B. Tech. Degree
in
CHEMICAL ENGINEERING

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(For students admitted in 2013-14)

DEPARTMENT OF CHEMICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI - 620 015
TAMIL NADU, INDIA

CURRICULUM

The total minimum credits required for completing the B. Tech. Programme in Chemical Engineering is 182 (45+137)

SEMESTER III

CODE	COURSE OF STUDY	L	T	P	C
MA201	Transforms, Special Functions and Partial Differential Equations	2	1	0	3
CH201	Organic Chemistry	3	0	0	3
EE227	Electrical and Electronics Engg	3	0	0	3
CL203	Chemical Technology	3	0	0	3
CL205	Momentum Transfer	3	0	0	3
CL207	Process Calculations	3	1	0	4
CL209	Technical Analysis Lab	0	0	3	2
EE221	Applied Electrical & Electronics Engineering laboratory	0	0	3	2
	Total	**17**	**2**	**6**	**23**

SEMESTER IV

CODE	COURSE OF STUDY	L	T	P	C
MA202	Numerical Techniques	2	1	0	3
CL202	Advanced Programming Languages, C++	3	0	0	3
CL204	Physical Chemistry	3	0	0	3
CL206	Chemical Engineering Thermodynamics	3	1	0	4
CL208	Particulate Science and Technology	2	1	0	3
CL210	Environmental Engineering	3	0	0	3
CL212	Momentum Transfer Lab	0	0	3	2
CL214	Physical Chemistry Lab	0	0	3	2
	Total	**16**	**3**	**6**	**23**

SEMESTER V

CODE	COURSE OF STUDY	L	T	P	C
CL301	Chemical Reaction Engineering – I	2	1	0	3
CL303	Material Science and Technology	3	0	0	3
CL305	Mass Transfer	3	0	0	3
CL307	Heat Transfer	2	1	0	3
CL309	Biochemical Engineering	3	0	0	3
	Elective 1	3	0	0	3
CL311	Particulate Science and Technology Lab	0	0	3	2
CL313	Thermodynamics Lab	0	0	3	2
	Total	**16**	**2**	**6**	**22**

SEMESTER VI

CODE	COURSE OF STUDY	L	T	P	C
HM302	Human psychology & organisational behaviour	2	0	0	2
CL304	Chemical Reaction Engineering – II	2	1	0	3
CL306	Equilibrium staged Operations	3	1	0	4
CL308	Process Dynamics and Control	2	1	0	3
	Elective 2	3	0	0	3
	Elective 3	3	0	0	3
CL310	Heat Transfer Lab	0	0	3	2
CL312	Chemical Reaction Engineering Lab	0	0	3	2
	Industrial Lectures	1	0	0	1
	Internship / Industrial Training / Academic Attachment	0	0	3	2
	Total	**16**	**3**	**9**	**25**

SEMESTER VII

CODE	COURSE OF STUDY	L	T	P	C
CL401	Safety in Chemical Industries	3	0	0	3
CL403	Chemical Process Design	2	2	0	4
CL405	Project Engineering & Economics	2	1	0	3
CL407	Transport Phenomena	3	0	0	3
	Elective 4	3	0	0	3
	Elective 5	3	0	0	3
CL409	Comprehensive Viva-Voce	0	0	0	3
CL411	Mass transfer Lab	0	0	3	2
CL413	Process Dynamics and Control Lab	0	0	3	2
	Total	**16**	**3**	**6**	**26**

SEMESTER VIII

CODE	COURSE OF STUDY	L	T	P	C
HM402	Industrial Economics and Management	3	0	0	3
	Elective 6	2	1	0	3
	Elective 7	3	0	0	3
	Elective 8	3	0	0	3
CL402	Project Work	0	0	0	6
	Total	**11**	**1**	**0**	**18**

LIST OF ELECTIVES

ELECTIVE 1

CODE	COURSE OF STUDY	L	T	P	C
CL315	Petroleum and Petrochemical Engineering	3	0	0	3
CL317	Nuclear Engineering	3	0	0	3

ELECTIVE 2&3

CODE	COURSE OF STUDY	L	T	P	C
CL314	Fertilizer Technology	3	0	0	3
CL316	Biotechnology	3	0	0	3
CL318	Energy Engineering	3	0	0	3
CL320	Process Instrumentation	3	0	0	3

ELECTIVE 4&5

CODE	COURSE OF STUDY	L	T	P	C
CL415	Polymer science and Technology	3	0	0	3
CL417	New Separation Process	3	0	0	3
CL419	Applied Mathematics in Chemical Engineering	3	0	0	3
CL421	Renewable Energy	3	0	0	3

Any other electives from other department.

ELECTIVE 6,7&8

CODE	COURSE OF STUDY	L	T	P	C
CL404	Nano Technology	3	0	0	3
CL406	Fluidization Engineering	3	0	0	3
CL408	Pharmaceutical Technology	3	0	0	3
CL410	Process optimization	3	0	0	3

LIST OF ADVANCED LEVEL COURSES OFFERED TO OBTAIN B. Tech. HONOURS

(A student with consistent academic record of GPA ≥ 8.5 from I to IV semesters, and applied for B. Tech Honours can opt to study any 3 of the listed advanced level courses from V semester)

(A student who has consistently obtained a minimum GPA of 8.5 in the first 4 semesters and desires to apply for B. Tech. Honours should maintain the same minimum GPA in the subsequent semesters AND opt to study any 3 of the listed advanced level courses approved to be offered by the department concerned to such applicants from V semester)

LIST OF ADVANCED LEVEL COURSES OFFERED TO OBTAIN B. Tech. HONOURS

CODE	COURSE OF STUDY	L	T	P	C
CL601	Process Dynamics and control – II	3	0	0	3
CL602	Advances in Fluidization Engineering	3	0	0	3
CL603	Process Modelling and Simulation	3	0	0	3
CL604	Pinch Analysis and Heat Exchange Network Design	3	0	0	3
CL605	Design and Analysis of Experiments	3	0	0	3
CL606	Advances in Heat Transfer	3	0	0	3

COURSES OFFERED TO OTHER DEPARTMENTS

CODE	COURSE OF STUDY	L	T	P	C
ME 101	Engineering Mechanics	3	0	0	3
CE 283	Fluid Machinery & Thermodynamics Theory	3	0	0	3
CE 285	Fluid Machinery & Thermodynamics Lab	3	0	0	3

COURSES OFFERED FROM OTHER DEPARTMENTS

CODE	COURSE OF STUDY	L	T	P	C
MT403	Corrosion Engineering	3	0	0	3
IC452	Power Plant Instrumentation & Control	3	0	0	3
HM403	Human Values through Literature	3	0	0	3
HM404	Creative Writing through Literature	3	0	0	3

(SYLLABUS)

B.Tech. Chem. Engg. Syllabus for 2014 – 2015 onwards.

MA 201	TRANSFORMS, SPECIAL FUNCTIONS AND PARTIAL DIFFERENTIAL EQUATIONS	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES

(i) To understand the basic principle of contents of Mathematics

(ii) Mathematics is a tool in the hands of engineers to make it effective it is imperative to

a. know clearly how tool works
b. To build the logic of students
c. To increase the computational skill of student

(iii) Mathematics leads to creative thinking

(iv) To prepare students for their respective branches

COURSE CONTENT

Laplace Transform of Standard functions, derivatives and integrals – Inverse Laplace transform – Convolution theorem – Periodic functions – Application to ordinary differential equation and simultaneous equations with constant coefficients and integral equations.

Z-transforms – inverse Z-transforms – Solution of difference equation with constant coefficients using Z-transforms – Fourier Series – Dirichlet's conditions – Half range Fourier cosine and sine series – Parseval's relation

Bessel's Equation – Bessel Functions – Recurrence relations – Generating function for Bessel functions – Legendre's equation – Legendre polynomials – Rodrigue's formula-generating function and recurrence relations for Legendre polynomials – orthogonality property of Legendre polynomials.

Formation of partial differential equations by eliminating arbitrary constants and functions – solution of first order equations – four standard types – Lagrange's equation – homogeneous and non-homogeneous types of second order linear differential equation with constant coefficients.

Applications of Partial Differential Equations – Solution of one-dimensional heat flow equation and two dimensional heat flow equation (Cartesian and Polar form) in steady state by the method of separation of variables using Fourier series.

COURSE OUTCOME

i. The ability to derive and apply solutions from knowledge of Mathematics.
ii. Graduate will have confidence to apply science & Engg. Solutions in global & social context using Mathematics.
iii. Graduate can participate & attend to succeed in competitive exams like GATE, TOFEL, and GRE etc.
iv. Graduates will be capable of perusing higher studies, Research and development activities.
v. Graduates will have ability to identify, to formulate and solve engineering problems.

REFERENCES:

1. *GREWAL. B. S., "Higher Engineering Mathematics", Khanna Publishers.*
2. *SNEDDON, I. N., "Elements of Partial Differential Equations", McGraw Hill.*
3. *VENKATARAMAN, M. K., "Engineering Mathematics", Vol. III, National Publishing Company.*
4. *VENKATARAMAN, M. K., "Higher Mathematics for Engineering and Science", National Publishing Company.*

CH 201	ORGANIC CHEMISTRY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

(i) To impart the basic concepts of organic chemistry.

(ii) To develop understanding about concepts on organic reactions for analysis of unit processes.

COURSE CONTENT

Unit I: Fundamentals of Photochemistry, Qualitative introduction about different transitions, Cis-Trans isomerization, Paterno-Buchi reaction, Norrish type I and II reactions, photo reduction of ketones, di-pi-methane rearrangement, photochemistry of arenas .

Unit II: Pericyclic reactions, Classification, electrocyclic ring opening and closure, Cope & Claisen rearrangement, 2+2 and 4+2 cycloaddition and ene reactions, Woodward-Hoffmann rules, and FMO theory. Coal Tar distillation separation of aromatics. Theory of orientation in aromatic electrophilic substitution in benzenoid and heterocyclic compounds.

Unit III: Grignards Reagents, organo lithium compounds formation and reactions in organic synthesis. Ligand substitution, Oxidative Addition and Reductive Elimination, 1,1 Insertion and deinsertion reactions, asymmetric hydrogenation, Hydroformylation, Wacker-smidt Synthesis, Monsanto Acetic Acid and Eastman-Halcon Carbonylation process, Alkene Metathesis, Pd catalyzed coupling reactions- Heck, Suzuki coupling & Ene Reaction. The Pauson- Khand Reaction

Unit IV: Identification of organic compounds by using combined Mass, IR and NMR spectral analysis. Index of hydrogen deficiency. Mass spectroscopy: Methods of desorption and ionization (EI, CI, MALDI, ESI), study of fragmentation pattern. Basics of IR spectroscopy, applications. Basic Principles of ^{1}H & ^{13}C NMR, Applications of ^{1}H and ^{13}C NMR (DEPT) to organic chemistry, Case studies and combined problems

Unit V: Carbohydrates: Structure of ribose, glucose, fructose, sucrose, starch & cellulose and cyclodextrins, inter conversions of sugars. Dye industry, Synthesis and applications of Azodyes, Vat dyes, triphenyl methane dyes, Mordant Dyes, Leuco Dyes, Eco Friendly Dyes, Environmental hazards from dying industry, Waste treatment in dye industry, Oils and Fats, Analysis.

COURSE OUTCOME

i. Ability to understand the basic reactions required for chemical unit operations
ii. Ability to understand carbon chemistry.
iii. To understand the synthesis of organic compounds

TEXT BOOKS:

1. *R. R. Carey and R. J. Sundburg, Advanced Organic Chemistry, Part A and Part B, Springer, 5th Edn, 2007*
2. *Morisson and Boyd- A Text book of Organic Chemistry, 7th Edn, Pearson Education Singapore Pte Ltd, 2010*
3. *K. Jagadamba Singh, Jaya Singh, Photochemistry and Pericyclic Reactions, 3rd Edn, New Age International publications, 2009*

REFERENCES:

1. *R. M. Silverstein and F. X. Webster: Spectrometric Identification of Organic Compounds, 7th Edn, 2007*
2. *R.H. Crabtree, The Organometallic Chemistry of Transition Metals, 6 th Edn, Wiley, 2014*
3. *I. L. Finar. Organic Chemistry, Vol 1 &2, 5th Edn, ELBS, London, 1975*
4. *K. Hunger, Industrial Dyes, Chemsitry, Properties, Applications, 3rd Edn, Wiely VCH, 2003*

EE 221	ELECTRICAL AND ELECTRONICS ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide the key concepts about Transformers, DC and AC motors and thereby able to choose the appropriate drives for various applications.
- To equip students to understand and apply the basic concepts of Combinational logic circuits and INTEL 8085 Microprocessor.

Prerequisites: Basic Electrical and Electronics Engineering

DC motors - Characteristics - Starting and speed control – Testing - Applications. Transformers: (Single phase only) - equivalent circuit and regulation - losses and efficiency - Testing.

Three-phase induction motor - Cage and slip ring motors -torque slip characteristics –starting and speed control of induction motors - single phase induction motors and universal motors. Synchronous motors - starting and applications.

Electric drive for general factory, textile mill , cement mill - pump, blowers, hoists, traction etc. - group and individual drives

Combinational logic - representation of logic functions – SOP and POS forms K-map representations – minimization using K maps - simplification and implementation of combinational logic – multiplexers and demultiplexers – code converters, adders, subtractors, memory and its types.

Microprocessor – Architecture of INTEL 8085 – Instruction set – addressing modes - Basic assembly language programming

TEXT BOOKS:

1. *Mehta V K and Rohit Mehta, 'Principles of Electrical Machines', S Chand and company Ltd., 2006.*
2. *Dubey G K , 'Fundamentals of Electric drives', Narosa book distributors pvt. ltd , 2nd edition, 2012*
3. *Ramesh S. Gaonkar, 'Microprocessor Architecture Programming and Applications with 8085', Penram Intl. Publishing, 6th edition, 2013.*
4. *Morris Mano, Michael D Ciletti, 'Digital Design', Pearson Education, 4th edition, 2008.*

REFERENCE BOOKS:

1. *Theraja B L,'A TextBook of Electrical Technology', vol 2,S Chand,23rd edition,2007.*
2. *Vincent Del Toro, 'Electrical Engineering Fundamentals', PHI, 2nd edition, 2009.*

Subrahmanyan V, 'Thyristor control of Electric Drives', Tata McGraw Hill, 1st edition.

COURSE OUTCOMES:

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

1. Analyze the performance of DC Motors and Transformers under various operating conditions using their various characteristics.
2. Describe different types AC motors and their characteristics.
3. Select appropriate drive for any industrial application.
4. Design and analyze combinational logic circuits.

Understand the architecture and instruction set of 8085.

CL203	CHEMICAL TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

(i) To impart the basic concepts of chemical technology.
(ii) To develop understanding about unit process and unit operations in various industries.
(iii) To learn manufacturing processes of organic and Inorganic Chemicals and its applications.

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

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

Cement Gases, Water and Paints: Types and Manufacture of Portland cement, Glass:
Industrial Gases: Carbon dioxide, Nitrogen, Hydrogen, Oxygen and Acetylene - Manufacture of paints - Pigments

Fertilisers: Nitrogen Fertilisers; Synthetic ammonia, nitric acid, Urea, Phosphorous Fertilisers: Phosphate rock, phosphoric acid, super phosphate and Triple Super phosphate

COURSE OUTCOME:

i. Able to understand the manufacturing process organic and Inorganic materials
ii. To understand the unit operation in process.
iii. To understand various chemical reaction in the process

TEXT BOOK:

1. *G.T. Austin, N. Shreve's Chemical Process Industries", 5th Edn., McGraw Hill, NewYork, 1984.*
2. *W.V.Mark, S.C. Bhatia "Chemical Process Industries volume I and II", 2nd Edition 2007*

REFERENCES:

1. *R. Gopal and M. Sittig " Dryden's Outlines of Chemical Technology: For The 21st Century" Third Edition, Affiliated East-West Publishers, 1997.*
2. *2. S. D. Shukla and G. N. Pandey, "Text book of Chemical Technology" Vol 2, 1984*

CL 205	MOMENTUM TRANSFER	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

i. To impart the fundamental concepts of fluid statics, pressure distribution and dimensional analysis
ii. To nurture the students to solve fluid dynamics problems using Newton's laws of motion.
iii. To enable students to compute velocity profile ,friction factor and head loss in pipes and fittings
iv. To impart the knowledge of metering and transportation of fluids and fluid moving machinery performance

COURSE CONTENT

Properties of fluids and concept of pressure: Introduction - Nature of fluids - physical properties of fluids - types of fluids. Fluid statics: Pressure - density - height relationships. Pressure Measurement. Units and Dimensions - Dimensional analysis. Similarity - forces arising out of physical similarity - dimensionless numbers.

Momentum Balance and their Applications: Kinematics of fluid flow: Stream line -stream tube - velocity potential. Newtonian and non-Newtonian fluids - Time dependent fluids - Reynolds number - experiment and significance - Momentum balance - Forces acting on stream tubes - Potential flow - Bernoulli’s equation - Correction for fluid friction - Correction for pump work.

Flow of Incompressible Fluids Through Ducts: Flow of incompressible fluids in pipes - laminar and turbulent flow through closed conduits - velocity profile & friction factor for smooth and rough pipes - Head loss due to friction in pipes, fitting etc. Introduction to compressible flow. Isentropic flow through convergent and divergent nozzles and sonic velocity.

Flow of Fluids through Solids: Form drag - skin drag - Drag co-efficient. Flow around solids and packed beds. Friction factor for packed beds. Ergun's Equation - Motion of particles through fluids - Motion under gravitational and centrifugal fields - Terminal settling velocity. Fluidisation - Mechanism, types, general properties - applications.

Transportation and Metering: Measurement of fluid flow: Orifice meter, venturi meter, pitot tube, rotameter, weirs and notches Wet gas meter and dry gas meter. Hot wire and hot film anemometers. Transportation of fluids: Fluid moving machinery performance. Selection and specification. Air lift and diaphragm pump. Positive displacement pumps: Rotary and Reciprocating pumps. Centrifugal pumps and characteristics.

COURSE OUTCOME

The students would have

1. the Knowledge of fundamental concepts in fluids statics and to use dimensional analysis for scaling experimental results
2. the ability to solve hydrostatic and fluid flow problems using Newton's laws of motion.
3. the ability to analyze frictional flow in pipes and piping networks and to compute the head loss and power requirements for chemical process equipments
4. the ability to select the metering equipments and fluid moving machinery for an appropriate chemical engineering operations

TEXT BOOKS:

1. *Noel. D.Nevers, "Fluid Mechanics for Chemical Engineers", McGraw Hill, 3rd International Edition, 2005.*
2. *W. L. McCabe, J.C. Smith and P. Harriott, "Unit operations of Chemical Engineering”, 7th Edn., McGraw Hill, International Edn., 2004.*

REFERENCE:

J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol 1, 6th Edn. Butterworth-Heinemann, 1999.

CL 207	PROCESS CALCULATIONS	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES

1. To nurture students to observe and understand the need of material balance and energy balance in chemical process industries
2. To impart strong fundamental and technical knowledge among student to pursue various mathematical techniques to solve material balance and energy balance problems.
3. To provide students experience in data analysis to formulate, solve and interpret the solutions to various unit operation problems by writing material balance
4. To enable students to analyze and solve material balance and energy balance problems by applying basic principles of Chemical Engineering and Mathematics

COURSE CONTENT

Stoichiometry: Introduction - Units and Dimensions - Stoichiometric principles -composition relations, density and specific gravity.

Ideal Gases and Vapor Pressure: Behaviour of Ideal gases - kinetic theory of gases - application of ideal gas law - gaseous mixtures - volume changes with change in composition. Vapour pressure - effect of Temperature on vapour pressure - vapour pressure plots - vapour pressure of immiscible liquids - solutions.

Humidity and Solubility: Humidity - saturation - vaporization - condensation - wet and dry bulb thermometry Solubility and Crystallisation - Dissolution - solubility of gases.

Material Balance: Material Balance - Processes involving chemical reaction - Combustion of coal, fuel gases and sulphur - Recycling operations - bypassing streams - Degree of conversion - excess reactant - limiting reactant.

Energy Balance: Thermo chemistry - Hess's law of summation - heat of formation, reaction, combustion and mixing - mean specific heat - Theoretical flame Temperature.

COURSE OUTCOME

1. The students will have the capability to find out need of writing mass and energy balance for various unit operations in chemical process industries.
2. The students will have the capability to use mathematical knowledge for solving mass and energy balance problems.
3. The students will learn to integrate the data, formulate the mass and energy balance problems and to solve them.
4. Students will learn to use various mass and energy balance writing techniques in process design in chemical process industries.

TEXT BOOKS:

1. *O. A .Hougen, K. M. Watson and R. A. Ragatz, "Chemical Process Principles", Vol- I, CBS Publishers and Distributors, New Delhi, 1995.*
2. *Himmelblau, "Basic Principles and Calculations in Chemical Engineering", 8th Edn., Prentice Hall of India Ltd, India 2012.*

REFERENCES:

1. *B. I. Bhatt, "Stoichiometry", 5th Edn., Tata McGraw Hill Publishers Ltd., New Delhi, 2010.*
2. *V.Venkataramani, N.Anantharaman and K.M. Meera Sheriffa Begum, 2nd Edn., 'Process Calculations' Prentice Hall of India Ltd, New Delhi. 2013*

CL 209	TECHNICAL ANALYSIS LAB	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES

To enable the students to perform various analytical instruments for water and chemicals.

CONTENT

1-6 Analysis of water, oil, soap, cement, sugar, bleaching powder, fertilizer, drugs and vegetables, tannins, ores, alloys, cellulose

7-12 Analysis of products by colorimeter, polarimetry, potentiometric titration, Conductometric titrations, pH meter, gas chromatograph, flame photometer Turbidity meter, conductivity meter, refractometer, etc.

COURSE OUTCOME

Ability to undergo analysis for water and metal compositions.

EE 225	APPLIED ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY	L	T	P	C
		0	0	2	2

COURSE OBJECTIVE

List of Experiments

1. Load Test on DC Shunt Motor
2. Speed Control of DC Shunt Motor
3. Load Test on DC Series Motor
4. Open Circuit and Short Circuit Test on Single-Phase Transformer
5. Load Test on three phase induction motor
6. Combinational Logic circuit I
7. Combinational Logic circuit II
8. Arithmetic operation using 8085

COURSE OUTCOME

Understanding on usage of ammeter, voltmeter and other calibrations techniques would be enhanced.

MA 202	NUMERICAL TECHNIQUES	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES

(i) The use of probability models and statistical methods for analyzing data has become common practice in virtually all scientific disciplines.
(ii) Two modules of this course attempt to provide a comprehensive introduction to those models and methods most likely to be encountered and used by students in their careers in engineering.
(iii) A broad introduction to some important partial differential equations is also included to make the student get acquainted with the basics of PDE.
(iv) To impart the basic concepts of numerical analysis.
(v) To develop understanding about numerical solutions for engineering problems.

COURSE CONTENT

Solution of linear system – Gaussian elimination and Gauss-Jordan methods – LU – decomposition methods – Crout's method – Jacobi and Gauss-Siedel iterative methods - sufficient conditions for convergence – Power method to find the dominant eigenvalue and eigenvector.

Solution of nonlinear equation – Bisection method – Secant method – Regula falsi method – Newton - Raphson method for $f(x) = 0$ and for $f(x, y) = 0$, $g(x, y) = 0$ – Order of convergence – Horner's method – Graeffe's method – Bairstow's method.

Newton's forward, backward and divided difference interpolation – Lagrange's interpolation – Numerical Differentiation and Integration – Trapezoidal rule – Simpson's 1/3 and 3/8 rules – Curve fitting – Method of least squares and group averages.

Numerical solution of Ordinary Differential Equations – Euler's method – Euler's modified method – Taylor's method and Runge-Kutta method for simultaneous equations and 2^{nd} order equations – Multistep methods – Milne's and Adam's methods.

Numerical solution of Laplace equation and Poisson equation by Liebmann's method – solution of one dimensional heat flow equation – Bender – Schmidt recurrence relation – Crank – Nocolson method – Solution of one dimensional wave equation.

COURSE OUTCOME

1. To learned all types of numerical methods problem
2. The students were able to solve the problems individually.
3. Understand usage of numerical methods the chemical engineering problem application

TEXT BOOKS:

1. *Gerald, C.F, and Wheatley, P.O, "Applied Numerical Analysis", Addison Wesley.*
2. *Jain. M.K, Iyengar.S.R, and Jain.R.K, "Numerical Methods for Scientific and Engineering Computation", Wiley Eastern.*
3. *Kandasamy.P, Thilagavathy.K, and Gunavathy.S., "Numerical Methods", Chand and Company.*

CL 202 ADVANCED PROGRAMMING LANGUAGE, C++

L	T	P	C
2	1	0	3

COURSE OBJECTIVES

i. Understand object-oriented concepts and how they are supported by C++
ii. Gain some practical experience of C++.
iii. Understand implementation issues related to object-oriented techniques
iv. Build good quality software using object-oriented techniques
v. This course is to introduce computational and numerical techniques that may be used to solve a variety of chemical engineering problems

COURSE CONTENT

Objects and Classes: Concepts in object-oriented programming, classes and objects, C++ programming basics, object-oriented analysis, object-oriented design methods.

Working with Classes: Operators and Friends: Operator overloading, Friend functions and operators. Arrays, Pointers and References.

Class Inheritance: Derived classes, the protected access specifier, Derived class constructors, overriding member functions, Class hierarchies, Public and Private inheritance, Multiple inheritance.

Polymorphism: Virtual functions, Abstract base classes and pure virtual functions.

Files and Streams: Introduction to object-oriented database - case studies.

COURSE OUTCOME

i. Ability to solve Chemical engineering problems
ii. Select a computational tool that is capable of solving a particular chemical engineering problem. Such tools include, EXCEL, POLYMATH, Visual Basic, Metlab, Aspen, polymath, and Scilab
iii. Ability to identify, formulate, and solve engineering problems
iv. An ability to communicate effectively
v. Able to do modeling and simulation for unit operations and process in chemical engineering
vi. Able to solve various mathematical problems via programming

TEXT BOOK:

1. *Robert Lafore, "Object Oriented Programming Turbo C++", Gaogotia Pub. 1992.*

REFERENCES:

1. *Neill Graham, "Leaning C++", McGraw Hill Inc. Intl. Edn., 1991.*
2. *Roger S. Pressman, "Software Eng.," A Practitioner's Approach, McGraw Hill 7th Edn. 2009.*

CL 204	PHYSICAL CHEMISTRY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

(i) To impart the basic knowledge on different theories of chemical reaction.
(ii) To expose the students to understand the basic concepts of different isotherms and surface theories.

COURSE CONTENT

Gaseous State**:** Vander wall's equation. Law of equipartition principle, Translational, Rotational and vibrational energies of molecules, Joule-Thomson effect, liquefaction of gases. Critical constants.

Reaction Kinetics**:** Rate order and molecularity of chemical reactions. Methods of their evaluation. Calculation of rate constants. Consecutive - Parallel and opposing reactions. Chain reactions. Energy of activation - Theories on reaction rates. Heterogeneous reactions - zero order reactions.

Phase Equilibria**:** Phase rule: Application - to one components system (water, sulphur and carbon dioxide), Two component systems (Eutetic, Intermediate compound formation and solid solutions) and simple three component systems.

Solutions: Ideal and non-ideal solutions solubility of gases in liquids. Henry's law. Completely miscible liquids - Rauolt's law - vapour pressure and boiling point diagrams. Partially miscible liquids - Critical solution temperature -completely immiscible liquids - Nernst: distribution law - Dilute solution and their colligative properties. Molecular weight determination using these properties.

Electrical Conductance**:** Debye - Huckell Onsager theory; Ostwald's dilution law - solubility of electrolytes and solubility product – Applications, common ion action - acids, bases - definitions a) based on proton transference, dissociation constant, amphoteric electrolyte - pH - Buffer solutions. Hydrolysis of salts. Decomposition potential, over voltage, definitions of current density, current efficiency, energy consumption; oxidation - reduction redox couple; e.m.f. and energy relations. Conductometry, Potentiometry, Voltammetry, their applications. Fuel cells.

Surface Chemistry**:** Derivation of Langmuir adsorption isotherm, B.E.T adsorption isotherm, Determination of surface area of solids by B.E.T. method. Catalysis- Homogeneous catalysis, heterogeneous catalysis, Langmuir – Hinshelwood mechanism of a bimolecular surface reaction, Elay – Rideal mechanism of a surface reaction, Enzyme catalysis, Industrial applications of catalysis, zeolites as catalysts, Self-assembled monolayers and Langmuir-Blodgett films, adsorption chromatography.

COURSE OUTCOME

Able to understand all the basic laws and equations involved in any type of chemical reactions.

TEXTBOOKS:

1. *B. R. Puri and SL. R. Sharma, "Principles of Physical Chemistry", Shoban Lal Nagin Chand & Co.*
2. *P.L. Soni, "Text Book of Physical Chemistry ", S. Chand & Co., New Delhi.*

REFERENCES:

1. *K.J. Laidler, "Chemical Kinetics", 3rd Edn., PHI Publishers,1987.*
2. *Atkins, P and Julio De Paula, ‘Physical Chemistry’, 9th Edn., W. H. Freeman, 2009.*

CL 206 CHEMICAL ENGINEERING THERMODYNAMICS

L	T	P	C
3	1	0	4

COURSE OBJECTIVES

i. Study scope and limitations of thermodynamics
ii. Study laws of thermodynamics
iii. Understand equations of state and various processes
iv. Study fundamentals of heat effects
v. Derive Maxwell's equations, and relations for enthalpy, entropy and Gibb's energy
vi. Know applications of thermodynamic flow processes
vii. Know power cycles, refrigeration and liquefaction processes

COURSE CONTENT

Fundamentals of Thermodynamics: Laws of thermodynamics as applied to open and closed system - reversible and irreversible processes - state and point function - Absolute entropy - Thermodynamic property changes for ideal gas.

PVT Relations: PVT relationships for gases and liquids - equations of state - Z charts - gas mixtures. Compression - expansion. Refrigeration: Principles and application.
Thermodynamic Relations: Thermodynamic relations - Maxwell's relations - Jacobian algebra - estimation of thermodynamic properties.

Phase Equilibria: Phase equilibria - pure component and mixtures - Latent heat correlation - van Laar, Margules equations - Gibbs' - Duhem equation - consistency tests - partially miscible and immiscible systems - Azeotropes - retrograde condensation - thermodynamic diagrams.

Chemical equilibria - heat effects, industrial reactions - Free energy calculations - Homogeneous and heterogeneous reactions - Industrial reactions like NH_3 synthesis, SO_3 production etc.

COURSE OUTCOME

i. Students will have fundamental knowledge of temperature, force, pressure, energy, heat and work.
ii. Students will be able to identify the types of processes and know the applications of phase rule and first law of thermodynamics with limitations
iii. Students are expected to have ability to determine volumetric properties of non-ideal fluids using viral and cubic equations of state
iv. Students will have the ability to calculate heat of formation, heat of combustion and heat of reaction
v. Students will have knowledge of second law of thermodynamics, third law of thermodynamics and their scope of applications
vi. Students should be able to determine thermodynamic properties of fluids using Maxwell's relation and equations of state
vii. Students will have knowledge of application of thermodynamic flow processes
viii. Students will be able to convert heat into work by power cycles
ix. Students will be aware of refrigeration and liquefaction processes

TEXT BOOKS:

1. *J. M. Smith and Van Ness, "Introduction to Engineering Thermodynamics", McGraw Hill, New York, 7th Edition, 2005.*
2. *Sundaram, "Chemical Engineering. Thermodynamics", Ahuja Publishers, New Delhi, 1998.*

REFERENCE:

1. *B. F. Dodge, "Chemical Engineering. Thermodynamics, McGraw Hill., New York, 1971.*

CL 208 PARTICULATE SCIENCE AND TECHNOLOGY

L	T	P	C
2	1	0	3

COURSE OBJECTIVES

i. Understand many basic principles in various Chemical Engineering operations such as Size Reduction, Filtration, Sedimentation, Mixing and Agitation etc. and their mathematical relationships
ii. Understand basic principles of particle preparation and their characterization
iii. Study various methods for storage of solids and conveyors available for their transportation
iv. Understand the performance of different equipments for separation of solids and size reduction

COURSE CONTENT

Characteristics of Particulate Material: Properties and characterisation of particulate solids, analysis and technical methods for size and surface area distribution of powder; Flow properties of particulates.

Synthesis Methods: Introduction to synthesis of composite material by spray technique, aerosol generation, Introduction to size reduction equipment, energy and power requirement in milling operations, computer simulation techniques for mill performance.

Particulate Processes: Gas-liquid separation methods, Classification by size, agitation of liquids and mixing of solids, Fluidization, encapsulation etc.

Handling of Particulate Material: Conveying methods, Storage methods and design of silo, selection of feeders and elevators.

COURSE OUTCOME

i. Students are expected to understand the basic principles of particles preparation and their characterization
ii. Students are expected to have an understanding of solid storage and their conveying in chemical process industries.
iii. Students are expected to have an understanding of design of sedimentation tanks and other solid fluid separation equipments
iv. Students are expected to have knowledge about different size reducing equipments and power requirements during size reduction
v. Students should have an ability to design chemical engineering processes while including economic safety, environment and ethical consideration

TEXT BOOKS:

1. *Mc Cabe and J.C .Smith," Unit Operation of Chemical Engineering", 7th Edn., McGraw Hill., New York, 2004.*
2. *M. Coulson and J.F .Richardson, "Chemical Engineering", Vol. II, 5th Edn., Butterworth - Heinemann, 2002.*

.

REFERENCES:

1. *Raymond A. Kulweic, "Materials Handling Handbook", 2nd Edn, Wiley- Interscience Publications, 1985.*
2. *Badger and Banchero, "Introduction to Chemical Engineering", 1st Edn., McGraw Hill, NewYork, 1955*

CL 210 ENVIRONMENTAL ENGINEERING

L	T	P	C
3	**0**	**0**	**3**

COURSE OBJECTIVES

i. To impart the basic concepts of environmental engineering.
ii. To understand the problems of pollution, loss of forest, solid waste disposal, degradation of environment, loss of biodiversity and other environmental issues and create awareness among the students to address these issues and conserve the environment in a better way.
iii. To develop understanding about pollution and its treatment methodology.
iv. To impart the basic concepts of water treatment technology.

COURSE CONTENT

Environment, Environmental quality and degradation, description of environment setting and procedure for environment impact assessment policies and acts.

Sources of air pollution - effects of air pollution on the environment, on materials, on human health, on animals. Analytical methods. Equipments for control of air pollution. Measurements of air pollution.

Sources of water pollution – Effects of water pollution - control of water pollution and treatment methods for effluent water. Measurements of COD & COD.

Sources of noise pollution. Noise pollution measurements - controlling methods of noise pollution. Effects on human being.

Sources and classification public health aspects, methods of collection, disposal methods.

COURSE OUTCOME

i. Able to understand the effects of pollutants to the environment.
ii. Understand the various treatment technologies for water/wastewater, air effluents and solid waste released from chemical industries.
iii. Understand the development of various unit operation

TEXT BOOKS/REFERENCES:

1. *C. S. Rao, "Environmental Pollution Control Engineering", New Age International Pvt. Ltd., 2003.*
2. *M. N. Rao & H. V. N. Rao, "Air Pollution", Tata – McGraw Hill Publishing Ltd., 1993.*
3. *A. K. De, "Environmental Chemistry", Tata – McGraw Hill Publishing Ltd., 1999.*

CL 209 **Fluid Mechanics Lab**

L	T	P	C
0	0	3	2

Course Objective:
Understand and application of the principles & concepts of learned in momentum transfer theory course

Pre requisite:
Momentum Transfer course

List of Experiments

Flow Through Straight Pipe

Flow Through Pipe Fittings

Flow Through Helical Coil

Flow Through Spiral Coil

Flow Through Packed Bed

Flow Through Fluidized Bed

Flow Through Flow Meters (Orifice & Venturi)

Centrifugal Pump

Flow Of Non-Newtonian Fluid

REFERENCES:

1. Lab Manual
2. *W. L. McCabe, J.C. Smith and P. Harriott, "Unit operations of Chemical Engineering", 7th Edn., McGraw Hill, International Edn.., 2005.*

Course Outcome:
After completion of the course, student can able to
1. understand and application of the concept of manometers
2. understand and analyse the laminar and turbulent flow
3. understand, apply and and analyse the friction factor
4. understand and apply the concept

CL 214 PHYSICAL CHEMISTRY LABORATORY

L	T	P	C
0	0	3	2

COURSE OBJECTIVES

To impart the basic concepts of physical and analytical chemistry.

1 and 2 Molecular weight Determination
- a Rast's method.
- b B.Pt Depression.
- c B.Pt elevation and
- d Transition temperature methods.

3 and 4 partition experiments.
(a) Partition coefficient of iodine between two immiscible Solvents.
(b) Eq. constant of KI + I = KI
(c) Association factor of an organic acid
(d) Curramorium couples.

5. and 6. Phase rules
(a) Two component system
(b) Three component system
(c) Phenol - water system.

7 Optical experiments.
- a polarimetry
- b Refractometry.

8 Conductivity experiments.
- a Cell constant.
- b Ostwald Dilution law.
- c Basicity of an organic acid.
- d Conductometric titration.

9 Kinetics.
- a First order reaction.
- b Second order reaction

10 EMF
- a Single electro potentials.
- b Concentration cells.
- c Titrations
- d pH determination.

11 Miscellaneous.
- a Surface tension.
- b Viscosity
- c Adsorption.

COURSE OUTCOME

Able to understand the application of various laws and their importance for physical and chemical analysis.

CL 301 CHEMICAL REACTION ENGINEERING - I

L	T	P	C
2	1	0	3

COURSE OBJECTIVES

i. Introduce basic concepts of chemical kinetics like homogeneous and heterogeneous reactions, rate of reaction, order and molecularity of reaction, concentration and temperature dependency of rate of reaction
ii. Build up the concepts to analyze kinetic data and determine the rate expression for a reaction
iii. This course will guide students to make use of key concepts and techniques of chemical kinetics to design single reactor and multiple reactors
iv. Analyze multiple reactions to determine selectivity and yield
v. Work together in same-discipline teams to solve engineering problems

COURSE CONTENT

Basics of Kinetics: Introduction - kinetics of homogeneous reactions: Concentration dependent & Temperature dependent term of rate equation, Searching for a mechanism. Interpretation of Batch Reactor data.

Reactor Design: Introduction to Reactor Design. Single Ideal Reactors.

Design of Reactor for Multiple Reaction: Design for single and multiple Reactions. Size comparison of single reactors for single reactions. Multiple Reactor system for single reactions. Reactions in parallel, reactions in series and series - parallel reactions of first order. Recycle reactor, auto catalytic reactions.

Heat Effects: Temperature and pressure effects on single and multiple reactions.

Flow Behaviour of Reactors: Non - ideal flow: Residence time distribution studies: C, E, F and I curves, conversion calculations directly from tracer studies. Models for non-ideal flow - dispersion and tanks in series multi-parameter models.

COURSE OUTCOME

i. Classify reactions and identify the factors affecting the rate of reaction
ii. Predict effect of temperature on rate of reaction
iii. Analyze laboratory data for determining the order of reaction and reaction rate constant
iv. Ability to relate rate of reaction with design equation for reactor sizing
v. Make comparisons of ideal reactor types (batch, plug flow, mixed flow, etc.) and select the most suitable one.
vi. Determine optimal ideal reactor design for multiple reactions for yield or selectivity.
vii. Solve reaction engineering problems through logic rather than memorization

TEXT BOOK:

1. *O. Levenspiel, "Chemical Reaction Engineering", 3rd Edn., Wiley Easter Ltd., New York,1999.*

REFERENCE:

1. *J.M. Smith, “Chemical Engineering Kinetics", 3rd Edn., McGraw Hill, New York, 1981.*

CL 303 MATERIAL SCIENCE AND TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

i. To impart the basic concepts of material science.

ii. To develop understanding about selection based on properties for various applications.

COURSE CONTENT

Atomic Bonding: Classes of engineering materials - engineering requirement of materials - selection of materials - structure of atoms and molecules - Bonding in solids - types of bonds and comparison of bonds.

Structure and Imperfections in Crystals: Crystal structure Crystal geometry, structure of solids, methods of determining structures. Imperfection in crystals - types of imperfection. Point imperfection, diffusion in solids - self diffusion Fick's law, self diffusion. Applications of diffusion.

Properties and Corrosion of Material: Mechanical, Electrical and magnetic properties of materials - Deformation of materials - Heat Treatment techniques - corrosion, theories of corrosion - control and prevention of corrosion.

Metals: Engineering materials - ferrous metals - Iron and their alloys Iron and steel Iron carbon equilibrium diagram. Non ferrous metals and alloys - Aluminium, copper, Zinc, lead, Nickel and their alloys with reference to the application in chemical industries.

Non Metals: Inorganic materials: Ceramics, Glass and refractories - organic materials: wood, plastics, and rubber and wood with special reference to the applications in chemical Industries.

COURSE OUTCOME

i. To provide experience in the process of Material
ii. To understand the handling material in chemical engineering in the areas of equipment design
iii. To understanding execute the design and evaluating its performance of materials including economic considerations.

TEXT BOOKS:

1. *Lawrence H. Van Vlack, "Elements of Material Science and Engineering", 1971.*
2. *S. K. Hajra Choudhury, "Material Science and processes", 1st Edn. , 1977. Indian Book Distribution Co., Calcutta.*

REFERENCES:

1. *V. Raghavan, Materials Science and Engineering, Prentice Hall*

CL 305 MASS TRANSFER

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

i. To understand mass Transfer Operations
ii. To learn concept of diffusion in gas, liquid & solid
iii. To learn fundamental mass transfer coefficient
iv. To understand basic of interphase mass transfer
v. To learn application of gas liquid operation

COURSE CONTENT

Definition, Ficks law, Molecular and eddy diffusion, Diffusion in gaseous mixtures, liquid mixtures and solids, Types of solid diffusion, Pseudo steady state diffusion, measurement and calculation of diffusivities. Ordinary diffusion in multicomponent gaseous mixtures. Unsteady state Diffusion.

Equilibria, Mass transfer coefficients - Individual and overall with relations, Theories of mass transfer, Analogies between momentum, heat and mass transfer to predict mass transfer coefficients.

Absorption – Solubility, theory of gas absorption, Design of absorption towers, Concept of Equilibrium and operating lines. Mass Transfer Equipments- Batch and continuous Stage wise contactors and Differential contactors, Concept of HTU and NTU, Tower packings and packing characteristics, Non-isothermal absorbers, Absorption with chemical reactions.

Humidification Theory, Psychometric Chart, Adiabatic Saturator, Wet Bulb Theory, Methods of Humidification and dehumidification, Cooling tower theory, Design of cooling towers, Industrial cooling towers, Air conditioning process, Recirculating water gas humidification system.

Drying Theory and Mechanism, Drying Characteristics, Estimation of Drying time, drying rate curve, Classification of Driers, Through circulation driers design, Design of driers, Description and Application of Driers, Analysis of continuous driers.

Crystallization Theory, Solubility curve, Types of crystals, Principles of Crystallization, Supersaturation Theory, Factors governing nucleation and crystal growth. Theory of crystallization, Classification of crystallizers and their applications. Product size distribution by MSMPR model. Industrial crystallizers, Crystallizer Design.

COURSE OUTCOME

i. Have demonstrated knowledge of the mathematical, science, and engineering principles fundamental to the practice of chemical engineering
ii. Have a broad enough education to understand the impact of engineering solutions in a global and societal context
iii. Indicate a motivation to continue developing knowledge and skills after graduation
iv. Have knowledge of contemporary issues related to chemical engineering
v. Demonstrate an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

TEXT BOOKS:

1. *R. E. Treybal, "Mass Transfer Operations", 3rd Edn., McGraw Hill Book Co., New York, 1981.*
2. *W .L. McCabe, J.C Smith and P. Harriot, "Unit Operations of Chemical Engineering", 7th Edn., McGraw Hill Book Co., New York, 2004.*
3. *N. Anantharaman and K.M.Meera Sheriffa Begum, "Elements of Mass Transfer-Part I", Printice Hall of India Pvt. Ltd., New Delhi, 2005.*

REFERENCE:

1. *J. M. Coulson and J. F. Richardson, "Chemical Engineering", 5th Edition Vol. II, P Butterworth Heinemann, New, 2002.*
2. *C.J.Geankoplis, "Transport Processes and Separation Process Principles," IV edition,*

Prentice Hall of India Pvt. Ltd, New Delhi, 2004.

CL 307 HEAT TRANSFER

L	T	P	C
2	1	0	3

COURSE OBJECTIVES

i. To introduces the fundamental concepts of momentum and heat transfer as well as their use in typical engineering applications
ii. To emphasize on analogies between the balance equations of fluid flow and heat flow, on dimensional analysis, and the prediction of friction losses

COURSE CONTENT

Basic modes of heat transfer and the laws governing them. Steady state conduction through plane and composite walls general heat conduction equation, concepts of thermal diffusivity and equivalent thermal conductivity. Radial Heat conduction through thick cylindrical and spherical vessels, Transient heat conduction.

Convection – Dimensional analysis and empirical correlations, critical insulation thickness for cylindrical and spherical surfaces, Hydrodynamic and thermal Boundary layers, physical significance of the dimensionless groups.

Thermal Radiation laws, spectrum of electromagnetic radiation, Black and Gray bodies, and configuration factor – typical examples. Boiling and condensation.

Heat Exchangers – classification and design, overall and individual film coefficients, mean temperature difference, LMTD correction factor for multiple pass exchanger, NTU and efficiency of Heat exchangers, use of efficiency charts.

Evaporation, single and multiple effect operation, material and Energy balance in evaporators, boiling point elevation, Duhrin'gs rule, effect of liquid head, illustrative examples.

COURSE OUTCOME

i. To Apply the Fourier law of heat conduction to homogeneous and heterogeneous objects of various shapes
ii. To Estimate transient and steady state heat transfer rates from/to object such as tanks, pipes, buildings, etc
iii. To Apply the macroscopic balances of mass, momentum, and energy, as well as the differential continuity equation and the equations of motion to simple systems using both Cartesian and polar coordinate

TEXT BOOKS:

1. *W. L. McCabe and J. C. Smith, "Unit Operations In Chemical Engineering", 7th Edn., McGraw Hill Publishing Co., 2004.*
2. *Binay. K. Dutta, "Heat Transfer Principles and applications" Prentice Hall of India Pvt. Ltd., 2003*

REFERENCES:

1. *S. Foust, L. A. Wenzel, C. W. Clump, Louis maus and L. B. Anderson Principles of Unit Operations'' John Wily, New York.*
2. *D.Q. Kern," Process Heat Transfer," McGraw Hill Publishing*

CL 309 BIOCHEMICAL ENGINEERING

L	T	P	C
3	**0**	**0**	**3**

COURSE OBJECTIVES

1. To impart the basic concepts of biochemical engineering
2. To develop understanding about biochemistry and bioprocesses

COURSE CONTENT

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. Assay of Enzymes.

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.

Enzyme Technology and Kinetics: Applied Enzyme catalysis, Applications of enzymes in industry and medicine. Immobilization of enzymes. Kinetics of enzyme catalytic reactions involving isolated enzymes. Reversible inhibition.

Reactions Catalysed by Enzymes, Reactors, Analysis: Reactor Design and Analysis for soluble enzyme systems. Cofactor regeneration. Membrane reactor. Effect of mass transfer in immobilised enzyme particle systems. Reactors for immobilised enzyme systems.

BioReactors, Effect of Transport Processes: 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.

COURSE OUTCOME

An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.

TEXT BOOKS:

1. *J. E. Bailey and D. F. Ollis. " Biochemical Engineering Fundamentals", 2nd Edn., McGraw Hill, New York , 1986.*
2. *Trevan, Boffey, Goulding and Stanbury," Biotechnology", Tata McGraw Hill Publishing Co., New Delhi, 1987.*

REFERENCE:

1. *M. L. Shuler and F. Kargi, “Bio Process Engineering: Basic concepts”, 2ndEdn., Prentice Hall of India, New Delhi, 2002.*

CL 311	PARTICULATE SCIENCE AND TECHNOLOGY LABORATORY	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES

i. To impart hands on experience on different unit operation equipments.

ii. Apply principles developed in chemical engineering courses to the analysis of chemical engineering processes and unit operations.

1. Sphericity factor on friction losses.
2. Agitated vessel
3. Settling studies
4. Drag studies
5. Filtration (constant rate)
6. Filtration (constant pressure)
7. Screening
8. Elutriation
9. Jaw crusher
10. Ball mill
11. Particle size distribution
12. Storage of Solids

COURSE OUTCOME

Ability to operate different unit operations and their calculations involved have improved.

CL 315	Thermodynamics Lab	L	T	P	C
		0	0	3	2

Course Objective:

Understand the principles & concepts learned in Chemical Engineering thermodynamics theory course

Pre requisite:

Chemical Engineering thermodynamics course

List of Experiments

1. Excess property determination
2. Heat of solution by solubility method
3. Equilibrium constant determination
4. Liquid-liquid equilibrium
5. Vapor compression refrigeration test rig
6. Boiling point apparatus – VLE Data (Txy diagram)
7. Test for thermodynamic consistency (Estimation of thermodynamic model constants using Othmer still)
8. Air water heat pump
9. Bomb calorimeter
10. Gas calorimeter

REFERENCES:

1. Lab Manual
2. *J. M. Smith and Van Ness, "Introduction to Engineering Thermodynamics", McGraw Hill, New York, 6th Edition, 2004.*

HM 302	HUMAN PSYCHOLOGY & ORGANISATIONAL BEHAVIOUR	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES

To impart the students with human behavior, teamwork skills and leadership qualities in industries.

COURSE CONTENT

Introduction: a. Principles of management, functions of organisations, organisational system - technology, process, design, structure and culture and their impact on the people at work. b. Definition - development of psychology as scientific discipline - methods and applications of psychology in human at work in industry.

Understanding Human Behaviour: Beliefs, values, feelings, perception and attitudes. Process of perception and other factors as above, in shaping human behaviour; Johari Window, FIRO-B, MBTI personality type test. Gestalt approach, attitude development, meaning of intelligence, factors of intelligence, intelligence tests, creativity. Personality - definition, determinants, psychoanalytic theory, assessment.

Motivation, Leadership, Teamwork, Communication: Concept of. Motivation; why to people work; theories on motivation, (Maslow, Herzberg , achievement orientation, expectancy theory, theory x, y, z); techniques of motivating employees, Leadership - role of leader, qualities of a leader; styles of leadership (blake and mouton managerial grid, Frid Fiedler's contingency approach, Rensis Likert's four styles), determinants of leadership style to be adopted, Power, authority and accountability; delegation, Dynamics of groups; work groups, Mentoring, teamwork, Communication - Channels of communication, feedback, Barrier to communication; Non-verbal communication, grapevine, Transactional analysis

Human Engineering: Human and Engineering Factors influencing each other - Ergonomics, Effect of Physical environment - illumination, temperature, noise etc; Social economic and political responsibilities of an engineer.

Psychological aspects Expounded by Thirukural: Realisation of truth, power of speech (utterances of pleasant words) and Action, Mutual desire, human effort, inconsistent conduct, possession of Decorum manly effort, energy.

COURSE OUTCOME

The students have understood the importance of psychology and how organize a task in industries.

***TEXT BOOKS**:*

1 *J. Tiffin, and E.J. McCormick, "Industrial Psychology", Prentice Hall of India, 1979, 5th Edn.*
2 *K. Aswathappa,. "Organisational Behaviour Text and Cases", Himalaya Publishing House, 1997.*

REFERENCES:

1. *S. P. Robbins, "Organisational Behaviour", Prentice Hall of India, 1989 Edn.*
2. *F. Witting, "Introduction to Psychology", Schaum's outline Series, Tata McGraw Hill, 1974 Edn.*

CL 304	**CHEMICAL REACTION ENGINEERING - II**	**L**	**T**	**P**	**C**
		2	**1**	**0**	**3**

COURSE OBJECTIVES

i. To train students to analyze performance of real reactors with single chemical reactions and reactors operating at steady state
ii. To train students to derive rate expressions and mechanisms for elementary heterogeneous chemical reactions
iii. To train students to analyze rate data in order to derive rate expressions an mechanisms for heterogeneous catalytic reactions and design heterogeneous reactors
iv. To train students to appreciate the importance of both external and internal mass transfer effects in heterogeneous systems

COURSE CONTENT

Modes of contacting different phases: Self mixing of single fluids, mixing of two miscible fluids, Introduction. Design for heterogeneous reacting systems.

Design of reactor for non catalytic reactions: Fluid-particle systems: Models for non-catalytic heterogeneous reactions, their limitations, selection and their applications to design.

Design of Slurry Reactor: Fluid- Fluid Reactions: Rate equations for instantaneous, fast, intermediate, slow, and infinitely slow reactions. Slurry reaction kinetics. Application to design.

Characterisation of catalyst: Catalysis: Introduction. Physical and chemical adsorption catalysts. Preparation and properties. Promoters. Inhibitors. Poisons. Surface area by BET method. Pore size distribution, Catalysts deactivation.

Kinetics of heterogeneous chemical reaction: Kinetics and mechanism of heterogeneous catalytic reactions. Various models. Evaluation and elimination of internal and external diffusional resistances, effectiveness factor. Solid catalysed reactions, heat effects, controlling resistances, rates of chemisorption, adsorption isotherms, rates of adsorption and desorption.

COURSE OUTCOME

i. Students will be able to determine performance of real flow reactor and compare it with ideal flow reactor
ii. Students will be able to classify heterogeneous reactions and to determine the catalyst properties such as surface area and pore volume
iii. Students will be able to analyze and interpret kinetic data to determine the rate controlling step, model and to design a reactor for various heterogeneous reactions
iv. Students will be able to design a reactor for a given chemical engineering process

TEXT BOOKS:

1. *O. Levenspiel, "Chemical Reaction Engineering", 3rd Edn., Wiley Eastern, New York, 1999.*
2. *J .M. Smith, "Chemical Kinetics", 3rd Edn., McGraw Hill, New York, 1981.*
3. *H.Scott Fogler, "Elements of Chemical Reaction Engineering",4th Edn., Prentice Hall of India Ltd.,2008.*

CL 306	EQUILIBRIUM STAGED OPERATIONS	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES

i. To impart the basic concepts of mass transfer in distillation, extraction, leaching and membrane operations.

ii. To develop understanding about design and analysis of distillation, extraction, leaching and membrane operation units.

COURSE CONTENT

Principle, theory, Vapour Liquid Equilibria calculations, Effect of Pressure and temperature on VLE, Methods of distillations, batch, continuous, flash, steam, vacuum, molecular distillations. Design of single stage flash and simple distillation columns.

Stage-wise and continuous Differential contact operations, Design calculations using Ponchon-Savarit and Mc-Cabe Thiele Methods, Efficiency interrelations. Reboilers and condensers. Open steam Distillation, Multicomponent Distillation- Azeotropic distillation and Extractive distillation, Multi component Flash and differential distillation.

Liquid - Liquid Equilibria for Different systems, Effect of Pressure and Temperature on LLE, Solubility criteria, Design of Batch and continuous extraction towers for miscible and immiscible systems. Industrial Applications, Design of Extractors with reflux.

Theory, Mechanism, Types of leaching, Solid - Liquid equilibria, Design of Batch and continuous extractors. Equipments and industrial applications.

Types of adsorption, nature of adsorbents, Adsorption isotherms, Operation of adsorption columns. Batch and continuous operations, Design of adsorbers.

COURSE OUTCOME

1. An ability to design the systems and find the number of stages required for the separation of the components involving different phases.

(ii) An ability to apply diffusion concepts in analyzing all the transfer processes to meet the required specifications.

TEXT BOOKS:

1. *R. E. Treybal, "Mass Transfer Operations", 3rd Edn., McGraw Hill Book Co., New York, 1981.*
2. *W. L. Mccabe, J. C. Smith and P. Harriot, "Unit Operations in Chemical Engg.",7th Edn., McGraw Hill Book Co., New York, 2004.*

REFERENCES:

1. *M. Coulson and J. F. Richardson, "Chemical Engineering.", Vol - II, 5th Edn., Pergamon Press, New York, 2002.*
2. *C. J. Geankopolis, "Transport Processes in Chemical Operations", 4th Edn., Prentice Hall of India, New Delhi, 2004.*

CL 308	PROCESS DYNAMICS AND CONTROL	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES

i. To introduce students to the terminology, concepts and practices of input/output modeling and automatic process control.
ii. To impart knowledgeable in the design of control systems and controller tuning for chemical processes.

COURSE CONTENT

Introduction - Control system, components of a feed back control system, Lags in the control system – transfer lag, transportation lag, pneumatic PID controller, control valve – valve characteristics.

Laplace transforms - properties of Laplace transform, solution of linear differential equations using Laplace transform techniques, piecewise continuous functions

Dynamic behaviour of systems - derivation of transfer functions for first and second order systems, liquid level, temperature, pressure, flow and concentration control processes, linearization of nonlinear systems, interacting and non-interacting systems.

Transient response of first and second order systems, natural frequency, damping factor, overshoot, decay ratio, rise time and settling time.

Transient analysis of control systems - block diagram algebra, overall transfer function of closed loop control systems, regulator and servo problems, transient response of first and second order systems with P, PI and PID controller.

Definition of stability of control systems, Routh test, limitations of Routh test, Pade's approximation of time delay systems.

Introduction to frequency response - Bode diagrams, Bode diagrams for first and second order systems, P, PI, PID controllers, transportation lag. Bode stability criteria, phase margin and gain margin, Nichols chart, Ziegler - Nichols Optimum controller settings. Nyquist stability criteria, calculation of phase margin, gain margin, peak gain and resonant frequency using nyquist plot.

COURSE OUTCOME

i. To write balance equations using first principles modeling and determine the response for various forcing functions
ii. To configure simple feedback control loops, and identify the components of those loops.
iii. To use the P-only control equation to compute gains, proportional bands and to describe the action of ON-OFF, proportional, and proportional-integral controllers.
iv. To describe the different types of control valves and can identify the types by their inherent flow curves.
v. To gain the knowledge of various controller designs, and methods of controller tuning

TEXT BOOKS / REFERENCE BOOKS:

1. *'Process Systems analysis and Control', D.R. Coughanour, Mc.Graw Hill, II Edition, 1991.*
2. *'Process Dynamics and Control', D.W.Seborg, T.F.Edger, and D.A.Millichamp, John Wiley and Sons, II Edition, 2004.*
3. *'Principle and Practice of Automatic Process Control', C.A.Smith and A.B.Corripio, John Wiley and Sons, 1985.*
4. *'Process Modelling Simulation and Control for Chemical Engineers'**,** W.L.Luyben, McGraw Hill, II Edition, 1990.*
5. *'Chemical Process Control – Theory and Practice', G. Stephanopoulous, Prentice Hall of India Ltd.,1984*

CL 310	HEAT TRANSFER LABORATORY	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES

To provide experience on testing, and analysis of heat transfer equipments in various approaches.

1. Shell and Tube Heat exchanger
2. Condenser (Vertical)
3. Condenser (Horizontal)
4. Natural convection
5. Radiation
6. Transient heat conduction
7. Agitated vessel heat transfer
8. Heat Transfer in Jacketed Kettle
9. Thermal Conductivity of metal rod
10. Plate Heat Exchanger

COURSE OUTCOME

The students have understood how heat transfer occurs for different equipments and worked out the parameters studied in theory.

CL 312	CHEMICAL REACTION ENGINEERING LABORATORY	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES

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

1. Reversible reaction in a batch reactor
2. Irreversible reaction in a batch reactor
3. Plug flow reactor
4. Mixed flow reactor
5. Adiabatic reactor
6. Combined reactor: Mixed flow -plug flow
7. Combined reactor: Plug flow -mixed flow
8. Heterogeneous catalytic reactor
9. Biochemical reactor
10. RTD studies
11. Photochemical reactor
12. Segregated flow reactor
13. Semibatch reactor
14. Gas-solid reaction

COURSE OUTCOME

The students could independently calculate the reaction kinetics of various reactors used for manufacturing of chemicals in industries.

CL 401 SAFETY IN CHEMICAL INDUSTRIES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

To create awareness about the hazards that can happen in various industries and methods of preventing them.

COURSE CONTENT

Introduction: Industrial safety principles. Site selection and plant layout. Legal Aspects. Emergency response systems for hazardous goods, basic rules and requirements which governs the chemical industries.

Hazards: Chemical hazards classification. Hazards due to fire, explosion and radiation. Hazard analysis, Reduction of process hazards by plant condition monitoring, Materials Safety Data sheets and National Fire protection agency's classifications.

Diseases: Dangerous occupational diseases, poisoning, dust effect, biomedical and engineering response to health hazards.

Control of Hazards: Engineering control of plants instrumentation, accident prevention signs and labels, Colour codes for pipe lines, Safety aspects of reactive chemicals.

Construction, Operation and Process Hazards: Safety in operations and processes. Runaway reactions, unstable products, safety in erection and commissioning.

COURSE OUTCOME

Students will be familiar with hazard analysis and prevention techniques, scope for entrepreneurship by consultancy, safety audit.

TEXT BOOKS:

1. *H. H. Fawcett and W. S. Wood, "Safety and Accident Prevention in Chemical Operation", 2nd Edn., Interscience, 1982.*
2. *"Loss Prevention and Safety Promotion in Chemical Process Industries", Vol. III, Published by Institution of Chemical Engineers U.K., 1983.*
3. *Roy E Sanders, "Chemical Process safety: Learning from case histories, Butterworth Heinemann, 1999.*

REFERENCES:

1. *T. Yoshida, "Safety of Reactive Chemicals", Vol. I, Elsevier, 1987.*
2. *H. Willium, "Industrial Safety Handbook", 2nd Edn., McGraw Hill, 1968.*

CL 403 CHEMICAL PROCESS DESIGN

L	T	P	C
2	2	0	4

COURSE OBJECTIVE:

(i) To apply the basic principles/concepts learned in yester semesters in the design of chemical process equipment

(ii) To develop the skill to select and design appropriate process equipment for the required operation

(iii) To analyse and evaluate the performance of existing equipments

PREREQUISITE:

Courses on Particulate science and technology, Heat transfer, Mass transfer and Equilibrium staged operations, Reaction engineering, Strength of materials

CONTENT:

Design of Pressure Vessels: Design of vessels and its components under internal pressure, external pressure and combined loadings, design of heads/closures, design of supports and design of high pressure vessels

Design of Storage tanks, Agitated vessels and Reaction vessels.

Design of Phase Separation Equipment: Design of physical separation equipments

Design of Heat Transfer Equipments: Design of Heat Transfer Equipments such as heat exchangers with and without phase change, evaporators, crystallizers.

Design of Mass Transfer Equipments: Design of mass transfer equipments such as distillation columns, absorption columns, extraction columns.

Design of Simultaneous Heat & Mass Transfer Equipments: Design of dryers and cooling towers.

TEXT BOOKS:

1 R. H. Perry, "Chemical Engineers' Handbook", 7th Edn., McGraw Hill , NewYork, 1998.

2 R. K. Sinnott, "Chemical Engineering Design", Coulson and Richardson's Chemical Engineering Series, Volume-6, Fourth Edition, Butterwoth-Heinemann, Elsevier, NewDelhi, 2005.

REFERENCES:

1. L. E. Brownell and E.H. Young, "Process Equipment Design - Vessel Design", Wiley Eastern Edn. New York, 1968.

2. B.C. Bhattacharyya, "Introduction to Chemical Equipment Design Mechanical Aspects", CBS Publishers & Distributors, NewDelhi.

3. D.Q.Kerm "Process Heat Transfer", Tata McGraw Hill Edn., 2004.

4. Robin Smith, "Chemical Process Design and Integration", Eighth Edition, Wiley India (P) Ltd., NewDelhi, 2006.

5. V. V.Mahajani and S. B. Umarjii, "Joshi's Process Equipment Design", 4th Edn., Mac Millan Publishers India Limited, NewDelhi, 2009.

COURSE OUTCOME:

After completing the course, A student can able to

1. understand the role of different types of loads on the vessels and its auxiliaries
2. perform the mechanical design of vessel and its auxiliaries
3. integrate the knowledge acquired from core chemical engineering subjects for design of chemical process equipments (pressure vessels, storage tanks, reactor vessels, phase separation equipments)
4. Carry out chemical process design of heat transfer equipments, mass transfer and simultaneous heat and mass transfer equipments
5. address the process equipment problems and provide suitable alternate solutions.

CL 405 PROJECT ENGINEERING & ECONOMICS

L	T	P	C
2	1	0	3

COURSE OBJECTIVES

i. To provide basic knowledge on chemical engineering research.

ii. For enabling the students to gain experience in organisation and implementation of a small project and thus acquire the necessary confidence to carry out main project in the final year.

i. To gain knowledge on cost analysis when it comes to start up a new industry after undergoing all major subjects of chemical engineering.
ii. To make the students to understand all the facility required for starting up a new industry apart from various unit operation/mass/heat transfer equipments.
iii. To make the students to gain all the knowledge in terms of financial analysis for starting up a new chemical industry.
iv. To give a clear linkage between technical knowledge and commercial aspects of the major chemical engineering unit operations and design.

Value of Money - Equivalence: Value of money, Equations for economic studies and equivalence. Amortization, Capital recovery and Depreciation.

COURSE CONTENT

Plant location and site selection, plat layout, factors affecting plant location, project planning and scheduling of projects, procurement operations, office procedures, project financing

Process utilities, process water, boiler feed water, water treatment & disposal, steam, steam distribution including appropriate mechanical valves and instrumentation, Furnaces, process pumps, compressors, vacuum pumps, pressurized air distribution systems, Refrigeration plant

Process auxiliaries, piping design, layout, Support for piping insulation, plant constructions, star up and commissioning.

Capital Requirements for process Plants: Project implementation steps, Feasibility studies, Capital requirements for process plants, Cost indices, Equipment cost, Service facilities. Capital requirements for complete plants, Balance sheet.

Market analysis: Situational analysis and specification of objectives, collection of secondary information, conduct of market survey, characterization of the market, demand forecasting, uncertainties in demand forecasting and market planning.

Cost, Earnings, Profits and Returns: Variable cost, Fixed cost, Income statement, Economic production charts. Capacity factors, Taxes and Insurance.

Economics of Selecting Alternates: Annual cost method, Present worth method, Equivalent alternates, Rate of return and Payout time. Cash flow analysis.

Overall Cost Analysis and Economic Trade Offs: Economic balance: Economic balance in batch operations, Plant layout & Overall cost analysis for the plant, Economic tradeoffs.

COURSE OUTCOME

i. The students have understood how a project has to be started, their pre-requirements, flow chart preparation, economic calculation and so on.

i. The students were able to work out the balance sheet and Income statement for a particular concern.
ii. The students have gained a good knowledge on when to run a industry in a profitable or without loss/gain of a particular concern.
iii. The students are able to choose between the equipments/instruments of the same function based on both technical and commercial point of view.
iv. The students were able draw a complete flowchart of a plant with complete cost analysis.

TEXT BOOKS:

1. *J.M. Coulson, JF Richardson, RK Sinnott Butterworth Heinman, Chemical Engineering Volume 6,Revised Second Edition, Butterworth-Heinemann, 1996*
2. *1. M. S. Peters and K. D. Timmerhaus, "Plant Design and Economics for Chemical Engineers", McGraw Hill book Co., New York, 1991*
3. *2. H. E. Schwyer, "Process Engineering Economics", McGraw Hill Book Co., N.Y*

REFERENCES:

1. *Rase and Barrow, Project Engineering of Process Plants, John Wiley.1964*
2. *M. S. Peters & K. D. Timmerhaus, 'Plant design & Economics for Chemical Engg.' McGraw-Hill Science/Engineering/Math 5th Ed., 2002.*
3. *Industrial Boilers, and Heat recovery Steam Generators Design, Applications and calculations by V.ganapathy, Marcel Dekker, Inc, 2003.*
4. *1. F. C. Jelen, "Cost and Optimization Engineering", McGraw Hill Book Co., New York, 1970.*
5. *2. Robin Smith, "Chemical Process Design", McGraw Hill Book Co., New York, 1995.*

CL 407	TRANSPORT PHENOMENA	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

i. Understand theory and basic principles of momentum. heat and mass transport
ii. Understand theory of velocity distribution for various systems.
iii. Understand Macroscopic balances for isothermal systems
iv. Understand theory of thermal conductivity energy transport
v. Understand diffusivity and mechanism of mass transport for homogeneous and heterogeneous systems.

COURSE CONTENT

Laminar Flow: Velocity distribution in Laminar flow - Shell momentum balances - Flow through tubes, surfaces. Flow of non - Newtonian fluids.

Equation of Motion: Equation of change for isothermal process - One dimensional equation of motion and continuity - Euler and Navier - Stokes equation. Dimensional analysis of equation of change.

Turbulent Flow: Velocity distribution in turbulent flow - Semi empirical expressions for Reynolds stress. Interphase transport in isothermal system - Ergun's equation.

Heat Transfer analysis: Temperature distribution in solids and fluids in laminar flow - Equations of change for multi component systems.

Mass Transfer analysis: Concentration distribution in solids and in fluids laminar flow - Equations of change for multi component systems.

COURSE OUTCOME

i. To identify, formulate, and solve problems isothermal systems particularly in the context of momentum, heat and mass transfer.
ii. use shell balance for diffusion with homogenous and heterogeneous systems
iii. Apply shell balance for different systems like flow through tube, annulus, along sphere, etc.

TEXT BOOKS:

1. *J.L. Stuart etal., "Transport Phenomena", John Wiley, New York, 1982.*
2. *B. R. Bird, W. Stewart and E. N. Lightfoot, "Transport Phenomena", Wiley, New York, 1960.*

REFERENCE:

1. *C. J. Geankopolis, "Transport Processes in Chemical Operations", 4^{th} Edn., Prentice Hall of India, New Delhi, 2003.*

CL 409	COMPREHENSIVE VIVA-VOCE	L	T	P	C
		0	0	0	3

COURSE OBJECTIVES

To examine the knowledge acquired by the student during the B.Tech. course, through an oral examination

COURSE OUTCOME

The students were able to know the status of their learning on all the core chemical engineering subjects they have studied and helped them to improve their knowledge.

CL 411	MASS TRANSFER LABORATORY	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES

To provide experience analysis of mass transfer operations.

1. Simple Distillation
2. Steam Distillation
3. Surface evaporation
4. Leaching
5. Batch adsorption
6. Diffusion
7. Air drying
8. Wetted wall column
9. Vacuum drying
10. H.E.T.P
11. Continuous adsorption
12. Extraction

COURSE OUTCOME

The thorough understanding of usage and employability of devices for determining the separation factors and efficiencies for the systems

CL 413	PROCESS DYNAMICS AND CONTROL LAB	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES

To impart hands on experience on various process control instruments for various unit operations.

1. Analog Simulator.
2. Process trainer
3. Interacting & non interacting Systems
4. Control of a thermal system
5. Flapper - Nozzle system
6. Control valve characteristics
7. Level control system
8. Transducer characteristics
9. I & II Order System Dynamics
10. Pressure control system
11. Frequency Response

COURSE OUTCOME

The students were able to apply the theoretical knowledge while performing experiments and different process control technologies for different chemical engineering processes.

HM 402	INDUSTRIAL ECONOMICS & MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

i. To impart the basic concepts of economics and management.
ii. To impart the basic concepts of management.

COURSE CONTENT

Demand and Supply - Forecasting techniques - Cost and Revenues - Competitive nature of the firms – Keynesian economics – National income – Trade cycle – Inflation – Index numbers – Capital budgeting – Cash flow analysis – Balance sheet – Risk and Decision Making – Technological Change in Global Economy – Locating the Firm in a global economy – Taxes and Decision Making - Exchange Rate determination – Marketing - Product life cycle – Marketing research – Branding, Total Quality Management – Personality - Motivation – Leadership – Working in Teams

COURSE OUTCOME

The students have understood how to lead a group of people in a concern and how to manage provided a task is undertook in an industry.

TEXT BOOKS:

1. *Burton Genie, Thakur Manab. "Management Today" TMH - 1996 Edn.*
2. *K.K. Dewett, "Modern Economic theory", S.Chand & Co. Ltd., 1999 Edn.*

REFERENCE:

1. *Arun Monappa and Saiyadin "Personnel Management", TMH, Delhi, 1983.*
2. *Ramasamy V.S. and Namakmaris., "Marketing Management, Planning implementation and control "Macmillan - 1996 edn.*

CL 406	PROJECT WORK	L	T	P	C
		0	0	0	6

COURSE OBJECTIVES

i. To provide students with an opportunity to apply the knowledge and skills acquired in previous coursework to solve a specific problem and/or acquire in-depth knowledge on a specific topic.
ii. To provide experience in carrying out a literature search.
iii. To work in a team in a planned manner on a chosen engineering topic based on the knowledge gained throughout the engineering programme.

LIST OF ELECTIVES

		L	T	P	C
CL 315	**PETROLEUM AND PETROCHEMICAL ENGINEERING**	**3**	**0**	**0**	**3**

COURSE CONTENT

Primary Processing of Crude Oil: Classification of crude oil, Atmospheric distillation, Vacuum distillation of residue-Products and distillation practice.

Secondary Processing of Crude Oil: FCCU, Hydro cracking, Visbreaking, Thermal cracking, Coking, Reforming, Alkylation, Polymerisation and Isomerisation process.

Treatment Techniques: Treatment techniques for removal of objectionable gases, Odours, to improve performance, Storage stability, Extraction of aromatics, Olefins and recovery operations from petroleum products.

Petrochemicals: Chemicals from methane and synthetic gas: Ammonia, Methanol and Hydrogen Cyanide, Chemicals from olefins: Ethylene derivatives, Propylene derivatives and Butylenes derivatives, Aromatics, intermediates for synthetic fibres, Plastics and rubber.

Environmental and Safety aspects in Refinery and Petrochemicals: Waste water and effluent gases treatment from alkylation units and petrochemical units, safety aspects in the above industries.

TEXT BOOKS:

1. *W.L. Nelson, "Petroleum Refinery Engineering", 4th Edn., McGraw Hill, New York,1985*
2. *B. K. Bhaskara Rao, "Modern Petroleum Refining Processes", 5th Edn., Oxford and IBH Publishing Company, New Delhi, 2012.*

REFERENCES :

1. *G. D. Hobson and W. Pohl., "Modern Petroleum Technology", John Wiley & sons Publishers, 4th Edn., 2004.*
2. *R. A. Meyers, "Hand book of Petroleum Refining Processes", McGraw Hill, 3rd Edn., 2003.*

		L	T	P	C
CL 317	**NUCLEAR ENGINEERING**	**3**	**0**	**0**	**3**

COURSE CONTENT

Principles of nuclear power generation, nuclear fission and fusion, energy from fission and fuel burn up.

Radioactivity, neutron energies, thermal neutrons, nuclear cross sections, Fission reactor types, reactor control, fuel arrangements in a thermal reactor.

Pressurized water reactor, PWR power plant, Boiling water reactor, BWR power plant, Gas cooled reactor, high temperature gas cooled reactor.

Concept of breeding, fast breeder reactors, Liquid metal fast breeder reactor and accessories.

Thermal pollution by nuclear power plants, Radio-active pollution of environment by nuclear power plants, radio-active waste disposal.

TEXT BOOKS / REFERENCES:

1. *Glasstone, "Nuclear Reactor Engineering".*
2. *M.N. El Vakil, "Nuclear Power Engineering".*
3. *Arora and S. Domkundwar, "Power Plant Engineering", Dhanpat Rai & Sons*

CL 314	FERTILIZER TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE CONTENT

Introduction to Chemical Fertilizers: Chemical inorganic Fertilizers and Organic manures. Types of fertilizers: Mixed, complex and Granulated, plant nutrients.

Processes for Raw Materials: Processes for manufacture of ammonia, nitric acid, phosphoric acid and sulphuric acid.

Nitrogenous and Potassium Fertilizers: Processes for urea and di-ammonium phosphate. Recovery of Potassium salts, processes for ammonium chloride and ammonium sulphate.

Complex Fertilizers: Processes for nitro **-** phosphates and complex NPK fertilizers liquid fertilizers

Phosphatic Fertilizers and Indian Fertilizer Industry: Single and Triple Superphosphate, biofertilizer. Fertilizer Industry in India.

TEXT BOOKS:

1. *Strelzoff, "Technology and Manufacture of Ammonia", 2nd Edn., Wiley, 1981.*
2. *L. J. Carpentire, "New Developments in Phosphate Fertilizer Technology", Elsevier, 1971.*

REFERENCES:

1. *"Handbook on Fertilizer Technology", Fertilizer Association of India, Near JNU, New Delhi 1992.*
2. *V. Slack, "Phosphoric Acid", 2nd Edn., Marcell Dekkar , 1968.*

CL 316	BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE CONTENT

Rates and Patterns of Changes in cell cultures: Kinetics of substrate utilization, biomass and product formation in cellular cultures. Stoichiometry of growth and product formation

Physical Parameters in Bioreactors and Downstream Separations: Transport phenomena and modelling in Bioprocesses. Product recovery operations.

Sensors, Monitoring and control systems in Bioprocesses: Instrumentation and process control in Bioprocesses.

Biochemical Reaction Engineering and Bioreactor design: Design and analysis of Bioreactors. Dynamic models and stability, non-ideal mixing, residence time. Sterilisation reactors. Immobilised bio-catalysts and multiphase bio reactors.

Fermentation Technology and R-DNA Technology: Bio-process Technology and Genetic Engineering.

TEXT BOOKS:

1. *J. E. Bailey and D. F. Ollis, "Biochemical Engineering Fundamentals", 2nd Edn., McGraw Hill, New York, 1986.*
2. *M. D. Trevan, S. Boffly, K.H. Golding and P. Stanbury, "Biotechnology", Tata McGraw Publishing Company, New Delhi 1987.*

REFERENCE:

1. *R.Lovitt and M.Jones, "Biochemical Reaction Engineering" in Chemical Engineering, Vol. III, 3rd Edn., Edited by J. F. Richardson and Peacock, Pergamon, London, 1994.*

CL 318	ENERGY ENGINEERING	L	T	P	C
		3	0	0	3

COURSE CONTENT

Coal: Coal and Coal derived fuels; Characteristics, production methods and uses. Coal combustion technology, waste heat recovery.

Oil and Gases: Fuels from oil and gases: Characteristics, production methods and uses. Technology for combustion of fuels derived from oil and gas.

Solar Energy: Solar energy utilization, Thermal application and photovoltaic applications; wind, geothermal and hydro energy utilization.

Bio Energy: Biomass conversion for fuels; production methods based on thermochemical and bioconversion. Characteristics and uses; Design of digestors.

Nuclear Energy: Nuclear Energy; Nuclear fission fuels processing, Nuclear reactions and nuclear reactors, Nuclear Engineering.

TEXT BOOKS:

1. *G.N.Rai, "Non conventional energy sources," Khanna Publishers, New Delhi.*
2. *Samir Sarkar, "Fuels and Combustion", 3rd Edn, University press Publication, 2008.*

REFERENCE:

1. *D.Reay, "Industrial Energy Conservation".*
2. *Om Prakash Gupta, "Fundamentals of Nuclear power reactors", Khanna Publishers, New Delhi.*

CL 320	PROCESS INSTRUMENTATION	L	T	P	C
		3	0	0	3

COURSE CONTENT

Principles of measurements

Analysis, measurement of force strain and torque-use of strain gauges. Transducers-resistive, capacitive,inductive and Piezo electric pickups

~~***TEXT BOOKS:***~~

3. ~~*G.N.Rai, "Non conventional energy sources," Khanna Publishers, New Delhi.*~~
4. ~~*Samir Sarkar, "Fuels and Combustion", 3rd Edn, University press Publication, 2008.*~~

~~***REFERENCE:***~~

3. ~~*D.Reay, "Industrial Energy Conservation".*~~
4. ~~*Om Prakash Gupta, "Fundamentals of Nuclear power reactors", Khanna Publishers, New Delhi.*~~

CL 415	POLYMER SCIENCE AND TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE CONTENT
Characteristics, Analysis of Polymers: The science of large molecules. Theory of polymer solutions. Measurement of molecular weight and size. Analysis and testing of polymers.

Polymer material structure and Properties: Deformation, flow and melt characteristics. Morphology and order in crystalline polymers. Rheology and the mechanical properties of polymers. Polymer structure and physical properties.

Polymer synthesis and reaction engineering: Condensation polymerization. Addition polymerization. Ionic and coordination polymerization. copolymerisation. polymerization conditions and polymer reactions.

Industrial polymers: Manufacturing processes and applications: Hydrocarbon plastics and elastomers. Other carbon chain polymers. Heterochain thermoplastics. Thermosetting resins.

Processing of polymers: Plastics, Fibres and Elastomers: Polymers developed for synthetic plastics, fibres and elastomer applications. Plastics technology. Fiber technology. Elastomer technology.

TEXT BOOK:
1. *F. W. Billmeyer Jr., "Text Book of Polymer Science", 3rd Edn., Wiley- Inter Science, 1984.*

REFERENCES:
1. *F. Rodriguez, Claude Cohen, Christopher K. Ober and Lynden A. Archer "Principals of Polymer Systems", 5th Edn., Taylor and Francis, Washington, 2003.*
2. *"Encyclopedia of Polymer Science and Technology", John Wiley-Inter Science.*

CL 417	NEW SEPERATION PROCESSES	L	T	P	C
		3	0	0	3

COURSE CONTENT
Thermal Separation: Thermal Diffusion: Basic Rate Law, phenomenological Theories of Thermal Diffusion for gas and liquid mixtures, Equipments design and Applications. Zone Melting: Equilibrium diagrams, Controlling factors, Apparatus and Applications.

Sorption Techniques: Types and choice of adsorbents, Normal Adsorption techniques, chromatographic techniques, types and Retention theory mechanism Equipment and commercial processes, Recent advances and economics, Molecular Sieves.

Membrane Separation Processes: Types and choice of membranes, their merits, commercial, pilot plant and laboratory membrane permeators, Dialysis, Reverse Osmosis, Ultra filtration, Concentration Polarization in Membrane and Economics of Membrane operations.

Ionic Separation: Controlling factors, Applications, Equipments for Electrophoresis, Dielectrophoresis, Electro Dialysis and Ion - Exchange, Commercial processes.

Other Techniques: Adductive crystallization: Molecular addition compounds, Clathrate compounds and adducts, Equipments, Applications, Economics and Commercial processes. Foam Separation: Surface Adsorption, Nature of foams, Apparatus, Applications, and Controlling factors.

TEXT BOOKS:
1. *H. M. Schoen, "New Chemical Engineering Separation Techniques", Inter Science Publications, New York, 1972.*

2. *C. Loeb and R. E. Lacey, "Industrial Processing with Membranes", Wiley Inter Science, 1972.*
3. *B.Sivasankar, "Bioseparations – Principles and Techniques", Prentice Hall of India Pvt. Ltd, New Delhi, 2005.*

REFERENCES:

1. *R.H. Perry and D.W. Green, "Perry's Chemical Engineers Hand book", 8th Edn., McGraw Hill, New York, 2007.*
2. *J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol.II, 5th Edn., Butterworth - Heinemann, London, 2002*

CL 419	APPLIED MATHEMATICS IN CHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE CONTENT

Design of engineering experiments: Treatment of experimental data and interpretation of results. Experiments with a single factor: the analysis of variance. Factorial designs. Curve fitting methods, Interpolation and extrapolation.

Formulation of physical problems: Mathematical modelling of chemical engineering processes based on first principles.

Analytical solutions of equations: Separable forms, homogeneous equations, exact solutions, singular solutions.

Numerical solution of non-linear equations: Linearization of nonlinear equations. Numerical solution of ordinary differential equations: Initial value and boundary value problems. Stiff differential equations. Numerical solution of partial differential equations.

Optimization: Types of optimization problems, optimization of a function of single variable, unconstrained minimization, constrained minimization.

TEXT BOOKS:

1. *Douglas C. Montgomery, "Design and Analysis of Experiments" John Wiley, 8th Edition, 2012*

2. *Harold S. Mickley, Thomas S. Sherwood, Charles E. Reed, "Applied Mathematics in Chemical Engineering" Tata McGraw Hill Publishing Company Limited, Second Edition, 1975.*

3. *Richard G. Rice & Duong D. D, "Applied Mathematics and Modelling for Chemical Engineers" John Wiley & Sons, 1995.*

REFERENCES:

1. *Mark E. Davis, "Numerical Methods and Modelling for Chemical Engineers", John Wiley & Sons, 1984.*

2. *S. K. Gupta, "Numerical Techniques for Engineers", Wiley Eastern Ltd., New York, 1995.*

CL 421	RENEWABLE ENERGY	L	T	P	C
		3	0	0	3

COURSE CONTENT

Introduction – Global warming, Green house gases, Coal thermal power plant efficiency, Kyoto protocol, Carbon credits, Renewable Energy.

Renewable Energy – Quality, quantity, availability, advantageous and limitations.

Solar energy. Solar radiation. Heat transfer and fluid mechanics equations.

Solar thermal energy conversion. Types of collectors. Efficiencies. Solar energy storage. Solar passive concepts. Solar photo Voltaic energy – silicon cell, VI characteristics, PV plant layout, efficiency improvement in PV cell.

Bio energy. Conversion. Bio degradation. Biogas generation. Fuel properties. Biomass gasifier.

Wind energy. Data and energy estimation. Conversion. Wind mill. Performance, applications. - Geothermal energy.

Tidal energy. Magneto hydrodynamic. Thermionic. Fuel cell.

REFERENCES:

1. *Rao, S. and Parulekar, R.B., Energy Technology - Nonconventional, Renewable and Conventional, Khanna Publishers, 1995.*
2. *Rai, G.D., Nonconventional Energy Sources, Khanna Publishers, 1999.*
3. *John Twidell and Tony Weir, Renewable Energy Resources, Taylor and Francis, 2000.*

		L	T	P	C
CL 404	**NANO TECHNOLOGY**	**3**	**0**	**0**	**3**

COURSE CONTENT

Supramolecular Chemistry. Definition and examples of the main intermolecular forces used in supramolecular chemistry. Self-assembly processes in organic systems. Main supramolecular structures.

Physical Chemistry of Nanomaterials. Students will be exposed to the very basics of nanomaterials; A series of nanomaterials that exhibit unique properties will be introduced.

Methods of Synthesis of Nanometerials. Equipment and processes needed to fabricate nanodevices and structures such as bio-chips, power devices, and opto-electronic structures. Bottom-up (building from molecular level) and top-down (breakdown of microcrystalline materials) approaches.

Biologically-Inspired Nanotechnology Basic biological concepts and principles that may lead to the development of technologies for nanoengineering systems. Coverage will be given to how life has evolved sophisticatedly; molecular nanoscale engineered devices, and discuss how these nanoscale biotechnologies are far more elaborate in their functions than most products made by humans.

Instrumentation for Nanoscale Characterization. Instrumentation required for characterization of properties on the nanometer scale. The measurable properties and resolution limits of each technique, with an emphasis on measurements in the nanometer range.

TEXT BOOKS:

1. *Supramolecular Chemistry by Jean-Marie Lehn,*
2. *Supramolecular Chemistry by Jonathan Steed & Jerry Atwood*
3. *Intermolecular and Surface Forces by Jacob Israelachvili.*

CL 406	FLUIDIZATION ENGINEERING	L	T	P	C
		3	0	0	3

COURSE CONTENT

Introduction and applications: Introduction to fluidised bed systems. Fundamentals of fluidisation. Industrial applications of fluidised beds - Physical operations. Synthesis reactions, cracking and reforming of hydrocarbons, Gasification, Carbonisation, Gas-solid reactions, calcining and clinkering.

Gross behaviour of Fluidised beds: Gross behaviour of fluidised beds. Minimum and terminal velocities in fluidised beds. Types of fluidisation. Design of distributors. Voidage in fluidised beds. TDH, variation in size distribution with height, viscosity and fluidity of fluidised beds, Power consumption.

Analysis of bubble and emulsion Phase: Davidson's model, Frequency measurements, bubbles in ordinary bubbling bed model for bubble phase. Emulsion phase: Experimental findings. Turn over rate of solids. Bubbling bed model for emulsion phase Interchange co-efficients.

Flow pattern of Gas and heat & mass transfer in Fluidised beds: Flow pattern of gas through fluidised beds. Experimental findings. The bubbling bed model for gas inter change Interpretation of Gas mixing data. Heat and Mass Transfer between fluid and solid: Experiment findings on Heat and Mass Transfer. Heat and mass transfer rates from bubbling bed model.

Heat transfer between Fluidised beds and surfaces - Entrainment & Elutriation: Heat transfer between fluidised beds and surfaces: Experiment finding theories of bed heat transfer comparison of theories. Entrainment of or above TDH, model for Entrainment and application of the entrainment model to elutriation.

TEXT BOOK:

1. *D. Kunii and O. Levenspiel, "Fluidisation Engineering", 2nd Edn., Butterworth Heinemann, 1991.*

CL 408	PHARMACEUTICAL TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE CONTENT

Introduction to Physical Pharmaceutics: Metrology and Calculations, Molecular structure, properties and States of Matter, Solutions, Phase Equilibra, Micromeritic and Powder Rheology, Surface and Interfacial Phenomena, Dispersion Systems,

Diffusion & Dissolution, Kinetics and drug stability, Viscosity & Rheology, and Polymer Science and Applications.

Formulations and Development, Packaging, Introduction to Industrial Processing, Transport Phenomena (Fluid Flow, Heat Transfer and Mass Transfer),

Particulate Technology (Particle Size, Size reduction, Size Separation, Powder Flow and Compaction), Unit Operations (Mixing, Evaporation, Filtration, Centrifugation, Extraction, Distillation, and Drying),

Materials of Pharmaceutical Plant Construction, Good Manufacturing Practice (GMP's) Guidelines

TEXT BOOKS:

1. *Physical Pharmacy by Alfred Martin.*
2. *Remington's Pharmaceutical Sciences*

REFERENCES:

1. *Bentley's Pharmaceutics by E A Rawlins*
2. *Cooper and Gunn's Tutorial Pharmacy*

CL 410	PROCESS OPTIMIZATION	L	T	P	C
		3	0	0	3

COURSE CONTENT

General: Functions of single and multiple variables - optimality criteria, direct and indirect search methods.

Linearisation: Constraint optimality criteria, transformation methods based on linearisation.

Quadratic And Geometric Programming: Quadratic and geometric programming problems, calculus of variations.

Optimality Criteria & Optimal Control Problems:Euler-Lagrange optimality criteria, Pontryagin's maximum principle, optimal control problems. Numerical methods.

Artificial Intelligence In Optimization: Introduction to Artificial Intelligence in optimization.

TEXT BOOK:

1. T.F. Edgar and D.M. Himmelblau," Optimization Techniques for Chemical Engineers", McGraw Hill, New York, 1985.

REFERENCE:

1.K. Deo, "Optimization Techniques", Wiley Eastern, 1995.

Electives for B.Tech. Honours

CL 601	PROCESS DYNAMICS AND CONTROL - II	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

Expose students to the advanced control methods used in industries and research. This course prepares the student to take up such challenges in his profession.

COURSE OUTCOMES

Upon completing the course, the student should have understood

- controller tuning
- type of controller that can be used for specific problems in chemical industry
- design of controllers for interacting multivariable systems
- design of digital control systems

COURSE CONTENT

Review of Systems: Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances. Transient response. Block diagrams.

Stability Analysis: Frequency response, design of control system, controller tuning and process identification. Zigler-Nichols and Cohen-Coon tuning methods, Bode and Nyquist stability criterion. Process identification.

Special Control Techniques: Advanced control techniques, cascade, ratio, feed forward, adaptive control, Smith predictor, internal model control.

Multivariable Control Analysis: Introduction to state-space methods, , Control degrees of freedom analysis and analysis, Interaction, Bristol arrays, Niederlinski index - design of controllers, Tuning of multivariable controllers.

Sample Data Controllers: Basic review of Z transforms, Response of discrete systems to various inputs. Open and closed loop response to step, impulse and sinusoidal inputs, closed loop response of discrete systems. Design of digital controllers. Introduction to PLC and DCS.

TEXT BOOKS:

6. *D.R. Coughanour, 'Process Systems analysis and Control', McGraw-Hill, 2nd Edition, 1991.*
7. *D.E. Seborg, T.F. Edger, and D.A. Millichamp, 'Process Dynamics and Control', John Wiley and Sons, 2nd Edition, 2004.*

REFERENCES:

1 *B.A.Ogunnaike and W.H.Ray, "Process Dynamics, Modelling and Control", Oxford Press, 1994.*
2 *W.L.Luyben, 'Process Modelling Simulation and Control for Chemical Engineers', McGraw Hill, 2nd Edition, 1990.*
3 *B.W. Bequette, 'Process Control: Modeling, Design and Simulation', PHI, 2006.*
4 *S. Bhanot, 'Process Control: Principles and Applications', Oxford University Press, 2008.*

CL 602	ADVANCES IN FLUIDIZATION ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

Fluidization finds extensive application today in Process Industry and also in combustion. Objective of this course is to make the student aware of fundamentals of Fluidization and understand the design aspects of fluidized bed systems.

COURSE OUTCOME

The student at the end of the course will be in a position to design a fluidized bed system for different applications.

COURSE CONTENT

Applications of fluidized beds: Introduction, Industrial application of fluidized beds, Physical operations and reactions.

Fluidization and analysis of different phases: Gross behavior of fluidized beds. Bubbles in dense beds. The emulsion phase in dense bubbling beds. Flow pattern of gas through fluidized beds.

Heat and Mass transfer in fluidized bed systems: Mass and heat transfer between fluid and solid. Gas conversion in bubbling beds. Heat transfer between fluidized bed and surfaces.

Elutriation and entrainment: TD and also distribution of solid in a fluidized bed. Circulation systems.

Design of fluidized bed systems: design of fluidization columns for physical operations, catalytic and non- catalytic reactions, three phase fluidization.

CA: 2 Tests each for 20 marks + Assignment/seminar for 10 marks
50 marks for end semester examination.

TEXT BOOK:

1. *Diazo Kunji and O. Levenspiel, "Fluidization Engg". 2nd Ed., Butterworth Heinemann, 1991.*

REFERENCE:

1. *J. F. Davidson and Harrison, "Fluidization", 10th Ed, Academic Press, London, 1994.*

2. *Jackson, R., “The Dynamics of Fluidized Particles,” Cambridge University Press, New York (2000).*
3. *Fan, L.-S. and C. Zhu, Principles of Gas-Solid Flows, Cambridge University Press, New York (1998).*

CL 603	**PROCESS MODELLING AND SIMULATION**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

To give an overview of various methods of process modeling, different computational techniques for simulation. The focus shall be on the techniques themselves, rather than specific applications so that the student can take up modeling and simulation challenges in his profession.

COURSE OUTCOME

Upon completing the course, the student should have understood

- Development of process models based on conservation principles and process data
- Computational techniques to solve the process models
- How to use simulation tools such as MATLAB/SCILAB

COURSE CONTENT

Introduction to process modeling **-** a systematic approach to model building, classification of models. Conservation principles, thermodynamic principles of process systems.

Development of steady state and dynamic lumped and distributed parameter models based on first principles. Analysis of ill-conditioned systems. Models with stiff differential equations.

Development of grey box models. Empirical model building. Statistical model calibration and validation. Examples. Introduction to population balance models, multi-scale modeling.

Solution strategies for lumped parameter models and stiff differential equations. Solution methods for initial value and boundary value problems. Euler’s method. R-K methods, shooting method, finite difference methods – predictor corrector methods.

Solution strategies for distributed parameter models. Solving parabolic, elliptic and hyperbolic partial differential equations. Introduction to finite element and finite volume methods.

Solving the problems using *MATLAB/SCILAB.*

TEXT BOOKS:

1. *K. M. Hangos and I. T. Cameron, “Process Modeling and Model Analysis”, Academic Press, 2001.*
2. *W.L. Luyben, “Process Modeling, Simulation and Control for Chemical Engineers”, 2nd Edn., McGraw Hill Book Co., New York, 1990.*
3. *Singiresu S. Rao, “Applied Numerical Methods for Engineers and Scientists” Prentice Hall, Upper Saddle River, NJ, 2001*

REFERENCES:

1. *Bruce A. Finlayson, Introduction to Chemical Engineering Computing, Wiley, 2010.*
2. *W. F. Ramirez, “Computational Methods for Process Simulation”, 2nd ed., Butterworths, 1997.*
3. *Amiya K. Jana, Chemical Process Modelling and Computer Simulation, Prentice Hall of India, 2nd Edition, 2011*
4. *Laurene V. Fausett, Applied Numerical Analysis using MATLAB, Second edition, Pearson, 2009.*

CL 604	PINCH ANALYSIS & HEAT EXCHANGER NETWORK DESIGN	L	T	P	C
		2	1	0	3

PRE-REQUISITES: Basics of Heat Transfer, Mathematics, Process Design

COURSE OBJECTIVES

Understanding on Pinch concept, Application to Process Heat Exchange Networking, Identification of Energy Minimization in the Process, Retrofitting Concepts and Setting up Targets for Energy Minimization.

COURSE OUTCOME

After the course, you are able to appreciate the pinch concept and process thermodynamics, able to identify minimum energy targets, identification of different choices and constraint during heat exchange networking, strategies for retrofitting existing process plant, integration of energy demands of multiple processes.

COURSE CONTENT

Thermodynamical review of the process, Pinch Concept, significance of pinch, pinch in grid representation, Threshold problems, capital cost implication of the pinch.

Targeting: Heat exchanger networks, energy targeting, area targeting, unit targeting, shell targeting, cost targeting, super targeting, continuous targeting.

Pinch Methodology: Problem representation, temperature enthalpy diagram, simple match matrix. Heat content diagram, Temperature interval diagram.

Pinch Design and Optimization: Networks for maximum energy recovery, Pinch design method, Flexibility criteria of the pinch, cp table, the tick of heuristic, case studies, optimization of heat exchanger network optimality for a minimum area network, Sensitivity analysis.

Energy and Resource Analysis of various processes, Batch process, flexible process, distillation process, evaporation process, reaction process, process using mass separating agent. Heat pipes and Heat pumps,

TEXT BOOKS:

1. *V. UdayShenoy" Heat Exchanger network synthesis" Gulf Publishing Co, USA, 1995*
2. *D.W. Linnhoff et al., "User Guide on Process Integration for the efficient use of Energy", Institution of Chemical Engineers, U.K., 1994.*

REFERENCES:

1. *James M. Douglas "Conceptual Design of Chemical Process", McGraw Hill, New York, 1988.*

Anil Kumar, "Chemical Process Synthesis and Engineering Design", Tata McGraw Hill New Delhi, 1977.

CL 605	DESIGN AND ANALYSIS OF EXPERIMENTS	L	T	P	C
		3	0	0	3

PREREQUISITES: Fundamental statistics

COURSE OBJECTIVES

The aim of the course to give competences in the field of applied statistical methods for work concerning planning and analysis of experiments, regression analysis, optimization of processes and multivariate analysis.

COURSE OUTCOME

- Plan experiments according to a proper and correct design plan.
- Analyse and evaluate experimental results (statistically), according to chosen experimental design (ANOVA, regression models).
- Control and properly use fundamentals such as hypothesis testing, degrees of freedom, ANOVA, fractional design and other design methods/techniques and so on.
- Know the fundamentals of multivariate analysis and chemometric methods (PCA and PLS) with simple applications.

COURSE CONTENT

- Statistics
- Simple Comparative Experiments
- Experiments of a single factor, analysis of variance.
- Randomized blocks
- Latin squares
- The 2k factor design
- Blocking and confounding
- Two level fractional Factorial design.
- Three level and mixed level factorial and fractional factorial design.
- Fitting regression methods. LS method.
- Robust parameter design
- Experiment with random factors.
- Nested design
- Response surfaces, EVOP.
- Multivariate data analysis

COURSE ORGANISATION

The course contains lectures mixed with calculation examples showing practical applications of basic theories. The assignments and calculation are based on realistic industrial examples taken from literature and research projects. The projects are problem based with active learning activities. This part has been a very successful part in terms of life-long learning for the students and highly appreciated among students for many years.

Textbook:

Douglas C. Montgomery: Design and Analysis of Experiments, Wiley, 6th Edition.

		L	T	P	C
CL 606	**ADVANCES IN HEAT TRANSFER**	**2**	**1**	**0**	**3**

COURSE CONTENT

Transient Heat conduction, Extended surfaces and generalized expressions for fins or spines. Effectiveness of fins and spines, Temperature - time response of thermocouples and use of transient heat conduction charts.

Convection - Theory and practice. Energy equation for thermal boundary layer over a flat plate. Data analysis for forced and free convection problems, Analogy between heat, mass and momentum transfer.

Heat Transfer with phase change, Boiling and condensation, Boiling Regimes and types of condensation processes, effect of pressure, turbulence and other factors on boiling and condensation heat transfer.

Advances in heat exchanger design: and compact heat exchangers, Heat transfer in liquid metals. Heat transfer in packed and fluidised beds and Heat transfer process in nuclear reactors.

TEXT BOOKS:

1. *James G. Knudsen and Donald L. Katz, "Fluid Dynamics and Heat Transfer", McGraw Hill Book Company, 1958.*
2. *Antony F. Mills, "Heat Transfer", Richard D. Irwin, Inc., 1992, Homewood, IL60430 and Boston, MA021163.*

REFERENCES:

1. *W. M. Rohsenow and H.Y. Choi,"Heat Mass and Momentum Transfer", PrenticeHall, Inc., 1961.*
2. *W .H. Mc Adams," Heat Transmission", McGraw Hill, New York,1995*

<u>Courses offered from other departments</u>

		L	T	P	C
MT 403	**CORROSION ENGINEERING**	**3**	**0**	**0**	**3**

COURSE CONTENT

Electrochemical and thermodynamic principles, Nernst equation and electrode potentials of metals, EMF and galvanic series, merits and demerits; origin of Pourbaix diagram and its importance to iron, aluminium and magnesium metals

Exchange current density, polarization - concentration, activation and resistance, Tafel equation; passivity, electrochemical behaviour of active/passive metals, Flade potential, theories of passivity

Atmospheric, pitting, dealloying, stress corrosion cracking, intergranular corrosion, corrosion fatigue, fretting corrosion and high temperature oxidation; causes and remedial measures

Purpose of testing, laboratory, semi-plant and field tests, susceptibility tests for IGC, stress corrosion cracking and pitting, sequential procedure for laboratory and on-site corrosion investigations, corrosion auditing and corrosion map of India

Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors

TEXT BOOKS:

1. *Raj Narayan, 'An Introduction to Metallic Corrosion and its Prevention', 1st Edition, Oxford and IBH, 1983*
2. *Fontana M. G., Greene N. D., 'Corrosion Engineering', 3rd Edition, McGraw Hill, 1985*

REFERENCES:

1. *Denny Jones, "Principles and Prevention of Corrosion", Prentice Hall of India, 1996.*

		L	T	P	C
IC 452	**POWER PLANT INSTRUMENTATION AND CONTROL**	**3**	**0**	**0**	**3**

COURSE CONTENT

Brief survey of methods of power generation-hydro, thermal, nuclear, solar and wind power – Introduction to thermal power plant processes – building blocks - ideal steam cycles – Boiler – types, Boiler - turbine units and its range systems, feed water systems, steam circuits, combustion process, products of combustion process, fuel systems, treatment of flue gases, steam turbine, condensate systems, alternator, feed water conditioning, turbine bypass valves. Importance of instrumentation in power generation – details of boiler processes, P & I diagram of boiler – combined cycle power plant, power generation and distribution.

Measurement in boiler and turbine: Metal temperature measurement in boilers, piping system for pressure measuring devices, smoke and dust monitor, flame monitoring. Introduction to turbine supervising system, pedestal vibration, shaft vibration, eccentricity measurement. Installation of non-contracting transducers for speed measurement, rotor and casing movement and expansion measurement.

Controls in boiler: Problems associated with control of multiple pulverizers. Draught plant: Introduction, natural draught, forced draught, induced draught, power requirements for draught systems. Fan drives and control, control of air flow. Combustion control: Fuel/Air ratio, oxygen, CO and CO2 trimming, combustion efficiency, excess air, parallel and cross limited combustion control, control of large systems.

Controls in boiler: Boiler drum level measurement methods, feedwater control, soot-blowing operation, steam temperature control, Coordinated control, boiler following mode operation, turbine following mode operation, sliding pressure mode operation, selection between boiler and turbine following modes. Distributed control system in power plants-interlocks in boiler operation. Turbine control: Shell temperature control-steam pressure control – lubricant oil temperature control – cooling system.

Nuclear power plant instrumentation: Piping and instrumentation diagram of different types of nuclear power plant, Nuclear reactor control loops, reactor dynamics, excess reactivity, pulse channel and logarithmic instrumentation, control and safety instrumentation, reliability aspects.

TEXT BOOKS:

1. *Sam. G.Dukelow, "The Control of Boilers", 2nd Edition, ISA Press, New York, 1991.*
2. *Gill A.B, "Power Plant Performance", Butterworth, London, 1984.*
3. *P.C Martin, I.W Hannah, "Modern Power Station Practice", British Electricity International Vol. 1 & VI, Pergamon Press, London, 1992.*

REFERENCE BOOKS:

1. *David Lindsley, "Boiler Control Systems", McGraw Hill, New York, 1991.*
2. *Jervis M.J, "Power Station Instrumentation", Butterworth Heinemann, Oxford, 1993.*
3. *Modern Power Station Practice, Vol.6, "Instrumentation, Controls andTesting", Pergamon Press, Oxford, 1971.*

		L	T	P	C
HM 403	**HUMAN VALUES THROUGH LITERATURE**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES

The course aims to enable engineering students perform better in corporate world by providing insights into human values through literature.

COURSE DESCRIPTION

This course intends to initiate non-literature students to the intricacies of "the written word". Covering representative works by diverse writers, this course while providing an overview of the formal properties of literature will also emphasize on the social, moral, emotional, political and cultural mores of literary works. Further, the course will acquaint the students to contextualize and historicize literary works, to interpret and evaluate literature and finally, to appreciate figurative/ expressive nature of language. At the end of the course, the students shall demonstrate familiarity by being able to read and write critically about one of the literary forms/genres. All these will enable the students' to understand people better.

Definitions of Literature. Role and Purpose of literature. Literary language and scientific language. Author/Text/Reader.
Genres of literature (eg. Novel/Short Story/ Poetry/ Drama etc.) and tools of literary study.
Critical/Creative/Lateral thinking. Close reading techniques.

Writing about Literature. Major theories governing the appreciation of literature.
Dissertation

REFERENCES:

1.Abrams, M.H. ***A Glossary of Literary Terms.*** *(Seventh Edition). Thomson: Prism. 1999.*
2.Barry, Peter. ***Beginning Theory: An Introduction to Literary and Cultural Theory.*** *Manchester: Manchester University Press, 1995.*
3.Laguardia, Dolores and Guth, Hans P. ***American Voices.*** *London: Mayfield Publishing Company, 1993.*
4.Rees, R.J. ***English Literature. An Introduction for Foreign Readers.*** *Basingstoke: Macmillan, 1973.*

HM 404	CREATIVE WRITING THROUGH LITERATURE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE
Finding one's voice is the primary objective for any creative writing program. The course will enable the participant to give shape to his/her creative ideas that can be published.

COURSE DESCRIPTION
This course is meant for the students of engineering who have the talent for creative writing. The course provides a dynamic forum to engage a variety of literary texts. Through such engagements a keener sense about the process of creative writing can be developed. To this end the course is designed with well-considered exercises meant to enable appreciation of literary texts. Further, these exercises would provide a prospect into the demands of creative writing. The student gets an opportunity to make a realistic assessment of his/her abilities in the field. At the end of the program the student will be sufficiently motivated to transform himself/herself from having, merely, a talent for writing to becoming a published writing talent.

Course content
With this in mind, the student is expected to involve in a series of classroom activities and extra-classroom assignments that provide the impetus to discover one's actual talent. There are FIVE compulsory units which are to be completed through lectures, discussions and individual read-aloud sessions.

Understanding literary forms

Thinking about texts: Role-playing the Reader, the Author, and the Individual as both the Reader-Author.

Intensive reading of a poem, short story, a novel, a bestseller, a film, a drama, an essay, a news story, an Ad-campaign, an interview.

Designing the individual reading list. Pursing one's own competence

Dissertation: Performance in the chosen genre

REFERENCES:

1. *Abrams, M.H.* ***A Glossary of Literary Terms.*** *(Tenth Edition). Thomson: New York. 2011.*
2. *Packard, William.* ***The Poet's Craft.*** *Virago: New York, 2003.*
3. *Tuchman, Barbara.* ***Practising History.*** *Routledge: London, 2006*
4. *Bowra, C.M.* ***The Romantic Imagination.*** *Faber: London, 1965.*
5. *Wallace, Irving.* ***The Making of a Bestseller.*** *Corgi: New York, 1984.*