 5 : Non-ideal Distillation (7 Hrs)

Azeotropic systems; detecting binary azeotropes, Residue curve maps for azeotropic systems, Topological analysis, Feasibility for single azeotropic columns ,Binary VLLE and pressure-swing separation, Non-ideal distillation synthesis. Equipment sequencing: VLE + VLLE , Detailed Residue Curve Maps, Residue curve maps: Interior structure

Unit 6 : Reactor Networks (7 Hrs)

Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps

Total Contact Hours: 42

Text Books:

1. Douglas, J. *Conceptual Design of Chemical Processes*. New York, NY: McGraw-Hill Science/Engineering/Math, 1988. ISBN: 0070177627.
2. Seider, W. D., J. D. Seader, and D. R. Lewin. *Product and Process Design Principles: Synthesis, Analysis, and Evaluation*. 2nd ed. New York, NY: Wiley, 2004

Reference Books :

1. Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz. Analysis, Synthesis, and Design of Chemical Processes, 2nd Edition, 2002, Prentice Hall
2. L.T. Biegler, I.E. Grossmann and A.W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall, 1997.

CH52112: Fluidization Engineering (Elective)

Course Objectives:
The focus of the course is on elements of fluidization engineering with coverage of the following topics:

1. Basics of fluidization,
2. Hydrodynamics of fluidization systems,
3. Solid mixing and segregation,
4. Heat and mass transfer fluidization systems,
5. Classical and miscellaneous fluidization systems

Course Outcomes:

1. In-depth understanding of fluidization
2. Mass and energy balances in fluidization systems
3. Modeling of classical fluidization systems
4. Introduction to miscellaneous fluidization systems

Unit 1 : Introduction **(7 Hrs)**
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.

Unit 2 :Hydrodynamics of Fluidization System **(8 Hrs)**

General bed behavior pressure drop, Flow regimes, Incipient fluidization, pressure fluctuations, phase holdups, Measurement techniques, Empircial correlations for soilds holdup, liquid holdup and gas holdup, Flow models - generalized wake model, structural wake model and other imporatant models.

Unit 3 :Solid Mixing and Segregation: **(6Hrs)**

Phase juxtaposition operation shifts, Reversal points, Degree of segregation, Mixing - segregation equilibrium, Generalized fluidization of poly disperse systems, liquid phase mixing and gas phase mixing.

Unit 4 :Heat and Mass Transfer Fluidization Systems **(7 Hrs)**

Mass transfer - gas-liquid mass transfer, Liquid soild 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.

Unit 5 :Classical Systems **(7 Hrs)**

Conical fluidized bed, Moving bed, Slurry bubble columns, Turbulent bed contactor, Draft tube systems, Semi fluidized bed systems, Annular systems, typical applications.

Unit 6 :Miscellaneous Systems **(7 Hrs)**

Two phase and three phase inverse fluidized bed,Geldart's classification for power assessment, Powder characterization and modeling by bed collapsing.

Total Contact Hours: 42

Text Books:

1. Fluidization Engineering, O. Levenspiel and D. Kunii, John Wiley, 1972.
2. Gas-Liquid-Solid Fluidization Engineering, Liang-Shih Fan, Butterworths, 1989.

Reference Books :

1. Fluidization Idealized and Bubbleless, with Applications, Mosoon Kwauk, Science Press, 1992.
2. Advances in Fluidization Engineering (AIChE Symposium Series, No 276, Vol 86), 1990.

CH52113: Polymer Engineering (Elective)

Course Objectives:

1. To acquire fundamental, chemical and physical information on polymerization processes.
2. To determine the data required for the design of polymerization reactors of a variety of types
3. To provide a foundation for industrial practice in polymer science and engineering

Course Outcomes:

1. Able to develop basic models for polymerization reactions and explain the significance of these for reactor design
2. Understanding of control engineering aspects in operation of polymerization process

Unit 1: Introduction: (7 Hrs)

Classification of polymerization reactions. addition polymerization reaction mechanisms and rate equations; Dead end radical polymerization; molecular weight distribution in batch and continuous reactors; avg. molecular weight and experimental determination based on viscosity, osmotic pressure etc.

Unit 2: Review of non idealities in polymerization reactors: (7 Hrs)

Review of RTD & macro and micro mixing in reaction vessels. Comparison of performance batch. Homogeneous continuously stirred tank, segregated continuous stirred tank reactor and laminar flow tubular reactor in case of ionic, free radical and step growth polymerization. Degree of polymerization and MWD

Unit 3: Polymerization processes I: (6 Hrs)

Tromsdorff effect in Free Radical Polymerization. Models of Tromsdorff effect. Extension of these models to step growth polymerizations at high conversions. Interfacial polymerizations in immiscible monomers case

Unit 4 : Polymerization processes II: (6 Hrs)

Models of Heterogeneous Polymerizations. Solution / precipitation, suspension and Emulsion polymerization. Smith Ewart Model. Application to continuous emulsion polymerization. Co-ordination polymerization in fluidized bed reactor.

Unit 5 : **Polymerization Reactors:** (8 Hrs)

Semi-batch reactor operation; Design of batch and continuous reactors. Heat removal from polymerization reaction. Heterogeneous poly-addition reactions; Stock Mayer’s equation; continuous emulsion polymerization; Anionic and Cationic poly addition; Co-polymerization; Mayo’s equation and reactivity ratio; Alfred- Price equation; Rate of co polymerization and y factor; Skiest’s equation. Poly-condensation reactions; Flory’s equation and molecular weight distribution; Molecular weight regulations. Typical case studies of polymers like PE, PP and PS.

Unit 6 : Recent advances in polymerization reactions and control: (6 Hrs)

Design fundaments of reactors for tailor making polymers example metalocene polyolefins. Qualitative account of control engineering considerations in operation of batch and continuous polymerization process

Total Contact Hours: 40

Text Books:

1. Polymer Reactor Engg. - McGreavy, Blackie Academic & Professional, Chapman & Hall, 1994.
2. G. M. Burnett, Mechanism of polymer Reactions, Interscience, 1954.

Reference Books :

1. F. W. Billemeyer, (Ed.) Encyclopaedia of Polymer science and Technology, Interscience, 1969
2. F. M. Bovey, A. K. Medalia, I. M. Kolthoff, Emulsion Polymerisation, Interscience, 1955.
3. G. E. Harn, Co polymerization, Intersicence, 1969.
4. F. W. Billemeyer, (Ed.) Encyclopaedia of Polymer science and Technology, Interscience, 1969.

CH52114:Computational Fluid Dynamics

Course Objectives:

1. To develop the concept and understanding for the various approaches and methodologies used in CFD
2. To develop understanding towards building geometrical model of the flow, applying necessary boundary conditions, specifying corresponding parameters for solution and analyzing the result
3. To build skills in the actual implementation of CFD methods and to analyze flow and heat transfer in problems of practical engineering interest

Course Outcomes:

1. Able to apply CFD analysis to real engineering designs
2. Able to implement CFD methods in commercial CFD codes

Unit 1 : Introduction to Fluid Dynamics: (7 Hrs)

Concepts of Fluid Flow, Pressure distribution in fluids, Reynolds transport theorem, Integral form of conservation equations, Differential form of conservation equations, Different Types of Flows, Euler and Navier Stokes equations, Properties of supersonic and subsonic flows, Flow characteristics over various bodies.

Unit 1a: Conjugate Heat Transfer (CHT): Introduction to CHT, Fluid boundary conditions, CHT solid boundary conditions, CHT interface conditions, many to one CHT interface conditions, linear solver.

Unit 1b: Geometric Modeling and CAD Repairing: Geometric transformations, Parametric representation of curves and surfaces, Concept of topology, Surface modeling, Faceted models, Solid modeling. Creation of water tight geometry, Faceted Boolean operations, Dependent and independent CAD errors.

Unit 2 : Structured and Unstructured Grid Generation: **(5 Hrs)**

Basic theory of structured grid generation, Surface grid generation, Mono block, multi block, hierarchical multi block, Moving and sliding multiblock, Grid clustering and grid enhancement. Basic theory of unstructured grid generation, advancing front, Delaunay triangulation and various point insertion methods, Unstructured quad and hex generation, grid based methods, various elements in unstructured grids, Surface mesh generation, Surface mesh repair, Volume grid generation, Volume mesh improvement, mesh smoothing algorithms, grid clustering and quality checks for volume mesh. Adaptive, Moving and Hybrid Grids, Need for adaptive and, moving grids, Tet, pyramid, prism, and hex grids, using various elements in combination

Unit 3 : Introduction to CFD: **(5 Hrs)**

Philosophy of CFD, Governing equations of fluid dynamics and their physical meaning, Mathematical behavior of governing equations and the impact on CFD simulations, Simple CFD techniques and CFL condition

Unit 4 : Numerical Methods in CFD: **(4 Hrs)**

Finite Difference, Finite Volume, and Finite Element, Upwind and downwind schemes, Simple and Simpler schemes, Higher order methods, Implicit and explicit methods, Study and transient solutions

Unit 5 : Introduction to Turbulence Modeling: **(5 Hrs)**

Introduction and background, Algebraic models, One equation models, Two equation models, Near wall treatment, Reynolds stress models, Eddy viscosity models (EVM), Nonlinear eddy viscosity models, LES, RANS, and, hybrids, Direct numerical simulation (DNS)

Unit 6 : Introduction to Multiphase Modeling: **(5 Hrs)**

Fundamentals of multiphase flows, Eulerian-Lagrangian (ELAG) approach, Eulerian-Eulerian (E2P) approach, Volume Of Fraction (VOF) approach, Solving example problems

Unit 7: Chemical Fluid Mixing Simulation: **(4 Hrs)**
Stirred tank modeling using the actual impeller geometry, Rotating frame model, The MRF Model Sliding mesh model, Snapshot model, Evaluating Mixing from Flow Field Results, Industrial Examples

Unit 8: Post-Processing of CFD results: **(5 Hrs)**
Contour plots, vector plots, and scatter plots, Shaded and transparent surfaces, Particle trajectories and path line trajectories, Animations and movies, Exploration and analysis of data.

Total Contact Hours: 40

Text Books:

1. Computational Fluid Dynamics: The Basics with Applications, John D.Anderson, Mc Graw Hill, 1995.
2. Computational Flow Moeling for Chemical Reactor Engineering, V. V. Ranade, Process Engineering Science, Volume 5, 2001.
3. Fundamentals of Grid Generation, Patrick Knupp and Stanly Steinberg, CRC Press, 1994.
4. An Introduction to Multigrid Methods, Pieter Wesseling, John Wiley & Sons, 1992.

Reference Books :

1. Turbulence Modelling for CFD, D.C. Wilcox 1993.
2. Numerical Grid Generation: Foundations and Applications, J. F.Thompson, Z. U. A.Warsi and C. W. Mastin, North Holland, 1985.
3. Numerical Heat Transfer and Fluid Flow, S.V. Patankar, McGraw-Hill,1981.
4. Simulation and Modelling of Turbulent Flows, Thomas B. Gatski, M. Yousuff Hussaini, John L. Lumley, Eds., Oxford University Press, 1996.
5. Computational Gas Dynamics, Laney, C. B., Cambridge Uni. Press, 1998.

CH52115: Green Chemistry (Elective)

Objectives:

1. To acquire knowledge of issues in sustainability as they relate to business and industry internationally and nationally.
2. To Examine and evaluate case studies of sustainable practices in business and industry.
3. To Visit National & if possible, international organizations that practice sustainability to gain first hand knowledge of operations.
4. To identify best trends and business practices in various concerned organizations.
5. To Understand and analyze the interconnectivity of global concerns.

Outcomes:

1. Understanding of Green Chemistry & Green Engg. Principles.
2. Knowledge of applications of green routes for synthesis of chemicals.
3. Better awareness about global environmental concerns and green remedies to address these concerns.
4. Appraising about tenets of sustainable development and its integration with Green practices.
5. Better realization about reflections of Green Chemistry on sustainable development initiatives.

Contents:

Unit 1: Green Chemistry - An Overview: (7 Hrs)

Introduction: Definition, the twelve basic principles of green chemistry. Green synthetic methods

Unit 2: Materials for green chemistry and technology: (7 Hrs)

Catalysis, environmental friendly catalysts, Biocatalysis, biodegradable polymers, alternative solvents, ionic liquids

Unit 3: Nonconventional energy sources: (7 Hrs)

Thermo-chemical conversion: direct combustion, gasification, pyrolysis and liquefaction, Bioenergy, Biophotolysis: Hydrogen generation from algae biological pathways; Storage and transportation; Applications

Unit 4: Green Synthetic Methods & Catalysis: (7 Hrs)

The design and development of environmentally friendly chemical pathways, Microwave synthesis, electro-organic synthesis, Supercritical fluids (SCFs): examples and properties, Extraction with SCFs

Unit 5: Green Chemistry & Sustainable development: (7 Hrs)

Green chemistry in batteries, production and recycling, Fuel cell and electric vehicles, Solar energy and hydrogen production, biodiesel, bio-hydrogen, Anaerobic digestion, alcohol production from biomass; Chemical conversion process: hydrolysis and hydrogenation; Best practices in Green Chemistry for sustainable development with suitable examples

Unit 6: Green Analytical Methods : (7 Hrs)

Relation between green chemistry and green analytical chemistry, Review of separation methods, Advantages of Electrophoresis, Micronization in Separation Methods, Alternative solvents, etc.

Total Contact Hours: 42

Text Books:

1. Lancaster, M.; Green Chemistry an Introductory Text, Royal Society of Chemistry, Cambridge, UK 2002.
2. Cann, M.C.; Connelly, M.E. Real World Cases in Green Chemistry, American Chemical Society: Washington DC. 2000.

Reference Books:

1. Anastas, P.; Warner, J. Green Chemistry: Theory and Practice; Oxford University Press: London, 1998.
2. Zimmerman, J.B.; Anastas, P.T. "The 12 Principles of Green Engineering as a Foundation for Sustainability" in Sustainability Science and Engineering: Principles. Ed. Martin Abraham, Elsevier Science. available 2005.
3. Anastas, P.; Zimmerman, J. "Design through the Twelve Principles of Green Engineering," Environmental Science and Technology, 37, 94A – 101A, 2003.
4. Tundro, P.; Anastas, P., *Green Chemistry Challenging Perspectives,* Oxford Press, Oxford, 2000.
5. Matlack, A.S., *Introduction to Green Chemistry,* Marcel Dekker, Inc., New York, 2001.

CH52116: Pharmaceutical Chemistry

Course Objectives:

1. To get introduced to principles of manufacturing of pharmaceutical products.
2. To get acquaintance with evolution of pharmaceutical industry.
3. To get thorough understanding of diverse pharmaceutical products, their testing and analysis as well as packaging and marketing.

Course Outcomes:

1. Enrichment in the knowledge of application of Chemistry principles in the formulation of drugs.
2. Better understanding and exposure to developments in Pharmaceutical industry as a key industry.
3. Exposure to various trends in the identification of drug leads leading to pathways for the development of pharmaceutical products.
4. Through understanding of testing and analysis platforms for various pharmaceutical products.
5. Enrichment in knowledge of manufacturing, packging, and marketing principles & practices of Pharmaceutical products.,

Unit 1: Introduction: (7 Hrs)

Development of pharmaceutical Industry, Organic therapeutic agents, uses and economics, Drug metabolism, Physic Chemical principles, Pharma Kinetics, Action of drugs on human bodies.

Unit 2: Manufacturing Principles: (7 Hrs)

Compressed tablets, Wet granulation, Dry granulation or slugging, Direct compression, Tablet formulation, coating pills, capsules oral liquids, injections and ointments.

Unit 3: Pharmaceutical Products: (7 Hrs)

Vitamins, cold remedies, Laxatives, Analgesics, Nonsterodial conceptive, External antiseptics, Antacids and others.

Unit 4: Mircrobiological and animal products: (7 Hrs)

Antibiotics, Biological, Hormones, Vitamins, preservation.

Unit 5: Pharmaceutical Analysis: (7 Hrs)

Analytical methods and tests for various drugs and pharmaceuticals.

Unit 6: Packing and Quality Control: (7 Hrs)

Packing, Packing techniques, Quality control.

Total Contact Hours: 42

Text Books:

1. Rawlines, E.A., " Bentleys Textbook of Pharmaceuticals ", III Edition, Bailliere Tindall, London, 1977

2. " Remingtons Pharmaceutical Sciences ", Mack Publishing Co., 1975.

Reference Books :

1. Yalkonsky, S.H., Swarbrick, J., " Drug and Pharmaceutical Sciences ", Vol. I, II, III, IV, V, VI and VII, Marcel Deker Inc., New York 1975.
2. David G. Watson, Pharmaceutical Chemistry, Elsevier Health Sciences, 09-Feb-2011

CH52117: Materials Chemistry (Elective)

Course Objectives:

1. To get introduced to Materials and the Chemistry underlying its design
2. To get acquainted with techniques for synthesis and characterization of materials
3. To get introduced to methods of nanomaterials, their fabrication etc.
4. To get an exposure to Superconductors, conducting organics etc.

Outcomes:

1. Will enable to understand the utility of materials in design
2. Will be able to synthesize and characterize the materials
3. Will be able to understand properties and use of advanced materials
4. Will get an acquaintance with diverse materials

Unit 1 : Title : Introduction **(8 Hrs)**

A] Materials and their classification, Role of Chemistry in Material design**,** Synthesis and Characterization of Materials - Preparative techniques: Ceramic methods; chemical strategies, chemical vapour deposition, Introduction to Crystals and Lattices, Solid state materials and their applications, Fundamental types of two-dimensional lattices, Fundamental types of three-dimensional lattices

B] Some Examples of Crystal Structures - Metals and close packing, Ionic crystals and interstitial sites, Ionic crystals and Madelung energy

Unit 2 : Title : **Preparation of nanomaterials** **(8 Hrs)**

A] Nanomaterial synthesis, Langmuir- Blodgett Films. Fabrication of ordered nanostructures Composition and purity of materials. Some Examples of Crystal Structures - Metals and close packing, Ionic crystals and interstitial sites, Ionic crystals and Madelung energy, Preparation methods for Thin Films - Evaporation, sputtering, and chemical vapor deposition (CVD), Preparation methods for Nanostructured Materials - Molecular beam epitaxy (MBE), Sol-gel processing, Quantum structures (dots, wells, wires, and tubes)

B] Structural Analysis of Crystals - Index systems for crystallographic planes and axes, X-ray, scattering, and crystallography, Powder X-ray diffraction

Unit 3 : Title : **High- Tc Oxide Superconductors** . **(8 Hrs)**

A] Structural features of cuprate superconductors. 1-2-3 and 2-1-4 cuprates; structure. Normal state properties: anisotropy and temperature dependence of electrical resistance. Superconducting state: heat capacity, coherence length, relation between Tc and hole concentration in cuprates; mechanism of superconductivity in cuprates. Applications of high Tc cuprates

B] Preparation methods for Bulk Solids - Nucleation and growth of crystals, Reactions involving different states (solid, solution, and gas), Colloidal materials

Unit 4 : Title : Organic Materials **(8 Hrs)**

A] Conducting organics - Metals from molecules, charge transfer materials and conducting polymers. Organic superconductors. Fullerenes. Molecular ferromagnets and ferroelectrics. Liquid crystals: mesomorphic behaviour, optical properties of liquid crystals, display devices, Electronic and Optoelectronic Devices - Metals, semiconductors, and insulators, Doping, contacts, and junctions, Field-effect transistors and light-emitting diodes
B] Band Structures of Solid Materials - One-dimensional chain systems, Energy diagram and density of states

Unit 5 : Title : Non-linear materials **(8 Hrs)**
A]Second and third order non-linear effects; molecular rectifiers and frequency doublers; unimolecular electronic devices. Photochromic materials; optical data storage, memory and switches. Case Studies - Materials for Microelectronics - Si and III-V group semiconductors (doping, etching, and patterning), Molecular electronics, Materials for Information Storage - Dielectric materials (both high-k and low-k), Magnetic and magnetoresistive materials
B] Ferroelectric and piezoelectric materials - Materials for Photonics and Catalysis - Photonic crystals, Zeolites and mesoporous materials

Text Books:
1. A.R. West, Solid State Chemistry and its Applications, (1984) John Wiley & Sons, Singapore.
2. C.N R. Rao and J. Gopalkrishnan, New Directions in Solid State Chemistry, (1997) Cambridge Univ. Press.
3. Solid State Chemistry, Anthony R. West, John Wiley & Sons, 1989
4. Introduction to Solid State Physics, Charles Kittel, John Wiley & Sons, 1986

Reference Books :

1. T. V. Ramakrishnan and C.N.R. Rao, Superconductivity Today, (1992) Wiley Eastern Ltd., New Delhi.
2. P. Ball, Designing the Molecular World: Chemistry at the Frontier, (1994) Princeton Univ. Press.

CH52118: Evolutionary Optimization Techniques (Elective)

Prerequisites:
Nil

Course Objectives:
1. Introduce formulation of basic modeling skills necessary to describe and formulate
Stochastic optimization problems in chemical engineering
2. Provide students with the basic mathematical concepts of population based optimization along solution techniques such as GA and DE;
3. Enhance students' skills in the use of spreadsheets applications for optimization and other useful software such as Matlab and various applications to engineering systems.

Course Outcomes:
Upon successful completion of this course, the student will be able to understand:
1. Basic principles of stochastic modeling and classification;
2. Various solution methods such as GA and DE for 1D and multidiamentional optimization;
3. Use of spreadsheets and mathematical software to obtain solutions;
4. Applications to a wide range of Chemical engineering problems.

Unit-1 : Introduction
Introduction to deterministic and stochastic modeling, limitations of deterministic model, Black box optimization methods such as simulated annealing, artificial neural networks, genetic algorithms, differential evolution etc…

Unit -2 : Genetic Algorithm
Introduction to genetic algorithm, variable coding and string structure, string length algorithms, valuation of fitness function, Operators in genetic algorithm, reproduction, crossover, mutation, Comparison of GA with traditional optimization techniques.

Unit-3 : Differential Evolution
Introduction to differential evolution, XOR and ADD algorithms, choice of key diferential evolution parameters, DE strategies such as DE/best/1/exp; DE/best/2/exp, DE/Best/1/bin, DE/Best/2/bin, Innovations in differential evolutions, Comparison of DE with GA and other traditional optimization techniques.

Unit-4 : Optimization with software & packages

Optimization with softwares & packages with the use of specific spread sheet applications such as MS Excel and other software such as Matlab , Mathematica, Scilab etc…. (Any one of these).

Unit-5 : Chemical Engineering Applications

Chemical engineering applications of Evolutionary Optimization with case studies such as optimal process design of ammonia synthesis reactor, fuzzy design making problems of fuel ethanol production, optimization of thermal cracker operation, optimal design of shell and tube heat exchanger etc..

Unit-6 : Other Engineering Applications

Engineering applications fermentation process, estimation of heat transfer parameters in trickle bed reactors, optimal design of heat exchangers, optimization and synthesis of heat integrated distillation systems, optimization of non-linear functions etc…

Reference

1. Kalyanmoy Deb ,Optimization for engineering design, , Prentice Hall of India
2. B. V. Babu, Process Plant Simulation, Oxford University Press
3. T.F.Edgar and D.M.Himmelblau, optimization of chemical processes, Mc Graw Hill International editions, chemical engineering series, 1989.
4. G.S. Beveridge and R.S. Schechter, Optimization theory and practice, Mc Graw Hill, Newyork, 1970.
5. Rekllitis, G.V., Ravindran, A., and Ragdell, K.M., Engineering Optimization-
Methods and Applications, John Wiley, New York, 1983.

Department Level Open Elective (Semester III)

CH62101: Intellectual Property Rights (Open Elective)

Course Objectives:

1. To develop the skill of interpreting the invention with the prior art
2. To know the international strategies in presenting the inventions and other intellectual properties, to increase the ability for own composition of patents.

Course Outcomes:

1. After learning this course students will be able to understand the concepts of IPR, patents, copyrights and trademark
2. They would be able to understand the process for patent drafting, patent filing and legal issues and infringement, violation cases

Unit 1: Introduction: (7 Hrs)

Meaning of Intellectual property, Meaning of Intellectual Property rights, History of IPR, Development of IPR, International scenario, IPR offices.

Unit 2: Trademarks & Trade Secrets: (7 Hrs)

Trademarks- Definition, service marks, smell marks, audio, 2D-3D trademarks, trademarks laws & protection, trademark case study. Trade secrets- Definition, need of trade secrets, trade secret laws & protection, case study.

Unit 3: Geographical indications & Copyright: (7 Hrs)

Geographical Indications- Definition, GI Act, Protection of GI, case study. Copyright- Definition, difference between patents and copyrights, Copyright act, Copyright protection & case study, fair use of it, remedies in copyright protection

Unit 4: Industrial designs & Patents: (7 Hrs)

Patents- Definition, requirements of patents, types of patents, patent act & amendments, exclusions of patent, software and biological patents. Industrial design- Definition, industrial design act, registration and use.

Unit 5: Patent treaties and Patent co-operations:

American and European patent systems, International treaties like PCT, Paris convention, TRIPS and compulsory licensing, Indian patent systems.

Unit 6 : Patent drafting & Patent cases (7 Hrs)

Claims, their types and claim construction, preamble, specification, prior art, patent infringements & infringement remedies. Biopiracy, infringement laws and infringement cases, case studies of pharma products, biotechnology patents etc.

Total Contact Hours: 42

Text Books:

1. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007
2. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand.

Reference Books :

1. Robert P. Merges, Peter S. Menell, Secret A. Lemley, “Intellectual Property in New Technological Age”.
2. Mayall , “Industrial Design”, Mc Graw Hill

CH62102: Industrial Organization & Management (Open Elective)

Course Objectives:

1. To develop understanding of various functions of management
2. To develop understanding of role of workers and engineers
3. To provide knowledge about safety and labour, industrial laws and management in different areas.
4. To gain understanding of Environmental, Marketing, Financial & Sales Management.

Course Outcomes:

1. Will be able to learn thoroughly functions & role of management
2. Will get acquainted with role of engineers in various industrial entities.
3. Better appraised of industrial safety laws & Management
4. Will gain thorough knowledge about various aspects of Management.

Unit 1 : **(7 Hrs)**
Principles of Management, Human and Industrial Relations & Professional Ethics

Unit 2 : **(7 Hrs)**
Motivation, Leadership

Unit 3 : **(7 Hrs)**
Human Resource Development, Wage Payment

Unit 4 : **(7 Hrs)**
Labour, Industrial and Tax Laws, Accidents and Safety

Unit 5 : **(7 Hrs)**
Environmental Management, Materials Management

Unit 6 : **(7 Hrs)**
Financial Management, Marketing and Sales

Total Contact Hours: 42 hours

Text Books:

1. Industrial Engineering and Management by TR Banga
2. Industrial Engineering and Management by OP Khanna, Dhanpat Rai Publications, Delhi.

Reference Books :

1. Marketing Management by Philip Kotler, Prentice Hall of India, New Delhi

2. Principles of Management by Philip Kotler, TEE Publication.
3. Industrial Organisation and Management by Tara Chand, Nem Chand and Brothers, Roorkee

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