B.TECH (Part – time) DEGREE COURSE IN CHEMICAL ENGINEERING

(2017 Admissions)

SCHEME OF EXAMINATION & SYLLABUS

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

KOCHI – 682 022

B.Tech (Part-time) DEGREE COURSE IN CHEMICAL ENGINEERING

Scheme of Examination (2017 admissions)

SEMESTER I

Code No.	Subject	L Hrs/Wk	T Hrs/Wk	P/D Hrs/ Wk	C	Marks		Total
						CA	ESE	
AS 17P 1101*	Linear Algebra and Calculus	3	0	0	3	40	60	100
GE 17P 1102*	Computer Programming	2	0	1	3	40	60	100
CH 17P 1103	Physical Chemistry	3	0	0	3	40	60	100
CH 17P 1104	Momentum Transfer	3	0	0	3	40	60	100
GE 17P 1105**	Electrical Technology	3	0	0	3	40	60	100
CH 17P 11L1	Fluid Mechanics Lab	0	0	3	2	25	25	50
	TOTAL	**14**	**0**	**4**	**17**			

CA – Continuous Assessment, ESE – End Semester Examination

*Common for CE, CH and ME

** Common for CH and ME

SEMESTER II

Code No.	Subject	L Hrs/Wk	T Hrs/Wk	P/D Hrs/ Wk	C	Marks		Total
						CA	ESE	
AS 17P 1201*	Complex Variables and Transform Techniques	3	0	0	3	40	60	100
CH 17P 1202	Material Science and Engineering	3	0	0	3	40	60	100
CH 17P 1203	Organic Chemistry	2	1	0	3	40	60	100
CH 17P 1204	Chemical Process Calculations	2	1	0	3	40	60	100
CH 17P 1205	Particulate Science and Technology	3	0	0	3	40	60	100
CH 17P 12L1	Particle Technology Lab	0	0	3	2	25	25	50
	TOTAL	**13**	**2**	**3**	**17**			

* Common for CE, CH and ME

SEMESTER III

Code No.	Subject	L Hrs/ Wk	T Hrs/ Wk	P Hrs/ Wk	C	CA	ESE	Total
AS 17P 1301*	Numerical and Statistical Methods	3	0	0	3	40	60	100
HS 17P 1302*	Technical Communication & Professional Ethics	3	0	0	3	40	60	100
CH 17P 1303	Chemical Engineering Thermodynamics I	2	1	0	3	40	60	100
CH 17P 1304	Process Heat Transfer	2	1	0	3	40	60	100
CH 17P 1305	Inorganic Chemical Technology	3	0	0	3	40	60	100
CH 17P 13 L1	Chemical Technology Lab	0	0	3	2	25	25	50
	TOTAL	**13**	**2**	**3**	**17**			

*Common for CE, CH and ME

SEMESTER IV

Code No.	Subject	L Hrs/ Wk	T Hrs/ Wk	P Hrs/ Wk	C	CA	ESE	Total
CH 17P 1401	Mass Transfer Operations I	3	0	0	3	40	60	100
CH 17P 1402	Chemical Reaction Engineering I	2	1	0	3	40	60	100
CH 17P 1403	Chemical Engineering Thermodynamics II	2	1	0	3	40	60	100
CH 17P 1404	Environmental Engineering	3	0	0	3	40	60	100
CH 17P 1405	Organic Chemical Technology	2	1	0	3	40	60	100
CH 17P 14 L1	Heat Transfer Operations Lab	0	0	3	2	25	25	50
	TOTAL	**12**	**3**	**3**	**17**			

SEMESTER V

Code No.	Subject	L Hrs/ Wk	T Hrs/ Wk	P Hrs/ Wk	C	CA	ESE	Total
CH 17P 1501	Mass Transfer Operations II	2	1	0	3	40	60	100
CH 17P 1502	Chemical Reaction Engineering II	2	1	0	3	40	60	100
CH 17P 1503	Process Instrumentation and Automatic Control	3	0	0	3	40	60	100
CH 17P 1504	Economics and Management of Chemical Industries	2	1	0	3	40	60	100
CH 17P 1505	Elective I	3	0	0	3	40	60	100
CH 17P 15 L1	Mass Transfer Operations Lab	0	0	3	2	25	25	50
	TOTAL	**12**	**3**	**3**	**17**			

Elective I

E1: Petroleum Refining and Petrochemicals
E2: Energy Engineering
E3: Drugs and Pharmaceutical Technology
E4: Process Plant Utilities
E5: Food Processing Technology

SEMESTER VI

Code No.	Subject	L Hrs/Wk	T Hrs/Wk	P Hrs/ Wk	C	CA	ESE	Total
CH 17P 1601	Transport Phenomena	2	1	0	3	40	60	100
CH 17P 1602	Biochemical Engineering	3	0	0	3	40	60	100
CH 17P 1603	Process Plant Safety and Hazard Mitigation	2	1	0	3	40	60	100
CH 17P 1604	Process Equipment Design	2	0	1	3	40	60	100
CH 17P 1605	Elective II	3	0	0	3	40	60	100
CH 17P 16 L1	Seminar & Project Preliminaries	0	0	3	2	50	-	50
	TOTAL	**12**	**3**	**3**	**17**			

Elective II

E1: New Separation Processes
E2: Fertilizer Technology
E3: Nuclear Process Engineering
E4: Chemical Process Optimization
E5: Fuel Cell Engineering

SEMESTER VII

Code No.	Subject	L Hrs/ Wk	T Hrs/ Wk	P Hrs/ Wk	C	CA	ESE	Total
CH 17P 1701	Chemical Engineering Design and Drawing	2	0	1	3	40	60	100
CH 17P 1702	Elective III	3	0	0	3	40	60	100
CH 17P 17 L1	Reaction Engineering and Process Control Lab	0	0	3	2	50	-	50
CH 17P 17 L2	Project	0	0	9	7	200	-	200
CH 17P 17 L3	Comprehensive Viva Voce	0	0	0	2	-	50	50
	TOTAL	**5**	**1**	**12**	**17**			

Elective III

E1: Electrochemical Engineering
E2: Process Modelling and Simulation
E3: Piping Engineering
E4: Polymer Technology
E5: Nano Technology

AS 17P-1101 LINEAR ALGEBRA AND CALCULUS
(Common for all branches)

Course Objective:

To acquire fundamental knowledge of Calculus and Linear Algebra and apply in engineering disciplines.

Course Outcome:

On completion of this course, the student will be able to:
CO1 Solve linear system of equations and to determine Eigen values and vectors of a matrix.
CO2 Find area as double integrals and volume as triple integrals in engineering applications.
CO3 Solve ordinary and partial differential equations and apply them in engineering problems
CO4 Estimate the maxima and minima of multi variable functions.

Module I

Linear Algebra: Rank of a matrix, solution of linear system of equations- existence, uniqueness, general form-Eigen values and Eigen vectors- properties of Eigen values - Diagonalization of a matrix - Cayley Hamilton theorem (without proof) Verification-Finding inverse and power of a matrix using it-Quadratic form-orthogonal reduction of quadratic form to Canonical form.

Module II

Integral Calculus: Application of definite integrals: Area, Volume, Arc length, Surface area.
Multiple integral : Evaluation of double integrals-Change of order of integration. Evaluation of triple integrals -Change of Variables in integrals.
Applications of multiple integrals. Plane Area, Surface area &Volumes of solids.

Module III

Ordinary Differential Equations: First order differential equations - exact differential equations, Bernoulli's equations--Methods of solution and Simple applications.
Linear differential equations of higher orders with constant co-efficient-Methods of solution of these equations. Cauchy's linear differential equations. Simultaneous linear differential equations- Simple applications of linear differential equations in engineering problems –Electrical Circuits, Mechanical Systems.

Module IV

Partial Differentiation: Partial differentiation-Concept of partial derivative - Chain rule- Total derivative- Euler's theorem for homogeneous functions, Differentials and their applications in errors and approximations, Jacobians - Maxima minima of functions of two variables(Proof of the result not required)-Simple applications.
Solution of first order equation-four standard types- Lagrange's equation—Linear homogeneous partial differential equation with constant coefficient.

References:

1. Sastry, S.S. Engineering Mathematics: Vol 1. (fourth edition).PHI Learning, New Delhi, 2008.
2. Erwin Kreyzig. Advanced Engineering Mathematics (tenth edition). John Wiley & Sons, Hoboken, NJ., 2011
3. Veerarajan, T. Engineering Mathematics. (third edition). Tata McGraw Hill Publishers, New Delhi, 2011
4. Grewal, B.S. Higher Engineering Mathematics. (Forty third Edition). Khanna Publishers, New Delhi, 2013.

Type of Questions for End Semester Examination

PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I
Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

GE 17P 1102 COMPUTER PROGRAMMING

(Common for all branches)

Course Objective:

To learn the problem solving techniques by writing algorithms and to develop skills in programming using C language

Course Outcome:

On completion of this course, the student will be able to:

CO1 Write algorithms for problems

CO2 Acquire knowledge of the syntax and semantics of C programming language

CO3 Code a given logic in C language

CO4 Use C language for solving problems

Module I

Basics of Computer and Information Technology:

Digital Computer System (CPU, Memory, I/O devices)- Working of a digital computer- Hardware and Software : Definition - Categories of Software, Application of Computers – Role of Information Technology – Internet Services

Problem Solving Methodology:

Problem statement, Analysis, Design a solution, Implement/Coding the solution, Test the solution, Design tools (Algorithm, Flow-chart, Pseudo-code)- Develop algorithms for simple problems.

Programming Languages:

Types and generation of programming languages- Compiler – Interpreter-Linker –Loader –Execution of Program

Module II

Basics of C:

Character set-Identifier- Keywords- Constants –Data Types- Variables and declaration –Operators and Expressions – Operator precedence and associativity – Expression Evaluation (Simple Examples) - Input and output functions – Simple computational problems involving the above constructs.

Control Statements:

Selection, Conditional operator, Iteration (for, while, do-while), Branching (switch, break, continue, goto), Nesting of control statements- Problems using control statements.

Module III

Arrays and Strings:

1D and 2D arrays –Searching (Linear and Binary) - Sorting (Bubble, Selection) – Matrix manipulation programs – Strings and basic operations on strings – Strings functions - Programs on string manipulation

Functions:

Definition – Calling – Declaration – Parameter Passing (by value and by reference) – Recursion – Library functions –Programs based on functions

User defined data types:
Structure – Union - Enumerated data type - Programs involving structure and union.

Module IV
Pointers:
Declaration, Initialization – Pointers and arrays – Pointers and structures – Pointers and functions – Command line arguments – Dynamic memory allocation – Operations on pointers – Programs involving the above concepts
Files:
File concept – File pointer – File handling operations (open, close, read, write etc) on sequential and random access files. Programs on file manipulations using fgetc(), fgets), fseek.

References:

1. Dey, Pradip and Ghosh, Manas. Computer fundamentals and programming in C. (second edition). Oxford University Press, New Delhi, 2013.
2. Ghosh, Smarajit. All of C. PHI Learning Pvt. Ltd, New Delhi, 2009.
3. Gottfried, Byron. Programming with C. (second edition). Tata McGraw-Hill, New Delhi, 2006.
4. Brian W. Kernighan and Dennis M. Ritchie. The C programming language. (second Edition). Pearson Education, New Delhi, 2001.
5. Paul, Varghese. Computer fundamentals. (second edition). Educational Publishers & Distributers, Ernakulam, 2007.

Type of Questions for End Semester Examination

PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I
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Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 1103 PHYSICAL CHEMISTRY

Course objective:

To understand the fundamentals related to the phase diagrams and their applications, solutions, chemical kinetics and advanced electrochemistry.

Course outcome:

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

CO1 Apply phase rule to one component and two component systems.

CO2 Acquire knowledge about various types of solutions and their properties

CO3 Acquire knowledge in kinetics and mechanisms of chemical reactions.

CO4 Acquire knowledge about advances in electro chemistry and its applications

MODULE I

Phase Rule: Phase diagram - Information from phase diagram - Terminology used in phase diagram. Gibb's phase rule - Derivation. One component system: Water system. Two component alloy systems: Classification - Reduced phase rule - Thermal analysis. Simple eutectic system: Lead-silver system. Congruent System: Zinc-magnesium system.

Incongruent system: Sodium-potassium system. Phase diagram of simple three component system.

MODULE II

Solutions: Solid solution - Hume Rothery's rule. Types of solid solutions: Liquid solutions: Solubility of partially miscible liquids - Phenol-water system. Colligative properties: Lowering of vapour pressure. Raoult's law: Derivation - Osmotic pressure - Isotonic solution - Relationship between osmotic pressure and vapour pressure.

Depression in freezing point - Derivation. Elevation in boiling point - Derivation - Problems.

MODULE III

Chemical Kinetics: First and second order reactions: Integration - Integration of nth order reaction. Methods of determining order and molecularity. Collision theory of bimolecular gaseous reactions - Activated complex of bimolecular reactions - Lindemann theory of unimolecular equation - Kinetics of complex reactions: Reversible reaction - Consecutive reaction - Chain reactions - Autocatalysis - Problems.

MODULE IV

Advanced Electrochemistry: Cell constant - Equivalent conductance - Molar conductance. Ionic mobility: Transport number -Moving boundary method - Hittorff's method. Debye Huckel theory of strong electrolytes. Concentration cells: Types -Concentration cells without transference and with transference. Potentiometric tritrations: Redox titration.

Polarography - Applications of polarography.

References:

1. Puri B.R., Sharma L. R., Madan. S.Pathania, Principles of Physical Chemistry, 41st Edition, Vishal Publishing co., 2004.
2. Keith J. Laidler, Chemical Kinetics, Third Edition, Pearson education limited, 2004.
3. Atkins P. W., Physical Chemistry, 6th edition, Oxford University press, 1998.
4. Barrow G. M., Physical Chemistry, 5th edition, McGraw-Hill, 1988.
5. Glasstone S., A Text book of Physical Chemistry, Macmillan Ltd, 1976.

Type of Questions for End Semester Examination

PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I
Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 1104 MOMENTUM TRANSFER

Course Objective
To understand the governing principles of momentum transport in chemical process systems.

Course outcome
On successful completion of the course, student will be able to:
CO1 understand the various physical properties and flow regimes of fluids
CO2 understand and apply the basic equations to solve related problems
CO3 evaluate the operations involving flow through pipes
CO4 select and evaluate the performance of various fluid transport and metering devices

MODULE I
Fluid flow phenomena: Nature of fluids-properties of fluids, incompressible and compressible, hydrostatic equilibrium. Manometers. U-Tube and inclined. Potential flow, boundary layer, the velocity field, laminar flow, Newtonian and Non Newtonian fluids, Newton's law of viscosity, turbulence. Reynolds number and transition from laminar to turbulent flow, Eddy viscosity, flow in boundary layers

MODULE II
Kinematics of fluid flow : Streamlines and stream tubes, equation of continuity, Bernoulli equation. Flow of incompressible fluids in conduits and thin layers: friction factor, relationships between skin friction parameters, average velocity for laminar flow of Newtonian fluids, Hagen-Poiseuille equation, hydraulically smooth pipe, von Karman equation, roughness parameter, friction-factor chart, equivalent diameter.

MODULE III
Flow past immersed bodies and fluidization and metering of fluids: Drag and drag coefficients. Ergun equation, terminal settling velocity, free and hindered settlings, Stokes' law, Newton's law. Fluidization, conditions for fluidization, minimum fluidization velocity.
Constructional features and working principles of Venturi meter, Orifice meter, Area meters-Rota meter, Point velocity-Pitot tube, V-element meter, Target meter-ultrasonic meters, vortex shredding meter, Turbine meter.

MODULE IV
Transportation of fluids: Introduction to pipe and tubing, joint and fittings, stuffing boxes, mechanical seals, gate valves and globe valves, plug cocks and ball valves. Classification and selection of pumps, Reciprocating and Centrifugal pumps, developed head, power requirement, suction lift cavitation and pump work in Bernoulli equation, characteristic curves**.**

TEXT / REFERENCE BOOKS
1. McCabe, W.L, Smith J.C and Harriot. P., Unit Operations in Chemical Engineering, 7th Edition, Mc-Graw-Hill, 2009.
2. Noel de Nevers, Fluid Mechanics for Chemical Engineers, 2nd Edition, McGraw-Hill, 1991.
3. Coulson J.M. and Richardson J.E.,Chemical Engineering, Volume 1, 3rd Edition, Pergamon Press, 2000.
4. Shames, I.H., Mechanics of Fluids, 3rd Edition, McGraw-Hill Inc., 1992.

Type of Questions for End Semester Examination

PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I
Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

GE 17P 1105 ELECTRICAL TECHNOLOGY

Course Objective:
To understand the concept, working and performance of transformers, motors, generators and alternators.

Course Outcome:
On completion of this course, the student will be able:
CO1 To study the different types, constructional details, operational principles, and performance characteristics of DC motors and DC generators.
CO2 To understand the construction and working of transformers, transformer losses, current transformer, and potential transformers.
CO3 To understand the constructional details, operational principles, and performance characteristics of induction motors and alternators.
CO4 To learn about the generation, transmission, and distribution of electrical energy.

Module I
DC machines: Basic principle of operation of DC Generator, construction, emf equation, types of generators, armature reaction and commutation, characteristics, losses and efficiency .
DC Motor: working principle, Concepts of motoring and generating action, Torque equation, Types of motors, characteristics, starting, speed control, losses and efficiency ,brake test, Swinburne's test, applications.

Module II
Transformers: Working principles and elementary theory of an ideal transformer, Constructional features of single phase transformer, emf equation, turns ratio, vector diagram, equivalent circuit, impedence transformation, transformer losses, flux leakage, efficiency, open circuit and short circuit test, load test. Auto transformer – working principle and saving copper, basic idea of current transformer and potential transformer, distribution and power transformer, applications, standard rating, IS specifications.

Module III
AC Machines: Alternator- rotating field, speed and frequency, effect of distribution of winding, coil span, characteristics, emf equation, losses and efficiency, regulation (emf method only), applications, synchronous motor-principles of operation, over excited and under excited, starting, applications, synchronous capacitor.
Induction Motor: Induction motor, principles of operation, constructional features of squirrel cage and slip ring motors, torque-slip characteristics, starting, speed control, losses and efficiency.

Module IV
Generation, transmission & distribution of electrical energy: Different methods of power generation-thermal, hydro-electric, nuclear, diesel, gas turbine stations(general idea only), electrical equipment in power stations, concept of bus bar, load dispatching, methods of transmission, transmission lines, overhead lines and insulators, corona and skin effect of DC & AC distribution, substation (elementary idea only).

References
1. Hughes, K, Electrical Technology, English Language Book Society, 1996.

2. Cotton, H., Advanced Electrical Technology, CBS Publishers and Distributors, New Delhi, 1984.
3. Nagrath, I. J, Kothari D.P, Electrical Machines, Tata McGraw Hill Publishing Co. Limited, 1997.
4. Bimbra, F. S., Electrical Machines, 7th Edition, Khanna publishers, 2007.
5. Gupta B.R and Vandana Singhal, Fundamentals of Electric machines, D. K Publishers, 2000.
6. Vincent Del Toro, Electrical Machines & Power systems, Prentice Hall, 1998.
7. Chapman, S. J, Electric Machines & Power systems, McGraw Hill, 1999.

Type of Questions for End Semester Examination

PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I
Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 11L1 FLUID MECHANICS LAB

Course Objective
To learn experimentally to calibrate flow meters, find pressure loss for fluid flows and determine pump characteristics.

Course Outcome
On completion of this course, the student will be able to
CO1 Use variable area flow meters and variable head flow meters
CO2 Analyze the flow of fluids through closed conduits, open channels and flow past immersed bodies
CO3 Select pumps for the transportation of fluids based on process conditions/requirements and fluid properties

LIST OF EXPERIMENTS

1. Flow through Venturimeter
2. Flow through Orifice meter
3. Flow through Pitot tube
4. Calibration of Rotameter
5. Characteristics of a Reciprocating pump
6. Characteristics of a Centrifugal pump
7. Characteristics of a Gear pump
8. Flow through packed bed
9. Flow through fluidized bed
10. Flow through helical coil
11. Flow through V- Notches
12. Flow through annular pipe/ non circular conduits

AS 17P 1201 COMPLEX VARIABLES AND TRANSFORM TECHNIQUES
(Common for all branches)

Course Objective:
To acquire fundamental knowledge in complex variables, function integrals, Fourier series and Laplace transforms and apply them to engineering problems

Course Outcome:
On completion of this course, the student would be able to
CO1 Transform a region to another region using conformal mapping.
CO2 Evaluate real integrals using residue theorem.
CO3 Determine Fourier series and transform.
CO4 Solve linear differential equation and integral equation using Laplace transform.

Module I
Analytic function - Cauchy-Riemann equation (Cartesian and polar)-Harmonic function- construction of analytic function given real or imaginary parts- Conformal mapping of standard elementary function and bilinear transformation.

Module II
Cauchy's integral theorem, Cauchy's integral formula and for derivatives-Taylor's and Laurent's expansion (without proof)-Singularities-Residues-Cauchy's Residues theorem- Contour integration involving unit circle.

Module III
Fourier analysis: Periodic function, Fourier series, Functions of arbitrary period, Even and odd functions, Half Range Expansion, Harmonic analysis, Complex Fourier Series, Fourier Integrals, Fourier Cosine and Sine Transform, Fourier Transform.

Module IV
Laplace Transforms: Gamma functions and Beta function-Definition and properties, Laplace transforms. Inverse Laplace Transform, Shifting theorem, Transform of Derivative and Integrals, Solution of differential equation and integral equation using Laplace transform, Convolution, Unit step function, Second Shifting theorem, Laplace transform of periodic function.

References:
1. Erwin Kreyzig, Advanced Engineering Mathematics, 10^{th} Edition, John Wiley & Sons, 2010.
2. Grewal, B. S., Higher Engineering Mathematics, 43^{rd} Edition, Khanna Publishers, 2013.

PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)
PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I
Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 1202 MATERIAL SCIENCE AND ENGINEERING

Course Objective:
Students will be able to understand various material and its properties and manufacturing methods.
Course Outcome:
On completion of this course, the student will be able to
CO1 Understand basic and the mechanical behaviour of the metals
CO2 Understand phase diagrams and phase transformations of metals.
CO3 Understand the manufacturing process of ferrous, non-ferrous metals and composites.
CO4 Understand the basic concepts of nano materials

Module I
Introduction and mechanical behaviour: Structure – Property relationship - Selection criteria and processes: General criteria of selection of materials in process industries. Properties: Mechanical, Thermal, Physical, Chemical, Electrical, Magnetic and Technological properties.
Elastic, Anelastic and Viscoelastic Behaviour – Introduction to Slip, Slip planes, Plastic Deformation by Slip: Critical resolved shear stress, Mechanism of Creep, Creep Resistant Materials – Fracture: Ductile and Brittle, Fatigue fracture, Griffith's theory, S-N curves, Fracture toughness.

Module II
Phase diagrams and phase transformations: Gibb's Phase rule : Uniary and Binary phase diagrams , Al CO - Cr O , Pb-Sn, Ag-Pt and Iron- Iron Carbide Phase Diagram – Lever rule – Invariant reactions- TTT diagrams – Micro structural changes – Nucleation and growth – Martensitic transformations – Solidification and Crystallization – Glass transition – Recrystallization and Grain growth

Module III
Ferrous, non-ferrous metals and composites: Pig iron, Cast iron, Mild Steel-Manufacturing process, properties &, Applications. Stainless steels, Special Alloy steels-properties and uses; Heat treatment of plain-carbon steels.
Manufacturing methods of Lead, Tin and Magnesium. Properties and applications in process industries.
FRP-Fiber Reinforced Plastics (FRP), manufacturing methods; Asphalt and Asphalt mixtures; Wood.

Module IV
Nanomaterials: Introduction to Nanotechnology- Zero Dimensional Nano Structures – Nano particles – One Dimensional Nano Structures- Nano wires and Nano rods – Two Dimensional Nano Structures, Films – Special Nano Materials - Nano Structures fabricated by Physical Techniques – Characterisation and Properties of Nano Materials – Applications of Nano Structures.

References

1. Khanna O P, "Material Science and Metallurgy" Dhanpat Rai Publications (1995)
2. Raghavan V, "Materials and Engineering" Prentice Hall of India, Newdelhi (2006)
3. Van Vlack M., Materials Science for Engineers, Addison Welsey Publishing Company, 1980.
4. Brenner D, "Hand book of Nanoscience and technology" (2002)

Type of questions for End Semester Examination
PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I
Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 1203 ORGANIC CHEMISTRY

Course Objective:
To study the type of components in which organic reactions take place and also to know the preparation of the essential organic compounds.
Course Outcome:
On completion of this course, the student will be able to
CO1 Understand the classification of carbohydrates its preparation.
CO2 Acquire knowledge about the preparation and properties of heterocyclic compounds.
CO2 Understand the dye chemistry and synthesis of dyes.
CO3 Apply the concept to prepare organic compounds and synthesis the anti-malarial and antibacterial drugs.

Module I
Carbohydrates: Introduction – various definitions and classifications of carbohydrates – Preparation, Physical & Chemical properties, Structure and Uses of Monosaccharides (Glucose & Fructose).
Inter conversions – Aldo pentose to aldo hexose–Aldo hexose to aldo pentose- aldose to isomeric Ketose – Ketose to isomeric Aldose – Aldose to epimer.

Module II
Heterocyclic compounds: Preparation, Physical & Chemical properties and Uses of Pyrrole, Furan, Furfural, TetrahydroFuran, Thiophene, Indole, Pyridine, Quinoline and Isoquinoline.

Module III
Dye Chemistry: Witt's theory and modern theory of colors – Synthesis of Methyl red, Methyl orange, Congo red, Malachite green, para-rosaniline, phenolphthalein, fluorescence, Eosin dyes.

Module IV
Synthetic organic chemistry: Preparation and Synthetic utilities of Grignard reagent, Ethyl aceto acetate and Malonic ester.
Synthesis of Antimalarial drugs – isopentaquine and chloroquine. Synthesis of Antibacterial drugs – Sulphaniliamide and Sulphapyridine.

References:
1. Morrison R.T and Boyd R.N. "Organic Chemistry" VI Edition Prentice Hall Inc, USA (1996)
2. Tiwari K S, Vishnoi N K and Malhotra S N "A Text book of Organic Chemistry" Second Edition, Vikas Publishing House Pvt. Ltd. New Delhi (1998).

Type of Questions for End Semester Examination
PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)
PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I
Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 1204 CHEMICAL PROCESS CALCULATIONS

Course Objective:
To acquire a concept of degree of freedom and its application to solution of mass and energy balance equations for single and network of units and introduce to process simulators.

Course Outcome:
On completion of this course, the student will be able to
CO1 Understand the fundamentals of units and stoichiometric equations.
CO2 Write material balance for different chemical process.
CO3 Understand the fundamentals of ideal gas behaviour and phase equilibrium.
CO4 Write energy balance for different chemical process.

Module I
Introduction - Units and Dimensions, Basic and derived units, use of model units in calculations, Methods of expressing, compositions of mixture and solutions. Gas Calculations: Ideal and real gas laws, Gas constant, Calculations of pressure, volume and temperature using ideal gas law. Use of partial pressure and pure component volume in gas calculations, applications of real gas relationship in gas calculation.

Module II
Material Balance - Application of material balance to unit operations like distillation, evaporation, crystallization, extraction, absorption and stripping, drying.
Material balance with chemical reaction - Stoichiometric principles, Limiting and excess reactant, conversion, selectivity and yield. Application of material balance to systems with recycle, bypass and purging.

Module III
Fuels and Combustion - Determination of Composition by Orsat analysis of products of combustion of solid, liquid and gaseous fuels - Calculation of excess air from Orsat technique, problems on sulphur and sulphur containing compounds.

Module IV
Energy Balance - Heat capacity of solids, liquids and gases, mean heat capacity, sensible heat and latent heat, evaluation of enthalpy, Standard heat of reaction, heat of formation, combustion, solution, mixing etc.,calculation of standard heat of reaction ,Effect of pressure and temperature on heat of reaction - Energy balance for systems with and without chemical reaction

References:
1. Himmelblau, D.M., Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall Inc., 2003
2. Houghen. O.A., Watson. K.M and Ragatz. R.A, Chemical Process Principles, PART I, 2nd Edition, John Wiley and Asia Publishing, 1970.
3. Narayanan K V, Lakshmikutty B, Stoichiometry and Process Calculations, Prentice-Hall of India Pvt. Ltd, 2006
4. Venkataramani, V and Anantharaman.N., Process Calculations, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2003
5. Bhatt, B.L., Vora, S.M., Stoichiometry, 4th Edition, Tata McGraw-Hill, 2004.

Type of Questions for End Semester Examination

PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I
Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 1205 PARTICULATE SCIENCE AND TECHNOLOGY

Course Objective
The students will learn characterization of solids, size reduction, techniques of solid - fluid separation and mixing.

Course Outcome
On completion of this course, the student will be able to
CO1 Apply the principles of size analysis
CO2 Apply size reduction techniques of solids by selecting proper equipment such as crushers, grinders, etc.,
CO3 Understand the working principles of thickeners, gravity settling tanks, cyclone separators, and other mechanical separation devices
CO4 Select filtration equipment, mixing and agitation equipment, and storage and transportation equipment used for handling solids in Chemical process industries.

Module I
Particle size and shape: Scope & Application of Solid Fluid Operation. Particle Size Analysis:-Particle Size Measurement & Distribution, Sieve Analysis- Differential and Cumulative screen analysis, Specific surface area, Particle population, Different mean diameters for a mixture of particles. Particle size measurement, Surface area measurements, Statistical mean diameters, Screening Equipments : Size separation, Screening, Industrial screens, Grizzly, Gyratory and Vibratory screens, Revolving screens, Trommels, Capacity and Effectiveness of screens, Relevant equations and problems.

Module II
Size reduction: Principles of Comminution - Laws of crushing & Power Requirement in Milling Operations, Crushing and Grinding efficiency, Description and working of size reduction equipment, Jaw and Roll crushers, Hammer mill,Gyratory crushers, Ball mills, Revolving mills, Attrition mills, Fluid energy mill, Cutting machines, Open and Closed circuit grinding, Wet and Dry grinding, Grindability Index.

Module 3
Sedimentation, storage and conveying of solids: Batch sedimentation, Equipments for sedimentation, Kynch theory of sedimentation, Calculation of area and depth of continuous thickeners, Batch thickeners and Continuous thickeners. Phase separation: Centrifugal separation, Electrostatic precipitators and Magnetic separation. Gas-solid separation: Gravity settling, Impingement separators, Cyclone separators, Bag filters, Scrubbers, Mineral jig, Cyclone separator, Hydro cyclone types and Centrifuges, Centrifugal clarifier.
Storage and Conveying of Solids: Introduction to storage and conveying of solids, Bins, Hoppers and Silos,Flow out of bins, design consideration of bins, loading and unloading of solids. Bucket elevators, Apron conveyors. Belt conveyors: Types of Belt conveyors, Selection considerations.

Module 4
Filtration and mixing: Filter media and filter aids, Classification of filtration, Pressure drop through filter cake, Filter medium resistance, Specific cake resistance, Continuous Filtration, Washing and Dewatering of filter cakes, Centrifugal filtration. Filtration equipment.
Mixing and agitation: Necessity of mixing & agitation in chemical industries, Types of Impellers & propellers, Different flow patterns in mixing, Calculation of power requirement of mixing equipment, Mixing equipment of pastes & viscous material, Solid - Solid Mixing, Agitator selection.

References

1. Warren L. Mccabe, Julian C. Smith and Peter Harriott, Unit Operations of Chemical Engineering, 8th Edition, McGraw Hill International Edition., New York 2009.
2. Badger and Banchero, Introduction to Chemical Engineering, 2nd Edition, McGraw Hill, 2001.
3. Coulson J.M., Richardson J.F., Backhurst J.R. and Harker J.M., Coulson & Richardson's Chemical Engineering, Vol. II, 5 th Edition,Butter worth Heinemann, Oxford, 2002.
4. Brown, G.G., Unit Operations, 2nd Edition, CBS Publishers & Distributors, New Delhi, 2005.

Type of Questions for End Semester Examination

PART A

Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)

Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I

Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II

Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III

Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 12 L1 PARTICLE TECHNOLOGY LAB

Course Objective
Students develop a sound working knowledge on different types of crushing equipment and separation characteristics of different mechanical operation separators.

Course Outcome
On completion of this course, the student will be able to
CO1 Determine work index, average particle size through experiments by crushers, ball mill and conducting sieve analysis.
CO2 Design size separation equipment such as cyclone separator, sedimentation, Filters etc.

LIST OF EXPERIMENTS
1. Particle size distribution - differential and cumulative analysis by manual method using standard screens
2. Determination of Screen Effectiveness by Mechanical Method using Standard screens
3. Energy requirement and crushing constants determination using:
i. Ball mill
ii. Drop weight crusher
4. Determination of filtration constants at constant pressure conditions using:
i. Plate and Frame Press
ii. Vacuum Leaf Filter
5. Minimum thickener area calculations performing Batch Sedimentation test
6. Calculation of Angle of nip – Roll Crusher

AS 17P 1301 NUMERICAL AND STATISTICAL METHODS
(Common for all branches)

Course Objective:

To understand the concept of probability, statistics and numerical methods which are useful for engineering applications.

Course Outcome:

On completion of this course, the student will be able to:

CO1 Solve algebraic and transcendental equations by numerical methods

CO2 Perform numerical differentiation and integration

CO3 Find the mean and variance of a probability distribution including the binomial distribution.

CO4 Use statistical tests in testing hypotheses on data

ModuleI

Numerical solution of algebraic and transcendental equation by - Regula-Falsi method, Newton Raphson's method. Gauss Seidal iteration method to solve a system of equations and convergence (without proof) Newton's forward and backward interpolation formula. Lagrange interpolation, Newton's divided difference and central differences.

Module II

Numerical differentiation at the tabulated points with forward, backward and central diffrences. Numerical integration with trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule. Taylor series method. Euler method, Modified Euler method, Runge–Kutta method of second and fourth order for solving 1st order ordinary differential equation.

Module III

Random variable (discrete and continuous) Expectation-mean and variance of probability distribution. Binomial, Poisson and Normal distribution and Fitting of this Distribution to the given data. Curve fitting-fitting of straight line, parabola, exponential.

Module IV

Population and Sample-Sampling Distribution (of mean and variance) Testing of Hypothesis-level of significance, Z-test statistic, Chi square test for variance, for goodness of fit and F-test.

References:

1. Erwin Kreyzig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, (2010).
2. Grewal, B.S., Higher Engineering Mathematics, 43rd Edition, Khanna Publishers, (2013).
3. Kandaswamy, P., Thilagavathy, K., & Gunavathy, K., Numerical methods, S. Chand & Co., (2007).
4. Richard A. Johnson, Irwin Miller & Freund, J. E., Probabilty and statistics for Engineers, 8th Edition, Pearson, (2010).

Type of Questions for End Semester Examination

PART A

Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)

Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I

Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II

Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III

Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

HS 17P 1302 TECHNICAL COMMUNICATION AND PROFESSIONAL ETHICS
(Common for all branches)

Course Objective:

The primary objective is to develop in the under-graduate students of engineering a level of competence in English required for independent and effective communication for their professional needs. It is also intended to develop awareness about the role of ethics in the practice of engineering profession.

Course Outcome:

On completion of this course the student will be able to:

CO1 Understand basic grammar principles and comprehend English speech sound system, stress and intonation

CO2 Speak English at the formal and informal levels and use it for daily conversation, presentation, group discussion and debate.

CO3 Read, comprehend and answer questions based on literary, scientific and technological texts

CO4 Write instructions, recommendations, check lists, CV, process description, letters and reports.

CO5 Recognise the importance of ethical principles in engineering profession and understand the responsibilities and rights of engineers.

Module I

Remedial Grammar :Errors of Accidence and syntax with reference to Parts of Speech; Agreement of Subject and Verb; Tense and Concord; Conditional Clauses; Use of connectives in Complex and Compound sentences; Question tags and short responses. Word Formations (by adding suffixes and prefixes); Technical Word Formation; Synonyms, Antonyms, Homophones, and Homonyms; One Word Substitution; Misappropriations; Indianisms; Redundant Words; Phrasal Verb Idioms.

Elementary Phonetics (Speech Mechanism, The Description of Speech Sounds, The Phoneme, the syllable; Prosodic Features, Word Accent, Features of Connected Speech); Paralanguage and Body language; and Classroom Presentations, Hearing and Listening; Essentials of Good Listening: Achieving ability to comprehend material delivered at relatively fast speed.

Module II

Oral Communication: Starting and ending a conversation; telling and asking people to do things; expressing opinions and ideas, decisions and intentions, offers and invitations, feelings, right and wrong, numbers and money.

Purpose and audience; dealing with customers and clients; face-to-face discussions; meetings and attending meetings; checking understanding; raising questions; giving and receiving feedback; using body language; leading and directing discussions; concluding discussions; using graphics in oral presentations

Group Discussion: Use of persuasive strategies including some rhetorical devices for emphasizing (for instance; being polite and firm; handling questions and taking in criticism of self; turn-taking strategies and effective intervention; use of body language).

Reading Comprehension and reference skills: Skimming and scanning; factual and inferential comprehension; prediction; guessing meaning of words from context; word reference; comprehending graphics in technical writing.

Reading strategies; reading speed; reading between the lines for hidden meaning; interpreting graphics; using a dictionary; using an index; using a contents list to find information; choosing the right reference source.

Module III

Written Communication: note making and note taking; summarising; notes and memos; developing notes into text; organisation of ideas: cohesion and coherence; paragraph writing: ordering information in space and time; short essays: description and argument; comparison and contrast; illustration; using graphics in writing: tables and charts; diagrams and flow-charts; maps, plans and graphs.

Spelling rules and tips; writing a rough draft; editing and proof reading; writing the final draft; styling text; filling in complex forms; standard letters; CV; writing a report; writing leaflets and brochures; writing references; essay writing: expository writing; description of processes and products; classification; the instructional process; arguments and presentation of arguments; narrating events chronologically.

(Emphasis should be given to the practice sessions for developing the oral and written communication skills of students.)

Module IV

Engineering ethics: Senses of Engineering Ethics - Variety of moral issues - Types of inquiry - Moral dilemmas - Moral autonomy. Kohlberg's theory - Gilligan's theory - Consensus and Controversy - Professional ideals and virtues - Attributes of an ethical personality - Theories about right action - Self-interest. Responsibilities and Rights of engineers - Collegiality and Loyalty - Respect for authority - Collective bargaining. Confidentiality - Conflicts of interest - Professional rights.

References

1. John Seely. Oxford guide to writing and speaking. Oxford University Press, New Delhi, 2005.

2. Muralikrishna, C. and Sunita Mishra. Communication skills for engineers. (second edition). Pearson, New Delhi, 2011.

3. Meenakshi Raman and Sangeetha Sharma. Technical communication: Principles and practice. Oxford University Press, New Delhi, 2004.

4. Krishna Mohan and Meenakshi Raman. Effective English communication. Tata Mc-GraHill, New Delhi, 2000.

5. William Sanborn Pfeiffer and Padmaja, T.V.S. Technical communication – A practical approach. Pearson, New Delhi, 2007.

6. Bhatia, R.C. Business Communication.Second edition). Ane Books Pvt. Ltd., New Delhi, 2008.

7. Krishna Mohan and Meera Banerji. Developing communication skills. Mac Millan India Ltd, New Delhi, 2000.

8. Jayashree Suresh and Raghavan, B.S. Professional ethics. S. Chand & Company Ltd, New Delhi, 2005.

9. Edmund D. Seebaur and Robert L. Barry. Fundamentals of ethics for scientists and engineers. Oxford University Press, New Delhi, 2001.

Type of Questions for End Semester Examination

PART A

Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)

Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I

Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II

Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III

Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

The questions shall be framed in such a way that they test the grammatical and communication skills of the student.

CH 17P 1303 CHEMICAL ENGINEERING THERMODYNAMICS I

Course Objective:
To acquire basic understanding of concepts and laws of thermodynamics, volumetric properties of fluids and thermodynamic properties of fluids

Course Outcome:
On completion of this course, the student will be able to
CO1 Understand the fundamental concepts of thermodynamics
CO2 Apply second law and analyse the feasibility of systems/devices; understand the real gas behaviour
CO3 Understand thermodynamic formulations and equations of state
CO4 Acquire knowledge on the working of compressors and expanders.

Module I
Basic concepts & first law of thermodynamics: The terminologies of thermodynamics - Work, energy, heat, internal energy, extensive & intensive properties, equilibrium, the variables and quantities of thermodynamics, categorization of systems and processes. Energy classifications, point and path properties, reversible and irreversible processes, Zeroth law of thermodynamics, statements of first law for the non-flow and flow systems, enthalpy and heat capacity, limitations of the first law.

Module II
Laws of thermodynamics: Statements of the second law of thermodynamics, Heat Engines, Heat pumps, Carnot principle, The entropy function, Calculation of entropy changes - for phase change, processes involving ideal gas, adiabatic mixing process, isothermal mixing of ideal gases, chemical reactions, clausius inequality, applications of the second law. Third law of thermodynamics.

Module III
Thermodynamic equations of state and formulations: The PVT behaviour of pure fluids, laws of corresponding states and equation of states approaches to the PVT relationships of real gases - Vander waals equation, Redlich Kwong Equation, Bertholet equation, Virial equation, compressibility factors, generalized equations of state, property estimation via generalized equation of state.
Measurable quantities, basic energy relations, Maxwell relations, thermodynamic formulations to calculate enthalpy, internal energy and entropy as function of pressure and temperature.

Module IV
Applications of the laws of thermodynamics: Flow Processes - Continuity Equation, Energy Equation, Flow through nozzles, Ejectors , compression process, classification of compression processes, the work expression for different situations, the effect of clearance volume, multistage compression, Refrigeration- Vapor compression and Vapor absorption refrigeration, Choice of refrigerant, Liquefaction processes.

References
1. Smith, J.M., and Van Ness, H.C., Introduction to Chemical Engineering Thermodynamics, 6th Edition Mc-Graw-Hill, 2004.
2. Narayanan K.V, A Text Book of Chemical Engineering Thermodynamics, 3rd Edition Prentice Hall of India Pvt. Ltd. 2001.
3. Hougen, O.A., Watson, K.M., and Ragatz, R.A., Chemical Process Principles, PART II, Thermodynamics, 3rd Edition, John Wiley 1970.

4. Gopinath Halder, Introduction to Chemical Engineering Thermodynamics, 2nd Edition, PHI Learning Private Limited, 2009.
5. Rao Y.V.C., Chemical Engineering Thermodynamics, 1st Edition, University Press (I) Ltd., Hyderabad, 1997.

Type of Questions for End Semester Examination

PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I
Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 1304 PROCESS HEAT TRANSFER

Course Objective:
To learn heat transfer by conduction, convection and radiation and heat transfer equipments like evaporator and heat exchanger

Course Outcome:
On completion of this course, the student will be able to
CO1 Understand the fundamentals of heat transfer by conduction
CO2 Understand the concepts of heat transfer by convection
CO3 Analyse heat transfer to fluids with phase change
CO4 Understand the applications of heat transfer equipment and determine the efficiency and effectiveness of evaporators and heat exchangers.

Module I
Importance of heat transfer in Chemical Engineering operations - Modes of heat transfer - Fourier's law of heat conduction - one dimensional steady state heat conduction equation for flat plate, hollow cylinder, - Heat conduction through a series of resistances – Thermal conductivity measurement; effect of temperature on thermal conductivity; Heat transfer in extended surfaces.

Module II
Concepts of heat transfer by convection - Natural and forced convection, analogies between transfer of momentum and heat - Reynold's analogy, Prandtl and Coulburn analogy. Dimensional analysis in heat transfer, heat transfer coefficient for flow through a pipe, flow past flat plate, flow through packed beds. Log mean temperature difference - Single pass and multipass heat exchangers; plate heat exchangers; use of correction factor charts - Fouling factors

Module III
Heat transfer to fluids with phase change - heat transfer from condensing vapours, drop wise and film wise condensation, Nusselt equation for vertical and horizontal tubes, condensation of superheated vapours, Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling and film boiling.

Module IV
Theory of evaporation - single effect and multiple effect evaporation - Design calculation for single and multiple effect evaporation. Radiation heat transfer - Black body radiation, Emissivity, Stefan - Boltzman law, Plank's law, radiation between surfaces.

References

1. Kern, D.Q., "Process Heat Transfer ", McGraw-Hill, 1999.
2. Datta B.K., "Heat Transfer – Principles and Applications", PHI Learning Pvt. Ltd., 2012.
3. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering",6th Edn., McGraw-Hill, 2001
4. Coulson, J.M. and Richardson, J.F., "Chemical Engineering "Vol. I, 4th Edn., Asian Books Pvt. Ltd., India, 1998.

Type of Questions for End Semester Examination

PART A

Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)

Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I

Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II

Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III

Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 1305 INORGANIC CHEMICAL TECHNOLOGY

Course Objective:
To gain knowledge on unit processes and unit operations involved in the manufacture of different chemicals in different industries like chloro-alkali, acids, cement, fertilizer etc.

Course Outcome:
On completion of this course, the student will be able to
CO1 Understand the role of Chemical Engineers in process industries such as chlor-alkali and acids
CO2 Understand the processes for the manufacture of cement, and glass.
CO3 Understand manufacturing processes of industrial gases, and paints.
CO4 Understand the unit operations and unit processes involved in fertiliser manufacture.

Module I
Alkalies: Chlor - alkali Industries: Manufacture of Soda ash, Manufacture of caustic soda and chlorine - common salt.
Acids: Sulphur and Sulphuric acid: Mining of sulphur and manufacture of sulphuric acid. Manufacture of hydrochloric acid.

Module II
Cement and Glass: Cement: Types and Manufacture of Portland cement, Glass: Manufacture of glasses and special glasses, Ceramics: Refractories and its classification.

Module III
Gases, Water and Paints: Industrial Gases: Carbon dioxide, Nitrogen, Hydrogen, Oxygen and Acetylene - Water Treatment: Industrial and municipal water treatment - Manufacture of paints – Pigments

Module IV
Fertilisers: Nitrogen Fertilisers; Synthetic ammonia, nitric acid, Urea, Ammonium Chloride, CAN, Ammonium Sulphate - Phosphorous Fertilisers: Phosphate rock, phosphoric acid, Super phosphate and Triple Super phosphate - MAP, DAP, Potassium Fertilisers; Potassium chloride, Potassium sulphate and Bio fertilizers.

References
1. Dryden, C. E., "Outlines of Chemicals Technology", Edited and Revised by Gopala Rao, M. and M. Sittig, Second Edition, Affiliated East-West press, 1993.
2. Austin, G. T., "Shreve's Chemical Process Industries", Fifth Edition, McGraw Hill, Singapore, 1984.
3. Shukla S D and Pandey G N, "Text book of Chemical Technology" Vol 1, Vikas Publishing Company, 1984.

Type of Questions for End Semester Examination

PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I

Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 13L1 CHEMICAL TECHNOLOGY LAB

Course Objective:
To learn basic principles involved in estimation and characterization of industrially important materials.

Course Outcome:
On completion of this course, the student will be
CO1 Able to analyse and determine the various properties of soap, oils, cement, and coal
CO2 Able to determine the properties of substance using calorimetric, conductivity and pH measurement techniques.

LIST OF EXPERIMENTS

1. Estimation of total fatty acid in soap
2. Estimation of percentage alkali content in soap
3. Estimation of free acid of oil.
4. Determination of Saponification value of oil
5. Determination of iodine value of oil
6. Estimation of calcium oxide content in cement
7. Ultimate analysis of coal
8. Proximate analysis of coal
9. Estimation of available chlorine in bleaching powder
10. Calorimetric measurements
11. Conductivity measurement of an electrolyte solution
12. pH measurement

CH 17P 1401 MASS TRANSFER OPERATIONS I

Course Objective

Students will learn to determine mass transfer rates under laminar and turbulent conditions and apply these concepts in the design of humidification columns, dryers and crystallisers.

Course Outcome:

On completion of this course, the student will be able to
CO1 Understand diffusional operations and theories of mass transfer
CO2 Understand the principles of humidification and its applications
CO3 Analyse and design constant rate drying systems
CO4 Analyse and design crystallization systems.

Module I

Introduction to mass transfer operations; Molecular diffusion in gases, liquids and solids; diffusivity measurement and prediction; multi-component diffusion.
Eddy diffusion, concept of mass transfer coefficients, theories of mass transfer, different transport analogies, application of correlations for mass transfer coefficients, inter phase mass transfer, relationship between individual and overall mass transfer coefficients. NTU and NTP concepts, Stage-wise and differential contactors.

Module II

Humidification – Equilibrium, humidity chart, adiabatic and wet bulb temperatures; humidification operations; theory and design of cooling towers, dehumidifiers and humidifiers using enthalpy transfer unit concept.

Module III

Drying– Equilibrium; classification of dryers; batch drying – Mechanism and time of cross through circulation drying, continuous dryers – material and energy balance; determination of length of rotary dryer using rate concept.

Module IV

Crystallization - Equilibrium, classification of crystallizers, mass and energy balance; kinetics of crystallization – nucleation and growth; design of batch crystallizers; population balance model and design of continuous crystallizers.

References

1. Treybal, R.E., "Mass Transfer Operations", 3rd Edn, McGraw-Hill, 1981.
2. Anantharaman N., Meera Sheriffa Begum K. M., Mass Transfer Theory and Practice, 1st Edition, PHI, 2011.
3. Geankoplis, C.J., "Transport Processes and Unit Operations", 4th Edition, Prentice Hall Inc., New Jersey, 2003.
4. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7th Edn., McGraw-Hill, 2005.

5. Coulson, J.M. and Richardson, J.F., “Chemical Engineering” Vol. I and II, 4th Edition, Asian Books Pvt. Ltd, 1998.

Type of Questions for End Semester Examination

PART A

Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)

Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I

Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II

Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III

Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 1402 CHEMICAL REACTION ENGINEERING I

Course Objective:
Students gain knowledge on different types of chemical reactors, the design of chemical reactors under isothermal and non-isothermal conditions

Course Outcome:
On completion of the course, the student will be able to
CO1 Apply the principles of reaction kinetics, formulate rate equations and analyse the batch reactor data.
CO2 Analyse the experimental kinetic data to select a suitable reactor for a particular application and to workout conversion and space time for different types of reactors.
CO3 Evaluate selectivity, reactivity and yield for parallel and mixed reactions.
CO4 Examine how far real reactors deviate from the ideal.

Module I
Rate equation, elementary, non-elementary reactions, theories of reaction rate and Prediction;
Design equation for constant and variable volume batch reactors, analysis of experimental kinetics data, integral and differential analysis.

Module II
Design of continuous reactors - stirred tank and tubular flow reactor, recycle reactors, combination of reactors, size comparison of reactors.
Design of reactors for multiple reactions - consecutive, parallel and mixed reactions – factors affecting choice, optimum yield and conversion, selectivity, reactivity and yield.

Module III
Non-isothermal homogeneous reactor systems, adiabatic reactors, rates of heat exchanges for different reactors, design for constant rate input and constant heat transfer coefficient, operation of batch and continuous reactors, optimum temperature progression.

Module IV
The residence time distribution as a factor of performance; residence time functions and relationship between them in reactor; basic models for non-ideal flow; conversion in non-ideal reactors.

References
1. Levenspiel O "Chemical Reaction Engineering", 3rd Edn., Wiley Eastern Ltd., New York,1999.
2. Smith J M, "Chemical Engineering Kinetics", 3rd Edn., McGraw Hill, New York, 1981.
3. Fogler.H.S., "Elements of Chemical Reaction Engineering", Prentice Hall of India Ltd., IIIrd Edition, 2000

Type of Questions for End Semester Examination

PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I

Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 1403 CHEMICAL ENGINEERING THERMODYNAMICS II

Course Objective

The Students will be well versed with the behaviour of fluids under PVT conditions and also apply them for practical purpose. The study further provides a comprehensive exposition to theory and application of solution thermodynamics.

Course Outcome:

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

CO1 Understand and evaluate the thermodynamic properties of pure fluids and solutions

CO2 Evaluate and analyse the phase equilibrium data

CO3 Understand the criteria of phase equilibrium for mixtures and the assumptions behind Raoult's law and the ideal solution as well as what things will make them fail.

CO4 Analyse chemical reaction rates and evaluate reaction equilibrium constant

Module I

Properties of solutions: Partial molar properties, ideal and non-ideal solutions, standard states definition and choice, Gibbs-Duhem equation, excess properties of mixtures.

Module II

Phase equilibria: Criteria for equilibrium between phases in multi component non-reacting systems in terms of chemical potential and fugacity, application of phase rule, vapour-liquid equilibrium, phase diagrams for homogeneous systems and for systems with a miscibility gap, effect of temperature and pressure on azeotrope composition, liquid-liquid equilibrium, ternary liquid- liquid equilibrium.

Module III

Correlation and prediction of phase equilibria: Activity coefficient-composition models, Thermodynamic consistency of phase equilibria, application of the correlation and prediction of phase equilibria in systems of engineering interest particularly to distillation and liquid extraction processes.

Module IV

Chemical reaction equilibria: Definition of standard state, standard free energy change and reaction equilibrium constant, evaluation of reaction equilibrium constant, prediction of free energy data, equilibria in chemical reactors, calculation of equilibrium compositions for homogeneous chemical reactors, thermodynamic analysis of simultaneous reactions.

References

1. Smith, J.M., and Van Ness, H.C., Introduction to Chemical Engineering Thermodynamics, 6th Edition Mc-Graw-Hill, 2004.
2. Narayanan K.V, A Text Book of Chemical Engineering Thermodynamics, 3rd Edition Prentice Hall of India Pvt. Ltd. 2001.
3. Hougen, O.A., Watson, K.M., and Ragatz, R.A., Chemical Process Principles, PART II, Thermodynamics, 3rd Edition, John Wiley 1970.
4. Gopinath Halder, Introduction to Chemical Engineering Thermodynamics, 2nd Edition, PHI Learning Private Limited, 2009.
5. Rao Y.V.C., Chemical Engineering Thermodynamics, 1st Edition, University Press (I) Ltd., Hyderabad, 1997.

Type of Questions for End Semester Examination
PART A
Question No. I (a) to (j) – Ten short answer questions of 2 marks each with at least two questions from each of the four modules (10 x 2 = 20 marks)

PART B (4 x 10 = 40 marks)
Question nos. II, III with sub sections if required. (10 marks each with options to answer either II or III) from Module I
Question nos. IV, V with sub sections if required. (10 marks each with options to answer either IV or V) from Module II
Question nos. VI, VII with sub sections if required. (10 marks each with options to answer either VI or VII) from Module III
Question nos. VIII, IX with sub sections if required. (10 marks each with options to answer either VIII or IX) from Module IV

CH 17P 1404 ENVIRONMENTAL ENGINEERING

Course Objective

To learn the various engineering techniques and management approaches for the prevention and control of air pollution, water pollution and pollution due to urban solid waste and hazardous waste.

Course Outcome

On completion of this course, the student will be able to:

CO1 Attain ability to choose the most suitable technique for air pollution monitoring and control technique for a given application.

CO2 Demonstrate an ability to recognise the type of unit operations and unit processes involved in wastewater treatment plants

CO3 Identify the techniques for the disposal and management of urban solid wastes and hazardous wastes

CO4 Demonstrate the ability to recognise the tools for environmental management in industries.

Module 1

Air pollution- Sources of air pollution, effects of air pollution, classification of pollutants, Atmospheric transport of pollutants-wind profiles, atmosphere stability, inversion, turbulence, dispersion and diffusion of air pollutants, Gaussian plume dispersion model. Principles and techniques of ambient air and stack emission monitoring; Particulate matter control equipment- working principles of gravity settlers , cyclones, wet scrubbers, fabric filters and electrostatic precipitators; Gaseous control methods- an overview of absorption, adsorption and combustion methods; Biological methods for VOC and odour control.

Module 2

Physical, chemical and biological characteristic of waste water; Effects of pollutants on water quality and aquatic life; Physical unit operations in waste water treatment- flow equalization, sedimentation, and flotation; Chemical unit processes in waste water treatment- coagulation and flocculation, chemical precipitation and adsorption; Biological unit processes- kinetics of microbial growth, Aerobic treatment systems: working principle and design parameters of trickling filter, activated sludge process, and rotating biological contactor; Anaerobic treatment systems: mechanism of anaerobic process, low rate and high rate digesters, working principle and applications of anaerobic filters and UASB; Biological nitrification –denitrification; Characteristics and treatment methods for the waste water from fertilizer plants, petroleum refineries, pulp and paper mills and distilleries.

Module 3

Solid wastes- environmental ,aesthetic and health risk; Sources, quantities and composition of solid wastes; Storage, collection and transportation of urban solid waste, disposal options- sanitary landfills, composting and its variations, anaerobic digestion, incineration and pyrolysis; Vermi composting; Recovery alternative ; Monitoring of solid wastes.

Hazardous wastes- definition and classification, health and environmental effects, treatment, disposal and management of hazardous wastes, legal frame work for hazardous waste management in India.

Module 4

Environmental management in industries- Principles and requirements of ISO 14001 EMS; Environmental auditing and auditing for waste minimization; Environmental impact assessment- description of the environmental setting, prediction and assessment of impacts, methods of impact analysis, Indian scenario, public participation in environmental decision making. Strategies for pollution prevention – recycle and reuse, cleaner technologies. Life cycle assessment – principle and methodology. The concept of industrial ecology. Clean development mechanism (CDM) – carbon trading.

Reference/Text Books

1. C.S. Rao: Environmental Pollution Control Engineering, New Age International (P) Ltd Publishers, 1991.
2. M.N. Rao and A.K. Dutta: Wastewater Treatment, Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi, 1987.
3. Metcalf and Eddy Inc.: Wastewater Engineering: Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, 2003.
4. Canter. L.W: Environmental Impact Assessment, Second Edition, Irwin / McGraw – Hill, 1996.
5. David H.F. Liu, I (Ed).: Environmental Engineers Handbook, Second Edition, Lewis Publishers, 1997.

CH 17P 1405 ORGANIC CHEMICAL TECHNOLOGY

Course Objective

To gain knowledge on unit processes and unit operations involved in the manufacture of different chemicals in different industries like pulp and paper, sugar, fermentation chemicals, soaps and detergents, petroleum products, petrochemicals, polymers, resins etc.

Course Outcome

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

CO1 Understand the role of Chemical Engineers in natural products industries such as pulp and paper, rayon, sugar and starch.

CO2 Understand manufacturing processes of fermentation products, edible oils, soap and detergents.

CO3 Understand the unit operations and unit processes involved in petroleum refining, manufacture of petrochemicals and polymeric materials.

Module 1

Natural Products Processing: Production of pulp, paper and rayon, Manufacture of sugar, starch and starch derivatives, Gasification of coal and chemicals from coal.

Module 2

Industrial Microbial Processes and Edible Oils: Fermentation processes for the production of ethyl alcohol, citric acid and antibiotics, Refining of edible oils and fats, fatty acids, Soaps and detergents.

Module 3

Petroleum Refining And Petrochemical Precursors: Petroleum refining to produce naphtha, fuel hydrocarbons and lubricants, Processes for the production of petrochemical precursors: ethylene, propylene, butadiene, acetylene, synthetic gas, benzene, toluene and xylene. (Cracking, Catalytic reforming and separation of products)

Module 4

Polymer Based Industries and Their Characteristics: Plastics: Production of thermoplastic and thermosetting resins such as polyethylene, polypropylene, phenolic resins and epoxy resins; Polymers and their applications in engineering practice.

Fibre Forming and Electrometric Polymers: Synthetic fibres: polyamides, polyesters and acrylics from monomers. Processes for the production of natural and synthetic rubbers.

Reference/Text Books

1. Dryden, C. E., “Outlines of Chemicals Technology”, Edited and Revised by Gopala Rao, M. and M. Sittig, Second Edition, Affiliated East-West press, 1993.

2. Austin, G. T., “Shreve’s Chemical Process Industries”, Fifth Edition, McGraw Hill, Singapore, 1984.

3. S. D. Shukla and G. N. Pandey, "Text book of Chemical Technology” Vol 2, Vikas Publishing Company, 1984

Type of Questions for End Semester Examination

Q1.Ten short answer questions of 2 marks each with at least 2 questions from each of the four modules.(10x2=20 marks)
Q 2.to Q 5: Two questions A &B of 10 marks from each module with option to answer either A or B. (4x 10=40 marks).

CH 17P 14L1 HEAT TRANSFER OPERATIONS LAB

Course Objective

• Students develop a sound working knowledge on different types of heat transfer equipment.

Course Outcome

On completion of the course, the student will be able to

CO1 Determine thermal conductivity of various substances

CO2 Estimate the heat transfer rate and overall heat transfer coefficient in different types of heat exchangers.

LIST OF EXPERIMENTS

1. Measure the emissivity of the test plate and plot a graph between emissivity and temperature.
2. Determine the thermal conductivity of metal rod. (Brass rod)
3. Determine the thermal conductivity of hylem, wood, and asbestos.
4. Find the thermal conductivity of the given insulated material by using lagged pipe.
5. Determine the temperature distribution for a cylinder due to heat transfer by natural convection.
6. Study and compare temperature distribution, heat transfer rate, overall heat transfer co-efficient in parallel flow heat exchanger.
7. Study and compare temperature distribution, heat transfer rate, overall heat transfer co-efficient in counter flow heat exchanger

CH 17P 1501 MASS TRANSFER OPERATIONS II

Course Objective

Students will learn to design absorber and stripper, distillation column, extraction and leaching equipment and absorber.

Course Outcome

On completion of the course, the student will be able to

CO1 Understand absorption and distillation operations and select methods of separation of mixtures based on mass transfer concepts.

CO2 Apply the ternary equilibrium diagram concepts to determine the number of stages required for separation of liquid-liquid and solid -liquid mixtures

CO3 Design a distillation tower and to perform calculations in adsorption operation

Module 1 ABSORPTION

Gas Absorption and Stripping – Equilibrium; material balance; limiting gas-liquid ratio; tray tower absorber - calculation of number of theoretical stages, tray efficiency, tower diameter; packed tower absorber – rate based approach; determination of height of packing using HTU and NTU calculations.

Module 2 DISTILLATION

Vapour liquid equilibria - Raoult's law, vapor-liquid equilibrium diagrams for ideal and non ideal systems, enthalpy concentration diagrams. Principle of distillation - flash distillation, differential distillation, steam distillation, multistage continuous rectification, Number of ideal stages by Mc.Cabe - Thiele method and Ponchan - Savarit method, Total reflux, minimum reflux ratio, optimum reflux ratio. Introduction to multi-component distillation, azeotropic and extractive distillation

Module 3 LIQUID-LIQUID EXTRACTION

Liquid - liquid extraction - solvent characteristics-equilibrium stage wise contact calculations for batch and continuous extractors- differential contact equipment-spray, packed and mechanically agitated contactors and their design calculations-packed bed extraction with reflux. Pulsed extractors, centrifugal extractors-Supercritical extraction

Module 4 LEACHING AND ADSORPTION

Solid-liquid equilibria- leaching equipment for batch and continuous operations- calculation of number of stages - Leaching - Leaching by percolation through stationary solid beds, moving bed leaching, counter current multiple contact (shank's system), equipment for leaching operation.

Adsorption - Types of adsorption, nature of adsorbents, adsorption equilibria, effect of pressure and temperature on adsorption isotherms, Adsorption operations - stage wise operations, steady state moving bed and unsteady state fixed bed adsorbers. Principle of Ion exchange, techniques and applications.

REFERENCE/TEXT BOOKS

1. Treybal, R.E., “Mass Transfer Operations “, 3rd Edn., McGraw-Hill, 1981.
2. Geankoplis, C.J., “Transport Processes and Unit Operations”, 4th Edition, Prentice Hall Inc., New Jersey, 2003.
3. McCabe, W.L., Smith, J.C., and Harriot, P., “Unit Operations in Chemical Engineering”, 7th Edn., McGraw-Hill, 2005.

Type of Questions for End Semester Examination

Q1.Ten short answer questions of 2 marks each with at least 2 questions from each of the four modules.(10x2=20 marks)
Q 2.to Q 5: Two questions A &B of 10 marks from each module with option to answer either A or B. (4x 10=40 marks).

CH 17P 1502 CHEMICAL REACTION ENGINEERING II

Course Objective

The objective is to study the non-ideal behaviour of homogeneous reactors, gas-solid catalytic and non-catalytic reactors and gas-liquid reactors.

Course Outcome

On completion of the course, the student will be able to

CO1 Understand catalysis and preparation and characterization, Apply adsorption isotherms for analysis of development of rate equations and rate controlling steps.

CO2 Understand the mechanism of pore diffusion in catalyst to calculate effectiveness factors and to demonstrate the application of volume and surface models and to calculate conversion in non-ideal flow reactor.

CO3 Design the absorption column combined with chemical reactions.

Module 1 CATALYSTS AND HETEROGENEOUS REACTORS

Nature of catalysts, surface area and pore-volume distribution, catalyst preparation.

Rate equations for heterogeneous reactions, adsorption isotherms, rates of adsorption and desorption, surface reaction analysis of rate equation and rate controlling steps.

Module 2 GAS-SOLID CATALYTIC REACTORS

Diffusion within catalyst particle, effective thermal conductivity, mass and heat transfer within catalyst pellets, effectiveness factor, Thiele Modulus, fixed bed reactors.

Module 3 GAS-SOLID NON-CATALYTIC REACTORS

Models for explaining kinetics; volume and surface models; controlling resistances and rate controlling steps; time for complete conversion for single and mixed sizes, fluidized and static reactors.

Module 4 GAS-LIQUID REACTORS

Absorption combined with chemical reactions; mass transfer coefficients and kinetic constants; application of film, penetration and surface renewal theories; Hatta number and enhancement factor for first order reaction, tower reactor design.

REFERENCE/ TEXT BOOKS

1. Levenspiel, O., “Chemical Reaction Engineering “, III Edition, John Wiley, 1999.
2. Fogler. H. S. “Elements of Chemical Reaction Engineering “, III Edition. Prentice Hall of India, 1999.
3. Smith J.M., “Chemical Engineering Kinetics “, III Edition, McGraw-Hill, New York, 1981.
4. Froment G.F & K.B. Bischoff, “Chemical Reaction Analysis and Design”, John Wiley and Sons, 1979.

CH 17P 1503 PROCESS INSTRUMENTATION AND AUTOMATIC CONTROL

Course Objective
To introduce dynamic response of open and closed loop systems, control loop components and stability of control systems along with instrumentation.

Course Outcome
On completion of this course, the student will be able to
CO1 Understand the prerequisites of control strategies and design different process control systems
CO2 Evaluate the suitable controllers for different chemical process.
CO3 Analyse and tune the control systems unto stability
CO4 Understand the mechanism of advance control systems

Module 1 INSTRUMENTATION
Principles of measurements and classification of process instruments, measurement of temperature, pressure, fluid flow, liquid weight and weight flow rate, viscosity, pH, concentration, electrical and thermal conductivity, humidity of gases.

Module 2 OPEN LOOP SYSTEMS
Laplace transformation, application to solve ODEs. Open-loop systems, first order systems and their transient response for standard input functions, first order systems in series, linearization and its application in process control, second order systems and their dynamics; transportation lag.

Module 3 CLOSED LOOP SYSTEMS
Closed loop control systems, development of block diagram for feed-back control systems, servo and regulatory problems, transfer function for controllers and final control element, principles of pneumatic and electronic controllers, transient response of closed-loop control systems and their stability.

Module 4 FREQUENCY RESPONSE AND ADVANCED CONTROL SYSTEMS
Introduction to frequency response of closed-loop systems, control system design by frequency response techniques, Bode diagram, stability criterion, tuning of controller settings.
Introduction to advanced control systems, cascade control, feed forward control, Smith predictor controller, control of distillation towers and heat exchangers, introduction to computer control of chemical processes.

REFERENCE/ TEXT BOOKS

1. D.R. Coughanowr and S. E. LeBlanc, 'Process Systems Analysis and Control', Mc.Graw Hill, III Edition, 2009.
2. D. E. Seborg, T. F. Edger, D. A. Millichamp and F.J. Doyle III, 'Process Dynamics and Control', Wiley, III Edition, 2013.
3. C.A.Smith and A.B.Corripio, 'Principle and Practice of Automatic Process Control', John Wiley and Sons, 1985.

4. W.L.Luyben, ‘Process Modelling Simulation and Control for Chemical Engineers’, McGraw Hill, II Edition, 1990.
5. G. Stephanopoulous, ‘Chemical Process Control – Theory and Practice’, Prentice Hall of India Ltd., 1984

CH 17P 1504 ECONOMICS AND MANAGEMENT OF CHEMICAL INDUSTRIES

Course Objective
To impart the basic concepts of economics and management

Course Outcome
On completion of the course, the student will be able to
CO1

Module 1
Equivalence and cost comparison - time value of money and equivalence - equations used in economic analysis - compound interest and continuous interest as una cost - Hoskold's formula - capitalized cost - cost comparison with equal and unequal duration of service life - depreciation and taxes - nature of depreciation - methods of determining depreciation - straight line - sinking fund - declining balances - double declining balance - sum of years digits and units of production methods - present worth after taxes - cost comparison after taxes

Module 2
Cost estimation - equipments for process plants - cost indices - construction cost indices - material cost indices - labour cost indices - William's sixteenth factor - location index – types of cost estimates - order of magnitude estimate - study estimate - preliminary estimate - definitive estimate - detailed estimate - techniques of cost estimates - conference techniques - comparison techniques graphic relationship - tabular relationship - unit rate techniques – lang factor method - hand factor method - Chilton method - miller method - Peter's and Timmerhaus ratio factor method - check list of items for capital cost estimates, product cost estimates, direct production cost, administration expenses - check list of items for total product cost estimates - elements of complete costs - start-up costs.

Module 3
Profitability analysis - mathematical methods for profitability evaluation - payout time - payout time with interest - return on average investment - DCF rate of return - net present value - net present value index - incremental analysis - break even analysis - variable cost and fixed cost - economic production chart for 100% capacity and dumping - non-linear economic production chart.

Module 4
Inflation - cost comparison under inflation - una burden - allowance for inflation - displacement vs replacement - one year more of existent - more than one year of the existent - principles of accounting - accounting definition - trial balance - balance sheet - profit and loss accounts - financial ratios related to balance sheet and profit and loss account – financial institutions - feasibility analysis report of a venture - canons of ethics of engineers

Reference/Text Books
1. Jelen F.C., and Black J.H., Cost and Optimisation Engineering, Second Edn., McGraw Hill, 1983.

2. Davies G.S., Chemical Engineering Economics and Decision Analysis, Chem. Eng. Ed. Dev. Centre, IIT Madras, 1981.
3. Max Peters, Klaus Timmerhaus, Ronald West., Plant Design and Economics for Chemical Engineers, Fifth Edn., Mc-Graw Hill Education, 2003
4. Vilbrant F.C., Dryden, C.E., “Chemical Engineering and Plant Design”, 4th Ed., McGraw-Hill, New York, 1959

CH 17P 1505 E1 PETROLEUM REFINING AND PETROCHEMICALS

Course Objective
Students will gain knowledge about petroleum refining process and production of petrochemical products

Course Outcome
On completion of this course, the student will be able to
CO1 Understand the classification, composition and testing methods of crude petroleum / product to develop innovative refining process and develop quality control and assurance techniques.
CO2 Apply the knowledge of treatment processes to develop the manufacture of petroleum products.

Module 1
Origin, Formation and Evaluation of Crude Oil. Testing of Petroleum Products. Refining of Petroleum – Atmospheric and Vaccum Distillation.
Cracking, Thermal Cracking, Vis-breaking, Catalytic Cracking (FCC), Hydro Cracking, Coking and Air Blowing of Bitumen.

Module 2
Treatment Techniques: Removal of Sulphur Compounds in all Petroleum Fractions to improve performance, Solvent Treatment Processes, Dewaxing, Clay Treatment and Hydrofining.

Module 3
Cracking of Naphtha and Feed stock gas for the production of Ethylene, Propylene, Isobutylene and Butadiene. Production of Acetylene from Methane, Catalytic Reforming of Petroleum Feed Stocks and Extraction of Aromatics.

Module 4
Production of Petrochemicals like Dimethyl Terephathalate (DMT), Ethylene Glycol, Synthetic Glycerine, Linear Alkyl Benzene (LAB), Acrylonitrile, Methyl Methacrylate (MMA), Vinyl Acetate Monomer, Phthalic Anhydride, Maleic Anhydride, Phenol and Acetone, Methanol, Formaldehyde, Acetaldehyde, Pentaerythritol and Production of Carbon Black.

REFERENCE/TEXT BOOKS
1. Nelson, W. L., “Petroleum Refinery Engineering”, 4th Edn., McGraw Hill, New York, 1985.
2. Bhaskara Rao, B. K., “Modern Petroleum Refining Processes”, 2nd Edn., Oxford and IBH Publishing Company, New Delhi, 1990.
3. Bhaskara Rao, B. K. “A Text on Petrochemicals”, 1st Edn., Khanna Publishers, New Delhi, 1987.

CH 17P 1505 E2 ENERGY ENGINEERING

Course Objective
Students will gain knowledge about different energy sources

Course Outcome
On completion of this course, the student will be able to
CO1 Understand conventional Energy sources, Non- conventional Energy sources, biomass sources and develop design parameters for equipment to be used in Chemical process industries.
CO2 Understand energy conservation in process industries

Module 1 ENERGY
Introduction to energy – Global energy scene – Indian energy scene - Units of energy, conversion factors, general classification of energy, energy crisis, energy alternatives.
Conventional energy resources, Thermal, hydel and nuclear reactors, thermal, hydel and nuclear power plants, efficiency, merits and demerits of the above power plants, combustion processes, fluidized bed combustion.

Module 2 NON-CONVENTIONAL ENERGY
Solar energy, solar thermal systems, flat plate collectors, focusing collectors, solar water heating, solar cooling, solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar energy application in India, energy plantations. Wind energy, types of windmills, types of wind rotors, Darrieus rotor and Gravian rotor, wind electric power generation, wind power in India, economics of wind farm, ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion, geothermal energy.

Module 3 BIOMASS ENERGY
Biomass origin - Resources – Biomass estimation. Thermochemical conversion – Biological conversion, Chemical conversion – Hydrolysis & hydrogenation, solvolysis, biocrude, biodiesel power generation gasifier, biogas, integrated gasification.

Module 4 ENERGY CONSERVATION
Energy conservation - Act; Energy management importance, duties and responsibilities; Energy audit – Types methodology, reports, instruments. Benchmalcing and energy performance, material and energy balance, thermal energy management.

REFERENCE/ TEXTBOOKS
1. Rao, S. and Parulekar, B.B., Energy Technology, Khanna Publishers, 2005.
2. Rai, G.D., Non-conventional Energy Sources, Khanna Publishers, New Delhi, 1984.
3. Nagpal, G.R., Power Plant Engineering, Khanna Publishers, 2008.
4. Energy Management, Paul W.O’Callaghan McGraw – Hill, 1993
5. Nejat Vezirog, Alternate Energy Sources, McGraw Hill, New York.
6. El. Wakil, Power Plant Technology, Tata McGraw Hill, New York, 2002.

CH 17P 1505 E3 DRUGS AND PHARMACEUTICAL TECHNOLOGY

Course Objective
Students will gain fundamental knowledge about Drugs and Pharmaceutical and their manufacturing process

Course Outcome
On completion of this course, the student will be able to
CO1 Understand the Drug Metabolism and pharmaco–kinetics principles
CO2 Apply knowledge of unit processes and analytical methods to develop new processes and product formulations.
CO3 Demonstrate statistical quality control procedure and quality assurance programmes in various stages of pharmaceutical process.

Module 1
Development of drugs and pharamaceutical industry; organic therapeutic agents - uses and Economics.
Drug metabolism; physico chemical principles; pharma kinetics-action of drugs on human bodies. Antibiotics- gram positive, gram negative and broad spectrum antibiotics; hormones

Module 2
Chemical conversion processes; alkylation; carboxylation; condensation and cyclisation; dehydration, esterification, halogenation, oxidation, sulfonation; complex chemical conversions fermentation.

Module 3
Compressed tablets; wet granulation; dry granulation or slugging; advancement in granulation; direct compression, tablet presses formulation; coating pills; capsules sustained action dosage forms; parential solutions, oral liquids; injections; ointments; standard of hygiene and manufacturing practice. Packing; packing techniques; quality control.

Module 4
Vitamins; cold remedies; laxatives; analgesics; nonsteroidal contraceptives; external antiseptics; antacids and others. Analytical methods and tests for various drugs and pharmaceuticals – spectroscopy, chromatography, fluorimetry, polarimetry, refractometry, pHmetry.

REFERENCE/ TEXT BOOKS
1. Rawlines, E.A.; "Bentleys Text book of Pharmaceutics ", III Edition, Bailliere Tindall, London, 1977.
2. Yalkonsky, S.H.; Swarbick. J.; "Drug and Pharamaceutical Sciences ", Vol. I, II, III, IV, V, VI and VII, Marcel Dekkar Inc., New York, 1975.

CH 17P 1505 E4 PROCESS PLANT UTILITIES

Course Objective
Students will gain knowledge about auxiliary equipment used in chemical process plants

Course Outcome
On completion of this course, the student will be able to
CO1 Comprehend the principles of water treatment, and methods of treating cooling water; understand the principles of efficient steam generation and utilisation.
CO2 Understand methods of compression of air, air drying system and different types of refrigeration and humidification systems used in process industries; simple calculations of compressors
CO3 Understand the types of fuels and its disposal methods.

Module 1 IMPORTANCE OF UTILITIES AND STEAM
Hard and Soft water, Requisites of Industrial Water and its uses. Methods of water Treatment such as Chemical Softening and Demineralization, Resins used for Water Softening and Reverse Osmosis. Effects of impure Boiler Feed Water.
Properties of Steam, problems based on Steam, Types of Steam Generator such as Solid Fuel Fired Boiler, Waste Gas Fired Boiler and Fluidized Bed Boiler. Scaling and Trouble Shooting. Steam Traps and Accessories.

Module 2 REFRIGERATION
Refrigeration Cycles, Methods of Refrigeration used in Industry and Different Types of Refrigerants such as Monochlorodifluro Methane, Chlorofluro Carbons and Brins. Refrigerating Effects and Liquefaction Processes.

Module 3 COMPRESSED AIR
Classification of Compressor, Reciprocating Compressor, Single Stage and Two Stage Compressor, Velocity Diagram for Centrifugal Compressor, Silp Factor, Impeller Blade Shape. Properties of Air –Water Vapours and use of Humidity Chart. Equipment used for Humidification, Dehumidification and Cooling Towers.

Module 4 FUEL AND WASTE DISPOSAL
Types of Fuel used in Chemical Process Industries for Power Generation such as Natural Gas, Liquid Petroleum Fuels, Coal and Coke. Internal Combustion Engine, Petrol and Diesel Engine. Waste Disposal.

REFERENCE/TEXT BOOKS
1. Eckenfelder, W. W, Jr. “Industrial Water Pollution Control” McGraw-Hill: New York, 1966.
2. P. L. Ballaney, “Thermal Engineering”, Khanna Publisher New Delhi, 1986.
3. Perry R. H. Green D. W. “Perry’s chemical Engineer’s Handbook”, McGraw Hill, New York, 2007.
4. P. N. Ananthanarayan, “Basic Refrigeration & Air conditioning”, Tata McGraw Hill, New Delhi, 2007.

CH 17P 1505 E5 FOOD PROCESSING TECHNOLOGY

Course Objective

The course is aimed to impart knowledge of various areas related to Food processing and technology.

Course Outcome

On completion of the course, the students will be familiar with

CO1 application of biotechnology in food industry.

CO2 appropriate processing, preservation, and packaging methods.

CO3 the aspects of food safety.

CO4 opportunities for higher studies in food science, chemical engineering, biotechnology, and allied fields.

Module 1

Biotechnology in relation to the food industry; Nutritive value of food; types of microorganisms associated with food, its sources, types and behaviour in foods.

Module 2

Preservation of meat, Fisheries, Vegetables, dairy products; Enzymes and Chemicals used in food processing, Thermal inactivation of micro-organisms; Thermal process evaluations; Freezing and thawing of foods. Beverages and related products of baking.

Module 3

Food borne illness, quality control. Case studies on Biotechnology in the evolution of food quality, HFCS (High fructose corn syrup) and Myco-proteins.

Module 4

Rheology and Fluid flow; Calculation of power requirements for pumping of food materials Material and energy balances in Food processing; Thermal processing of food; Microwave heating; Biochemical engineering for flavor and food production.

REFERENCE/TEXT BOOKS

1. William Frazier, Dennis Westhoff, Food Microbiology, 4th Edition, Mcgraw Hill Education, 2008.
2. Roger Angold , Gordon A. Beech, John Taggart, Food Biotechnology, Volume 7, Cambridge University Press, 1989.
3. George J Banward, Basic Food Microbiology, CBS Publishers, New Delhi, 1987.
4. Lindsay, Biotechnology challenges for the flavour and food industry, Elsevier Applied Science, 1988.
5. H.G.Muller, An Introduction to Tropical Food Science, C L P Edition, Cambridge, University Press, 1989.

CH 17P 15 L1 MASS TRANSFER OPERATIONS LAB

Course Objective
Students develop a sound working knowledge on different types of mass transfer equipment.

Course Outcome
CO1 Determine diffusivity, mass transfer rate and mass transfer co-efficient of given system using fundamental principles.
CO2 Generate VLE data and evaluate the performance calculate the parameters in different distillation processes
CO3 Evaluate the performance calculate the parameters in leaching and extraction operations

LIST OF EXPERIMENTS

1. Study the drying characteristics of calcium carbonate and find the critical moisture content and equilibrium moisture content of the sample.
2. Determine the diffusivity coefficient for the acetone - air system.
3. Determine the diffusivity coefficient for oxalic acid in water at different temperatures.
4. Verify Rayleigh’s equation for the given acetone - water system by simple distillation.
5. Conduct a batch leaching test to leach out sodium carbonate from the mixture given and hence find out the percentage of sodium carbonate leached out.
6. Verify Freundlich equation for the adsorption of oxalic acid onto activated carbon.
7. Determine the liquid - liquid equilibrium of the system (Benzene - Acetic acid - Water) and hence draw the ternary graph for the system.
8. Determine the mass transfer coefficient for the given system using Wetted wall column.
9. Determine the HETP of the packed column by Fenske’s method.
10. Studies on the Vapor Liquid Equilibrium (VLE) for the given system
11. Studies on the Absorption of Carbon dioxide in NaOH

CH 17P 1601 TRANSPORT PHENOMENA

Course Objective

To describe mass, momentum and energy transport at molecular, microscopic and macroscopic level, to determine velocity, temperature and concentration profiles.

Course Outcome

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

CO1 Understand the principles of momentum, heat and mass transport by developing mathematical models to determine respective fluxes and velocity, temperature and concentration distribution for flow channels, heat sources and systems involving diffusion and reactions.

CO2 Apply the equation of change and scale factors for different coordinate systems and solve momentum, mass and heat transport problems.

CO3 Analyse the analogy between the transports and understand the turbulence and boundary layer concept in heat and mass transport

Module 1 MOMENTUM TRANSPORT

Viscosity, temperature effect on viscosity of gases and liquids, Newton's law, mechanism of momentum transport, shell balance method, pressure and velocity distributions in falling film, circular tube, annulus, slit.

Module 2 EQUATIONS OF CHANGE AND TURBULENT FLOW

Equation of continuity, motion, mechanical energy, use of equations of change to solve flow problems, dimensional analysis of equations of change, comparison of laminar and turbulent flows, time-smoothed equation of change, empirical expressions.

Module 3 ENERGY TRANSPORT

Thermal conductivity, temperature and pressure effect on thermal conductivity of gases and liquids, Fourier's law, mechanism of energy transport, shell energy balance, temperature distribution in solids and laminar flow with electrical, nuclear, viscous, chemical heat source, heat conduction through composite walls, cylinders, spheres, fins, slits.

Energy equations, special forms, use of equations of change, dimensional analysis of equations of change, time-smoothed equations of change, empirical expressions, temperature distribution for turbulent flow in tubes, jets.

Module 4 MASS TRANSPORT, EQUATIONS OF CHANGE FOR MULTICOMPONENT SYSTEMS AND CONCENTRATION DISTRIBUTION IN TURBULENT FLOWS

Diffusivity, temperature and pressure effect, Fick's law, mechanism of mass transport, theory of diffusion in gases and liquids, shell mass balances, concentration distribution in solids and in laminar flow : stagnant gas film, heterogeneous and homogeneous chemical reaction systems, falling film, porous catalyst. The equation of continuity, summary of equations of change and fluxes, use of equations of change, dimensional analysis, and time smoothed equations of change, empirical expressions for turbulent mass flux.

REFERENCE/ TEXT BOOKS

1. Bird, R. B., Stewart, W. E. and Lighfoot, E. W., “Transport Phenomena”, 2nd Edn., John Wiley, 2002
2. Brodkey, R. S., and Hershey, H. C., “Transport Phenomena”, McGraw-Hill, 1988.
3. Welty, J. R., Wilson, R. W., and Wicks, C. W., “Fundamentals of Momentum Heat and Mass Transfer”, 3rd Edn. John Wiley, New York, 1984.

CH 17P 1602 BIOCHEMICAL ENGINEERING

Course Objective

To impart the basic concepts of biochemical engineering and to develop understanding about biochemistry and bioprocesses

Course Outcome

On completion of this course, the student can

CO1 Enhance his knowledge in the aspects of cell structure and its functions

CO2 Identify the importance of biomolecules in metabolic processes.

CO3 Analyse the kinetics of enzymatic reactions and their inhibitions.

CO4 Evaluate and model the cell growth kinetics in a bioreactor.

CO5 Design a bioprocess with various unit operations involved in it.

Module 1

Introduction to Bioscience: Types of Microorganisms: Structure and function of microbial cells. Fundamentals of microbial growth, batch and continuous culture. Isolation and purification of Enzymes from cells. Cell Growth Measurement.

Module 2

Functioning of Cells and Fundamental Molecular Biology: Metabolism and bio-energetics, photosynthesis, carbon metabolism, EMP pathway, tricarbocyclic cycle and electron transport chain, aerobic and anaerobic metabolic pathways. Synthesis and regulation of biomolecules, fundamentals of microbial genetics, role of RNA and DNA.

Module 3

Enzyme kinetics: Simple enzyme kinetics, Enzyme reactor with simple kinetics. Inhibition of enzyme reactions. Other influences on enzyme activity. Immobilization of enzymes. Effect of mass transfer in immobilised enzyme particle systems. Industrial applications of enzymes.

Cell kinetics and fermenter design: Growth cycle for batch cultivation, Stirred-tank fermenter, and multiple fermenters connected in series. Cell recycling. Structured Model.

Module 4

Introduction to Bioreactor design: Continuously Stirred aerated tank bioreactors. Mixing power correlation. Determination of volumetric mass transfer rate of oxygen from air bubbles and effect of mechanical mixing and aeration on oxygen transfer rate, heat transfer and power consumption. Multiphase bioreactors and their applications. Downstream processing and product recovery in bioprocesses.

REFERENCE/TEXT BOOKS

1. J. E. Bailey and D. F. Ollis. “Biochemical Engineering Fundamentals", 2nd Edn., McGraw Hill, New York , 1986.
2. M. L. Shuler and F. Kargi, “Bio Process Engineering: Basic concepts”, 2ndEdn. Prentice Hall of India, New Delhi, 2002.
3. Trevan, Boffey, Goulding and Stanbury," Biotechnology", Tata McGraw Hill Publishing Co., New Delhi, 1987.

4. H. W. Blanch and D. S. Clark, “Biochemical Engineering”, Marcel Dekker, Inc., New York, 1996.

CH 17P 1603 PROCESS PLANT SAFETY AND HAZARD MITIGATION

Course Objective

Students learn about implementation of safety procedures, fire prevention, hazard identification, and risk assessment.

Course Outcome

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

CO1 Analyse the effects of release of toxic substances.

CO2 Select the methods of prevention of fires and explosions.

CO3 Understand the methods of hazard identification and preventive measures.

CO4 Assess the risks using fault tree diagram

Module 1

Introduction: Safety Programs, Engineering Ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, Nature of the Accident Process, Inherent Safety.

Industrial Hygiene: Anticipation and Identification, Classification of atmospheric contaminants. TLV. Contamination reduction or removal methods. Handling and storage of Hazardous chemicals. Hygiene Evaluation, Hygiene Control.

Module 2

Fires and Explosions: Fire Triangle, Distinction between Fires and Explosions, Flammability Characteristics of Liquids and Vapors, Limiting Oxygen Concentration and Inerting, Flammability Diagram

Concepts to Prevent Fires and Explosions: Inerting, Controlling Static Electricity, Explosion-Proof Equipment and Instruments, Ventilation, Sprinkler Systems.

Module 3

Introduction to Reliefs: Relief Concepts, Location of Reliefs, Relief Types, Relief Scenarios, Data for Sizing Reliefs, Relief Systems.

Relief Sizing- Conventional Spring: Operated Reliefs in Liquid Service, Conventional Spring-Operated Reliefs in Vapour or Gas Service, Rupture Disc Reliefs in Liquid Service, Rupture Disc Reliefs in Vapour or Gas Service.

Module 4

Hazards Identification: Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Fault tree analysis.

Safety Procedures and Designs: Process Safety Hierarchy, Managing Safety, Best Practices, Procedures—Operating, Procedures—Permits, Procedures—Safety Reviews and Accident Investigations, Designs for Process Safety.

REFERENCE/TEXT BOOKS

1. D.A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 2011.
2. Wells, G. L., Safety in Process Plant Design, George Godwin Ltd, London
3. R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Vol. 6, Elsevier India, 2006.

CH 17P 1604 PROCESS EQUIPMENT DESIGN

Course Outcome

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

CO1 Demonstrate the skills in mechanical design of process equipment, design considerations of pressure vessels and its auxiliary devices.

CO2 Understand the symbols of various process equipment

CO3 Interpret a process flow diagram and a P&I diagram.

Module1

Introduction to Chemical Engineering Design, Process design, Mechanical aspects of process equipment design, General design procedure, Equipment classifications, Design codes and standards (IS, ASTM and BS)

Criteria in vessel design - Properties of materials, Material of construction for various equipment and services, Material specifications, Fabrication techniques

Module 2

Design of Pressure Vessels - Design of pressure vessels under internal pressure, Construction features, Pressure vessel code, Design of shell, various types of heads, nozzles, flanges for pressure vessel, Design and construction features of thick-walled pressure vessels, Various types of jackets and coils for reactors, Auxiliary process vessels

Module 3

Supports for vessels - Design consideration for supports for process equipment, Design of brackets support, leg support skirt, support, saddle support.

Design of storage vessel - Storage of non-volatile and volatile liquids and gases, Codes for storage vessel design, Bottom, Roof and Shell designs.

Design of vessels under external pressure - Design criteria for external design pressure, vessels operated under vacuum, Use of stiffeners, Design of covers, pipes and tubes

Module 4

Drawing of process equipment symbols for fluid handling, heat transfer, mass transfer, drawing of process equipment symbols for vessels, conveyers and feeders etc. Drawing of process equipment symbols for, separators, mixing & comminution etc. Drawing of process equipment symbols for distillation, driers, evaporators, scrubbers etc. Drawing of process equipment symbols for crystallizer, grinding, jigging, elutriation, magnetic separation, compressor etc. Drawing of basic instrumentation symbols for flow, temperature, level, pressure and combined instruments, Drawing of miscellaneous instrumentation symbols, Detailed drawing of equipment, Drawing of flow sheet. Preparation of P&I diagram.

Reference/Text Books

1. Joshi M.V., Mahajani V.V., “Process Equipment Design”, 3rd Ed., MacMillan, Delhi, 1996.
2. IS Code: 2825 (1969).
3. Bhattacharyya B.C., “Introduction to Chemical Equipment Design: Mechanical Aspects”, 5th Ed., CBS Publishers, New Delhi, 2008
4. Brownell L.E., Young E.H., “Process Equipment Design”, Wiley Eastern, Delhi, 1977.

CH 17P 1605 E1 NEW SEPARATION PROCESSES

Course Objective
Students will gain knowledge about recent separation methods

Course Outcome
On completion of this course, the student will be able to
CO1 Create the understanding of separation processes for selecting optimal process for new and innovative applications.
CO2 Exhibit the skill to develop membrane processes, adsorption process and inorganic separation process.
CO3 Apply the latest concepts like super critical fluid extraction, pervaporation, lyophilisation etc., in Chemical process industries.
CO4 Understand Innovative techniques of controlling and managing oil spills.

Module 1 BASICS OF SEPARATION PROCESS
Review of Conventional Processes, Recent advances in Separation Techniques based on size, surface properties, ionic properties and other special characteristics of substances, Process concept, Theory and Equipment used in cross flow Filtration, cross flow Electro Filtration, Surface based solid – liquid separations involving a second liquid.

Module 2 MEMBRANE SEPARATIONS
Types and choice of Membranes, Plate and Frame, tubular, spiral wound and hollow fibre Membrane Reactors and their relative merits, commercial, Pilot Plant and Laboratory Membrane permeators involving Dialysis, Reverse Osmosis, Nanofiltration, Ultra filtration and Micro filtration, Ceramic- Hybrid process and Biological Membranes.

Module 3 SEPARATION BY ADSORPTION
Types and choice of Adsorbents, Adsorption Techniques, Dehumidification Techniques, Affinity Chromatography and Immuno Chromatography, Recent Trends in Adsorption.

Module 4 INORGANIC SEPARATIONS AND OTHER TECHNIQUES
Controlling factors, Applications, Types of Equipment employed for Electrophoresis, Dielectrophoresis, Ion Exchange Chromatography and Eletrodialysis, EDR, Bipolar Membranes. Separation involving Lyophilisation, Pervaporation and Permeation Techniques for solids, liquids and gases, zone melting, Adductive Crystallization, other Separation Processes, Supercritical fluid Extraction, Oil spill Management, Industrial Effluent Treatment by Modern Techniques.

Reference/ Text Books
1. King, C. J., “Separation Processes”, Tata McGraw Hill, 1982.
2. Roussel, R. W., “Handbook of Separation Process Technology”, John Wiley, New York, 1987.
3. Nakagawal, O. V., “Membrane Science and Technology”’ Marcel Dekkar, 1992.

CH 17P 1605 E2 FERTILIZER TECHNOLOGY

Course Objective
To make the students understand and improve the Technological advancements in agriculture and fertilizer industry.

Course Outcome
On completion of this course, the student will be able to
CO1 Classify fertilizers
CO2 Explain manufacturing processes involved in production of fertilizers.
CO3 Identify the effect of technologies on the health, safety and environment.
CO4 State the chemical reactions and their mechanism involved.

Module 1 INTRODUCTION TO FERTILIZERS & NITROGENOUS FERTILIZERS
Plant nutrients and its types, Fertilizer and its types, Production of Ammonia and Nitric acid, Methods of production, Specification, storage and handling of nitrogenous fertilizers, Ammonium sulphate, Ammonium nitrate, Urea, Calcium ammonium nitrate, Ammonium chloride.

Module 2 PHOSPHATIC AND POTASSIUM FERTILIZERS
Raw materials, Phosphoric acid, Sulphuric acid, Phosphate rock, Sulphur, pyrite. Methods of production, Specification, storage and handling of Phosphatic fertilizers, ground rock phosphate, Bone meal, Single super phosphate, Triple super phosphate, Thermal phosphate.
Sources of potassium, Location, Methods of production, Specification, storage and handling of potassic fertilizers, potassium chloride, Potassium choenites. Function of potassium in plants.

Module 3 COMPLEX AND MISCELLANEOUS FERTILIZERS
Types of complex fertilizers, composition ,Production of ammonium phosphate fertilizers, Ammonium sulfate, Diammonium phosphate, Nitro phosphate , Mono Ammonium Phosphate and various grade of NPK fertilizers produced in industries. Mixed fertilizers and granulated mixtures, Biofertilizers and nutrients. Secondary nutrients and Micronutrients, Fluid fertilizers.

Module 4 ENVIRONMENTAL PROTECTION & POLLUTION PREVENTION
Environmental issues related to the use of fertilizers, Environmental impact of the fertilizer industry, Phosphogypsum, Environmental Impact Assessment, and Role of international organizations.

Reference/Text Books
1. Handbook of Fertilizer Technology, Fertilizer Association of India, New Delhi, 1998.
2. George T. Austin, Shreve’s Chemical Process Industries, 5th Edition, McGraw-Hill International Editions, Singapore, 1984.
3. Gopala Rao M. and Marshall Sittig, Dryden’s Outlines of Chemical Technology, 3rd Edition., East-West Press, New Delhi, 1997.
4. Slack. A.V., Chemistry and Technology of Fertilizers, 2nd Edition, Interscience, Newyork, 1967.
5. Fertilizer Manual, Kluwer Academic Publishers, Netherlands, 1998.

CH 17P 1605 E3 NUCLEAR PROCESS ENGINEERING

Course Outcome

On completion of this course, the student will be able to
CO1 Understand radioactivity, nuclear fission and fusion.
CO2 Understand the interaction of alpha, beta particles and neutrons with matter.
CO3 Understand neutron cycle, critical mass, reactor period and transient conditions.
CO4 Understand engineering aspects of nuclear power production and environmental effects.

Module 1
Nuclear Energy Fundamentals: Atomic structure and Radio isotopes, Nuclear fission and fusion, types and classification of nuclear reactors, nuclear fuels, other reactor materials, fuel processing flow sheet, chemical processes for nuclear power industries, separation of reactor products, nuclides.

Module 2
Nuclear Reactions and radiations: Radioactivity, interaction of alpha and beta particles with matter, decay chains, neutron reactions, fission process, growth and decay of fission products in a reactor with neutron burnout and continuous processing. Make up of reactor, reactor fuel process flow sheet, irradiation schemes, neutron balance, feed requirements and fuel burn up for completely mixed fuels with no recycle.

Module 3
Nuclear Reactor theory: The neutron cycle, critical mass, neutron diffusion, the diffusion equation, slowing down of neutrons, reactor period, transient conditions and reflectors.

Module 4
Engineering Consideration of nuclear Power-Environmental effects: Introduction to nuclear power systems, Thermal-hydraulics: Thermal parameters: definitions and uses. Sources and distribution of thermal loads in nuclear power reactors. Conservation equations and their applications to nuclear power systems: power conversion cycles, containment analysis.
Thermal analysis of nuclear fuel, Single-phase flow and heat transfer, Two-phase flow and heat transfer.

Reference/Text Books
1. Glasstone S and Alexender Seasonske, Nuclear Reactor Engineering, 3rd Edition, CBS publisher, USA, 1994.
2. K. Sriram, Basic Nuclear Engineering, Wiley Eastern Ltd., 1990.
3. W Marshall, Nuclear Power Technology, Vol I, II, and III, Oxford University Press, New York 1983.

CH 17P 1605 E4 CHEMICAL PROCESS OPTIMIZATION

Course Outcome

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

CO1 Translate a verbal description of the chemical engineering problem into mathematical description.

CO2 Formulate unconstrained or constrained objective functions of chemical engineering problems

CO3 Understand how the problem formulation influences its solvability

CO4 Solve the optimization problem.

CO5 Interpret the results of optimization and present the insights.

Module 1

The nature and organization of optimization problems: Scope and Hierarchy, General procedure for solving optimization problems, Formulation of the objective function, Basic concepts of optimization - Continuity, Convexity and applications, Necessary and sufficient conditions for an extremum.

Module 2

Optimization of unconstrained functions: Functions of single variable, scanning and bracketing procedures, Newton and Quasi-Newton methods, Evaluation of one-dimensional search methods.

Unconstrained multivariable optimization: Methods using function values only, Methods using first derivatives, Newton's method and Quasi-Newton's method.

Module 3

Linear programming and applications: Graphical methods, Simplex algorithm, Barrier methods, Linear mixed integer programs. Non-linear programming with constraints - Direct substitution, Quadratic programming, Penalty, Barrier and Augmented Lagrangian methods.

Module 4

Optimization of stage and discrete processes, Applications of optimization: Heat transfer and energy conservation, separation processes, chemical reactor design and operation.

Reference/Text Books

1. Edgar T.F. and D. M. Himmelblau, 'Optimization of Chemical Processes', 2nd Edition, McGraw Hill, 2001

2. Singiresu S Rao, 'Engineering Optimization: Theory and Practice', 4th Edition, John Wiley & Sons Ltd., 2009

3. Mohan C. Joshi and Kannan M. Moudgalya, 'Optimization: Theory and Practice', Alpha Science International Limited, 2004

4. K. Urbanier and C. McDermott, 'Optimal Design of Process Equipment', John Wiley & Sons, 1986.

CH 17P 1605 E5 FUEL CELL ENGINEERING

Course Outcome

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

CO1 Understand fuel cell fundamentals.

CO2 Analyze the performance of fuel cell systems.

CO3 Understand construction and operation of fuel cell stack and fuel cell system.

CO4 Apply the modeling techniques for fuel cell systems.

Module 1

Overview of Fuel Cells: What is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

Module 2

Fuels for Fuel Cells: Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others.
Fuel cell electrochemistry: electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents.

Module 3

Fuel cell process design: Main PEM fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, Fuel cell operating conditions: pressure, temperature, flow rates, humidity.

Main components of solid-oxide fuel cells, Cell stack and designs, Electrode polarization, testing of electrodes, cells and short stacks, Cell, stack and system modelling.

Module 4

Fuel processing: Direct and in-direct internal reforming, Reformation of hydrocarbons by steam, CO2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal, Using renewable fuels for SOFCs.

Reference/Text Books

1. Hoogers G., Fuel Cell Technology Hand Book, CRC Press, 2003.
2. Karl Kordesch& Gunter Simader, Fuel Cells and Their Applications, VCH Publishers, NY, 2001.
3. F. Barbir, PEM Fuel Cells: Theory and Practice, 2nd Ed., Elsevier/Academic Press, 2013.
4. Subhash C. Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications, 2003.
5. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, NY 2006

CH 17P 16 L1 SEMINAR AND PROJECT PRELIMINARIES

Course Objective:

1. To express the details of solved problems, problems to be solved and their analysis
2. To increase the ability to communicate and express scientific knowledge

Course Outcome:

On successful completion, a student will be able to express and communicate scientific knowledge effectively.

Students shall individually prepare and submit a seminar report on a topic of current relevance related to the field of Chemical Engineering. The reference shall include standard journals, conference proceedings, reputed magazines and textbooks, technical reports and URLs. The references shall be incorporated in the report following International standards reflecting the state-of-the-art in the topic selected. Each student shall present a seminar for about 20 -30 minutes duration on the selected topic. The report and presentation shall be evaluated by a team of internal experts based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the seminar report.

CH 17P 1701 CHEMICAL ENGINEERING DESIGN AND DRAWING

Course Objective

Students learn to do in detail process and mechanical design and engineering drawing of different chemical engineering equipments.

Course Outcome

CO1 Apply the skill in thermal design of heat transfer equipment like shell and tube, double pipe heat exchangers and evaporators, and assessing thermal efficiency of the above equipment in practice.

CO2 Demonstrate the skills in basic design and drawing of different dryers, and cooling towers.

CO3 Apply the concepts involved in phase separation and design of distillation, Extraction and absorption columns.

Module 1

Process design and detailed drawing of shell and tube heat exchangers, double pipe heat exchangers and condensers.

Module 2

Process design and detailed drawing of: Evaporators- Standard short tube, Standard long tube and forced circulation evaporators. Multiple effect evaporators. Process design of Cooling Towers.

Module 3

Process design of steady state isothermal binary component distillation columns. Detailed drawing of distillation column and its accessories. Process design of steady state isothermal absorption and stripping column.

Module 4

Process design and drawing of: tray and packed Extraction columns; Rotary Dryers and tray dryers.

References:

1**.** Perry. R.H & Green.D.W., Chemical Engineers Handbook, 7th Edn, McGraw hill.
2. B.C Bhattacharya, Introduction to Chemical Equipment Design, CBS Publishers & Distributors, New Delhi.
3. M.V Joshi & Mahajan V.V., Process Equipment Design, 3rd Edn, Mac-Milan & Co. India.
4. R.E.Treybal, Mass Transfer Operations, McGraw hill.
5. J.M.Coulson & J.F.Richardson, Chemical Engineering, Vol.6, 3rd Edn, ButterworthHeinemann, (Indian print)
6. E. Ludwig, Applied Process Design for Chemical & Petrochemical Plants, Vol I, II, II, Gulf Publication, London.
7. IS Codes.
8. D.Q.Kern, Process Heat Transfer, Tata Mc-Graw Hill
9. McCabe W.L., Smith J.C., & Harriot P., Unit Operations In Chemical Engineering, McGraw Hill.

CH 17P 1702 E1 ELECTROCHEMICAL ENGINEERING

Course Objective

Students will gain knowledge about electrochemical process and its application

Course Outcome

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

CO1 Understand the principles of electrochemistry and mechanism involved in electrochemical systems

CO2 Understand the mechanism of corrosion.

CO3 Apply the concepts involved in electro process and design of batteries, fuel cell and electrochemical reactors

Module 1

Review basics of electrochemistry: Faraday's law -Nernst potential –Galvanic cells –Polarography, The electrical double layer: its role in electrochemical processes –Electro capillary curve –Helmoltz layer –Guoy –Steven's layer –fields at the interface.

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

Module 2

Introduction to corrosion, series, corrosion theories derivation of potential-current relations of activities controlled and diffusion controlled corrosion process. Potential-pH diagram, Forms of corrosion- definition, factors and control methods of various forms of corrosion-corrosion control measures- industrial boiler water corrosion control –protective coatings –Vapor phase inhibitors –cathodic protection, sacrificial anodes –Paint removers.

Module 3

Electro deposition –electro refining –electroforming –electro polishing –anodizing –Selective solar coatings, Primary and secondary batteries –types of batteries, Fuel cells.

Module 4

Electrodes used in different electrochemical industries: Metals-Graphite –Lead dioxide –Titanium substrate insoluble electrodes –Iron oxide –semi conducting type etc. Metal finishing cell design. Types of electrochemical reactors, batch cell, fluidized bed electrochemical reactor, filter press cell, Swiss roll cell, plug flow cell, design equation, figures of merits of different types of electrochemical reactors.

Reference/Text Books

1. Picket, “Electrochemical Engineering “, Prentice Hall. 1977.
2. Newman, J. S., “Electrochemical systems “, Prentice Hall, 1973.
3. Barak, M. and Stevenge, U. K., “Electrochemical Power Sources - Primary and Secondary Batteries” 1980
4. Mantell, C., “Electrochemical Engineering “, McGraw Hill, 1972.

CH 17P 1702 E2 PROCESS MODELLING AND SIMULATION

Course Objective
Students will develop suitable chemical process model to get process output

Course outcome
CO1 Understand the fundamentals of modelling and their applications to transport/energy equations, chemical and phase equilibria kinetics etc.,
CO2 Create the mathematical models for different unit operations equipments such as stirred tank heaters, Heat exchangers, Evaporators, Reactors, distillation columns etc.,.
CO3 Analyze the principles of steady state/unsteady state lumped systems and steady state/ unsteady state distributed systems and can select proper equation of state for estimating component properties and process flow sheeting.

Module 1 INTRODUCTION AND STEADY STATE LUMPED SYSTEMS
Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations.
Degree of freedom analysis, single and network of process units, systems yielding linear and non-linear algebraic equations, flow sheeting – sequential modular and equation oriented approach, tearing, partitioning and precedence ordering, solution of linear and non-linear algebraic equations.

Module 2 UNSTEADY STATE LUMPED SYSTEMS
Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems.

Module 3 STEADY STATE DISTRIBUTED SYSTEM
Analysis of compressible flow, heat exchanger, packed columns, plug flow reactor, solution of ODE boundary value problems.

Module 4 UNSTEADY STATE DISTRIBUTED SYSTEM & OTHER MODELLINGAPPROACHES
Analysis laminar flow in pipe, sedimentation, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor, hierarchy in model development, classification and solution of partial differential equations. Empirical modelling, parameter estimation, population balance and stochastic modelling.

Reference / Text Books

1. Ramirez, W.; “Computational Methods in Process Simulation “, 2nd Edn., Butterworths Publishers, New York, 2000.
2. Luyben, W.L., “ Process Modelling Simulation and Control “,2nd Edn, McGraw-Hill Book Co., 1990
3. Felder, R. M. and Rousseau, R. W., “Elementary Principles of Chemical Processes “, John Wiley, 2000.
4. Franks, R. G. E., “Mathematical Modelling in Chemical Engineering “, John Wiley, 1967.

CH 17P 1702 E3 PIPING ENGINEERING

Course Outcome

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

CO1 Understand the key steps in a pipeline's lifecycle: design, construction, installation and maintenance.

CO2 Draw piping and instrumentation diagrams (P&ID).

CO3 Understand codes, standards and statutory regulations.

CO4 Select pipe and pipe fittings.

Module 1

Piping: Pipeline Pigging, Pipe Laying, Pipe Lowering, Ditching, Pipeline Welding.

Pipe Design: Steel pipe design, Properties, Length and calculation of pipe in bends, American standard taper pipe threads, Floodlighting Concepts.

Module 2

Hydrostatic Testing: Benefits and limitations, charts; for estimating the amount of pressure change for a change in test water temperature, chart development.

Pipeline Drying: Pipeline Dewatering, Cleaning and Drying, Brush pig run with gas, Brush pig run with liquid, Internal sand blasting. Chemical cleaning, Pipeline drying, Moisture content of air, Vacuum drying, Corrosion/Coatings, Advances in Pipeline Protection.

Module 3

Gas—Hydraulics: Gas pipeline hydraulics calculations.

Liquids—Hydraulics: Marine Hose Data, CALM system, SALM system, Tandem system, Multi-point mooring system, Pressure Loss through Valves and Fittings.

Measurement: Multiphase flow meter, Pipeline flow measurement—the new influences, Liquid measurement orifice plate flange taps, Gas Measurement.

Module 4

Instrumentation: Developments in Pipeline Instrumentation; Flow measurements Proving devices, Valves Acoustic line break detectors, ''Smart'' pressure sensors, Densitometers, Pipeline samplers, Pipeline monitoring systems, Computer systems, SCADA systems, Cathodic protection.

Leak Detection: Pipeline leak detection techniques.

Reference/Text Books

1. McAllister E.W., Pipeline Rules of Thumb Handbook, 7th Edition, Gulf Publication, 2009.

2. Kellogg, Design of Piping System, 2nd Edition, M.W. Kellogg Co. 2009.

3. Weaver R., Process Piping Design Vol .1 and 2, Gulf Publication, 1989.

CH 17P 1702 E4 POLYMER TECHNOLOGY

Course Objective
Students will gain knowledge about mechanism of polymer process and its application

Course Outcome
CO1 Understand the fundamental of mechanism of polymerization
CO2 Apply the mechanism and effectiveness of polymerization in designing reactor systems.
CO3 Understand the knowledge of polymer stability for developing new formulations and products
CO4 Acquire knowledge on different test for characterization of polymer for applications in R & D work; understand the manufacture and properties of industrial polymers.

Module 1 GENERAL ASPECTS OF POLYMERS & APPLICATION ORIENTED POLYMERS
Classification, mechanisms and methods of polymerization, Properties-Molecular weight, Glass transition temperature, Crystallinity, thermal, Electrical and Mechanical properties.
Application oriented polymers - Resins – PVC, Silicon Oil and resins, fibrous Polymers – Nylon 66, Polyacrylonitrile, adhesives- Epoxides, Phenol formaldehyde, Urea formaldehyde.

Module 2 ELASTOMERS
Natural Rubber, Styrene – butadiene, Polyisopropane – Neoprene, Silicone rubber, Thermoplastic elastomers.

Module 3 PROCESSING OF POLYMERS
Processing additives, plasticizers, Antiaging additives, surface and optical properties, modifiers, fire retardants, additives for rubber and elastomers, various molding techniques.

Module 4 PHYSICAL AND CHEMICAL TESTING OF PLASTICS
Mechanical properties, tensile strength and hardness, electrical properties, volume resistivity, dielectric strength, optical properties- glass, light transmission and refractive index, chemical analysis – elemental and functional analysis

Reference/Text Books
1. Miles, D.C & Briston, J.H., “Polymer Technology”, Chemical Publishing Co. Inc, NY, 1979
2. Maturine Morton, “Rubber Technology”, 3rd Edition, Van Nostrand Re Inhold, NY, 1987
3. Mascic, L. “Thermoplastics Materials Engineering”, Applied Science Publishers Ltd, NY, 1986.
4. Raymond E. Seymour, “Engineering, Polymer Source Book”, McGraw Hill

CH 17P 1702 E5 NANO TECHNOLOGY

Course Outcome

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

CO1 Understand the properties of nano-materials and their applications

CO2 Apply chemical engineering principles to nano-particles production and scale-up

CO3 Solve the quantum confinement equations.

CO4 Characterize nano-materials.

CO5 State the applications of nanotechnology in electronics and chemical industries

Module 1

Introduction to Nanotechnology: Introduction to nanotechnology and materials, Nanomaterials, Introduction to nano sizes and properties comparison with the bulk materials, different shapes and sizes and morphology.

Fabrication of Nanomaterials: Top Down Approach, Grinding, Planetary milling and Comparison of particles, Bottom Up Approach, Wet Chemical Synthesis Methods, Micro emulsion Approach, Colloidal Nanoparticles Production, Sol Gel Methods, Sonochemical Approach, Microwave and Atomization, Gas phase Production Methods : Chemical Vapour Depositions.

Module 2

Kinetics at Nanoscale: Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface Charges, Zeta Potential and pH.

Carbon Nanomaterials: Synthesis of carbon buckyballs, List of stable carbon allotropes extended fullerenes, metallofullerenes solid C60, bucky onions nanotubes, nanocones. Difference between Chemical Engineering processes and nanosynthesis processes.

Module 3

Quantum mechanics: Quantum dots and its Importance, Application of quantum Dots: quantum well, wire, dot, characteristics of quantum dots, Synthesis of quantum dots, Semiconductor quantum dots, Introduction - Nanoclay Synthesis method, Applications of nanoclay.

Nanomaterials characterization: Instrumentation Fractionation principles of Particle size measurements, Particle size and its distribution, XRD, Zeta potential Microscopies SEM, TEM, Atomic Forced Microscopy, Scanning and Tunneling Microscopy

Module 3

Applications in Chemical Engineering: Self-assembly and molecular manufacturing : Surfactant based system Colloidal system applications, ZnO,TiO_2, Silver Nanoparticles Functional materials Applications, Production Techniques of Nanotubes, Carbon arc, bulk synthesis, commercial processes of synthesis of nanomaterials, Nanoclay, Commercial case study of nano synthesis - applications in chemical engineering, Nano inroganic materials - $CaCO_3$ synthesis, Hybrid wastewater treatment systems, Electronic Nanodevices, sensor applications.

Module 4

Nanobiology: biological methods of synthesis.Applications in drug delivery, Nanocontainers and Responsive Release of active agents, Layer by Layer assembly for nanospheres, Safety and health issues of nanomaterials, Environmental Impacts, Case Study for Environmental and Societal Impacts.

Reference/Text Books

1. Kulkarni Sulabha K., Nanotechnology: Principles and Practices, Capital Publishing Company, 2007.
2. Gabor L. Hornyak., H.F. Tibbals, Joydeep Dutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, 2005.
4. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
5. Davies, J.H. 'The Physics of Low Dimensional Semiconductors: An Introduction', Cambridge University Press, 1998.

CH 17P 17 L1 REACTION ENGINEERING AND PROCESS CONTROL LAB

Course Objective
To provide experience on analysis of process control and reaction engineering.

Course Outcome
On completion of this course, the student will be able to
CO1 Understand the prerequisites of control strategies and design different process control systems.
CO2 Evaluate the suitable controllers for different chemical process.
CO3 Understand rate equation for different types of reactors.
CO4 Design experiments in kinetics to determine conversion and effect of temperature on rate constant.

LIST OF EXPERIMENTS
1. Calibration of thermocouple
2. Dynamics of thermocouple
3. Dynamics of thermometer
4. Dynamics of thermometer with thermo well
5. Dynamics of liquid level system - single tank
6. Dynamics of liquid level system - non-interacting tanks in series
7. Dynamics of liquid level system - interacting tanks in series
8. Determination of activation energy
9. Kinetics of hydrolysis of methyl acetate
10. Kinetics of hydrolysis of ethyl acetate
11. Performance study of plug flow reactor
12. Performance study of CSTR
13. RTD studies

CH 17P 17 L2 PROJECT

Each batch of students (comprising of a maximum five students) shall carry out a project in an industry / R&D institution / university department.

- A detailed project report in the prescribed formal shall be submitted at the end of the semester. All test results and relevant design and engineering documentation shall be included in the report
- The work shall be reviewed and evaluated periodically

The final evaluation of the project shall be done by a team of internal examiners including the project guide. The evaluation shall be based on :

- Presentation of the work
- Oral examination
- Quality and content of the project report

Guidelines for evaluation:

i. Regularity and progress of work		40
ii. Work knowledge and involvement		60
iii. End semester presentation and oral examination		60
iv. Project Report – Presentation style and content		40
	Total	200 marks

Note : Points (i) and (ii) to be evaluated by the respective project guide and the project coordinator based on continuous evaluation. (iii)-(iv) to be evaluated by the final evaluation team comprising of internal examiners including the project guide.

CH 17P 17 L3 COMPREHENSIVE VIVA VOCE

Each student is required to appear for a comprehensive viva-voce examination at the end of the complete course work. The examination panel shall comprise of a minimum of one internal examiner and one external examiner, both appointed by the University. The examiners shall evaluate the students in terms of their conceptual grasp of the course of study and practical/analysis skills in the field.