COURSE STRUCTURE AND SYLLABSUS

For

PETROCHEMICAL ENGINEERING

(Applicable for batches admitted from 2016-2017)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
KAKINADA - 533 003, Andhra Pradesh, India

I Year I SEMESTER

S. No.	Subjects	L Hrs	T	P Hrs	Credits
1-HS	English – I	4		--	3
2-BS	Mathematics - I (Differential Equations)	4		--	3
3-ES	Engineering Chemistry	4		--	3
4-BS	Engineering Mechanics	4		--	3
5-BS	Computer Programming	4		--	3
6-ES	Environmental Studies	4		--	3
7-HS	Engineering/Applied Chemistry Laboratory	--		3	2
8-BS	English - Communication Skills Lab – I	--		3	2
9-ES	Computer Programming Lab	--		3	2
	Total credits				**24**

I YearII SEMESTER

S. No.	Subjects	L	T	P	Credits
1-HS	English – II	4		--	3
2-BS	Mathematics – II (Mathematical Methods)	4		--	3
3-BS	Mathematics – III (Linear Algebra & Vector Calculus)	4		--	3
4-ES	Engineering Physics	4		--	3
5-HS	Elements of Mechanical Engineering	4		--	3
6-ES	Engineering Drawing	4		--	3
7-BS	English - Communication Skills Lab - II	--		3	2
8-HS	Engineering/Applied Physics Lab	--		3	2
9-ES	Engineering/Applied Physics – Virtual Labs – Assignments	--		2	--
10	Engineering Workshop & IT Workshop	--		3	2
	Total credits				**24**

II Year I Semester

S. No.	Subjects	L	T	P	Credits
1	Complex Variables	4			3
2	Basic Electrical & Electronics Engineering	4			3
3	Organic Chemistry	4			3
4	Physical Chemistry	4			3
5	Chemical Process Calculations	4			3
6	Materials Science & Engineering	4			3
7	Basic Engineering (Mech. + Elec.) Lab			3	2
8	Physical & Organic Chemistry Lab			3	2
MC	Managerial Economics & Financial Analysis	2			-
	Total credits				**22**

II YearII Semester

S. No.	Subjects	L	T	P	Credits
1	Probability & Statistics	4			3
2	Momentum Transfer	4			3
3	Mechanical Unit Operations	4			3
4	Chemical Engineering Thermodynamics-I	4			3
5	Process Heat Transfer	4			3
6	Process Instrumentation	4			3
7	Momentum Transfer Lab			3	2
8	Process Heat Transfer Lab			3	2
MC	Professional Ethics & Human Values	2			--
	Total credits				**22**

III YearI Semester

S. No.	Subjects	L	T	P	Credits
1	Management Science	4			3
2	Petroleum Refinery Engineering	4			3
3	Chemical Engineering Thermodynamics-II	4			3
4	Petrochemical Engineering - I	4			3
5	Mass Transfer Operations – I	4			3
6	Mathematical Methods Lab			3	2
7	Petroleum Analysis Lab			3	2
8	Mass Transfer Operations Lab - I			3	2
9	Industrial Visits	-	-	-	-
MC	Mini Project-I	-	-	-	-
	Total credits				**21**

III Year II Semester

S. No.	Subjects	L	T	P	Credits
1	Petrochemical engineering- II	4			3
2	Mass Transfer Operations- II	4			3
3	Chemical Reaction Engineering –I	4			3
4	Process Dynamics & Control	4			3
5	**OPEN ELECTIVE** i. Electronic Instrumentation ii. Big Data Analytics iii. Alternative Energy Sources for Automobiles iv. Waste Water Management v. Fundamentals of Liquefied Natural Gas vi. Computational Fluid Dynamics	4			3
6	Mass Transfer Operations Lab – II			3	2
7	Instrumentation, Process Dynamics & Control Lab			3	2
8	Chemical Reaction Engineering Lab			3	2
9	Summer Internship (4-6 weeks)				
10 MC	Mini Project– II	-	-	-	-
	Total credits				**21**

IV Year I Semester

S. No.	Subjects	L	T	P	Credits
1	Transport Phenomena	4			3
2	Plant Design for Chemical Engineers	4			3
3	Chemical Reaction Engineering- II	4			3
4	Process Modelling & Simulation	4			3
5	**Elective I** i. Petroleum Production Engineering ii. Fluidization Engineering iii. Process Intensification iv. Optimization Techniques	4			3
6	**Elective II** i. Pipeline Engineering ii. FCC Technology iii. Process Integration iv. Computational Methods in Chemical Engineering	4			3
7	Process Equipment Design & Drawing Lab			2	2
8	Simulation Lab			2	2
MC	IPR & Patents		2		-
	Total credits				**22**

IV Year II Semester

S. No.	Subjects	L	T	P	Credits
1	Industrial Safety & Hazard Management	4			3
2	Process Engineering Economics	4			3
3	Multicomponent Distillation	4			3
4	**Elective III** i. Natural Gas Engineering ii. Prevention of Pollution through Process Integration iii. Nanotechnology iv. Design & Analysis of Experiments	4			3
5	Seminar (Presentation of SIP Report)				2
6	Project				10
	Total credits				**24**

Total course credits = 48+44 + 42 + 46 = 180

SYLLABUS

	L	T	P	C
I Year - I Semester	**4**	**0**	**0**	**3**

ENGLISH-I

Introduction:

In view of the growing importance of English as a tool for global communication and the consequent emphasis on training the students to acquire communicative competence, the syllabus has been designed to develop linguistic and communicative competence of the students of Engineering.

As far as the detailed Textbooks are concerned, the focus should be on the skills of listening, speaking, reading and writing. The nondetailed Textbooks are meant for extensive reading for pleasure and profit.

Thus the stress in the syllabus in primarily on the development of communicative skills and fostering of ideas.

Objectives:

1. To imporve the language proficiency of the students in English with emphasis on LSRW skills.
2. To enable the students to study and comprehend the prescribed lessons and subjects more effectively relating to their theorotical and practical components.
3. To develop the communication skills of the students in both formal and informal situations.

LISTENING SKILLS:

Objectives:

1. To enable the students to appreciate the role of listening skill and improve their pronounciation.
2. To enable the students to comprehend the speech of people belonging to different backgrounds and regions.
3. To enable the students to listen for general content, to fill up information and for specific information.

SPEAKING SKILLS:

Objectives:

1. To make the students aware of the importance of speaking for their personal and professional communication.
2. To enable the students to express themselves fluently and accurately in social and professional success.
3. To help the students describe objects, situations and people.
4. To make the students participate in group activities like roleplays, discussions and debates.
5. To make the students particiapte in Just a Minute talks.

READING SKILLS:

Objectives:

1. To enable the students to comprehend a text through silent reading.
2. To enable the students to guess the meanings of words, messages and inferences of texts in given contexts.
3. To enable the students to skim and scan a text.
4. To enable the students to identify the topic sentence.
5. To enable the students to identify discourse features.
6. To enable the students to make intensive and extensive reading.

WRITING SKILLS:

Objectives:

1. To make the students understand that writing is an exact formal skills.
2. To enable the students to write sentences and paragraphs.
3. To make the students identify and use appropriate vocabulary.
4. To enable the students to narrate and describe.
5. To enable the students capable of note-making.
6. To enable the students to write coherently and cohesively.
7. To make the students to write formal and informal letters.
8. To enable the students to describe graphs using expressions of comparision.
9. To enable the students to write techincal reports.

Methodology:

1. The class are to be learner-centered where the learners are to read the texts to get a comprehensive idea of those texts on their own with the help of the peer group and the teacher.
2. Integrated skill development methodology has to be adopted with focus on individual language skills as per the tasks/exercise.
3. The tasks/exercises at the end of each unit should be completed by the learners only and the teacher interventionis perimitted as per the complexity of the task/exercise.
4. The teacher is expected to use supplementary material wherever necessary and also generate activities/tasks as per the requirement.
5. The teacher is perimitted to use lecture method when a completely new concept is introduced in the class.

Assessment Procedure: Theory

1. The formative and summative assessment procedures are to be adopted (mid exams and end semester examination).
2. Neither the formative nor summative assessment procedures should test the memory of the content of the texts given in the textbook. The themes and global comprehension of the units in the present day context with application of the langauge skills learnt in the unit are to be tested.
3. Only new unseen passages are to be given to test reading skills of the learners. Written skills are to be tested from sentence level to essay level. The communication formats—emails,letters and reports-- are to be tested along with appropriate langauge and expressions.
4. Examinations:

I mid exam + II mid exam (15% for descriptive tests+10% for online tests)= 25%

(80% for the best of two and 20% for the other)

Assignments= 5%

End semester exams=70%

5. Three take home assignments are to be given to the learners where they will have to read texts from the reference books list or other sources and write their gist in their own words.

The following text books are recommended for study in I B.Tech I Semester (Common for all branches)and I B.Pharma I Sem of JNTU Kakinada from the academic year 2016-17

(R-16 Regualtions)

DETAILED TEXTBOOK:

ENGLISH FOR ENGINEERS AND TECHNOLOGISTS, Published by **Orient Blackswan Pvt Ltd**

NON-DETAILED TEXTBOOK:

PANORAMA: A COURSE ON READING, Published by **Oxford University Press India**

The course content along with the study material is divided into six units.

UNIT I:

1. 'Human Resources' from English for Engineers and Technologists.

OBJECTIVE:

To develop human resources to serve the society in different ways.

OUTCOME:

The lesson motivates the readers to develop their knowledge different fields and serve the society accordingly.

2. 'An Ideal Family' from Panorama: A Course on Reading

OBJECTIVE:

To develop extensive reading skill and comprehension for pleasure and profit.

OUTCOME:

Acquisition of writing skills

UNIT 2:

1. ' Transport: Problems and Solutions' from English for Engineers and Technologists.

OBJECTIVE:

To highlight road safety measures whatever be the mode of transport.

OUTCOME:

The lesson motivates the public to adopt road safety measures.

2.'War' from 'Panorama : A Course on Reading'

OBJECTIVE:

To develop extensive reading skill and comprehension for pleasure and profit.

OUTCOME:

Acquisition of writing skills

UNIT 3:

1. 'Evaluating Technology' from English for Engineers and Technologists.

OBJECTIVE:

To highlight the advantages and disadvantages of technology.

OUTCOME:

The lesson creates an awareness in the readers that mass production is ultimately detrimental to biological survival.

2. 'The Verger' from 'Panorama : A Course on Reading'

OBJECTIVE:

To develop extensive reading skill and comprehension for pleasure and profit.

OUTCOME:

Acquisition of writing skills

UNIT 4:

1. 'Alternative Sources of Energy' from English for Engineers and Technologists.

OBJECTIVE:

To bring into focus different sources of energy as alternatives to the depleting sources.

OUTCOME:

The lesson helps to choose a source of energy suitable for rural India.

2. ' The Scarecrow' from Panorama : A Course on Reading

OBJECTIVE:

To develop extensive reading skill and comprehension for pleasure and profit.

OUTCOME:

Acquisition of writing skills

UNIT 5:

1. 'Our Living Environment' from English for Engineers and Technologists.

OBJECTIVE:

To highlight the fact that animals must be preserved beacuase animal life is precious.

OUTCOME:

The lesson creates an awareness in the reader as to the usefulness of animals for the human society.

2.'A Village Host to Nation'from Panorama : A Course on Reading

OBJECTIVE:

To develop extensive reading skill and comprehension for pleasure and profit.

OUTCOME:

Acquisition of writing skills

UNIT 6:

1. ' Safety and Training' from English for Engineers and Technologists.

OBJECTIVE:

To highlight the possibility of accidents in laboratories, industries and other places and to follow safety measures.

OUTCOME:

The lesson helps in identifying safety measures against different varieties of accidents at home and in the workplace.

2. 'Martin Luther King and Africa' from Panorama : A Course on Reading

OBJECTIVE:

To develop extensive reading skill and comprehension for pleasure and profit.

OUTCOME:

Acquisition of writing skills

NOTE:

All the exercises given in the prescribed lessons in both detailed and non-detailed textbooks relating to the theme and language skills must be covered.

OVERALL COURSE OUTCOME:

1. Using English languages, both written and spoken, competently and correctly.
2. Improving comprehension and fluency of speech.
3. Gaining confidence in using English in verbal situations.

MODEL QUESTION PAPER FOR THEORY

PART- I

Six short answer questions on 6 unit themes

One question on eliciting student's response to any of the themes

PART-II

Each question should be from one unit and the last question can be a combination of two or more units.

Each question should have 3 sub questions: A,B& C

A will be from the main text: 5 marks

B from non-detailed text: 3 marks

C on grammar and Vocabulary: 6 marks

I Year - I Semester

L	T	P	C
4	0	0	3

MATHEMATICS-I
(Differential Equations)
(Common to ALL branches of First Year B.Tech.)

Learning Objectives:

- The course is designed to equip the students with the necessary mathematical skills and techniques that are essential for an engineering course.
- The skills derived from the course will help the student from a necessary base to develop analytic and design concepts.

UNIT-I:

Differential equations of first order and first degree: Linear-Bernoulli-Exact-Reducible to exact.

Applications: Newton's Law of cooling-Law of natural growth and decay-Orthogonal trajectories- Electrical circuits- Chemical reactions.

UNIT-II:

Linear differential equations of higher order: Non-homogeneous equations of higher order with constant coefficients with RHS term of the type e^{ax}, sin ax, cos ax, polynomials in x, $e^{ax}V(x)$, $xV(x)$- Method of Variation of parameters.

Applications: LCR circuit, Simple Harmonic motion.

UNIT-III:

Laplace transforms: Laplace transforms of standard functions-Shifting theorems - Transforms of derivatives and integrals – Unit step function –Dirac's delta function- Inverse Laplace transforms– Convolution theorem (without proof).

Applications: Solving ordinary differential equations (initial value problems) using Laplace transforms.

UNIT-IV:

Partial differentiation: Introduction- Homogeneous function-Euler's theorem-Total derivative-Chain rule-Generalized Mean value theorem for single variable (without proof)-Taylor's and Mc Laurent's series expansion of functions of two variables– Functional dependence- Jacobian.

Applications: Maxima and Minima of functions of two variables without constraints and Lagrange's method (with constraints).

UNIT-V:

First order Partial differential equations: Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions –solutions of first order linear (Lagrange) equation and nonlinear (standard types) equations.

UNIT-VI:

Higher order Partial differential equations: Solutions of Linear Partial differential equations with constant coefficients. RHS term of the type $e^{ax+by}, \sin(ax+by), \cos(ax+by), x^m y^n$. Classification of second order partial differential equations.

Outcomes:

At the end of the Course, Student will be able to:

- Solve linear differential equations of first, second and higher order.
- Determine Laplace transform and inverse Laplace transform of various functions and use Laplace transforms to determine general solution to linear ODE.
- Calculate total derivative, Jocobian and minima of functions of two variables.

Text Books:

1. Higher Engineering Mathematics, B.S.Grewal, 43rd Edition, Khanna Publishers.
2. Engineering Mathematics,N.P.Bali, Lakshmi Publications.

Reference Books:

1. Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, Wiley-India.
2. Advanced Engineering Mathematics, Micheael Greenberg, 9th Edition, Pearson edn.
3. Advanced Engineering Mathematics with MATLAB, Dean G. Duffy, CRC Press.
4. Advanced Engineering Mathematics, Peter O'neil, Cengage Learning.
5. Engineering Mathematics, Srimanta Pal, Subodh C.Bhunia, Oxford University Press.
6. Higher Engineering Mathematics, Dass H.K., Rajnish Verma. Er.,S. Chand Co. Pvt. Ltd, Delhi.

I Year - I Semester

L	T	P	C
4	0	0	3

ENGINEERING CHEMISTRY

(CE, ME, PCE, PE, Met.E, Mining, Automobile, Aeronautical, Chemical, Bio.tech.)

Knowledge of basic concepts of Chemistry for Engineering students will help them as professional engineers later in design and material selection, as well as utilizing the available resources.

Learning Objectives:

- Plastics are nowadays used in household appliances; also they are used as composites (FRP) in aerospace and automotive industries.
- Fuels as a source of energy are a basic need of any industry, particularly industries like thermal power stations, steel industry, fertilizer industry etc., and hence they are introduced.
- The basics for the construction of galvanic cells are introduced. Also if corrosion is to be controlled, one has to understand the mechanism of corrosion which itself is explained by electrochemical theory.
- With the increase in demand, a wide variety of materials are coming up; some of them have excellent engineering properties and a few of these materials are introduced.
- Water is a basic material in almost all the industries, more so where steam is generated and also where it is supplied for drinking purposes.
- Materials used in major industries like steel industry, metallurgical industries and construction industries and electrical equipment manufacturing industries are introduced. Also lubrication is introduced.

UNIT I: HIGH POLYMERS AND PLASTICS

Polymerisation:- Introduction- Mechanism of polymerization - Stereo regular polymers – methods of polymerization (emulsion and suspension) -Physical and mechanical properties – ***Plastics*** as engineering materials : advantages and limitations – Thermoplastics and Thermosetting plastics – Compounding and fabrication (4/5 techniques)- Preparation, properties and applications of polyethene, PVC, Bakelite Teflon and polycarbonates

Elastomers:- Natural rubber- compounding and vulcanization – Synthetic rubbers : Buna S, Buna N, Thiokol and polyurethanes – Applications of elastomers.

Composite materials& Fiber reinforced plastics – Biodegradable polymers – Conducting polymers.

UNIT II: FUEL TECHNOLOGY

Fuels – Introduction – Classification – Calorific value - HCV and LCV – Dulong's formula – Bomb calorimeter – Numerical problems – Coal — Proximate and ultimate analysis – Significance of the analyses – Liquid fuels – Petroleum- Refining – Cracking – Synthetic petrol –Petrol knocking – Diesel knocking - Octane and Cetane ratings – Anti-knock agents – Power alcohol – Bio-diesel – Gaseous fuels – Natural gas, LPG and CNG – Combustion – Calculation of air for the combustion of a fuel – Flue gas analysis – Orsat apparatus – Numerical problems on combustion.

Explosives:- Rocket fuels

UNIT III: ELECTROCHEMICAL CELLS AND CORROSION

Galvanic cells - Reversible and irreversible cells – Single electrode potential – Electro chemical series and uses of this series- Standard electrodes (Hydrogen and Calomel electrodes) - Concentration Cells – Batteries: Dry Cell - Ni-Cd cells - Ni-Metal hydride cells - Li cells - Zinc – air cells.

Corrosion :- Definition – Theories of Corrosion (chemical & electrochemical) – Formation of galvanic cells by different metals, by concentration cells, by differential aeration and waterline corrosion – Passivity of metals – Pitting corrosion - Galvanic series – Factors which influence the rate of corrosion - Protection from corrosion – Design and material selection – Cathodic protection - Protective coatings: – Surface preparation – Metallic (cathodic and anodic) coatings - Methods of application on metals (Galvanizing, Tinning, Electroplating, Electroless plating).

UNIT IV: CHEMISTRY OF ADVANCED MATERIALS

Nano materials:- Introduction – Sol-gel method & chemical reduction method of preparation – Characterization by BET method and TEM methods - Carbon nano tubes and fullerenes: Types, preparation, properties and applications

Liquid crystals:- Introduction – Types – Applications

Super conductors:-Type –I, Type II – Characteristics and applications

Green synthesis:- Principles - 3or 4 methods of synthesis with examples – R_4M_4 principles

UNIT V: WATER TECHNOLOGY

Hard water:- Reasons for hardness – units of hardness - determination of hardness and alkalinity - Water for steam generation - Boiler troubles – Priming and Foaming, Scale formation, Boiler corrosion, Caustic embrittlement - Internal treatments - Softening of Hard water : Lime – Soda process, Zeolite process and numerical problems based on these processes and Ion Exchange process - Water for drinking purposes- Purification – Sterilization and disinfection : Chlorination, Break point chlorination and other methods – Reverse Osmosis and Electro Dialysis.

UNIT VI: CHEMISTRY OF ENGINEERING MATERIALS AND FUEL CELLS

Refractories: - Definition, characteristics, classification, properties, failure of refractories

Lubricants: - Definition, function, Theory and mechanism of lubricants, properties (Definition and importance)

Cement: - Constituents, manufacturing, hardening and setting, deterioration of cement

Insulators: - Thermal and electrical insulators

Fuel cells: - Hydrogen Oxygen fuel cells – Methanol Oxygen fuel cells

Outcome: The advantages and limitations of plastic materials and their use in design would be understood. Fuels which are used commonly and their economics, advantages and limitations are discussed. Reasons for corrosion and some methods of corrosion control would be understood. The students would be now aware of materials like nano materials and fullerenes and their uses. Similarly liquid crystals and superconductors are understood. The importance of green synthesis is well understood and how they are different from conventional methods is also explained. The impurities present in raw water, problems associated with them and how to avoid them are understood. The advantages and limitations of plastic materials and their use in design would be understood. The commonly used industrial materials are introduced.

Standard Books:

1. Engineering Chemistry by Jain and Jain; Dhanpat Rai Publicating Co.

2. Engineering Chemistry by Shikha Agarwal; Cambridge University Press, 2015 edition.

Reference Books:

1. Engineering Chemistry of Wiley India Pvt. Ltd., Vairam and others, 2014 edition (second).
2. Engineering Chemistry by Prasanth Rath, Cengage Learning, 2015 edition.
3. A text book of engineering Chemistry by S. S. Dara; S. Chand & Co Ltd., Latest Edition
4. Applied Chemistry by H.D. Gesser, Springer Publishers
5. Text book of Nano-science and nanotechnology by B.S. Murthy, P. Shankar and others, University Press, IIM

	L	T	P	C
I Year - I Semester				
	4	**0**	**0**	**3**

ENIGINEERING MECHANICS

Learning Objectives:

- The students completing this course are expected to understand the concepts of forces and its resolution in different planes, resultant of force system, Forces acting on a body, their free body diagrams using graphical methods.
- They are required to understand the concepts of centre of gravity and moments of inertia and their application, Analysis of frames and trusses, different types of motion, friction and application of work - energy method.

UNIT–I:

Objectives: The students are to be exposed to the concepts of force and friction, direction and its application.

Introduction to Engg. Mechanics – Basic Concepts.

Systems of Forces: Coplanar Concurrent Forces – Components in Space – Resultant – Moment of Force and its Application – Couples and Resultant of Force Systems.

Friction: Introduction**,** Limiting friction and impending motion, Coulomb's laws of dry friction, Coefficient of friction, Cone of friction.

UNIT-II:

Objectives: The students are to be exposed to application of free body diagrams. Solution to problems using graphical methods and law of triangle of forces.

Equilibrium of Systems of Forces: Free body diagrams, Equations of equilibrium of coplanar systems, Spatial systems for concurrent forces,LamisTheorm, Graphical method for the equilibrium of coplanar forces, Converse of the law of triangle of forces, Converse of the law of polygon of forces condition of equilibrium, Analysis of plane trusses.

UNIT-III:

Objectives: The students are to be exposed to concepts of centre of gravity.

Centroid: Centroids of simple figures (from basic principles) – Centroids of composite figures

Centre of Gravity: Centre of gravity of simple body (from basic principles), Centre of gravity of composite bodies, Pappus theorems.

UNIT-IV:

Objective: The students are to be exposed to concepts of moment of inertia and polar moment of inertia including transfer methods and their applications.

Area moments of Inertia: Definition – Polar moment of inertia, Transfer theorem, Moments of inertia of composite figures, Products of inertia, Transfer formula for product of inertia.

Mass Moment of Inertia: Moment of inertia of masses, Transfer formula for mass moments of Inertia, Mass moment of inertia of composite bodies.

UNIT-V:

Objectives: The students are to be exposed to motion in straight line and in curvilinear paths, its velocity and acceleration computation and methods of representing plane motion.

Kinematics: Rectilinear and Curvelinear motions – Velocity and Acceleration – Motion of rigid body – Types and their analysis in planar motion.

Kinetics: Analysis as a particle and analysis as a rigid body in translation – Central force motion – Equations of plane motion – Fixed axis rotation – Rolling bodies.

UNIT-VI:

Objectives: The students are to be exposed to concepts of work, energy and particle motion

Work-Energy Method: Equations for translation, Work-Energy applications to particle Motion, Connected system-Fixed axis rotation and plane motion, Impulse momentum method.

Text Books:

1. Engg. Mechanics, S.Timoshenko&D.H.Young., 4thEdn, McGraw Hill Publications.

References Books:

1. Engineering Mechanics Statics and Dynamics, R.C.Hibbeler, 11thEdn.,Pearson Publ.
2. Engineering Mechanics, Statics, J.L.Meriam, 6thEdn.,Wiley India Pvt. Ltd.
3. Engineering Mechanics, Statics and Dynamics, I.H.Shames, Pearson Publ.
4. Mechanics For Engineers, Statics, F.P.Beer&E.R.Johnston, 5thEdn.,McGraw Hill Publ.
5. Mechanics For Engineers, Dynamics, F.P.Beer&E.R.Johnston, 5thEdn.,McGraw Hill Publ.
6. Theory & Problems of Engineering Mechanics, Statics & Dynamics, E.W.Nelson, C.L.Best& W.G. McLean, 5thEdn., Schaum's Outline Series, McGraw Hill Publ.
7. Singer's Engineering Mechanics: Statics And Dynamics, K. Vijay Kumar Reddy, J. Suresh Kumar, Bs Publications.
8. Engineering Mechanics, Fedinand. L. Singer, Harper – Collins.
9. Engineering Mechanics Statics and Dynamics , A Nelson , McGraw Hill Publications.

	L	T	P	C
I Year - I Semester				
	4	**0**	**0**	**3**

COMPUTER PROGRAMMING

Learning objectives:
Formulating algorithmic solutions to problems and implementing algorithms in C.

- Notion of Operation of a CPU, Notion of an algorithm and computational procedure, editing and executing programs in Linux.
- Understanding branching, iteration and data representation using arrays.
- Modular programming and recursive solution formulation.
- Understanding pointers and dynamic memory allocation.
- Understanding miscellaneous aspects of C.
- Comprehension of file operations.

UNIT-I:
History and Hardware - Computer Hardware, Bits and Bytes, Components, Programming Languages - Machine Language, Assembly Language, Low- and High-Level Languages, Procedural and Object-Oriented Languages, Application and System Software, The Development of C Algorithms The Software Development Process.

UNIT-II:
Introduction to C Programming- Identifiers, The main () Function, The printf () Function
Programming Style - Indentation, Comments, Data Types**,** Arithmetic Operations, Expression Types, Variables and Declarations, Negation, Operator Precedence and Associativity, Declaration Statements, Initialization.
Assignment - Implicit Type Conversions, Explicit Type Conversions (Casts), Assignment Variations, Mathematical Library Functions, Interactive Input, Formatted Output, Format Modifiers.

UNIT -III:
Control Flow-Relational Expressions - Logical Operators:
Selection: if-else Statement, nested if, examples, Multi-way selection: switch, else-if, examples.
Repetition: Basic Loop Structures, Pretest and Posttest Loops, Counter-Controlled and Condition-Controlled Loops, The while Statement, The for Statement, Nested Loops, The do-while Statement.

UNIT-IV
Modular Programming: Function and Parameter Declarations, Returning a Value, Functions with Empty Parameter Lists, Variable Scope, Variable Storage Class, Local Variable Storage Classes, Global Variable Storage Classes, Pass by Reference, Passing

Addresses to a Function, Storing Addresses, Using Addresses, Declaring and Using Pointers, Passing Addresses to a Function.
Case Study: Swapping Values, Recursion - Mathematical Recursion, Recursion versus Iteration.

UNIT-V:
Arrays & Strings
Arrays: One-DimensionalArrays, Input and Output of Array Values, Array Initialization, Arrays as Function Arguments, Two-Dimensional Arrays, LargerDimensionalArrays-Matrices
Strings: String Fundamentals, String Input and Output, String Processing, Library Functions

UNIT-VI:
Pointers, Structures, Files
Pointers: Concept of a Pointer, Initialisation of pointer variables, pointers as function arguments, passing by address, Dangling memory, address arithmetic, character pointers and functions, pointers to pointers, Dynamic memory management functions, command line arguments.
Structures: Derived types,Structuresdeclaration, Initialization of structures, accessing structures, nested structures, arrays of structures, structures and functions, pointers to structures, self referential structures, unions, typedef, bit-fields.
Data Files: Declaring, Opening, and Closing File Streams, Reading from and Writing to Text Files, Random File Access

Outcomes:
- Understand the basic terminology used in computer programming
- Write, compile and debug programs in C language.
- Use different data types in a computer program.
- Design programs involving decision structures, loops and functions.
- Explain the difference between call by value and call by reference
- Understand the dynamics of memory by the use of pointers
- Use different data structures and create/update basic data files.

Text Books:

1. ANSI C Programming, Gary J. Bronson, Cengage Learning.
2. Programming in C, Bl Juneja Anita Seth, Cengage Learning.
3. The C programming Language, Dennis Richie and Brian Kernighan, Pearson Education.

Reference Books:

1. C Programming-A Problem Solving Approach, Forouzan, Gilberg, Cengage.
2. Programming with C, Bichkar, Universities Press.
3. Programming in C, ReemaThareja, OXFORD.
4. C by Example, Noel Kalicharan, Cambridge.

	L	T	P	C
I Year - I Semester				
	4	**0**	**0**	**3**

ENVIRONMENTAL STUDIES

Learning Objectives:

The objectives of the course is to impart:

- Overall understanding of the natural resources.
- Basic understanding of the ecosystem and its diversity.
- Acquaintance on various environmental challenges induced due to unplanned anthropogenic activities.
- An understanding of the environmental impact of developmental activities.
- Awareness on the social issues, environmental legislation and global treaties.

UNIT-I:

Multidisciplinary nature of Environmental Studies: Definition, Scope and Importance – Sustainability: Stockholm and Rio Summit–Global Environmental Challenges: Global warming and climate change, acid rains, ozone layer depletion, population growth and explosion, effects. Role of information Technology in Environment and human health.

Ecosystems: Concept of an ecosystem. - Structure and function of an ecosystem. - Producers, consumers and decomposers. - Energy flow in the ecosystem - Ecological succession. - Food chains, food webs and ecological pyramids. - Introduction, types, characteristic features, structure and function of Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystems.

UNIT-II:

Natural Resources: Natural resources and associated problems.

Forest resources – Use and over – exploitation, deforestation – Timber extraction – Mining, dams and other effects on forest and tribal people.

Water resources – Use and over utilization of surface and ground water – Floods, drought, conflicts over water, dams – benefits and problems.

Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources.

Food resources: World food problems, changes caused by non-agriculture activities-effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity.

Energy resources: Growing energy needs, renewable and non-renewable energy sources use of alternate energy sources.

Land resources: Land as a resource, land degradation, Wasteland reclamation, man induced landslides, soil erosion and desertification. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.

UNIT-III:

Biodiversity and its conservation: Definition: genetic, species and ecosystem diversity-classification - Value of biodiversity: consumptive use, productive use, social-Biodiversity at national and local levels. India as a mega-diversity nation - Hot-sports of biodiversity - Threats to biodiversity: habitat loss, man-wildlife conflicts. - Endangered and endemic species of India – Conservation of biodiversity: conservation of biodiversity.

UNIT – IV Environmental Pollution: Definition, Cause, effects and control measures of Air pollution, Water pollution, Soil pollution, Noise pollution, Nuclear hazards. Role of an individual in prevention of pollution. - Pollution case studies, Sustainable Life Studies. Impact of Fire Crackers on Men and his well being.

Solid Waste Management: Sources, Classification, effects and control measures of urban and industrial solid wastes. Consumerism and waste products, Biomedical, Hazardous and e – waste management.

UNIT – V Social Issues and the Environment: Urban problems related to energy -Water conservation, rain water harvesting-Resettlement and rehabilitation of people; its problems and concerns. Environmental ethics: Issues and possible solutions. Environmental Protection Act -Air (Prevention and Control of Pollution) Act. –Water (Prevention and control of Pollution) Act -Wildlife Protection Act -Forest Conservation Act-Issues involved in enforcement of environmental legislation. -Public awareness.

UNIT – VI Environmental Management: Impact Assessment and its significance various stages of EIA, preparation of EMP and EIS, Environmental audit. Ecotourism, Green Campus – Green business and Green politics.

The student should Visit an Industry / Ecosystem and submit a report individually on any issues related to Environmental Studies course and make a power point presentation.

Text Books:

1. Environmental Studies, K. V. S. G. Murali Krishna, VGS Publishers, Vijayawada
2. Environmental Studies, R. Rajagopalan, 2nd Edition, 2011, Oxford University Press.
3. Environmental Studies, P. N. Palanisamy, P. Manikandan, A. Geetha, and K. Manjula Rani; Pearson Education, Chennai

Reference:

1. Text Book of Environmental Studies, Deeshita Dave & P. Udaya Bhaskar, Cengage Learning.
2. A Textbook of Environmental Studies, Shaashi Chawla, TMH, New Delhi
3. Environmental Studies, Benny Joseph, Tata McGraw Hill Co, New Delhi

4. Perspectives in Environment Studies, Anubha Kaushik, C P Kaushik, New Age International Publishers, 2014

	L	T	P	C
I Year - I Semester				
	0	**0**	**3**	**2**

ENGINEERING /APPLIED CHEMISTRY LABORATORY

Learning Objectives:

-

1. Introduction to Chemistry laboratory – Molarity, Normality, Primary, secondary standard solutions, Volumetric titrations, Quantitative analysis, Qualitative analysis, etc.
2. Trial experiment - Determination of HCl using standard Na_2CO_3 solution.
3. Determination of alkalinity of a sample containing $Na_2CO_3$and NaOH.
4. Determination of $KMnO_4$ using standard Oxalic acid solution.
5. Determination of Ferrous iron using standard $K_2Cr_2O_7$ solution.
6. Determination of Copper using standard $K_2Cr_2O_7$ solution.
7. Determination of temporary and permanent hardness of water using standard EDTA solution.
8. Determination of Copper using standard EDTA solution.
9. Determination of Iron by a Colorimetric method using thiocynate as reagent.
10. Determination of pH of the given sample solution using pH meter.
11. Conductometric titration between strong acid and strong base.
12. Conductometric titration between strong acid and weak base.
13. Potentiometric titration between strong acid and strong base.
14. Potentiometric titration between strong acid and weak base.
15. Determination of Zinc using standard EDTA solution.
16. Determination of Vitamin – C.

Outcomes: The students entering into the professional course have practically very little exposure to lab classes. The experiments introduce volumetric analysis; redox titrations with different indicators; EDTA titrations; then they are exposed to a few instrumental methods of chemical analysis. Thus at the end of the lab course, the student is exposed to different methods of chemical analysis and use of some commonly employed instruments. They thus acquire some experimental skills.

Reference Books

1. A Textbook of Quantitative Analysis, Arthur J. Vogel.
2. Dr. Jyotsna Cherukuris (2012) *Laboratory Manual of engineering chemistry-II,* VGS Techno Series
3. Chemistry Practical Manual, Lorven Publications
4. K. Mukkanti (2009) *Practical Engineering Chemistry,* B.S. Publication

	L	T	P	C
I Year - I Semester	**0**	**0**	**3**	**2**

ENGLISH - COMMUNICATION SKILLS LAB- I

Prescribed Lab Manual For Semester I:

Interact: English Lab Manual for Undergraduate Students' Published by **Orient Blackswan Pvt Ltd.**

Learning Objectives:

To enable the students to learn through practice the communication skills of listening, speaking, reading and writing.

UNIT 1:

1. WHY study Spoken English?
2. Making Inqueries on the phone, thanking and responding to Thanks
   Practice work.

UNIT 2:

1. Responding to Requests and asking for Directions
   Practice work.

UNIT 3:

1. Asking for Clarifications, Inviting, Expressing Sympathy, Congratulating
2. Apologising, Advising, Suggesting, Agreeing and Disagreeing
   Practice work.

UNIT 4:

1. Letters and Sounds
   Practice work.

UNIT 5:

1. The Sounds of English
   Practice work.

UNIT 6:

1. Pronunciation
2. Stress and Intonation
   Practice work.

Assessment Procedure: Laboratory

1. Every lab session (150 minutes) should be handled by not less than two teachers (three would be ideal) where each faculty has to conduct a speaking activity for 20/30 students.

2. The teachers are to assess each learner in the class for not less than 10 speaking activities, each one to be assessed for 10 marks or 10%. The average of 10 day-to-day activity assessments is to be calculated for 10 marks for internal assessment.

The rubric given below has to be filled in for all the students for all activities.

The rubric to assess the learners:

	Body language		Fluency & Audibility	Clarity in Speech	Neutralization of accent	Appropriate Language		Total 10 marks	Remarks
	Gestures & Postures	Eye Contact				Grammar	Vocabulary & expressions		

- **Lab Assessment: Internal (25 marks)**
  1. Day-to-Day activities: 10 marks
  2. Completing the exercises in the lab manual: 5 marks
  3. Internal test (5 marks written and 5 marks oral)
- **Lab Assessment: External (50 marks)**
  1. Written test: 20 marks (writing a dialogue, note-taking and answering questions on listening to an audio recording.
  2. Oral: Reading aloud a text or a dialogue- 10 marks
  3. Viva-Voce by the external examiner: 20 marks

Outcome:

A study of the communicative items in the laboratory will help the students become successful in the competitive world.

The course content along with the study material is divided into six units.

Reference Books:

1. Strengthen your communication skills by Dr M Hari Prasad, Dr Salivendra Raju and Dr G Suvarna Lakshmi, Maruti Publications.
2. English for Professionals by Prof Eliah, B.S Publications, Hyderabad.
3. Unlock, Listening and speaking skills 2, Cambridge University Press
4. Spring Board to Success, Orient BlackSwan
5. A Practical Course in effective english speaking skills, PHI
6. Word power made handy, Dr shalini verma, Schand Company
7. Let us hear them speak, Jayashree Mohanraj, Sage texts
8. Professional Communication, Aruna Koneru, Mc Grawhill Education
9. Cornerstone, Developing soft skills, Pearson Education

	L	T	P	C
I Year - I Semester				
	0	**0**	**3**	**2**

COMPUTER PROGRAMMING LAB

Learning Objectives:

- Understand the basic concept of C Programming, and its different modules that includesconditional and looping expressions, Arrays, Strings, Functions, Pointers, Structures and File programming.
- Acquire knowledge about the basic concept of writing a program.
- Role of constants, variables, identifiers, operators, type conversion and other building blocks of C Language.
- Use of conditional expressions and looping statements to solve problems associated withconditions and repetitions.
- Role of Functions involving the idea of modularity.

Programming

Exercise - 1 Basics
a) What is an OS Command, Familiarization of Editors - vi, Emacs
b) Using commands like mkdir, ls, cp, mv, cat, pwd, and man
c) C Program to Perform Adding, Subtraction, Multiplication and Division of two numbers From Command line

Exercise - 2 Basic Math
a) Write a C Program to Simulate 3 Laws at Motion
b) Write a C Program to convert Celsius to Fahrenheit and vice versa

Exercise - 3 Control Flow - I
a)Write a C Program to Find Whether the Given Year is a Leap Year or not.
b)Write a C Program to Add Digits & Multiplication of a number

Exercise – 4 Control Flow - II
a)Write a C Program to Find Whether the Given Number is
i) Prime Number
ii) Armstrong Number
b) Write a C program to print Floyd Triangle
c) Write a C Program to print Pascal Triangle

Exercise – 5 Functions
a) Write a C Program demonstrating of parameter passing in Functions and returning values.
b) Write a C Program illustrating Fibonacci, Factorial with Recursion without Recursion

Exercise – 6 Control Flow - III
a) Write a C Program to make a simple Calculator toAdd, Subtract, Multiply or Divide Using switch…case
b) Write a C Program to convert decimal to binary and hex (using switch call function the function)

Exercise – 7 Functions - Continued

Write a C Program to compute the values ofsin x and cos x and e^x values using Series expansion. (use factorial function)

Exercise – 8 Arrays
Demonstration of arrays
a) Search-Linear.
b) Sorting-Bubble, Selection.
c) Operations on Matrix.

Exercises - 9 Structures
a)Write a C Program to Store Information of a Movie Using Structure
b)Write a C Program to Store Information Using Structures with Dynamically Memory Allocation
c) Write a C Program to Add Two Complex Numbers by Passing Structure to a Function

Exercise - 10 Arrays and Pointers
a)Write a C Program to Access Elements of an Array Using Pointer
b) Write a C Program to find the sum of numbers with arrays and pointers.

Exercise – 11 Dynamic Memory Allocations
a) Write a C program to find sum of n elements entered by user. To perform this program, allocate memory dynamically using malloc () function.

b) Write a C program to find sum of n elements entered by user. To perform this program, allocate memory dynamically using calloc () function.

Understand the difference between the above two programs

Exercise – 12 Strings
a) Implementation of string manipulation operations **with** library function.
    i) copy
    ii) concatenate
    iii) length
    iv) compare
b) Implementation of string manipulation operations **without** library function.
    i) copy
    ii) concatenate
    iii) length
    iv) compare

Exercise -13 Files
a)Write a C programming code to open a file and to print it contents on screen.
b)Write a C program to copy files

Exercise - 14 Files Continued
a) Write a C program merges two files and stores their contents in another file.
b)Write a C program to delete a file.

Outcomes:

- Apply and practice logical ability to solve the problems.
- Understand C programming development environment, compiling, debugging, and linkingand executing a program using the development environment

- Analyzing the complexity of problems, Modularize the problems into small modules andthen convert them into programs
- Understand and apply the in-built functions and customized functions for solving theproblems.
- Understand and apply the pointers, memory allocation techniques and use of files fordealing with variety of problems.
- Document and present the algorithms, flowcharts and programs in form of user-manuals identification of various computer components, Installation of software

Note:

a) All the Programs must be executed in the Linux Environment. (Mandatory)
b) The Lab record must be a print of the LATEX (.tex) Format.

	L	T	P	C
I Year - II Semester				
	4	**0**	**0**	**3**

ENGLISH-II

Introduction:

In view of the growing importance of English as a tool for global communication and the consequent emphasis on training the students to acquire communicative competence, the syllabus has been designed to develop linguistic and communicative competence of the students of Engineering.

As far as the detailed Textbooks are concerned, the focus should be on the skills of listening, speaking, reading and writing. The nondetailed Textbooks are meant for extensive reading for pleasure and profit.

Thus the stress in the syllabus in primarily on the development of communicative skills and fostering of ideas.

Learning Objectives:

1. To imporve the language proficiency of the students in English with emphasis on LSRW skills.
2. To enable the students to study and comprehend the prescribed lessons and subjects more effectively relating to their theorotical and practical components.
3. To develop the communication skills of the students in both formal and informal situations.

LISTENING SKILLS:

Learning Objectives:

1. To enable the students to appreciate the role of listening skill and improve their pronounciation.
2. To enable the students to comprehend the speech of people belonging to different backgrounds and regions.
3. To enable the students to listen for general content, to fill up information and for specific information.

SPEAKING SKILLS:

Objectives:

1. To make the students aware of the importance of speaking for their personal and professional communication.
2. To enable the students to express themselves fluently and accurately in social and professional success.
3. To help the students describe objects, situations and people.
4. To make the students participate in group activities like roleplays, discussions and debates.
5. To make the students particiapte in Just a Minute talks.

READING SKILLS:

Objectives:

1. To enable the students to comprehend a text through silent reading.
2. To enable the students to guess the meanings of words, messages and inferences of texts in given contexts.
3. To enable the students to skim and scan a text.
4. To enable the students to identify the topic sentence.
5. To enable the students to identify discourse features.
6. To enable the students to make intensive and extensive reading.

WRITING SKILLS:

Objectives:

1. To make the students understand that writing is an exact formal skills.
2. To enable the students to write sentences and paragraphs.
3. To make the students identify and use appropriate vocabulary.
4. To enable the students to narrate and describe.
5. To enable the students capable of note-making.
6. To enable the students to write coherently and cohesively.
7. To make the students to write formal and informal letters.
8. To enable the students to describe graphs using expressions of comparision.
9. To enable the students to write techincal reports.

Methodology:

1. The class are to be learner-centered where the learners are to read the texts to get a comprehensive idea of those texts on their own with the help of the peer group and the teacher.
2. Integrated skill development methodology has to be adopted with focus on individual language skills as per the tasks/exercise.
3. The tasks/exercises at the end of each unit should be completed by the learners only and the teacher interventionis perimitted as per the complexity of the task/exercise.
4. The teacher is expected to use supplementary material wherever necessary and also generate activities/tasks as per the requirement.
5. The teacher is perimitted to use lecture method when a completely new concept is introduced in the class.

Assessment Procedure: Theory

1. The formative and summative assessment procedures are to be adopted (mid exams and end semester examination).
2. Neither the formative nor summative assessment procedures should test the memory of the content of the texts given in the textbook. The themes and global comprehension of the units in the present day context with application of the langauge skills learnt in the unit are to be tested.
3. Only new unseen passages are to be given to test reading skills of the learners. Written skills are to be tested from sentence level to essay level. The communication formats—emails,letters and reports-- are to be tested along with appropriate langauge and expressions.
4. Examinations:
   I mid exam + II mid exam (15% for descriptive tests+10% for online tests)= 25%

(80% for the best of two and 20% for the other)

Assignments= 5%

End semester exams=70%

5. Three take home assignments are to be given to the learners where they will have to read texts from the reference books list or other sources and write their gist in their own words.

The following text books are recommended for study in I B.Tech II Semester (Common for all branches)and I B.Pharma II Sem of JNTU Kakinada from the academic year 2016-17 **(R-16 Regulations)**

DETAILED TEXTBOOK:ENGLISH ENCOUNTERS Published by **Maruthi Publishers**.

DETAILED NON-DETAIL:THE GREAT INDIAN SCIENTISTS Published by **Cenguage learning**

The course content along with the study material is divided into six units.

UNIT 1:

1. ' The Greatest Resource- Education' from English Encounter

OBJECTIVE:

Schumacher describes the education system by saying that it was mere training, something more than mere knowledge of facts.

OUTCOME:

The lesson underscores that the ultimate aim of Education is to enhance wisdom.

2. ' A P J Abdul Kalam' from The Great Indian Scientists.

OBJECTIVE:

The lesson highlights Abdul Kalam's contributions to Indian science and the awards he received.

OUTCOME:

Abdul Kalam's simple life and service to the nation inspires the readers to follow in his footsteps.

UNIT 2:

1. ' A Dilemma' from English Encounters

OBJECTIVE: The lesson centres on the pros and cons of the development of science and technology.

OUTCOME: The lesson enables the students to promote peaceful co-existence and universal harmony among people and society.

2. 'C V Raman' from The Great Indian Scientists.

OBJECTIVE:

The lesson highlights the dedicated research work of C V Raman and his achievements in Physics.

OUTCOME:

The Achievements of C V Raman are inspiring and exemplary to the readers and all scientists.

UNIT 3:

1. 'Cultural Shock': Adjustments to new Cultural Environments from English Encounters.

OBJECTIVE:

The lesson depicts of the symptoms of Cultural Shock and the aftermath consequences.

OUTCOME:

The lesson imparts the students to manage different cultural shocks due to globalization.

2. 'Homi Jehangir Bhabha' from The Great Indian Scientists.

OBJECTIVE:

The lesson highlights Homi Jehangir Bhabha's contributions to Indian nuclear programme as architect.

OUTCOME:

The seminal contributions of Homi Jehangir Bhabha to Indian nuclear programme provide an aspiration to the readers to serve the nation and sterngthen it.

UNIT 4:

1. 'The Lottery' from English Encounters.

OBJECTIVE:

The lesson highlights insightful commentary on cultural traditions.

OUTCOME:

The theme projects society’s need to re examine its traditions when they are outdated.

2. 'Jagadish Chandra Bose' from The Great Indian Scientists.

OBJECTIVE:

The lesson gives an account of the unique discoveries and inventions of Jagadish Chandra Bose in Science.

OUTCOME: The Scientific discoveries and inventions of Jagadish Chandra Bose provide inspiration to the readers to make their own contributions to science and technology, and strengthen the nation.

UNIT 5:

1. ' The Health Threats of Climate Change' from English Encounters.

OBJECTIVE:

The essay presents several health disorders that spring out due to environmental changes

OUTCOME:

The lessonoffers several inputs to protect environment for the sustainability of the future generations.

2. ' Prafulla Chandra Ray' from The Great Indian Scientists.

OBJECTIVE:

The lesson given an account of the experiments and discoveries in Pharmaceuticals of Prafulla Chandra Ray.

OUTCOME:

Prafulla Chandra Ray's scientific achievements and patriotic fervour provide inspiration to the reader.

UNIT 6:

1. ' The Chief Software Architect' from English Encounters

OBJECTIVE:

The lesson supports the developments of technology for the betterment of human life.

OUTCOME:

Pupil get inspired by eminent personalities who toiled for the present day advancement of software development.

2. ' Srinivasa Ramanujan' from The Great Indian Scientists.

OBJECTIVE:

The lesson highlights the extraordinary achievements of Srinivasa Ramanujan, a great mathematician and the most romantic figure in mathematics.

OUTCOME:

The lesson provides inspiration to the readers to think and tap their innate talents.

NOTE:

All the exercises given in the prescribed lessons in both detailed and non-detailed textbooks relating to the theme and language skills must be covered.

MODEL QUESTION PAPER FOR THEORY

PART- I

Six short answer questions on 6 unit themes

One question on eliciting student's response to any of the themes

PART-II

Each question should be from one unit and the last question can be a combination of two or more units.

Each question should have 3 sub questions: A,B& C

A will be from the main text: 5 marks

B from non-detailed text: 3 marks

C on grammar and Vocabulary: 6 marks

I Year - II Semester

L	T	P	C
4	0	0	3

MATHEMATICS-II (Mathematical Methods)

(Common to ALL branches of First Year B.Tech.)

Learning Objectives:

- The course is designed to equip the students with the necessary mathematical skills and techniques that are essential for an engineering course.
- The skills derived from the course will help the student from a necessary base to develop analytic and design concepts.
- Understand the most basic numerical methods to solve simultaneous linear equations.

UNIT I: Solution of Algebraic and Transcendental Equations:

Introduction- Bisection method – Method of false position – Iteration method – Newton-Raphson method (One variable and simultaneous Equations).

UNIT II: Interpolation:

Introduction- Errors in polynomial interpolation – Finite differences- Forward differences-Backward differences –Central differences – Symbolic relations and separation of symbols - Differences of a polynomial-Newton's formulae for interpolation – Interpolation with unequal intervals - Lagrange's interpolation formula.

UNIT III: Numerical Integration and solution of Ordinary Differential equations:

Trapezoidal rule- Simpson's $1/3^{rd}$ and $3/8^{th}$ rule-Solution of ordinary differential equations by Taylor's series-Picard's method of successive approximations-Euler's method - Runge-Kutta method (second and fourth order).

UNIT IV: Fourier Series:

Introduction- Periodic functions – Fourier series of -periodic function - Dirichlet's conditions – Even and odd functions –Change of interval– Half-range sine and cosine series.

UNIT V: Applications of PDE:

Method of separation of Variables- Solution of One dimensional Wave, Heat and two-dimensional Laplace equation.

UNIT VI: Fourier Transforms:

Fourier integral theorem (without proof) – Fourier sine and cosine integrals - sine and cosine transforms – properties – inverse transforms – Finite Fourier transforms.

Outcomes: At the end of the Course, Student will be able to:

- Calculate a root of algebraic and transcendental equations. Explain relation between the finite difference operators.
- Compute interpolating polynomial for the given data.
- Solve ordinary differential equations numerically using Euler's and RK method.
- Find Fourier series and Fourier transforms for certain functions.
- Identify/classify and solve the different types of partial differential equations.

Text Books:

1. **B.S.Grewal,** Higher Engineering Mathematics, 43rd Edition, Khanna Publishers.
2. **N.P.Bali**, Engineering Mathematics, Lakshmi Publications.

Reference Books:

1. **Dean G. Duffy,** Advanced engineering mathematics with MATLAB, CRC Press
2. **V.Ravindranath and P.Vijayalakshmi,** Mathematical Methods, Himalaya Publishing House.
3. **Erwin Kreyszig,** Advanced Engineering Mathematics, 10th Edition, Wiley-India
4. **David Kincaid, Ward Cheney**, Numerical Analysis-Mathematics of Scientific Computing, 3rd Edition, Universities Press.
5. **Srimanta Pal, Subodh C.Bhunia**, Engineering Mathematics, Oxford University Press.
6. **Dass H.K., Rajnish Verma. Er.,**Higher Engineering Mathematics, S. Chand Co. Pvt. Ltd, Delhi.

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I Year - II Semester				
	4	**0**	**0**	**3**

MATHEMATICS-III (Linear Algebra & Vector Calculus)
(Common to ALL branches of First Year B.Tech.)

Learning Objectives:

- The course is designed to equip the students with the necessary mathematical skills and techniques that are essential for an engineering course.
- The skills derived from the course will help the student from a necessary base to develop analytic and design concepts.
- Understand the most basic numerical methods to solve simultaneous linear equations.

UNIT I: Linear systems of equations:

Rank-Echelon form-Normal form – Solution of linear systems – Gauss elimination - Gauss Jordon- Gauss Jacobi and Gauss Seidal methods.Applications: Finding the current in electrical circuits.

UNIT II: Eigen values - Eigen vectors and Quadratic forms:

Eigen values - Eigen vectors– Properties – Cayley-Hamilton theorem - Inverse and powers of a matrix by using Cayley-Hamilton theorem- Diagonalization- Quadratic forms- Reduction of quadratic form to canonical form – Rank - Positive, negative and semi definite - Index – Signature.

Applications: Free vibration of a two-mass system.

UNIT III: Multiple integrals:

Curve tracing: Cartesian, Polar and Parametric forms.

Multiple integrals: Double and triple integrals – Change of variables – Change of order of integration.

Applications: Finding Areas and Volumes.

UNIT IV: Special functions:

Beta and Gamma functions- Properties - Relation between Beta and Gamma functions- Evaluation of improper integrals.

Applications: Evaluation of integrals.

UNIT V: Vector Differentiation:

Gradient- Divergence- Curl - Laplacian and second order operators -Vector identities.

Applications: Equation of continuity, potential surfaces

UNIT VI: Vector Integration:

Line integral – Work done – Potential function – Area- Surface and volume integrals Vector integral theorems: Greens, Stokes and Gauss Divergence theorems (without proof) and related problems.

Applications: Work done, Force.

Outcomes: At the end of the Course, Student will be able to:

- Determine rank, Eigenvalues and Eigen vectors of a given matrix and solve simultaneous linear equations.
- Solve simultaneous linear equations numerically using various matrix methods.
- Determine double integral over a region and triple integral over a volume.
- Calculate gradient of a scalar function, divergence and curl of a vector function. Determine line, surface and volume integrals. Apply Green, Stokes and Gauss divergence theorems to calculate line, surface and volume integrals.

Text Books:

1. **B.S.Grewal,** Higher Engineering Mathematics, 43rd Edition, Khanna Publishers.
2. **N.P.Bali**, Engineering Mathematics, Lakshmi Publications.

Reference Books:

1. **Greenberg,** Advanced Engineering Mathematics, 2nd edition, Pearson edn
2. **Erwin Kreyszig,** Advanced Engineering Mathematics, 10th Edition, Wiley-India
3. **Peter O'Neil,** Advanced Engineering Mathematics,7th edition, Cengage Learning.
4. **D.W. Jordan and T.Smith,** Mathematical Techniques, Oxford University Press.
5. **Srimanta Pal, Subodh C.Bhunia**, Engineering Mathematics, Oxford University Press.
6. **Dass H.K., Rajnish Verma. Er.,**Higher Engineering Mathematics, S. Chand Co. Pvt. Ltd, Delhi.

I Year - II Semester

L	T	P	C
4	0	0	3

ENGINEERING PHYSICS

(ME, CE, PE, PCE, MET.E, MINING, AUTOMOBILE, CHEMICAL,AERONAUTICAL, BIO.TECH)

Learning Objectives: Physics curriculum which is re-oriented to the needs of Circuital branches of graduate engineering courses offered by JNTUniv.Kkd. that serves as a transit to understand the branch specific advanced topics. The courses are designed to

- Impart concepts of Optical Interference, Diffraction and Polarization required to design instruments with higher resolution - Concepts of coherent sources, its realization and utility optical instrumentation.
- Study the Structure-property relationship exhibited by solid crystal materials for their utility.
- Tap the Simple harmonic motion and its adaptability for improved acoustic quality of concert halls.
- To explore the Nuclear Power as a reliable source required to run industries
- To impart the knowledge of materials with characteristic utility in appliances.

UNIT-I

Interference: Principle of Superposition – Coherent Sources – Interference in thin films (reflection geometry) – Newton's rings – construction and basic principle of Interferometers.

UNIT-II

Diffraction: Fraunhofer diffraction at single slit cases of double slit, N-slits & Circular Aperture (Qualitative treatment only)-Grating equation - Resolving power of a grating, Telescope and Microscopes.

UNIT-III

Polarization: Types of Polarization-production - Nicol Prism -Quarter wave plate and Half Wave plate – Working principle of Polarimeter (Sacharimeter)

Lasers: Characteristics– Stimulated emission – Einstein's Transition Probabilities- Pumping schemes - Ruby laser – Helium Neon laser.

UNIT-IV

Acoustics: Reverberation time - Sabine's formula – Acoustics of concert-hall. **Ultrasonics:** Production - Ultrasonic transducers- Non-Destructive Testing – Applications.

UNIT-V

Crystallography & X-Ray Diffraction: Basis and lattice – Bravais systems- Symmetry elements- Unit cell- packing fraction – coordination number- Miller indices – Separation between successive (h k l) planes – Bragg's law.

Nuclear Energy – Source of Power: Mass defect & Binding Energy – Fusion and Fission as sources – Fast breeder Reactors.

UNIT-VI

Magnetism: Classification based onField, Temperature and order/disorder –atomic origin – Ferromagnetism- Hysteresis- applications of magnetic materials (Para &Ferro)..

Dielectrics: Electric Polarization – Dielectrics in DC and AC fields – Internal field – Clausius Mossoti Equation - Loss, Breakdown and strength of dielectric materials – Ferroelectric Hysteresis and applications.

Outcome: Construction and working details of instruments, ie., Interferometer, Diffractometer and Polarimeter are learnt. Study Acoustics, crystallography magnetic and dielectric materials enhances the utility aspects of materials.

Text Books:

1. A Text book of Engineering Physics – by Dr. M.N.Avadhanulu and Dr.P.G.Kshirasagar, S.Chand & Company Ltd., (2014)
2. Physics for Engineers by M.R.Srinasan, New Age international publishers (2009)
3. Engineering Physics by D.K.Bhattacharya and Poonam Tandon , Oxford press (2015)

Refference books:

1. Applied Physics by P.K.Palanisamy , Scitech publications (2014)
2. Lasers and Non-Linear optics by B.B.Laud , Newage international publishers (2008)

I Year - II Semester

L	T	P	C
4	0	0	3

ELEMENTS OF MECHANICAL ENGINEERING

Learning Objectives: The content of this course shall provide the student the basic concepts of various mechanical systems and exposes the student to a wide range of equipment and their utility in a practical situation. It shall provide the fundamental principles of materials, fuels, Steam, I.C. Engines, compressors, hydraulic machines and transmission systems that usually exist in any process plant.

UNIT –I:

Stresses and strains: kinds of – stress-strains, elasticity and plasticity, Hooks law, stress – strain diagrams, modules of elasticity, Poisson's ratio, linear and volumetric strain, relation between E, N, and K, bars of uniform strength, compound bars and temperature stresses.

UNIT– II:

Types of supports – loads – Shear force and bending moment for cantilever and simply supported beams without overhanging for all types of loads.

Theory of simple bending, simple bending formula, Distribution of Flexural and Shear stress in Beam section – Shear stress formula – Shear stress distribution for some standard sections

UNIT-III:

Thin cylindrical shells: stress in cylindrical shells due to internal pressures, circumferential stress, longitudinal stress, design of thin cylindrical shells, spherical shells, change in dimension of the shell due to internal pressure, change in volume of the shell due to internal pressure.

Thick Cylinders: Lame's equation- cylinders subjected to inside and outside pressures columns and Struts.

UNIT-IV:

Steam boilers and Reciprocating air compressors: Classification of boilers, essentialities of boilers, selection of different types of boilers, study of boilers, boiler mountings and accessories.

Reciprocating air compressors: uses of compressed air, work done in single stage and two-stage compression, inter cooling and simple problems.

UNIT-V:

Internal combustion engines: classification of IC engines, basic engine components and nomenclature, working principle of engines, Four strokes and two stroke petrol and diesel engines, comparison of CI and SI engines, comparison of four stroke and two stroke engines, simple problems such as indicated power, brake power, friction power, specific fuel consumption, brake thermal efficiency, indicated thermal efficiency and mechanical efficiency.

UNIT-VI:

Transmission systems:Belts –Ropes and chain: belt and rope drives, velocity ratio, slip, length of belt , open belt and cross belt drives, ratio of friction tensions, centrifugal tension in a belt, power transmitted by belts and ropes, initial tensions in the belt, simple problems.

Gear trains: classification of gears, gear trains velocity ratio, simple, compound –reverted and epicyclic gear trains.

Outcomes: After completing the course, the student shall be able to determine:

- The stress/strain of a mechanical component subjected to loading.
- The performance of components like Boiler, I.C. Engine, Compressor, Steam/Hydraulic turbine, Belt, Rope and Gear.
- The type of mechanical component suitable for the required power transmission.

Text Books:

1. Strength of Materials and Mechanics of Structures, B.C.Punmia, Standard Publications and distributions, 9 th edition, 1991.
2. Thermal Engineering, Ballaney,P.L., Khanna Publishers, 2003.
3. Elements of Mechanical Engineering, A.R.Asrani, S.M.Bhatt and P.K.Shah, B.S. Publs**.**
4. Elements of Mechanical Engineering, M.L.Mathur, F.S.Metha&R.P.Tiwari Jain Brothers Publs., 2009**.**

Reference Book:

1. Theory of Machines, S.S. Rattan, Tata McGraw Hil., 2004 & 2009.

	L	T	P	C
I Year - II Semester				
	4	**0**	**0**	**3**

ENGINEERING DRAWING

Learning Objectives:

- Engineering drawing being the principle method of communication for engineers, the objective is to introduce the students, the techniques of constructing the various types of polygons, curves and scales. The objective is also to visualize and represent the 3D objects in 2D planes with proper dimensioning, scaling etc.

UNIT-I:

Objective: To introduce the students to use drawing instruments and to draw polygons, Engg. Curves.

Polygons: Constructing regular polygons by general methods, inscribing and describing polygons on circles.

Curves: Parabola, Ellipse and Hyperbola by general methods, cycloids, involutes, tangents &normals for the curves.

UNIT-II:

Objective: To introduce the students to use scales and orthographic projections, projections of points & simple lines.

Scales: Plain scales, diagonal scales and vernier scales

Orthographic Projections: Horizontal plane, vertical plane, profile plane, importance of reference lines, projections of points in various quadrants, projections of lines, lines parallel either to of the reference planes (HP,VP or PP)

UNIT-III:

Objective: The objective is to make the students draw the projections of the lines inclined to both the planes.

Projections of straight lines inclined to both the planes, determination of true lengths, angle of inclination and traces- HT, VT

UNIT-IV:

Objective: The objective is to make the students draw the projections of the plane inclined toboth the planes.

Projections of planes: regular planes perpendicular/parallel to one plane and inclined to the other reference plane; inclined to both the reference planes.

UNIT-V:

Objective: The objective is to make the students draw the projections of the various types of solids in different positions inclined to one of the planes.

Projections of Solids – Prisms, Pyramids, Cones and Cylinders with the axis inclined to one of the planes.

UNIT-VI:

Objective: The objective is to represent the object in 3D view through isometric views. The student will be able to represent and convert the isometric view to orthographic view and vice versa.

Conversion of isometric views to orthographic views; Conversion of orthographic views to isometric views.

Text Books:

1. Engineering Drawing, N.D. Butt, Chariot Publications.
2. Engineering Drawing, Agarwal & Agarwal, Tata McGraw Hill Publishers.

Reference Books:

1. Engineering Drawing, K.L.Narayana& P. Kannaiah, Scitech Publishers.
2. Engineering Graphics for Degree, K.C. John, PHI Publishers.
3. Engineering Graphics, PI Varghese, McGrawHill Publishers
4. Engineering Drawing + AutoCAD, K Venugopal, V. Prabhu Raja, New Age.

I Year - II Semester

L	T	P	C
0	0	3	2

ENGLISH - COMMUNICATION SKILLS LAB-II

PRESCRIBED LAB MANUAL FOR SEMESTER II:

INTERACT: English Lab Manual for Undergraduate Students' Published by **Orient Blackswan Pvt Ltd.**

Learning Objectives:

To enable the students to learn demonstratively the communication skills of listening, speaking, reading and writing.

UNIT 1:

1. Debating
   Practice work

UNIT 2:

1. Group Discussions
   Practice work

UNIT 3:

1. Presentation Skills
   Practice work

UNIT 4:

1. Interview Skills
   Practice work

UNIT 5:

1. Email,
2. Curriculum Vitae
   Practice work

UNIT 6:

1. Idiomatic Expressions
2. Common Errors in English
   Practice work

Outcome:

A study of the communicative items in the laboratory will help the students become successful in the competitive world.

The course content along with the study material is divided into six units.

Reference Books:

1. Strengthen your communication skills by Dr M Hari Prasad, Dr Salivendra Raju and Dr G Suvarna Lakshmi, Maruti Publications.
2. English for Professionals by Prof Eliah, B.S Publications, Hyderabad.
3. Unlock, Listening and speaking skills 2, Cambridge University Press
4. Spring Board to Success, Orient BlackSwan
5. A Practical Course in effective english speaking skills, PHI
6. Word power made handy, Dr shalini verma, Schand Company
7. Let us hear them speak, Jayashree Mohanraj, Sage texts
8. Professional Communication, Aruna Koneru, Mc Grawhill Education
9. Cornerstone, Developing soft skills, Pearson Education

	L	T	P	C
I Year - II Semester	**0**	**0**	**3**	**2**

ENGINEERING/APPLIED PHYSICS LAB

(Any Ten of the following)

Learning Objective: Training field oriented Engineering graduates to handle instruments and their design methods to improve the accuracy of measurements.

List Of Experiments:

1. Determination of wavelength of a source-Diffraction Grating-Normal incidence.
2. Newton's rings – Radius of Curvature of Plano - Convex Lens.
3. Determination of thickness of a spacer using wedge film and parallel interference fringes.
4. Determination of Rigidity modulus of a material- Torsional Pendulum.
5. Determination of Acceleration due to Gravity and Radius of Gyration- Compound Pendulum.
6. Melde's experiment – Transverse and Longitudinal modes.
7. Verification of laws of vibrations in stretched strings – Sonometer.
8. Determination of velocity of sound – Volume Resonator.
9. L- C- R Series Resonance Circuit.
10. Study of I/V Characteristics of Semiconductor diode.
11. I/V characteristics of Zener diode.
12. Characteristics of Thermistor – Temperature Coefficients.
13. Magnetic field along the axis of a current carrying coil – Stewart and Gee's apparatus.
14. Energy Band gap of a Semiconductor p - n junction.
15. Hall Effect in semiconductors.
16. Time constant of CR circuit.

17. Determination of wavelength of laser source using diffraction grating.

18. Determination of Young's modulus by method of single cantilever oscillations.

19. Determination of lattice constant – lattice dimensions kit.

20. Determination of Planck's constant using photocell.

21. Determination of surface tension of liquid by capillary rise method.

Outcome: Physics Lab Curriculum Gives Fundamental Understanding Of Design Of An Instrument With Targeted Accuracy For Physical Measurements.

	L	T	P	C
I Year - II Semester	**0**	**0**	**2**	**0**

ENGINEERING /APPLIED PHYSICS- VIRTUAL LAB-ASSIGNMNETS

(Constitutes 5% marks of 30marks of Internal-component)

Learning Objective: Training Engineering students to prepare a technical document andimproving their writing skills.

List Of Experiments:

1. Hall Effect
2. Crystal Structure
3. Hysteresis
4. Brewster's angle
5. Magnetic Levitation / SQUID
6. Numerical Aperture of Optical fiber
7. Photoelectric Effect
8. Simple Harmonic Motion
9. Damped Harmonic Motion
10. LASER – Beam Divergence and Spot size
11. B-H curve
12. Michelson's interferometer
13. Black body radiation

URL: ***www.vlab.co.in***

Outcome: Physics Virtual laboratory curriculum in the form of assignment ensures an engineering graduate to prepare a /technical/mini-project/ experimental report with scientific temper.

	L	T	P	C
I Year - II Semester	**0**	**0**	**3**	**2**

ENGINEERING WORKSHOP & IT WORKSHOP

ENGINEERING WORKSHOP:

Learning Objective: To impart hands-on practice on basic engineering trades and skills.

Note: At least two exercises to be done from each trade.

Trade:

Carpentry	1. T-Lap Joint
	2. Cross Lap Joint
	3. Dovetail Joint
	4. Mortise and Tenon Joint
Fitting	1. Vee Fit
	2. Square Fit
	3. Half Round Fit
	4. Dovetail Fit
Black Smithy	1. Round rod to Square
	2. S-Hook
	3. Round Rod to Flat Ring
	4. Round Rod to Square headed bolt
House Wiring	1. Parallel / Series Connection of three bulbs
	2. Stair Case wiring
	3. Florescent Lamp Fitting
	4. Measurement of Earth Resistance
Tin Smithy	1. Taper Tray
	2. Square Box without lid
	3. Open Scoop
	4. Funnel

IT WORKSHOP:

Learning Objectives:

- Understand the basic components and peripherals of a computer.
- To become familiar in configuring a system.
- Learn the usage of productivity tools.
- Acquire knowledge about the netiquette and cyber hygiene.
- Get hands on experience in trouble shooting a system?

1. **System Assembling, Disassembling and identification of Parts / Peripherals**

2. **Operating System Installation**-Install Operating Systems like Windows, Linux along with necessary Device Drivers.

3. **MS-Office / Open Office**

a. **Word** - Formatting, Page Borders, Reviewing, Equations, symbols.
b. **Spread Sheet** - organize data, usage of formula, graphs, charts.
c. **Power point** - features of power point, guidelines for preparing an effective presentation.
d. **Access**- creation of database, validate data.

4. **Network Configuration & Software Installation**-Configuring TCP/IP, proxy and firewall

settings. Installing application software, system software & tools.

5. **Internet and World Wide Web**-Search Engines, Types of search engines, netiquette, cyber hygiene.

6. Trouble Shooting-Hardware trouble shooting, Software trouble shooting.

7. **MATLAB-** basic commands, subroutines, graph plotting.

8. **LATEX**-basic formatting, handling equations and images.

Outcomes:

- Common understanding of concepts, patterns of decentralization implementation in Africa †
- Identified opportunities for coordinated policy responses, capacity building and implementation of best practices †
- Identified instruments for improved decentralization to the local level †
- Identified strategies for overcoming constraints to effective decentralization and sustainable management at different levels

Text Books:

1. Computer Hardware, Installation, Interfacing, Troubleshooting and Maintenance, K.L. James, Eastern Economy Edition.
2. Microsoft Office 2007: Introductory Concepts and Techniques, Windows XP Edition by Gary B. Shelly, Misty E. Vermaat and Thomas J. Cashman (2007, Paperback).
3. LATEX- User's Guide and Reference manual, Leslie Lamport, Pearson, LPE, 2/e.
4. Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers, Rudraprathap, Oxford University Press, 2002.
5. Scott Mueller's Upgrading and Repairing PCs, 18/e, Scott. Mueller, QUE, Pearson, 2008
6. The Complete Computer upgrade and repair book, 3/e, Cheryl A Schmidt, Dreamtech.
7. Comdex Information Technology course tool kit Vikas Gupta, WILEY Dreamtech.
8. Introduction to Information Technology, ITL Education Solutions limited, Pearson Education.

II Year - I Semester

L	T	P	C
4	0	0	3

COMPLEX VARIABLES

Learning Objectives:

- The aim of this course is to introduce the special functions, their generating functions and the algebra, geometry and calculus of functions of a complex variable. The emphasis will be on gaining a geometric understanding of complex analytic functions as well as developing computational skills in employing the powerful tools of complex analysis for solving theoretical and applied problems.

UNIT-I:

Functions of a complex variable: Introduction -Continuity – Differentiability – Analyticity – Properties – Cauchy-Riemann equations in Cartesian and polar coordinates. Harmonic and conjugate harmonic functions – Milne – Thompson method

Applications: Potential between parallel plates, coaxial cylinders, potential in angular regions

UNIT-II:

Elementary functions and Mapping: Exponential, trigonometric, hyperbolic functions and their properties – General power Z (c is complex), principal value.

Applications: Polar plots of sinusoidal transfer function. (Section 7.3 of reference book 5)

UNIT-III:

Complex integration: Line integral – Cauchy's integral theorem – Cauchy's integral formula – Generalized integral formula -Liouville Theorem - Morera's Theorem

Applications: Circulation along closed curve, conservative fields.

UNIT-IV:

Power series: Radius of convergence – Taylor's series,-Maclaurin's series -Laurent series-Singular point –Isolated singular point – pole of order m – essential singularity.

UNIT-V:

Evaluation of Integrals: Residue – Residue theorem

Application: Types of real integrals:

(a) Improper real integrals $\int_{-\infty}^{\infty} f(x)dx$ (b) $\int_{c}^{c+2\pi} f(\cos\theta,\sin\theta)d\theta$

(c) $\int_{-\infty}^{\infty} e^{imx} f(x)dx$ (d) Integrals by indentation

UNIT-VI:

Transformation by exp z, ln z, z^2, z^n (n positive integer), Sin z, Cos z, z+a/z, Translation, rotation, inversion and bilinear transformation –fixed point- cross ratio – properties-invariance of circles.

Applications: Mapping theorem (without proof) with application to stability analysis of closed loop systems, Nyquist stability criterion and its Remarks.(Section 7.5 of reference book 5)

Outcomes:

Upon successful completion of the course, the students should be able to:

- Discuss continuity and analyticity of various complex valued functions.
- Find the Taylor or Laurent series of a given function. Use residue calculations to evaluate certain real definite integrals.
- Explain properties of various types of conformal mappings.

Text Books:

1. B.S.Grewal, Higher Engineering Mathematics, 43rd Edition, Khanna Publishers.
2. Micheael Greenberg, Advanced Engineering Mathematics, 2nd edition, Pearson edn

Reference Books:

1. Advanced Engineering Mathematics,Erwin Kreyszig, 10th Edition, Wiley-India
2. Complex Analysis for Mathematics and Engineering,John H Mathews, Russell W. Howell, 5th Edition, Jones and Bartlett Publishers, 2006
3. Fundamentals of Complex Analysis,Saff, E.B and A.D Snider, 3rd Edition, Pearson,2003
4. A First course in Complex Analysis with Application, Dennis G. Zill and Patrick Shanahan, Jones and Bartlett Publishers, 2011
5. Modern Control Engineering,Katsuhiko Ogata, 5th Edition, Pearson Publishers.

II Year - I Semester

L	T	P	C
4	0	0	3

BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

Learning Objectives:

This is a basic course designed to make the student:

- Learn the basic principles of electrical laws and analysis of networks.
- Understand the principle of operation and construction details of dc machines.
- Understand the principle of operation and construction details of transformer.
- Understand the principle of operation and construction details of alternator and 3-phase induction motor.
- Study the operation of PN junction diode, half wave, full wave rectifiers and op-amps.
- Learn the operation of PNP and NPN transistors and various amplifiers.

UNIT-I:

Electrical Circuits: Basic definitions, Types of network elements, Ohm's Law, Kirchhoff's Laws, inductive networks, capacitive networks, series, parallel circuits and star-delta and delta-star transformations.

UNIT-II:

Dc Machines: Principle of operation of DC generator – emf equation - types – DC motor types –torque equation – applications – three point starter, swinburn's Test, speed control methods.

UNIT-III:

Transformers: Principle of operation of single phase transformers – emf equation – losses – efficiency and regulation

UNIT-IV:

Ac Machines: Principle of operation of alternators – regulation by synchronous impedance method –principle of operation of 3-Phase induction motor – slip – torque characteristics - efficiency – applications.

UNIT-V:

Rectifiers & Linear Ics: PN junction diodes, diode applications(Half wave and bridge rectifiers). Characteristicsof operation amplifiers (OP-AMP) - Application of OP-AMPs(inverting, non inverting,integrator and differentiator).

UNIT-VI:

Transistors: PNP and NPN junction transistor, transistor as an amplifier, single stage CE Amplifier, frequency response of CE amplifier, concepts of feedback amplifier.

Outcomes:

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

- Analyze the various electrical networks.
- Understand the operation of dc generators,3-point starter and conduct the swinburn's test.
- Analyze the performance of transformer.
- Explain the operation of 3-phase alternator and 3-phase induction motors.
- Analyze the operation of half wave, full wave rectifiers and op-amps.
- Explain the single stage CE amplifier and concept of feedback amplifier.

Text Books:

1. Electronic Devices and Circuits, R.L. Boylestad and Louis Nashelsky, 9th Edition, PEI/PHI 2006.
2. Surinder Pal Bali, Electrical Technology: Vol – I Electrical Fundamentals & Vol – II Machines and Measurement, Pearson, 2013.
3. John Bird, Electrical Circuit Theory and Technology, 4th Edition, Elsevier, 2010.

Reference Books:

1. Naidu, M. and S. Kamakshaiah, Electrical Technology, Tata McGraw-Hill, 2006.
2. Rajendra Prasad, Fundamentals of Electrical Engineering, 2nd Edition, PHI Learning, 2009.
3. Nagasarkar, T. K. and M. S. Sukhya, Basic Electrical Engineering, 2nd Edition, Oxford Publications, 2009.
4. Mithal, G. K., Industrial Electronics, 9th Edition, Khanna Publishers, 2000.

II Year - I Semester

L	T	P	C
4	0	0	3

ORGANIC CHEMISTRY

Learning Objectives:

The students will be imparted the knowledge of

- Organic reactants, intermediates and their stability- effect of intermediates and steric inhibition on reaction rates and mechanism of the reaction.
- The step wise mechanism of reactions – different intermediates formed in the reactions -the reaction path way in the formation of products.
- Reactions which are proceeding through free radical mechanism-effect of heat and light on these chemical reactions.
- The static and dynamic aspects of three-dimensional shapes of molecules-a foundation for understanding structure and reactivity.
- Coal-its constituents - aromatic compounds and their extraction methods - is important.
- Synthesis and reactivity of heterocyclics- the recent trends in application of heterocyclic compounds in advanced chemical synthesis.
- The functional groups which impart colour to the compounds-preparation and uses of these compounds.

UNIT-I:

Polar effects – Inductive effect, Electromeric effect, Resonance, Hyper conjugation, Steric Inhibition of resonance – Examples.

UNIT-II:

Mechanism and application of following organic reactions: a) Friedel-Craft reaction b) Riemer- Teimenn Reaction c) Beckmann rearrangement d) Aldol condensation e) Perkin Reaction f) Benzoin condensation, claiser condensation, Reformatory.

UNIT-III:

a) Halogenation of Alkane b) Addition of HBr to Alkene in the presence of peroxide c) Allylic halogenation using N-Bromo succinimide (NBS) d) Thermal halogenation of Alkanes, catalytic hydrogenation- Reduction with $LiAlH_4$, $NaBH_4$.

UNIT-IV:

Stereo isomerism; Optical isomerism; Symmetry and chirality; Optical isomerism in lactic acid and tartaric acid; Sequence rules; Enantiomers, Geometrical Isomerism; E-Z system of nomenclature, conformational analysis of ethane and cyclohexane.

UNIT-V:

Sources of aromatic compounds: Aromatics from coal, High temperature and low temperature carbonization of coal, coal gas manufacture and recovery of aromatics, fractional distillation of coal tar, methods of preparation of aromatics from petroleum products (catalytic reforming, high temperature cracking etc.,), Reactivity of aromatic hydrocarbons.

UNIT-VI:

Heterocyclic compounds: Nomenclature, preparation, properties and uses of (1) Pyrrole (2) Furan (3) Thiophene (4) Pyridine (5) Quinoline (6) Iso-quinoline.

Dyes- Colour and Constituion; Classification of Dyes; Preparation and uses of (1) Malachite green (2) Rosaniline (3) Congored (4) Bismark brown (5) Fluoroscien.

Analysis of Organic Compounds using FTIR, FDX, NMR etc tools.

Outcomes:

After successful completion of the course, the students will

- Have a basic knowledge of the factors that influence the stability and the reactivity of organic substances.
- Be able to conduct a chemical reaction whether it is on lab scale or industrial scale with comlete understanding of its mechanism.
- Be able to understand reactions taking place via free radical mechanism particularly in petroleum refining processes
- Have knowledge of isomerism, particularly stereoisomerism and the complexity of organic molecules.
- Have knowledge of aromatic compounds which are precursors for a number of industrial organic products like drugs, dyes etc.

Text Books:

1. Morrison, R. T., R. N. Boyd and Saibal, Kranti Bhattacharjee, Organic Chemistry, Pearson, 2011.
2. L. N. Ferguson, Text Book of Organic Chemistry, 2nd Edition, East-West Press, 2009.

Reference Books:

1. Organic Chemistry,Finar, I. L., Vol 1, Pearsons, 2002.
2. A Guidebook to Mechanism in Organic Chemistry,Peter Sykes, 6th Edition, Pearson, 2003.
3. A Textbook of Organic Chemistry, Bansal, R. K., 5th Edition, New Age International, 2007.
4. Organic Chemistry Reactions and Reagents, Agarwal, O. P., 47th Edition, Krishna Prakashan Media (P) Ltd., 2011.
5. Advanced Organic Chemistry,Arun Bahl and B. S. Bahl, S. Chand Publishers, 2010.
6. Textbook of Organic Chemistry, H. M. Chawla and P. L. Soni, Sultan Chand & Sons, 2012.

II Year - I Semester

L	T	P	C
4	0	0	3

PHYSICAL CHEMISTRY

Learning objectives:

- The students will learn the basic concepts of distribution law, phase rule, chemical kinetics, solutionsThe distribution law helps in understanding how a solute is distributed between two immiscible solvents; and also in selecting conditions for extraction of solutes (particularly naturally occurring products).
- Phase rule explains the equilibrium existing between the different phases of a heterogeneous system, solubility limits in a ternary system of water and two other liquids; construction of the solubility curve of the system; distribution ratio of the miscible component in the immiscible phases.
- Study of chemical kinetics explains the rates at which Arhenius theory chemical reactions occur and also explains theories of reaction rates (Collision theory, Transition state theory) - rates of different chain reactions –Steady state approximation- these are important for chemical engineers to design equipment.
- The study of solutions is to understand total vapor pressure of ideal or non-ideal mixtures of two volatile liquids as a function of chemical composition, miscibility of liquids, ideal and non - ideal solutions – distillation methods– azeotropic mixtures.
- Study of fundamentals of spectroscopy gives an understanding of qualitative and quantitative analysis of substances (functional groups, ions, elements) and also helps in handling the spectrophotometers.
- The study of Chromatography is useful in quantitative and qualitative analysis of mixtures, and also to understand the mechanism by which components are separated on GC and HPLC techniques, spectro-photometry and separation techniques.

UNIT-I:

Distribution Law: Distribution Law – Nernst Distribution Law – Distribution Coefficient – Explanation and Limitations of Distribution Law - Modification of Distribution Law – Determination of Equilibrium Constant from Distribution Coefficient – Applications of Distribution Law.

UNIT-II:

Phase Rule: Phase Rule – Terms involved in Phase Rule – Types of Liquids – Derivation of Phase Rule – Phase Diagrams of One Component System (Water and Sulphur system), Two Component System – Eutectic Point (Lead Silver System) and three component system. Applications of Phase Rule.

UNIT-III:

Chemical Kinetics: Introduction to Chemical Kinetics – Theories of Reaction Rates – Collision Theory – Modified Collision Theory –Arhenius Theory –Absolutelute Reaction Rate Theory (Transition State Theory) – Reaction between Ions – Influence of Solvent (Double Sphere Activated Complex and Single Sphere Activated Complex) – Influence of Ionic Strength on the Rate of the Reactions - Chain Reactions – Hydrogen and Bromine, Hydrogen and Oxygen (Steady State Treatment) – Explosion Limits.

UNIT-IV:

Solutions: Liquid-liquid-ideal solutions, Raoult's law. Ideally dilute solutions, Henry's law. Non-ideal solutions, Vapor pressure - composition and vapor pressure-temperature curves. Azeotropes-HCl-H_2O, ethanol-water systems and fractional distillation. Partially miscible liquids-phenol-water, trimethylamine-water, nicotine-water systems, effect of impurity on consulate temperature. Immiscible liquids and steam distillation.

UNIT-V:

Spectrophotometry: General features of absorption-spectroscopy, Beer-Lambert's law and its limitations, transmittance, Absorbance, and molar absorptivity; Single and double beam spectrophotometers. Application of Beers-Lamberts law for quantitative analysis of
1) Chromium in $K_2Cr_2O_7$ 2) Mn in $MnSO_4$ 3) Iron (III) with thiocyanate.

UNIT-VI:

Separation Techniques:

Solvent extraction: Principle and process, Batch extraction, Continuous extraction and counter current extraction, Application-Determination of Iron (III).

Chromatography: Classification of chromatography methods, Principles of differential migration Adsorption phenomenon, nature of adsorbents, solvent systems, R_f values, factors affecting R_f values.

High Performance Liquid Chromatography (HPLC): Principles and Applications.

Gas Liquid Chromatography (GLC): Principles and Applications.

Outcomes:

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

- Apply the principles of extraction to the industrial ternary systems.
- Have an insight into the process of fractional distillation of petroleum, which is one of the major operations in petroleum refining.
- Understand the various reactions that one comes across in petrochemical industry.
- Use knowledge of solutions for the separations of liquid mixtures in industry and to develop the theoretical models for solutions.
- Implement the analytical methods to determine the quality of substances involved in process industry and thus help to maintain quality of products.

Text Books:

1. Physical Chemistry, Peter Atkins, Julia de Paula, 9th Edition, Oxford University Press, 2011.
2. Chemical Kinetics, Laidler, K. J., 2nd Edition, McGraw-Hill, 1965.
3. Principles of Physical Chemistry, Puri, B. R., L. R. Sharma, M. S. Pathama, Vishal Publishing Company, 2008.
4. Physical Chemistry, Castellan, G. W., 3rd Edition, Narosa Publishing House, 2004.
5. Atomic Structure and the Chemical Bond, Manas Chanda, 4th Edition, Tata-McGraw-Hill, 2000.
6. Essentials of Physical Chemistry, Bahl, B. S., G. D. Tuli and Arun Bahl, 24th Revised Version, Chand & Co, 2000.

Reference Books:

1. A Textbook of Physical Chemistry, Macmillan, Kapoor, K. L., 2000.
2. Chemical Separation Methods, John A. Dean, Van Nostrand Reinhold, 1969.
3. An Introduction to Chromatography, Kour, H., Pragati Publishers, 2007.
4. Separation Methods, Sastry, M. N., Himalaya Publications, 3rd Edition, 2005.

II Year - I Semester

L	T	P	C
4	0	0	3

CHEMICAL PROCESS CALCULATIONS

Learning Objectives:
The subject of chemical process calculations is intended to make the students understand mainly the calculations involved in material and energy balances of process units. The students will be trained to:

- Understand and correctly implement unit conversions in process calculations.
- Understand and apply theoretical knowledge towards problem solving.
- Analyze and solve elementary material balances in physical and chemical processes.
- Analyze and solve elementary energy balances in reactive and non-reactive processes.
- Formulate and solve combined material and energy balances.
- Realize the relevance of thermodynamics in process calculations.
- Carry out complex process calculations using MS Excel.

UNIT-I:
Stoichiometric relation: basis of calculations, methods of expressing compositions of mixtures and solutions, density and specific gravity, Baume and API gravity scales.
Behavior of Ideal gases: Kinetic theory of gases, application of ideal gas law, gaseous mixtures, gases in chemical reactions.

UNIT-II:
Vapor pressure: Liquefaction and liquid state, vaporization, boiling point, effect of temperature on vapor pressure, Antoine equation, vapor pressure plots, estimation of critical properties, vapor pressure of immiscible liquids and ideal solutions, Raoult's law, Non-volatile solutes.

UNIT-III:
Humidity and Saturation: Relative and percentage saturation or dew point, wet bulb and dry bulb temperature, use of humidity charts for engineering calculations.

UNIT-IV:
Material balances: Tie substance, Yield, conversion, processes involving chemical reactions.
Material balance calculation involving drying, dissolution and crystallization. Processes involving recycles, bypass and purge.

UNIT-V:
Thermophysics: Energy, energy balances, heat capacity of gases, liquid and mixture solutions. Kopp's rule, latent heats, heat of fusion and heat of vaporization, Trouton's rule, Kistyakowsky equation for non polar liquids enthalpy and its evaluation.
Thermochemistry: Calculation and applications of heat of reaction, combustion, formation and neutralization, Kirchoff's equation, enthalpy concentration change, calculation of theoretical and actual flame temperatures.

UNIT-VI:

Combustion Calculations: Introduction, fuels, calorific value of fuels, coal, liquid fuels, gaseous fuels, air requirement and flue gases, combustion calculations, incomplete combustion, material and energy balances, thermal efficiency calculations.

Outcomes: A student who successfully completes this course will be able to:

- Learn all background information/charts/datasheets required to carry out process calculations. Some of these are vapor pressure correlations, latent heat correlation, steam tables, psychrometric charts, enthalpy-concentration diagrams etc.,
- Formulate and solve simple and moderately complex process calculations associated to industrially prominent chemical processes and technologies.
- Conceptualize an integrated methodology that encompasses the knowledge in other subjects (Physical Chemistry, Thermodynamics and Mathematics) and MS Excel for a systematic and structured approach towards chemical process calculations.
- Analyze chemical processes through the power of modeling and computation. These include back-calculation methods, inventory losses and revenue related assessment etc.

Text Book:

1. Hougen O A, Watson K.M. and Ragatz R.A., Chemical Process Principles, Part -I, Material and Energy Balances, 2nd Edition, CBS Publishers & distributors, New Delhi (2010).
2. Basic Principles and Calculations in Chemical Engineering, D.H. Himmelblau, 7th Edition. PHI, New Delhi, 2009.

Reference Books:

1. R. M. Felder and R. W. Roussear, Elementary principles of chemical processes, 3rd Ed., Wiley, 1999.
2. N. Chopey, Handbook Chemical Engineering Calculations, 3rd Edition, Mc-Graw Hill, 2004.
3. Bhatt, B. I., Thakore S. B., Stoichiometry, 5th Ed., Tata Mc-Graw Hill Education 2010.

II Year - I Semester

L	T	P	C
4	0	0	3

MATERIALS SCIENCE & ENGINEERING

Learning objectives:

This subject is intended to:

- Provide all the technical/engineering inputs to the learner to choose or select suitable materials of construction of chemical/petrochemical process equipment, piping and internals..
- Impart expertise to the material so that it meets the specific life expectancy, by reducing the shutdown frequency.
- Learn the techniques in minimizing equipment breakdown and increasing the on-stream factor.
- Gain knowledge in choosing/selecting the material such that it withstands the severe process operating conditions such as cryogenic, high temperature, high pressure, acidic, basic, stress induced chemical/petrochemical environments keeping view the reliability and safety of the process equipment.

UNIT-I:

Classification of engineering materials, Levels of Structure, Structure-Property relationships in materials, Crystal Geometry and non-crystalline (amorphous) states. Lattice -Bravais lattices, crystal systems with examples. Lattice co-ordinates, Miller and Miller- Bravais Indices for directions and places: ionic, covalent and metallic solids; packing factors and packing efficiency, ligancy and coordination number. Structure determination by Brag's X-ray diffraction method.

UNIT-II:

Crystal Imperfections-classification-point defects-estimation of point defects-Dislocations-classification(edge and screw)-surface defects -dislocation motion and its relevance to mechanical and chemical properties –stress-strain relationship and diagrams for different materials(metals, non-metals, rubbers and plastics and polymers)-elastic and plastic deformation-slip -stress required to move a dislocation. Multiplication of dislocations –dislocation reactions, effect on mechanical behavior of materials. Strain hardening/work hardening –dynamic recovery and recrystallization.

UNIT-III:

Fracture and failure of materials: ductile fracture analysis-brittle fracture analysis-fracture toughness-ductile-brittle transition-fatigue fracture-theory, creep and mechanism –methods to postpone the failure and fracture of materials and increase the life of the engineering components /structures.

UNIT-IV:

Solid –liquid and solid-solid equilibria for metals and alloys. Phase rule-phase diagram for pure metals (single component system), alloys (binary systems)-micro structural changes during cooling-Lever rule and its applications-typical phase diagrams-homogeneous and heterogeneous systems, formation of Eutectic, Eutectoid mixtures- non-equilibrium cooling. Binary Systems (phase diagrams) for study: Cu-Ni/Bi-Cd/Pb-Sn/ Fe-C /Al-Cu

UNIT-V:
Materials for chemical and petrochemical industrial process equipment- Effect of alloying on mechanical and chemical behavior of materials, applications of heat treatment methods for strengthening of engineering materials.
Composite structures and their advantages over conventional materials–Matrix-reinforcement properties and evaluation of strength properties with different orientation of reinforcement-applications –Nano materials –synthesis and characterization.

UNIT-VI
Stability criteria of materials in chemical/petrochemical industrial environments. Corrosion and Oxidation of materials –basic mechanisms-types of corrosion, Corrosion testing and evaluation Prevailing methods to combat corrosion. Coatings –metallic non-metallic, passivity, cathodic protection.

Outcomes:
After the course, the students will be able to:

- Equip with knowledge to prepare material selection diagram, evaluation of equipment life and prediction of life of the equipment.
- Carryout reliability studies.
- Carryout equipment failure analysis and propose the remedial measures.

Text Books:

1. Raghavan, V., Materials Science and Engineering; 5th Edition, PHI, New Delhi, 2009.
2. Ravi Prakash, William F.Smith, and Javed Hashemi, Material Science and Engineering, 4th Edition, Tata-McGraw Hill, 2008.

Reference Books:

1 Elements of Material Science and Engineering, Lawrence H. Van Vlack, 6th Edition, Pearson, 2002.
2 Callister's Materials Science and Engineering, Balasubramaniam,R., Wiley, 2010.
3. Corrosion Engineering, Mars G. Fontana, Tata-McGraw Hill, 2005.

II Year - I Semester

L	T	P	C
0	0	3	2

BASIC ENGINEERING (Mech + Elec) LABORATORY

Any SIX experiments from each section
Section A: Mechanical Engineering Laboratory:

Learning Objectives:

- To impart practical exposure on the performance evaluation methods of various mechanical components like, I. C. Engine, Hydraulic turbine, hydraulic pump, Air compressor etc. and also understand the various processes that can be performed on a lathe machine.

List of Experiments:

1. Draw the valve timing diagram of a 4-stroke diesel engine and port timing diagram of a 2-stroke petrol engine.
2. Perform load test on a 4-stroke C.I. Engine and draw the performance curves.
3. Pattern design and making – for one casting drawing.
4. Taper turning and thread cutting on a Lathe machine.
5. Performance on an Impulse/Reaction Hydraulic Turbine.
6. Performance of Centrifugal/Reciprocating Pump.
7. Find the volumetric efficiency, isothermal efficiency of an Air compressor.

Outcomes:

- The student will be able to predict the performance of several mechanical components and operate a lathe machine to produce the required job work.

Section B: Electrical Engineering Laboratory:

Learning Objectives: This course course imparts knowledge to the students to:

- Learn the estimation of efficiency of a DC machine as motor & generator.
- Learn the estimation of efficiency of transformer at different load conditions & power factors.
- Study the performance of a 3-Phase induction motor by conducting direct test.
- Pre-determine the regulation of an alternator by Synchronous impedance method.
- Understand the speed control of a DC shunts motor.
- Study the performance of a DC shunts motor by conducting direct test.

The following experiments are required to be conducted as compulsory experiments:

1. Swinburne's test on D.C. Shunt machine. (Predetermination of efficiency of a given D.C. Shunt machine working as motor and generator).
2. OC and SC tests on single phase transformer (Predetermination of efficiency and regulation at given power factors)
3. Brake test on 3-phase Induction motor (Determination of performance characteristics)
4. Regulation of alternator by Synchronous impedance method.
5. Speed control of D.C. Shunt motor by
   a) Armature Voltage control b) Field flux control method
6. Brake test on D.C Shunt Motor

Outcomes:

After successful completion of the course, the students will be able to:

- Estimate the efficiency of a DC machine as motor & generator.
- Estimate the efficiency of transformer at different load conditions & power factors.
- Understand the performance of a 3-Phase induction motor by conducting direct test.
- Pre-determine the regulation of an alternator by Synchronous impedance method.
- Control the speed of a DC shunt motor by Field flux control method & Armature Voltage control method.
- Understand the performance characteristics of a DC shunt motor by conducting direct test.

II Year - I Semester

L	T	P	C
0	0	3	2

PHYSICAL & ORGANIC CHEMISTRY LABORATORY

Learning objectives:

Physical and Organic Chemistry Laboratory is intended to:

- Understand the concepts learned in theoretical, physical and organic chemistry.
- Emphasize in acquiring accurate data
- Make data and error analysis
- Correlate the data to theory
- Develop the ability to prepare organic compounds independently.

List of Experiments- Physical Chemistry:

1. Determination of density and surface tension of liquids against air at various temperatures using capillary rise method
2. Measurement of Dialectic constants of pure organic liquids
3. Determination of conductance of solutions
4. i. Determination of viscosities of pure liquids and solutions
   ii. Determination of size of the molecule from viscosity measurements
5. Determination of Kinetics of the Reduction of Methylene Blue by Ascorbic Acid.
6. i. Determination of vapor pressure molecular of weight liquid
   ii. Determination of latent heat of vaporization
7. Kinetics of Inversion of using a Polarimeter
8. Determination of VLE of binary mixtures
9. Ternary Liquid Equilibria: Determination of Binomial curve

List of Experiments- Organic Chemistry:

1. Qualitative analysis of simple organic compounds using systematic procedure.
2. Preparation of Organic Medicinal Compounds: i. Aspirin ii. Azodye iii. Aniline iv. Acetanilide v. Thiokol Rubber vi.paraacetamol

Out comes:

A student who successfully completes this laboratory should be able to do the following:

- Can determine accurate physical, thermodynamical and kinetic properties experimentally.
- Apply theoretical principles and mathematical analysis to the data obtained.
- Work effectively with others in performing experiments and writing reports.
- Understand and Practice ethically correct presentation of data.
- Understand and practice proper laboratory safety procedures.
- Gain familiarity with a variety of physic-chemical measurement techniques.
- Can identify, analyze and synthesize organic compounds.

II Year - I Semester

L	T	P	C
2	0	0	0

(MC)

MANAGERIAL ECONOMICS AND FINANCIAL ANALYSIS

Learning Objectives:

The Learning objectives of this paper is:

- To understand the concept and nature of Managerial Economics and its relationship with other disciplines and also to understand the Concept of Demand and Demand forecasting, Production function, Input Output relationship, Cost-Output relationship and Cost-Volume-Profit Analysis.
- To understand the nature of markets, Methods of Pricing in the different market structures and to know the different forms of Business organization and the concept of Business Cycles.
- To learn different Accounting Systems, preparation of Financial Statement and uses of different tools for performance evaluation. Finally, it is also to understand the concept of Capital, Capital Budgeting and the techniques used to evaluate Capital Budgeting proposals.

UNIT-I:

Introduction to Managerial Economics and demand Analysis: Definition of Managerial Economics –Scope of Managerial Economics and its relationship with other subjects – Concept of Demand, Types of Demand, Determinants of Demand- Demand schedule, Demand curve, Law of Demand and its limitations- Elasticity of Demand, Types of Elasticity of Demand and Measurement- Demand forecasting and Methods of forecasting, Concept of Supply and Law of Supply.

UNIT-II:

Production and Cost Analyses: Concept of Production function- Cobb-Douglas Production function- Leontief production function - Law of Variable proportions-Isoquants and Isocosts and choice of least cost factor combination-Concepts of Returns to scale and Economies of scale-Different cost concepts: opportunity costs, explicit and implicit costs- Fixed costs, Variable Costs and Total costs –Cost –Volume-Profit analysis-Determination of Breakeven point(simple problems)-Managerial significance and limitations of Breakeven point.

UNIT-III:

Introduction to Markets, Theories of the Firm & Pricing Policies: Market Structures: Perfect Competition, Monopoly, Monopolistic competition and Oligopoly – Features – Price and Output Determination – Managerial Theories of firm: Marris and Williamson's models – other Methods of Pricing: Average cost pricing, Limit Pricing, Market Skimming Pricing, Internet Pricing: (Flat Rate Pricing, Usage sensitive pricing) and Priority Pricing.

UNIT-IV:

Types of Business Organization and Business Cycles: Features and Evaluation of Sole Trader, Partnership, Joint Stock Company – State/Public Enterprises and their forms – Business Cycles : Meaning and Features – Phases of a Business Cycle.

UNIT-V:

Introduction to Accounting & Financing Analysis: Introduction to Double Entry Systems – Preparation of Financial Statements-Analysis and Interpretation of Financial Statements-Ratio Analysis – Preparation of Funds flow and cash flow statements (Simple Problems)

UNIT-VI:

Capital and Capital Budgeting: Capital Budgeting: Meaning of Capital-Capitalization-Meaning of Capital Budgeting-Time value of money- Methods of appraising Project profitability: Traditional Methods(pay back period, accounting rate of return) and modern methods(Discounted cash flow method, Net Present Value method, Internal Rate of Return Method and Profitability Index)

Outcomes:

- The Learner is equipped with the knowledge of estimating the Demand and demand elasticities for a product and the knowledge of understanding of the Input-Output-Cost relationships and estimation of the least cost combination of inputs.
- One is also ready to understand the nature of different markets and Price Output determination under various market conditions and also to have the knowledge of different Business Units.
- The Learner is able to prepare Financial Statements and the usage of various Accounting tools for Analysis and to evaluate various investment project proposals with the help of capital budgeting techniques for decision making.

Text Books:

1. Managerial Economics and Financial Analysis,Dr. N. AppaRao, Dr. P. Vijay Kumar: Cengage Publications, New Delhi – 2011
2. Managerial Economics and Financial Analysis, Dr. A. R. Aryasri, TMH 2011
3. Managerial Economics and Financial, Prof. J.V.Prabhakararao, Prof. P. Venkatarao Analysis', Ravindra Publication.

Reference Books:

1. Managerial Economics & Financial Analysis,Dr. B. Kuberudu and Dr. T. V. Ramana, Himalaya Publishing House, 2014.
2. Managerial Economics, V. Maheswari, Sultan Chand.2014
3. Managerial Economics, Suma Damodaran, Oxford 2011.
4. Managerial Economics, VanithaAgarwal, Pearson Publications 2011.
5. Financial Accounting for Managers, Sanjay Dhameja, Pearson.
6. Financial Accounting, Maheswari, Vikas Publications.
7. Managerial Economics and Financial Analysis, S. A. Siddiqui& A. S. Siddiqui, New Age International Publishers, 2012
8. Indian Economy, Ramesh Singh, 7th Edn., TMH2015
9. A Text Book of Microeconomic Theory,Pankaj Tandon, Sage Publishers, 2015

II Year - II Semester

L	T	P	C
4	0	0	3

PROBABILITY AND STATISTICS

Course Objectives: To acquaint students with the fundamental concepts of probability and statistics and to develop an understanding of the role of statistics in engineering. Also to introduce numerical techniques to solve the real world applications.

Course Outcomes: At the end of the Course, Student will be able to:

1. Examine, analyze, and compare various Probability distributions for both discrete and continuous random variables.
2. Describe and compute confidence intervals for the mean of a population.
3. Describe and compute confidence intervals for the proportion and the variance of a population and test the hypothesis concerning mean, proportion and variance and perform ANOVA test.
4. Fit a curve to the numerical data.

UNIT I: Discrete Random variables and Distributions:
Introduction-Random variables- Discrete Random variable-Distribution function-Expectation-Moment Generating function-Moments and properties.
Discrete distributions: Binomial, Poisson and Geometric distributions and their fitting to data.

UNIT II: Continuous Random variable and distributions:
Introduction-Continuous Random variable-Distribution function- Expectation-Moment Generating function-Moments and properties.
Continuous distribution: Uniform, Exponential and Normal distributions, Normal approximation to Binomial distribution -Weibull, Gamma distribution.

UNIT III: Sampling Theory:
Introduction - Population and samples- Sampling distribution of means (σ known)-Central limit theorem- t-distribution- Sampling distribution of means (σ unknown)- Sampling distribution of variances -χ^2 and F-distributions- Point estimation- Maximum error of estimate - Interval estimation.

UNIT IV: Tests of Hypothesis:
Introduction –Hypothesis-Null and Alternative Hypothesis- Type I and Type II errors –Level of significance - One tail and two-tail tests- Tests concerning one mean and proportion, two means- Proportions and their differences- ANOVA for one-way and two-way classified data.

UNIT V: Curve fitting and Correlation:
Introduction - Fitting a straight line –Second degree curve-exponential curve-power curve by method of least squares-Goodness of fit.
Correlation and Regression – Properties.

UNIT VI: Statistical Quality Control Methods:
Introduction - Methods for preparing control charts – Problems using x-bar, p, R charts and attribute charts.

Text Books:

1. **Jay l.devore,** Probability and Statistics for Engineering and the Sciences.8th edition,Cengage.
2. **Richards A Johnson, Irvin Miller and Johnson E Freund**. Probability and Statistics for Engineering, 9th Edition,PHI.

Reference Books:

1. **Shron L.Myers, Keying Ye, Ronald E Walpole,** Probability and Statistics Engineers and the Scientists,8th Edition, Pearson 2007.
2. **William Menden Hall, Robert J. Bever and Barbara Bever**, Introduction to probability and statistics, Cengage learning.2009
3. **Sheldon, M. Rosss**, Introduction to probability and statistics Engineers and the Scientists,
   4th edition, Academic Foundation,2011
4. **Johannes Ledolter and Robert V.Hogg**, Applied statistics for Engineers and Physical Scientists, 3rd Edition, Pearson,2010.

II Year - II Semester

L	T	P	C
4	0	0	3

MOMENTUM TRANSFER

Learning Objectives:

This course involves the fundamentals of fluid flow by including both theory and the applications of fluid flow in chemical engineering. Basic concepts of fluid mechanics will be taught to make the students to

- Understand basic concepts associated to fluid flow such as viscosity, shear, Newtonian and non-Newtonian fluids etc.
- Learn and apply continuity and Navier Stokes equations as fundamental equations for the analysis of chemical processes.
- Learn and apply the concept of boundary layer theory and governing mathematical equations for Newtonian and non-Newtonian fluid flows.
- Learn and apply Bernoulli's equation for various simple and complex cases of fluid flow.
- Understand the basic differences between compressible and incompressible fluid flows and suitably adapt, modify and apply suitable correlations for compressible fluid flows.
- Have sound knowledge with respect to various important fluid flows related machinery and equipment. Emphasis shall be towards various types of pumps, compressors and blowers.
- Master the relevant theory for the application of fluid flow past solid surfaces. Emphasis is towards drag and pressure drop correlations for packed and fluidized beds.
- Understand various accessories required for fluid flow such as fittings and valves and their relevance towards variation in pressure drop correlations.
- Understand the knowledge related to various fluid flow measuring devices (Venturi, Orifice, Rotameter and Pitot Tube).

UNIT-I:

Basic concepts of Dimensional analysis, nature of fluids, hydrostatic equilibrium, applications of fluid statics.

Fluid flow phenomena-Laminar flow, Shear rate, Shear stress, Rheological properties of fluids, Turbulence, Boundary layers.

UNIT-II:

Basic equation of fluid flow –Mass balance in a flowing fluid; continuity, differential momentum balance; equations of motion, macroscopic momentum balances, Mechanical energy equations,

Invisid flow: concepts of Source, sink, vortex, flow over a solid sphere/cylinder, superposition of flows: concept of flow separation.

UNIT-III:

Incompressible Newtonian/Non-Newtonian flow in pipes and channels- shear stress and skin friction in pipes, laminar flow in pipes and channels, turbulent flow in pipes and channels, friction from changes in velocity or direction. Losses in pipes.

UNIT-IV:

Flow of compressible fluids- Definitions and basic equations, Processes of compressible flow, Isentropic flow through nozzles, adiabatic frictional flow, and isothermal frictional flow.

UNIT-V:

Flow past immersed bodies, Drag and Drag coefficient, flow through beds of solids, motion of particles through fluids.

Fluidization, Conditions for fluidization, Minimum fluidization velocity, Types of fluidization, Expansion of fluidized bed, Applications of fluidization, Continuous fluidization, slurry and pneumatic transport.

UNIT-VI:

Transportation and Metering of fluids- Pipes, fittings and valves, pumps: positive displacement pumps, and centrifugal pumps, fans, blowers, and compressors Measurement of flowing fluids- full bore meters, insertion meters.

Outcomes:

By mastering the fluid mechanics course, the students shall be able to:

- Analyze fluid flow in circular and non-circular conduits.
- Do calculations associated to the estimation of friction factor and pressure drop in circular conduits.
- Do calculations involving Bernoulli's equation for the transport of acidic, alkaline, hydrocarbon and miscellaneous incompressible fluids in pipelines.
- Calculate the pressure drops and energy requirements associated to compressible fluid flow in circular and rectangular ducts.
- Estimate pressure drop in packed and fluidized beds.
- Rigorously carry out various calculations associated to fluid flow in various types of pumps, fans and blowers.
- Calculate, analyze and calibrate various flow measuring devices.

Text Books:

1. McCabe,W.L., J.C.Smith & Peter Harriot Unit Operations of Chemical Engineering, McGraw-Hill, 7th Edition, 2001.
2. Christie J. Geankoplis, Transport Processes and Unit Operations, PHI, 2003.

Reference Books:

1. Introduction to fluid mechanics, Fox, R.W. and A.T.McDonald, 5th edition, John Wiley & Sons, 1998.
2. Chemical engineering,J.M.Coulson and J.F.Richardson, Vol-1: Fluid flow, Heat Transfer and Mass Transfer, Pergamon Press, 4th Edition, 1990.
3. Fluid Mechanics for Chemical Engineers, Noel De Nevers, Tata McGraw-Hill, 2011.
4. Fluid Flow for Chemical and Process Engineers,Bragg R and F. A. Holland, 2nd Edition, Hodder Stoughton Educational, 1995.
5. Fluid Flow for the Practicing Chemical Engineer, Patrick Abulencia, J and Louis Theodore,John wiley and Sons, 2009.

II Year - II Semester

L	T	P	C
4	0	0	3

MECHANICAL UNIT OPERATIONS

Learning Objectives:

The course introduces the student to principles of mechanical operations and their application in chemical process industries.The students will be able to:

- Understand the fundamentals associated with liquid agitation and mixing.
- Gain basic knowledge in particle characterization namely particle size, shape and specific surface.
- Have knowledge of particulate solids handling and mixing
- Learn the principles of size reduction and screening
- Understand the principles and concepts of filtration
- Understand the functioning of various prominent solid fluid contactors namely gravity settlers, thickeners, classifiers, clarifiers, sedimenters and cyclones.
- Understand the working principle of electrostatic precipitation and flotation and their relevance in industrial practice.

UNIT-I:

Agitation and mixing of liquids: circulation velocities, power consumption in agitated vessels, purpose of agitation, types of impellers, standard Turbine Design,
Blending of liquids, suspension of solid particles, dispersion operations, Dimensionless groups involved.

UNIT-II:

Properties, handling and mixing of particulate solids: Characterization of solid particles, properties of particulate masses, storage of solids and mixing of solids, types of mixers, mixers for non-cohesive solids and cohesive solids.

UNIT-III:

Size reduction: Principles, criteria for comminution, characteristics of comminution, size reduction equipment-crushers, grinders, ultra-fine grinders, cutting machines, Equipment operation.
Screening: Screening, Industrial screening equipment, general factors in selecting a screening equipment, comparison of ideal and actual screens, Material balance over a screen and screening efficiency. Capacity and effectiveness of screens: factors influencing.

UNIT-IV:

Classification of filtration in terms of pressure, solid removal mode and an amount of solids
Filtration: Cake filters, centrifugal filters, filter aids, clarifying filters, liquid clarification, and gas cleaning.
Principles of cake filtration, clarification and centrifugal filtration.
Separations based on motion of particles through fluids: Gravity sedimentation process: gravity classifiers, sorting classifiers, clarifiers and thickeners, Equipment for sedimentation
Centrifugal settling process: Separations of solids from gases: Cyclones; Separations of solids from liquids: Hydro-cyclones, principles of centrifugal sedimentation, centrifugal classifiers.

UNIT-V:

Crystallization: Principles of crystallization, crystal size and geometry, purity of product-equilibrium and yields, energy balances, supersaturation, Nucleation-Homogenous and Heterogenous types, crystallization equipment.

UNIT-VI:
Electrostatic separation: Principle, charging by contact electrification, charging by conductive induction, charging by ion bombardment, types of equipment, effect of humidity, applications of process.
Flotation: General description, flotation reagents, applications, flotation machines, capacities, flotation economics.

Outcomes:
A student proficient in Mechanical Unit Operations will have working knowledge associated with:

- Particle characterizations and solids handling.
- Mixing and size reduction of solids.
- Screening and filtration.
- Equipment associated with solid -fluid mechanical operations such as gravity settlers, thickeners, classifiers, clarifiers, sedimenters and cyclones.
- Electrostatic precipitators and flotation equipment.
- Industrial case studies associated with mechanical unit operations.
- Conceptual design of equipment in mechanical unit operations.

Text Book:

1. McCabe,W.L., J.C.Smith and Peter Harriott, Unit Operations in Chemical Engineering, McGraw Hill, 7^{th} Edition. 2001.

Reference Books:

1. Unit Operations, Brown, G.G., CBS Publishers, 1995.
2. Introduction to Chemical Engineering, Badger,W.L.and J.T.Banchero, Tata McGraw-Hill, International Edition, 1997.
3. Narayanan, C.M., and Bhattacharya,B.C., Khanna Publishers, 2011.

II Year - II Semester

L	T	P	C
4	0	0	3

CHEMICAL ENGINEERING THERMODYNAMICS– I

Learning Objectives:

Basic concepts of thermodynamics will be taught to make the students to study and understand:

- The laws of thermodynamics and their application to engineering systems.
- Chemical potentials, Gibbs and Helmholtz Free Energies and real gases.
- The phase behavior and properties of pure fluids with applications to the analysis and preliminary design of power plants, refrigeration systems and chemical engineering systems.

UNIT-I:

Introduction: The scope of thermodynamics, defined quantities; temperature, volume, pressure, work, energy and heat.

The first law and other basic concepts: The first law of thermodynamics, thermodynamic state and state functions, enthalpy, the steady-state steady flow process, equilibrium, the reversible process, constant-V and constant-P processes, heat capacity, Gibbs phase Rule.

UNIT-II:

Volumetric properties of pure fluids: The PVT behavior of pure substances, virial equations, the ideal gas, the applications of the virial equations, Cubic equations of state, generalized correlations for gases. Mollier diagram and steam tables.

UNIT-III:

The second law of thermodynamics: Statements of the second law, heat engines, thermodynamic temperature scales, the ideal-gas scale, Entropy, Entropy changes of an ideal gas, mathematical statement of the second law.

Thermodynamic properties of fluids including residual and generalized property correlations.

UNIT-IV:

Thermodynamics of flow processes; principles of conservation of mass and energy for flow systems, analysis of expansion processes; turbines, throttling; compression processes – compressors and pumps; calculation of ideal work and lost work. Examples on hydrocarbons and natural gas.

UNIT-V:

Production of Power from Heat: Vapor Power Cycle: Simple Steam power cycle, Rankine cycle, and comparison of Rankin & Carnot cycles, Regenerative cycle.

UNIT-VI:

Refrigeration and liquefaction: The Carnot refrigerator, the vapor compression cycle, the comparison of refrigeration cycles, the choice of refrigerant, absorption refrigeration, the heat pump, liquefaction processes.

Outcomes:

After successful completion of this course, the students can obtain a good understanding of the principles of thermodynamics and a proficiency in applying these principles to the solution of a large variety of energy flow and equilibrium problems. The students will be able to:

- Solve problems using the energy balance appropriate for a system.
- Solve problems using the entropy balance appropriate for a system.
- Evaluate, manipulate and use thermodynamic partial derivatives.
- Correctly use a thermodynamic property chart and steam tables.
- Acquire an ability to identify, formulate and solve engineering problems.
- Acquire adequate ability to use techniques, skills and modern engineering tools necessary for engineering practice.

Text books:

1. Introduction to Chemical Engineering Thermodynamics,Smith, J.M. and HC Van Ness, M.M.Abbott, 7th Edition, McGraw Hill, 2010.
2. Chemical Engineering Thermodynamics, Rao, Y.V.C., Universities Press India Ltd., 1997.

Reference Books:

1. Engineering and Chemical Thermodynamics, Koretsky, M.D., John Wiley & Sons, 2004.
2. Introductory Chemical Engineering Thermodynamics,Richard Elliott,J. and Carl T.Lira, 2nd Edition, Prentice Hall, 2012.
3. Chemical, Biochemical and Engineering Thermodynamics, Stanley Sandler, 4th Edition, Wiley India Pvt Ltd, 2006.
4. Thermodynamics: Applications in Chemical Engineering and the Petroleum Industry, Vidal,J., Edition Technip, 2003.
5. Chemical and Process Thermodynamics,Kyle, B.G., 3rd Edition, PHI Learning, 2008.
6. Chemical Engineering Thermodynamics,Thomas E. Dauber, McGraw Hill, 1985.

II Year - II Semester

L	T	P	C
4	0	0	3

PROCESS HEAT TRANSFER

Learning Objectives:

- This course is designed to introduce a basic study of the phenomena of heat transfer to carry out thermal design/ heat transfer process design for heat exchange systems such as process heat exchangers, reboilers, air/utility coolers/condensers, furnaces, boilers, super-heaters, evaporators, driers, cooling towers etc. The principles involve the estimation of overall heat transfer coefficients, heat transfer surface area, pressure drop involved in single-phase and multi-phase flow regimes.
- The students will be trained to acquire skills to carry out the detailed mechanical design of heat exchangers such as number tubes, selection of shell and tube material, estimate number of baffles and also provide necessary information regarding TEMA classification.

UNIT-I:

Introduction: Nature of heat flow, conduction, convection, natural and forced convection, and radiation.

Heat transfer by conduction in Solids: Fourier's law, thermal conductivity, steady state conduction in plane wall & composite walls, compound resistances in series, heat flow through a cylinder, conduction in spheres, thermal contact resistance, plane wall: variable conductivity.

Unsteady state heat conduction: Equation for one-dimensional conduction, Semi-infinite solid, finite solid.

UNIT-II:

Principles of heat flow in fluids: Typical heat exchange equipment, countercurrent and parallel current flows, energy balances, rate of heat transfer, overall heat transfer coefficient, electrical analogy, critical radius of insulation, logarithmic mean temperature difference, variable overall coefficient, multi-pass exchangers, individual heat transfer coefficients, resistance form of overall coefficient, fouling factors, classification of individual heat transfer coefficients, magnitudes of heat transfer coefficients, effective coefficients for unsteady-state heat transfer.

UNIT-III:

Heat Transfer to Fluids without Phase change: Regimes of heat transfer in fluids, thermal boundary layer, heat transfer by forced convection in laminar flow, heat transfer by forced convection in turbulent flow, the transfer of heat by turbulent eddies and analogy between transfer of momentum and heat, heat transfer to liquid metals, heating and cooling of fluids in forced convection outside tubes.

UNIT-IV:

Natural convection: Natural convection to air from vertical shapes and horizontal planes, effect of natural convection in laminar flow heat transfer.

Heat transfer to fluids with phase change: Heat transfer from condensing vapors, heat transfer to boiling liquids.

UNIT-V:

Radiation: Emission of radiation**,** absorption of radiation by opaque solids, radiation between surfaces, combined heat transfer by conduction, convection and radiation.

Evaporators: Types ofEvaporators, performance of tubular evaporators, vapor recompression.

UNIT-VI:

Heat Exchange Equipment: General design of heat exchange equipment, heat exchangers, condensers, boilers and calendrias, extended surface equipment, heat transfer in agitated vessels, scraped surface heat exchangers, heat transfer in packed beds, heat exchanger effectiveness (NTU method).

Out Comes: Upon successful completion of this course, the students will be able to:

- Understand the basic laws of heat transfer.
- Account for the consequence of heat transfer in thermal analyses of engineering systems.
- Analyze problems involving steady state heat conduction in simple geometries.
- Develop solutions for transient heat conduction in simple geometries.
- Obtain numerical solutions for conduction and radiation heat transfer problems.
- Understand the fundamentals of convective heat transfer process.
- Evaluate heat transfer coefficients for natural convection.
- Evaluate heat transfer coefficients for forced convection inside ducts.
- Evaluate heat transfer coefficients for forced convection over exterior surfaces.
- Analyze heat exchanger performance by using the method of log mean temperature difference.
- Analyze heat exchanger performance by using the method of heat exchanger effectiveness.
- Calculate radiation heat transfer between black body surfaces as well as grey body surfaces

Text Books:

1. Unit Operations of Chemical Engineering, McCabe, W.L., J.C Smith and Peter Harriott, 7th Edition, McGraw-Hill, 2005.
2. Heat Transfer, Y.V.C.Rao, Universities Press (India) Pvt. Ltd., 2001.

Reference Books:

1. Process Heat Transfer, D.Q. Kern, Tata- McGraw-Hill, 1997.
2. Heat Transfer, Holman, J.P., 9th Edition, Tata McGraw-Hill, 2008.
3. Schaum's Outline of Heat Transfer, Donald Pitts and L.E.Sisson, 2nd Edition, McGraw-Hill, 1998.
4. A Text Book on Heat Transfer, Sukhatme, P., 5th Edition, Universities Press (India) Pvt. Ltd., 2005.
5. Heat Transfer: Principles and Applications, Binay Dutta, K., PHI Learning, 2009.
6. Chemical Engineering: Fluid Flow, Heat Transfer and Mass Transfer, Coulson, J.M.; Richardson, J.F.; Backhurst, J.R.; Harker, J.H., Vol.1, 6th Edition, Reed Elsevier India, 2006.

II Year - II Semester

L	T	P	C
4	0	0	3

PROCESS INSTRUMENTATION

Learning Objectives:

- To learn the basic elements of an instrument and its static and dynamic characteristics
- To study various types of industrial thermometers
- To learn basic concepts of various types of composition analysis
- To learn various types of instruments for measurement of pressure, vacuum, head, density, level and flow measurement
- To get an overview of various recording, indicating and signaling instruments, transmission of instrument readings, instrumentation diagrams, control center, process analysis and digital instrumentation.

UNIT-I:

Fundamentals: Elements of Instruments, static and dynamic characteristics-Basic concepts of response of first order type instruments.

Industrial Thermometers 1: Mercury in glass thermometer-Bimetallic thermometer-Pressure spring thermometer, Static accuracy and response of thermometry.

UNIT-II:

Industrial Thermometers 2: Thermo electricity-Industrial thermocouples-Thermo couple wires-Thermo couple wells and response of thermo couples; Thermal coefficient of resistance-Industrial resistance-thermometer bulbs and circuits-Radiation receiving elements-Radiation photo electric and optical pyrometers.

UNIT-III:

Composition analysis: Spectroscopic analysis by absorption, emission, mass and color measurement spectrometers-Gas analysis by thermal conductivity, analysis of moisture.

Pressure, vacuum and head: Liquid column manometers-Measuring elements for gauge pressure and vacuum-indicating elements for pressure gauges-Measurement of absolute pressure-Measuring pressure in corrosive liquids-Static accuracy and response of pressure gauges.

UNIT-IV:

Density and specific gravity measurements- direct measurement of liquid level-Pressure measurement in open vessels-Level measurements in pressure vessels-Measurement of interface level-Density measurement and level of dry materials.

UNIT-V:

Flow Meters: Head flow meters-Area flow meters-Open channel meters-Viscosity meters-Quantity meters-Flow of dry materials-Viscosity measurements.

UNIT-VI:

Recording instruments – Indicating and signaling instruments – Transmission of instrument readings – Controls center – Instrumentation diagram – Process analysis – Digital Instrumentation,
SCADA Systems.

Outcomes:

The students will be able to

- Understand the basic elements of an instrument and its characteristics
- Become familiar with various types of instruments for the measurement of various process variables like temperature, pressure, vacuum, head, level, composition, flow and density
- Get a clear perspective of various recording, indicating, signaling instruments and transmission of instrument readings
- Get an understanding of instrumentation diagrams, control center, process analysis and digital instrumentation

Text Book:

1. Industrial Instrumentation, Donald P.Eckman, CBS, 2004.
2. Instrumentation and Control Systems, K.Padmaraju, Y.J. Reddy, McGraw Hill Education, 2016.

Reference Books:

1. Principles of Industrial Instrumentation, Patranabis, 2nd Edition, Tata McGraw-Hill, 1996.
2. Process Control and Instrumentation Technology, Curtis D. Johnson, 3rd Edition, Prentice Hall, 1988.
3. Process Instrumentation Applications Manual, Bob Connell, 2nd Edition, McGraw-Hill, 1995.

II Year - II Semester

L	T	P	C
0	0	3	2

MOMENTUM TRANSFER LAB

Learning Objectives:

- Fundamentals of momentum transfer will be demonstrated in a series of laboratory exercises like determination of discharge coefficient of orifice, venturi, notches, friction factors in pipes, pressure drop in packed and fluidized beds, fluid viscosity, characteristics of centrifugal pump, characterization of fluid flow, verification of Bernoulli's theorem, and measurement of point velocities. Hands-on experience and communication skills will be achieved.

List of Experiments:

1. Identification of laminar and turbulent flows; Major equipment - Reynolds apparatus
2. Measurement of point velocities; Major equipment - Pitot tube setup
3. Verification of Bernoulli's equation; Major equipment – Bernoulli's Apparatus
4. Calibration of Rotameter; Major equipment – Rotameter Assembly
5. Variation of Orifice coefficient with Reynolds Number; Major equipment - Orifice meter Assembly.
6. Determination of Venturi coefficient; Major equipment – Venturi meter Assembly
7. Friction losses in Fluid flow in pipes; Major equipment - Pipe Assembly with provision for Pressure measurement
8. Pressure drop in a packed bed for different fluid velocities; Major equipment - Packed bed with Pressure drop measurement
9. Pressure drop and void fraction in a fluidized bed; Major equipment - Fluidized bed with Pressure drop measurement
10. Studying the coefficient of contraction for a given open orifice; Major equipment - Open Orifice Assembly
11. Studying the coefficient of discharge in a V-notch; Major equipment - V-notch Assembly
12. Studying the Characteristics of a centrifugal pump; Major equipment - Centrifugal Pump
13. Viscosity determination using Stoke's law; Major equipment – Terminal Velocity determination column.

Outcomes:

After completion of the course**,** students will be able to do the following:

- Operate fluid flow equipment and instrumentation.
- Collect and analyze data using momentum transfer principles and experimentation methods.
- Prepare reports following accepted writing and graphical techniques.
- Perform exercises in small teams.
- Demonstrate principles discussed in momentum transfer lecture course.
- Demonstrate appropriate work habits consistent with industry standards.

II Year - II Semester

L	T	P	C
0	0	3	2

PROCESS HEAT TRANSFER LAB

Learning Objectives:

- Fundamentals of process heat transfer will be demonstrated in a series of laboratory exercises like determination of thermal conductivities of composite wall and metal rod, natural convective and forced convective heat transfer coefficients, both film and overall coefficients, Stefen-Boltzman constant, emissivity of a metal plate etc. Students will achieve hands-on experience and acquire communication skills while conducting experiments in a team.

List of Experiments:

1. Determination of total thermal resistance and thermal conductivity of composite wall.
2. Determination of thermal conductivity of a metal rod.
3. Determination of natural convective heat transfer coefficient for a vertical tube.
4. Determination of critical heat flux point for pool boiling of water.
5. Determination of forced convective heat transfer coefficient for air flowing through a pipe
6. Determination of overall heat transfer coefficient in double pipe heat exchanger.
7. Study of the temperature distribution along the length of a pin-fin under natural and forced convection conditions
8. Estimation of un-steady state film heat transfer coefficient between the medium in which the body is cooled.
9. Determination of Stefan – Boltzmann constant.
10. Determination of emissivity of a given plate at various temperatures.

Out Comes:

Upon successful completion of this lab course, the student will be able to:

- Understand the basics of experimental techniques for heat transfer measurements.
- Operate the heat transfer equipment like heat exchangers
- Process experimental data and obtain correlations to predict heat transfer coefficients for design of heat transfer systems.
- Conduct the experiments at R & D level in the industry
- Understand the professional and ethical responsibilities in the field of heat transfer.
- Produce a written laboratory report.

II Year - II Semester

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2	0	0	0

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PROFESSIONAL ETHICSAND HUMAN VALUES

Learning Objectives:

- To give basic insights and inputs to the student to inculcate Human values to grow as a responsible human beings with proper personality.
- Professional ethics instills the student to maintain ethical conduct and discharge their professional duties.

UNIT I: Human Values:
Morals, Values and Ethics – Integrity –Trustworthiness - Work Ethics – Service Learning – Civic Virtue – Respect for others – Living Peacefully – Caring – Sharing – Honesty – Courage – Value Time – Co-operation – Commitment – Empathy – Self-confidence – Spirituality- Character.

UNIT: II: Principles for Harmony:
Truthfulness – Customs and Traditions -Value Education – Human Dignity – Human Rights – Fundamental Duties - Aspirations and Harmony (I, We & Nature) – Gender Bias - Emotional Intelligence – Salovey – Mayer Model – Emotional Competencies – Conscientiousness.

UNIT III: EngineeringEthics and Social Experimentation:
History of Ethics - Need of Engineering Ethics - Senses of Engineering Ethics- Profession and Professionalism —Self Interest - Moral Autonomy – Utilitarianism – Virtue Theory - Uses of Ethical Theories - Deontology- Types of Inquiry –Kohlberg's Theory - Gilligan's Argument –Heinz's Dilemma - Comparison with Standard Experiments — Learning from the Past –Engineers as Managers – Consultants and Leaders – Balanced Outlook on Law - Role of Codes – Codes and Experimental Nature of Engineering.

UNIT IV: Engineers' Responsibilities towards Safety and Risk:
Concept of Safety - Safety and Risk – Types of Risks – Voluntary v/sInvoluntary Risk – Consequences - Risk Assessment – Accountability – Liability - Reversible Effects - Threshold Levels of Risk - Delayed v/sImmediate Risk - Safety and the Engineer – Designing for Safety – Risk-Benefit Analysis-Accidents.

UNIT V: Engineers' Duties and Rights:
Concept of Duty - Professional Duties – Collegiality - Techniques for Achieving Collegiality – Senses of Loyalty - Consensus and Controversy - Professional and Individual Rights – Confidential and Proprietary Information - Conflict of Interest-Ethical egoism - Collective Bargaining – Confidentiality - Gifts and Bribes - Problem solving-Occupational Crimes-Industrial Espionage- Price Fixing-Whistle Blowing.

UNIT VI: Global Issues:
Globalization and MNCs –Cross Culture Issues - Business Ethics – Media Ethics - Environmental Ethics – Endangering Lives - Bio Ethics - Computer Ethics - War Ethics – Research Ethics -Intellectual Property Rights.

Related Cases Shall be dealt where ever necessary.

Outcomes:

- It gives a comprehensive understanding of a variety issues that are encountered by every professional in discharging professional duties.
- It provides the student the sensitivity and global outlook in the contemporary world to fulfill the professional obligations effectively.

Reference Books:

1. Professional Ethics, R. Subramaniam – Oxford Publications, New Delhi.
2. Ethics in Engineering, Mike W. Martin and Roland Schinzinger - Tata McGraw-Hill – 2003.
3. Professional Ethics and Morals, Prof.A.R.Aryasri, DharanikotaSuyodhana - Maruthi Publications.
4. Engineering Ethics, Harris, Pritchard and Rabins, Cengage Learning, New Delhi.
5. Human Values & Professional Ethics, S. B. Gogate, Vikas Publishing House Pvt. Ltd., Noida.
6. Engineering Ethics & Human Values, M.Govindarajan, S.Natarajan and V.S.Senthil Kumar-PHI Learning Pvt. Ltd – 2009.
7. Professional Ethics and Human Values, A. Alavudeen, R.Kalil Rahman and M. Jayakumaran – University Science Press.
8. Professional Ethics and Human Values, Prof. D.R.Kiran-Tata McGraw-Hill – 2013.
9. Human Values and Professional Ethics, Jayshree Suresh and B. S. Raghavan, S.Chand Publications.

III Year - I Semester

L	T	P	C
4	0	0	3

MANAGEMENT SCIENCE

Learning Objectives:

- To familiarize with the process of management and to provide basic insight into select contemporary management practices
- To provide conceptual knowledge on functional management and strategic management.

UNIT-I:

Introduction to Management: Concept –nature and importance of Management –Generic Functions of Management – Evaluation of Management thought- Theories of Motivation – Decision making process-Designing organization structure- Principles of organization – Organizational typology- International Management: Global Leadership and Organizational behavior Effectiveness(GLOBE) structure

UNIT-II:

Operations Management: Principles and Types of Management – Work study- Statistical Quality Control- Control charts (P-chart, R-chart, and C-chart) Simple problems- Material Management: Need for Inventory control- EOQ, ABC analysis (simple problems) and Types of ABC analysis (HML, SDE, VED, and FSN analysis).

UNIT-III:

Functional Management: Concept of HRM, HRD and PMIR- Functions of HR Manager-Wage payment plans(Simple Problems) – Job Evaluation and Merit Rating - Marketing Management- Functions of Marketing – Marketing strategies based on product Life Cycle, Channels of distributions. Operationlizing change through performance management.

UNIT-IV:

Project Management: (PERT/CPM): Development of Network – Difference between PERT and CPM Identifying Critical Path- Probability- Project Crashing (Simple Problems)

UNIT-V:

Strategic Management: Vision, Mission, Goals, Strategy – Elements of Corporate Planning Process – Environmental Scanning – SWOT analysis- Steps in Strategy Formulation and Implementation, Generic Strategy Alternatives. Global strategies, theories of Multinational Companies.

UNIT-VI:

Contemporary Management Practice: Basic concepts of MIS, MRP, Justin- Time(JIT) system, Total Quality Management(TQM), Six sigma and Capability Maturity Model(CMM) Levies, Supply Chain Management , Enterprise Resource Planning (ERP), Business Process outsourcing (BPO), Business process Re-engineering and Bench Marking, Balanced Score Card.

Outcomes:

- After completion of the Course the student will acquire the knowledge on management functions, global leadership and organizational behavior.
- Will familiarize with the concepts of functional management project management and strategic management.

Text Books:

1. Management Science, Dr. P. Vijaya Kumar & Dr. N. Appa Rao, Cengage, Delhi, 2012.
2. Management Science,Dr. A. R. Aryasri,TMH 2011.

Reference Books:

1. Essentials of management,Koontz & Weihrich, TMH 2011
2. Global Management Systems, Seth & Rastogi, Cengage learning , Delhi, 2011
3. Organizational Behaviour, Robbins, Pearson publications, 2011
4. Production & Operations Management, Kanishka Bedi, Oxford Publications, 2011
5. Principles of Marketing, Philip Kotler & Armstrong, Pearson publications
6. Human Resource Management, Biswajit Patnaik, PHI, 2011
7. Starategic Management, Hitt and Vijaya Kumar, Cengage learningPrem Chadha: Performance Management, Trinity Press(An imprint of Laxmi Publications Pvt. Ltd.) Delhi 2015.
8. Principles of Management, Anil Bhat& Arya Kumar, Oxford University Press, New Delhi, 2015.

III Year - I Semester

L	T	P	C
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PETROLEUM REFINERY ENGINEERING

Learning Objectives:
Basic concepts of process engineering and production technologies involved Petroleum Refinery processes will be taught to make the students to study understand and appreciate:

- Properties of crude oils and Petroleum fractions and their significance in meeting the fuel specifications.
- Various processes and production steps involved in primary separation of Crude Oil in to various intermediate product streams.
- Different processes and production steps involved to convert low value heavy fuels to high value lighter liquids.
- Various processes and production steps involved in treating / reforming the intermediate products to enhance their quality to a level sufficient for routing or blending to a final fuel product.

UNIT-I:
Introduction: Overall refinery operations & Indian scenario.
Refinery feed stocks: Crude oil classification-Composition and properties-Composition of petroleum crude suitable for asphalt/coke manufacture – Evaluation of crude oils.

UNIT-II:
Petroleum Products and their specifications: LPG- Gasoline- Diesel fuels- Jet and turbine fuels –Lube oils-Heating oils – Residual fuel oils - wax and asphalt- Petroleum coke- All Product specifications- Evaluation of all products- Product blending.

UNIT-III:
Crude distillation: Atmospheric and Vacuum distillation units, material and energy balances– Auxiliary equipment such as desalters, pipestill heaters and heat exchanger trains etc.

UNIT-IV:
Thermal & catalytic cracking processes: Visbreaking, Hydrovisbreaking, Thermal cracking, Delayed coking, Catalytic cracking, Fluid Catalytic cracking and Hydrocracking - Feed stocks – Feed treating – Catalysts - Process variables –Product Recoveries- Yield estimation-Latest developments.

UNIT-V:
Hydro processing: Naphtha, Distillate (Kerosene/ Diesel/ Cycle oils), Gas oil and Resid hydro processing — Different hydroprocessing technologies for feed stock and product treatment.
Lube Oil Refining: Lubricant base oil processes-Deasphalting-Solvent Extraction

UNIT-VI:
Catalytic reforming and isomerization: Catalytic reforming processes – Isomerization Processes -Feed stocks-Feed preparation – Yields.
Alkylation Processes: Alkylation feed stocks – Products – Catalysts – Hydrofluoric Acid and sulfuric acid alkylation processes – Comparison of processes.
Supporting processes: Hydrogen production and purification – Gas processing technologies -– Sulfur recovery processes – Sweetening processes.

Outcomes:

The students will be able to have thorough understanding of the following aspects:

- For a given crude assay, how to handle and store the crude oil.
- What will be the yield, quality of the product, estimation for the primary processes and treatment considerations.
- Characteristics such as crackability and reformability of the petroleum fractions.
- Maximizing the profitable products and minimize the quality giveaway.
- Processing the opportunity crudes (e.g. Blending with other crudes) to maximize the throughput and gross margin.
- Application of suitable Hydroprocessing/treatment technologies to meet product qualities and to minimize the CAPEX&OPEX (capital and operating expenditure).
- Application of suitable thermal/catalytic conversion (cracking) processes for Vacuum gas oil/resid-upgradation and to produce desired fuel blend components and petrochemical feed stocks.
- Application of suitable non – cracking (alkylation, reforming, isomerization) for converting light ends/ naphtha cuts to meet the desired gasoline blends.
- The refinery Hydrogen demand and its balance, applications of suitable feed stock/technology to meet the hydrogen quantity and quality demands.
- Application of suitable amine treating techniques and design considerations for purification of various sour gas steams generated in the refinery units.
- Application of caustic extraction & catalytic sweetening techniques for removal of H_2S &mercaptans fraction from light naphtha and LPG fractions.

Text Books:

1. Petroleum Refining: Technology and Economics, J.H. Gary and G.E.Handwerk, 4th Edition, Marcel Dekkar, Inc., New York, 2001.
2. Elements of Petroleum Processing, D S Jones, Wiley 1995.

References Books:

1. Petroleum Refinery Engineering, W.L.Nelson, 4th Edition, McGraw Hill, New York, 1958.
2. Handbook of Petroleum Refining Processes, Third edition, Robert A. Meyers, McGraw-Hill, 2003.
3. Modern Petroleum Refining processes, 5th Edition, B. K. Bhaskara Rao, Oxford and IBH Publishing Co. Pvt. Ltd., 2008.
4. Petroleum Refining Processes, RakeshRathi, SBS, Publishers, 2007.
5. Petroleum Refining: Crude Oil Petroleum Products, Process Flow Sheets, Jean-Pierre Wauquier, Editions Technip, 1995.
6. Practical Advances in Petroleum Processing, Chang S. Hsu and Paul Robinson, Vol. 1 & 2, Springer, 2006.
7. Thermal and Catalytic Processes in Petroleum Refining, Serge Raseev, Marcel Dekkar, Inc., 2003.
8. Fundamentals of Petroleum Refining, Mohammed A. Fahim, Taher A. Al-Sahhaf, AmalElkilani, Elsevier Science, 2009.
9. Handbook of Petroleum Processing, David S. J. Jones, Peter P. Pujado, Springer, 2006.
10. Refining Processes Handbook, SurinderParkash, Gulf Professional Publishing, 2003.
11. Petroleum Refining, Andrew Campbell, Rarebooksclub.com, 2012.

III Year - I Semester

L	T	P	C
4	0	0	3

CHEMICAL ENGINEERING THERMODYNAMICS –II

Learning Objectives:
The students will be imparted knowledge in the following topics:

- Sensible and latent heat effects
- Heat effects of industrial reactions.
- Heat effects for chemical change.
- Residual and excess property relations.
- Concept of fugacity and partial molar properties.
- VLE calculations using Raoult's law, modified Raoult's law and generalized method.
- VLE calculations from equation of state.
- Estimation of reaction equilibrium constant and equilibrium conversion for liquid phase reactions, gas phase reactions and industrial reactions.
- Applications of phase rule for reacting and non-reacting systems.

UNIT –I:
Heat effects: Sensible heat effects, Internal energy of ideal gases: Microscopic view, Latent heats of pure substances, heat effects of industrial reactions, heat effects of mixing processes. Standard heat of reaction, Standard heat of formation, Standard heat of combustion, temperature dependence of heat of reaction

UNIT-II:
Solution thermodynamics: Theory: Fundamental property relation, chemical potential as a criterion for phase equilibrium, partial molar properties, ideal gas mixtures, fugacity and fugacity coefficient for pure species, fugacity and fugacity coefficient for species in solutions, generalized correlations for Fugacity coefficient, The ideal solutions, excess properties.

UNIT-III:
Solution thermodynamics: applications: the liquid phase properties from VLE data, models for the excess Gibbs energy, property changes of mixing

UNIT–IV:
VLE at low to moderate pressures: The nature of equilibrium, the phase rule, Duhems theorem, VLE: Qualitative behavior, the gamma /Phi formulation of VLE, Dew point and bubble point calculations, flash calculations, solute (1)/solvent (2) systems

UNIT–V:
Thermodynamic properties and VLE from equations of state: properties of fluids from the virial equations of state, properties of fluids from cubic equations of state, fluid properties from correlations of the Pitzer type, VLE from cubic equations of state

UNIT–VI:

Chemical Reaction Equilibria: The reaction coordinate, application of equilibrium criterion to Petrochemical reactions, the standard Gibb's energy change and the equilibrium constant, effect of temperature on equilibrium constants, relation of equilibrium constants to composition, equilibrium conversion for single reactions, Phase rule and Duhem's theorem for reacting systems.

Outcomes:

After the completion of course, students will be able to:

- Estimate heat requirement for any physical and chemical change.
- Find fugacity coefficient and activity coefficient for a component in a mixture.
- Identify the non-ideal solution model for vapour liquid equilibrium.
- Obtain VLE data using appropriate cubic equations of state.
- Apply phase rule.
- Find reaction equilibrium constant and equilibrium conversion for single and multiple reactions.

Text Books:

1. Introduction to Chemical Engineering Thermodynamics, J.M. Smith, H.C. Van Ness and M.M. Abbott, 7th ed. McGraw Hill, 2005.
2. Chemical Engineering Thermodynamics, Rao Y.V.C., Universities Press (India) Pvt. Ltd., 1997.

Reference Books:

1. Chemical and Process Thermodynamics, BG Kyle, 3rd Edition, Phi Learning, 2008.
2. Introductory Chemical Engineering Thermodynamics, J. Richard Elliott, Carl T. Lira, 2nd Edition, Prentice Hall, 2012.
3. Chemical, Biochemical and Engineering Thermodynamics, Stanley I Sandler, 4th Edition, Wiley India Pvt Ltd, 2006.
4. Molecular Thermodynamics In Fluid Phase Equilibria, J.M. Prausnitz, R.N. Lichtenthaler, E.G.de Azvedo, 3rd Edition, Prentice-Hall, 1998.
5. Engineering and Chemical Thermodynamics, Milo D. Koretsky, Wiley India Pvt Ltd, 2009
6. Thermodynamics: Applications in Chemical Engineering and the Petroleum Industry, J. Vidal, Editions Technip, 2003.

III Year - I Semester

L	T	P	C
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PETROCHEMICAL ENGINGINEERING-I

(Process Engineering and Technology of production of Petrochemicals should be dealt with by the instructor).

Learning Objectives:

Basic concepts of process engineering and production technologies involved in industrial petrochemical processes will be taught to make the students to study, understand and appreciate:

- Various processes and production steps involved in the several petrochemical processes.
- Different pre-treatment processes involved in making the available and suitable feed stocks.
- Various products and by-products which can be produced in a variety of petrochemical processes.
- Challenges (including safety, catalyst degradation etc.,) and oppurtunities that exist for the production of various petrochemicals.
- Opportunities for energy, raw material and waste recovery and reuse in industrial petrochemical processes.

UNIT-I:

Introduction: Petrochemical industry-Structures of petrochemical complexes-Feedstock for petrochemical-Profile of petrochemical and their end products- Profile of Indian petroleum and petrochemical Industry.

UNIT-II:

Olefins production: Steam cracking for production of olefins-Gas sweetening unit-C_2/C_3 Extraction unit-Steam cracking process engineering and technology-Emerging technologies for production of olefins- Technologies for Alpha Olefins.

UNIT-III:

Processing of olefinic C_4 and C_5 cut from steam cracking and fluid catalytic cracking:

Fluid catalytic cracking-Growth of FCC technology-Chemistry of cracking and process variables- overview of FCC feed pretreatment-Description of the FCC process-FCC gases as petrochemical feedstock-Processing of C_4 stream from steam cracking and FCC-oxygenates from refinery C_4 and C_5 stream-Upgrading of C_5 cut for Recovery of C_5 chemicals.

UNIT-IV:

Aromatic production: Petroleum feedstock for aromatic hydrocarbons- catalytic reforming-Reactions in catalytic reforming-Reforming catalysts-Reforming process-Process variables in catalytic reforming- Pyrolysis gasoline for Aromatic separation from reformate and -Emerging technologies for the production of BTX- Aromatic conversion processes.

UNIT-V:

Methane and synthesis gas derivatives: synthesis gas and ammonia manufacture from steam reforming-Synthesis gas and ammonia manufacture from partial oxidation process-Urea processes.

Fischer-Tropschsyn gas techonology- Manufacture of Methanol, Formaldehyde, Acetic acid, Hexamethylenetetramine, Hexamethylene Diamine and Melamine.

UNIT-VI:

Ethylene and ethylene derivatives: Ethylene-Ethylene oxide and monoethyleneglycol: Process technologies-Process hazards-storage; Processes for Vinyl chloride-Vinyl acetate-Acetaldehyde-Ethanol-Acetic anhydride-Ethyl acetate- Ethanol amines- Ethylene glycol mono ethyl ether-Ethylene glycol mono butyl ether-Ethylene carbonate.

Ethylene to ethyl benzene & Styrene – Process technologies – Process Hazards – Storage.

Outcomes:

After completion of the course, students will able to apply/ acquire/appreciate:

- The basic principles on which a petrochemical industry complex is to be based.
- The principle of steam cracking and fluid catalytic cracking operations.
- Knowledge on various products which can be produced from steam cracking and fluid catalytic cracking process.
- Principles involved in aromatic production.
- Knowledge in the production of derivatives which can be produced from methane, synthesis gas & ethylene.
- Basic knowledge of distinguishing various processes involved.
- The various production technologies involved.
- Key operating and design parameters that critically influence the performance of the petrochemical processes in terms of the product quality and yield.
- Logic and reasoning associated to process integration and intensification in industrial petrochemical processes.

Text Book:

1. Petrochemical Process Technology, ID Mall, Macmillan India Ltd., New Delhi. 2007.

Reference Books:

1. Chemistry of Petrochemical Processes, Sami Matar and Lewis F.Hatch, 2nd Edition, Gulf Publishing Company, Houston, 2000.
2. Fundamentals of Petroleum Chemical Technology, P Belov, Mir Publishers, 1970.
3. Petrochemical Processes, A. Chauvel and G.Lefebvre, Volume 1 & 2, Gulf Publishing Company, 1989.
4. Handbook of Petrochemical Production Processes, Robert A. Meyers, McGraw-Hill, 2004.
5. Petrochemical Production Processes, N.Naderpour, SBS Publishers, 2009.
6. Petrochemicals, B. K. Bhaskara Rao, Oxford & IBH Publishing, 2002.
7. Chemicals from petroleum: An Introductory Survey, Waddams A.L., 4th Edition, Gulf Publishing, 1978.

III Year - I Semester

L	T	P	C
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MASS TRANSFER OPERATIONS-I

Learning Objectives:

The students will be able to learn:

- Classification of various mass transfer operations.
- Diffusional mass transfer for diffusion in solids & fluids and estimation of diffusivities.
- Estimation of Mass transfer coefficients for laminar and turbulent flow.
- Turbulent mass transfer theories and analogy between heat, mass and momentum transfer
- Equilibrium based separation by distillation and different types of distillation operations.
- The principles for design of distillation towers making simplified assumptions and also using enthalpy- concentration diagrams.
- The concepts of equilibrium based separation by absorption and stripping and corresponding data analysis.
- The concepts for design of equipment for gas-solid operations and gas-liquid operations

UNIT- I:

Introduction to Mass Transfer Operations: Classification of the Mass-Transfer Operations, Choice of Separation method, Methods of conducting the Mass-Transfer Operations, Design Principles, Unit systems.

Molecular Diffusion In Fluids: Molecular Diffusion, Equation of Continuity, binary solutions, Steady state molecular diffusion in fluids at rest and in laminar Flow, Estimation of diffusivity of gases and liquids, Momentum and Heat Transfer in laminar flow.

UNIT-II:

Diffusion: Diffusion in solids, Fick's diffusion, Unsteady state diffusion, Types of solid diffusion, diffusion through polymers, diffusion through crystalline solids, Diffusion through porous solids & hydrodynamic flow of gases.

Mass Transfer Coefficients: Mass Transfer Coefficients in Laminar Flow, Mass Transfer Coefficients in Turbulent Flow, eddy diffusion, Film Theory, Penetration theory, Surface-renewal Theory, Combined Film-Surface-Renewal theory, Surface-Stretch Theory, Mass, Heat and Momentum Transfer Analogies.

UNIT-III:

Inter Phase Mass Transfer: Concept of Equilibrium, Diffusion between Phases, Material Balances in steady state co-current and counter current stage processes, Stages, Cascades, Kremser – Brown equation.

Distillation-I : Fields of applications, VLE for miscible liquids, immiscible liquids, steam distillation, Positive and negative deviations from ideality, enthalpy-concentration diagrams, flash vaporization and differential distillation for binary and multi component mixtures.

UNIT- IV:

Distillation-II: Continuous rectification-binary systems, multistage tray towers–method of McCabe and Thiele, enriching section, exhausting section, feed section, total reflux, minimum and optimum reflux ratios, use of steam, total and partial condensers, cold reflux, multiple feeds, tray efficiencies.

Ponchon and Savarit method, the enriching and stripping sections, feed tray location, total reflux, minimum and optimum reflux ratios, reboilers, use of open steam, condenser and reflux accumulators, azeotropic distillation, extractive distillation, comparison of azeotropic and extractive distillation-Distillation in packed towers- Reactive Distillation.

UNIT-V:

Absorption and Stripping: Absorption equilibrium, ideal and non ideal solutions selection of a solvent for absorption, one component transferred: material balances. Determination of number of plates (graphical), absorption Factor, estimation of number of plates by Kremser Brown equation. Continuous contact equipment: HETP &HTU concepts, absorption of one component, determination of number of transfer units and height of the continuous absorber, overall coefficients and transfer units, dilute solutions, overall height of transfer units.

UNIT-VI:

Equipment For Gas-Liquid Operations: Gas dispersed, sparged vessels (bubble columns), mechanical agitated equipments(brief description),tray towers, general characteristics, sieve tray design for absorption and distillation (qualitative treatment), different types of tray efficiencies, liquid dispersed venturi scrubbers, wetted-wall towers, packed towers, counter current flow of liquid & gas through packing, mass transfer coefficients for packed towers, end effects and axial mixing- tray towesrvs packed towers.

Outcomes:

After completing the course, the students will be able to:

- Estimate the diffusivities of gases and liquids for diffusion through solids, liquids and gases.
- Estimate the mass transfer coefficients for laminar flow and turbulent flow.
- Design and operate stage wise and continuous contact distillation towers.
- Design and operate stage wise and continuous gas-liquid contact towers for absorption and stripping.

Text Books:

1. Mass Transfer Operations, R.E. Treybal, 3rdEdition.,McGraw Hill, 1980.
2. Unit Operations of Chemical Engineering, W.L.McCabe, J.C.Smith& Peter Harriott, McGraw- Hill, 6th Edition, 2001.

Reference Books:

1. Coulson and Richardson's Chemical engineering, Vol 1,Backhurst, J.R., Harker, J.H., Richardson, J.F., and Coulson, J.M., Butterworth-Heinemann, 1999.
2. Coulson and Richardson's Chemical engineering, Vol 2, Richardson, J.F. &Harker,J.H. with Backhurst, J.R., Butterworth-Heinemann, 2002.
3. Principles of Mass Transfer and Separation Processes, Binay K. Datta, PHI Learning Private Ltd., 2009.
4. Diffusion: Mass Transfer in Fluid Systems, Cussler, E.L., Cambridge Univ. Press, 1984.
5. Design of Equilibrium Stage Processes, B.D.Smith, McGraw-Hill, 1963.
6. Staged Cascades In Chemical Processing, P.L.T.Brian, Prentice-Hall, 1972.
7. Equilibrium Staged Separations, Phillip C.Wankat, Prentice-Hall PTR, 1988.
8. Equilibrium-Stage Separation Operations in Chemical Engineering, E.J.Henley and J.D.Seader, John Wiley & Sons, 1981.
9. Transport Processes and Unit Operations by Christie J. Geankoplis, 4th Edition, PHI,2009.
10. Separation Processes, C.J. King, 2nd Edition, McGraw- Hill, 1980.

III Year - I Semester

L	T	P	C
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MATHEMATICAL METHODS LAB

Learning Objectives:

- To train the students in writing MATLAB code, executing and doing what if analysis of the variations in the parameters for various problems using mathematical methods.

1. Determination of Molar volume and Compressibility from Redlich Kwong Equation
2. Calculation of flow rate in a pipeline
3. Adiabatic operation of a tubular reactor for acetone cracking
4. Correlation of the physical properties
5. Compressibility factor variation from vander waals equation
6. Isothermal compression of gas using Redlich-Kwong Equation of state
7. Thermodynamic properties of steam from Redlich-Kwong Equation
8. Complex chemical equilibrium by Gibbs Minimization
9. Solution of Stiff Ordinary Differential Equations
10. Iterative Solution of ODE boundary value problem
11. Shooting method for solving two-point boundary value problems
12. Expediting the solution of systems of nonlinear algebraic equations
13. Solving differential algebraic equations –DAEs
14. Method of lines for Partial Differential Equations
15. Estimating model parameters involving ODEs using fermentation data

Outcome:

- The students will be able to write MATLAB code and solve typical problems encountered in petrochemical and chemical engineering subjects.

Textbook:

1. Problem solving in Chemical and Biochemical Engineering with POLYMATH, Excel and MATLAB by Michael B. Cutlip and Mordechai Shacham, Prentice Hall, 2008.

III Year - I Semester

L	T	P	C
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PETROLEUM ANALYSIS LAB

Learning Objectives:

- The objective of the petroleum analysis lab is to determine the physical and transport properties like Reid vapor pressure, Viscosity, Smoke point, Flash point & Fire point, Aniline point, Cloud & Pour point, Softening point, Calorific value, Water content of different petroleum products by conducting laboratory experiments using different apparatus and to determine the distillation characteristics of petroleum products.

Experiments:

1. Determination of Distillation characteristics of Crude Oil, Gasoline, Diesel and Kerosene.
2. Determination of Reid Vapor Pressure of Crude oil & Gasoline.
3. Determination of Viscosity of Diesel and transformer oils.
4. Determination of Smoke Point of Kerosene.
5. Determination of Carbon Residue of petroleum oils.
6. Determination of Flash & Fire points of gasoline, kerosene and other products.
7. Estimation of water content in petroleum products.
8. Estimation of calorific value of solid, liquid and gaseous fuels.
9. Determination of Aniline point of Gasoline and Diesel oil.
10. Determination of Softening point of bitumen.
11. Determination of Cloud & Pour Points of petroleum products.
12. Detection of Corrosiveness of petroleum products

Outcomes:

- The students will be able to handle various apparatus/equipment in determining the physical and transport properties of different petroleum products and also will be able to analyze the various products of crude oil.

III Year - I Semester

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MASS TRANSFER OPERATIONS LAB-I

Learning Objectives:

The students will be able to learn:

- The basic concepts of diffusional processes.
- The experimental procedures for the determination of mass transfer properties.
- Handling different types of mass transfer equipment.
- Basic principles of VLE, steam distillation and differential distillation.
- The concept of HETP
- Estimation of mass transfer coefficients for surface evaporation and wetted wall column.

Experiments:

1. Estimation of diffusivity coefficients : vapors
2. Estimation of diffusivity coefficients : solids
3. Steam distillation
4. Differential distillation
5. Vapor Liquid Equilibria
6. HETP evaluation in Packed Towers
7. Hydrodynamics of Spray column
8. Evaluation of Mass transfer coefficients:
   (a)Surface evaporation
   (b)Wetted wall column

Outcomes:

The student will be able to:

- Recognize various modes of mass transfer to determine the mass transfer rates using Fick's law for estimating the diffusion coefficients.
- Conduct experiments; analyze and interpret data related to mass transfer.
- Visualize and understand mass transfer operations.
- Work in teams accommodating the contributions of team members having a variety of skills and perspectives.
- Identify, formulate and solve mass transfer problems.
- Attain proficiency in written, graphical and communications.
- Use techniques, skills, and modern engineering tools necessary for engineering practice.

III Year - I Semester

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INDUSTRIAL VISITS

Learning Objectives:
To make the students aware of industrial environment, culture, requirements, nature of jobs and to develop accordingly.

During the semester, all the students are required to visit minimum 6 major industries like petroleum refineries, petrochemical, fertilizer and organic chemical complexes accompanied by two faculty members. After each visit, every student should submit a very brief report on the industry with flow diagrams and salient features of the processes that include safety and environmental aspects.

Outcomes: The students will be able to

- Differentiate between the academic training and its relevance to industry.
- Understand the industrial safety measures.

III Year - I Semester

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(MC)
MINI PROJECT-I

Learning Objectives:

- To develop innovative and original ideas
- To promote team work

Three / four member teams will be formed to carry out the mini project which is a mandatory course. Under the guidance of an instructor / faculty, each team is given a project in the following subjects at the beginning of I Semester of III year of the 4 – year B. Tech. Program.

Fluid flow (Momentum Transfer), Heat Transfer, Mechanical Unit Operations, Process Instrumentation.

The project involves process and mechanical design calculations of an equipment / system / instrument and constructing a working model based on the above calculations. Finally a report will be submitted in a standard format along with the model. The model and report will be assessed by the concerned instructor / faculty for the completion of the mini project – I

Outcomes:
After successful completion of the mini project, students will be able to

- Practice acquired knowledge within the chosen area of technology for project development.
- Identify, discuss and justify the technical aspects of the chosen project with a comprehensive and systematic approach.
- Work as an individual or in a team in development of technical projects.
- Communicate and report effectively project related activities and findings.

III Year - II Semester

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PETROCHEMICAL ENGINEERING-II

(Process engineering and technology of production of petrochemicals should be dealt with by the instructor).

Learning Objectives:
Basic concepts of process engineering and production technologies involved in industrial petrochemical processes will be taught to make the students to study understand and appreciate:

- Various processes and production steps involved for producing propylene from various refinery streams.
- Different processes and production steps involved in processing C4 and C5 chemicals and aromatics.
- Various processes and production steps involved in producing polymers, elastomers and thermosetting resins, synthetic fibers and various environmental management aspects involved in petrochemical industries.
- Challenges (including safety, catalyst degradation etc.,) and opportunities that exist for the production of various petrochemicals.
- Opportunities for energy, raw material and waste recovery and reuse in industrial petrochemical processes.

UNIT-I:
Propylene and Its Derivatives: Propylene recovery from fluid catalytic cracking-Propane dehydrogenation, Metathesis-Dehydration of paraffins.
Propylene converted to Propylene oxide–Propylene glycol–Propylene glycol monoethyl ether–Isopropyl alcohol–Acetone–Acrylonitrile–Acetonitrile-Methyl methacrylate– Acrylic acid–Acrlamide- butyraldehydes -2-Ethyl hexanol –Methyl iso butyl ketone– Cumene.

UNIT-II:
Chemicals from C_4: Butadiene–1-Butene,–Butene-2,-Isobutylene–n-Butene–Octenes–1,4-Butanediol.
Chemicals from C_5: Chloroprene–Isoprene – Cyclopentadiene and decyclopentadiene
Aromatics- BTX Derivatives: Benzene, Toluene, Orthoxylene- Metaxylene- Paraxylene-Ethyl benzene and styrene–Phthalic anhydride– Maleic anhydride – Dimethylterphthalate-Terphthalic acid- Cyclohexane-Linear alkyl benzene–Phenol— Nitrobenzene and aniline – Benezoic acid- Bisphenol–A.

UNIT-III:
Polymers, Elastomers and Polyurethanes-I: Characteristics of polymers–Classification of polymers–Polymerization reactions–polymerization reactors – polyethylene – Polypropylene–Polyvinyl chloride–Polystyrene – Epoxy resins– Polycarbonates.

UNIT-IV:

Thermo settling resins, Elastomers and Polyurethanes-II: Phenol-Formaldehyde, Urea and melamine-Formaldehyde-Polyurethane. Classification of rubbers (Elastomer)-acrylonitrile-Butadiene styrene (ABS), Polybutadiene, Nitrile rubber-Butyl rubber (Teflon)-Polytetrafluoroethylene-Ethylene vinyl acetate-Polymethylmethacrylate.

UNIT-V:

Synthetic Fibres: Cyclohexane– Caprolactam – Adipic acid –Adiponitrile– Hexamethylenediamene –Polyester fibre (Polyethylene terephthalate)–Nylon 66–Nylon 6–Acrylic fibres.

UNIT-VI:

Environmental Management in Petrochemical Industries: Environmental Pollution Control: Acts, Regulations and Standards-Environmental Pollution in Petroleum and Petrochemical Industry-Environmental Impact Assessment-Corrosion and Its Control.

Outcomes:

After completion of the course the students will be able to:

- Work in the manufacture of various derivatives/products which can be produced from propylene, C4 and C5 Chemicals and various aromatics products; Production and operation of various thermoplastics, elastomers, thermosetting resins, polyurethanes, synthetic fibres.
- Implement various environmental management aspects involved in petrochemical industries.
- Key operating and design parameters that critically influence the performance of the petrochemical processes in terms of the product quality and yield.
- Logic and reasoning associated to process integration and intensification in industrial petrochemical processes.

Text Book:

1. Petrochemical Process Technology, ID Mall, Macmillan India Ltd., New Delhi. 2007.

Reference Books:

1. Chemistry of Petrochemical Processes, Sami Matar and Lewis F.Hatch, 2nd Edition, Gulf Publishing Company, Houston, 2000.
2. Fundamentals of Petroleum Chemical Technology, P Belov, Mir Publishers, 1970.
3. Petrochemical Processes, A. Chauvel and G.Lefebvre, Volume 1 & 2, Gulf Publishing Company, 1989.
4. Handbook of Petrochemical Production Processes, Robert A. Meyers, McGraw-Hill, 2004.
5. Petrochemical Production Processes, N.Naderpour, SBS Publishers, 2009.
6. Petrochemicals, B. K. Bhaskara Rao, Oxford & IBH Publishing, 2002.
7. Chemicals from Petroleum: An Introductory Survey, Waddams, A.L., 4th Edition, Gulf Publishing, 1978.

III Year - II Semester

L	T	P	C
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MASS TRANSFER OPERATIONS-II

Learning Objectives:
Students will be trained/taught in the following topics:

- Equilibrium separations based on liquid-liquid contact along with data analysis from equilibrium diagrams represented in triangular and rectangular coordinates.
- Equilibrium liquid-liquid separation using multistage counter current contactors.
- Different liquid- liquid extraction equipments like continuous contact equipments, agitated extractors, centrifugal extractors along with supercritical fluid extraction and fractional extraction.
- Basic concepts of leaching using single and multistage leaching operations.
- Usage of psychrometric charts and design of humidifiers and cooling towers.
- Mechanism of batch drying and details of batch and continuous drying.
- Basic concepts of adsorption and construction of adsorption isotherms.
- Different types of adsorbers like fixed bed, moving bed and fluidized bed.
- Details of different pressure driven, concentration driven, electro potential driven membrane separation processes and different types synthetic types membranes and modules.

UNIT-I:
Liquid-Liquid Operations: Applications, liquid-liquid equilibrium, equilateral triangular co-ordinates, choice of solvent, stage wise contact, multistage cross-current extraction, Multi stage counter current without reflux-multi stage counter current with reflux,.
Extraction Equipment: Differential (continuous contact) extractors, spray towers, packed towers, mechanically agitated counter-current extractors, centrifugal extractors, dilute solutions, super critical fluid extraction, fractional extraction.

UNIT- II:
Leaching: Fields of applications, preparation of solid for leaching, types of leaching, leaching equilibrium, single stage and multi stage leaching calculations, constant under flow conditions, equipment for leaching operation.
Humidification Operations: Vapor pressure curve, definitions, psychometric charts, enthalpy of gas-vapor mixtures, humidification and dehumidification, operating lines and design of packed humidifiers, dehumidifiers and cooling towers, spray chambers.

UNIT- III:
Drying: Equilibrium, definitions, drying conditions- rate of batch drying under constant drying conditions, mechanisms of batch drying, drying time through circulation drying.
Classification of Drying operations: Batch and continuous drying equipment, material and energy balances of continuous driers, rate of drying for continuous direct heat driers.

UNIT-IV:
Adsorption-I: Adsorption, types of adsorption, nature of adsorbents, adsorption equilibrium, Single gases and vapors: adsorption hysteresis, effect of temperature, heat of adsorption, vapor and gas mixtures- one component adsorbed, effect of change of temperature or pressure.
Liquids: adsorption of solute from dilute solution, the Freundlich equation, adsorption from concentrated solutions, adsorption operations, stage wise operation, application of Freundlich

equation to single and multistage adsorption (cross current & counter current), Langmuir isotherm.

UNIT-V:

Adsorption-II: Adsorption of vapor from a gas, fluidized bed, continuous contact, steady state moving bed adsorbers, unsteady state–fixed bed adsorbers, adsorption wave, elution, adsorption-desorption operations- thermal desorption of gases, activated carbon solvent recovery, pressure swing and vacuum swing adsorption (qualitative treatment), regeneration with purge and desorbent. Ion-Exchange: Principles of ion exchange, techniques and applications, ion-movement theory, ion exclusion.

UNIT-VI:

Membrane Separation Processes: Basic principles of membrane separation, classification of membrane processes – pressure driven, concentration gradient driven, electric potential driven processes – brief introduction on reverse osmosis, nanofiltration, ultrafiltration, microfiltration, pervaporation, dialysis, membrane extraction, electrodialysis. Types of synthetic membranes – microporous, asymmetric, thin-film composite, electrically charged and inorganic membranes. Membrane modules - industrial applications. Brief introduction to cryogenic separations.

Outcomes:

After completing the course the students will be able to:

- Analyse liquid-liquid equilibrium data.
- Design single stage and multi stage liquid extractors.
- Make calculations using psychometric charts for humidification and drying operations.
- Prepare the adsorption isotherm, screen and design adsorption equipment.
- Identify and analyze the membrane separation processes based on the driving force.
- Identify the membranes and design membrane modules for a specific use.

Text Books:

1. Mass transfer operations by R.E. Treybal, 3rd Edition, McGraw Hill, 1980.
2. Unit Operations of Chemical Engineering, W.L. McCabe, J.C. Smith & Peter Harriott, McGraw- ill, 6th Edition, 2001.
3. Membrane Separation Processes, KaushikNath, PHI, 2008

Reference Books:

1. Coulson and Richardson's Chemical engineering, Vol 1,Backhurst, J.R., Harker,J.H.,Richardson, J.F., and Coulson,J.M., Butterworth-Heinemann, 1999.
2. Coulson and Richardson's Chemical engineering, Vol 2, Richardson, J.F. &Harker,J.H. with Backhurst, J.R., Butterworth-Heinemann, 2002.
3. Principles of Mass Transfer and Separation Processes, Binay K. Datta, PHI Learning Private Ltd., 2009.
4. Diffusion: Mass Transfer in Fluid Systems, Cussler, E.L., Cambridge Univ. Press, 1984.
5. Design of Equilibrium Stage Processes, B.D.Smith, McGraw-Hill, 1963.
6. Staged Cascades In Chemical Processing, P.L.T.Brian, Prentice-Hall, 1972.
7. Equilibrium Staged Separations, Phillip C.Wankat, Prentice-Hall PTR, 1988.
8. Equilibrium-Stage Separation Operations in Chemical Engineering, E.J.Henley and J.D.Seader, John Wiley & Sons, 1981.
9 Transport Processes and Unit Operations by Christie J. Geankoplis, 4th Edition, PHI,2009.
10. Separation Processes, C.J. King, 2nd Edition, McGraw- Hill, 1980.

III Year - II Semester

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CHEMICAL REACTION ENGINEERING – I

Learning Objectives:

- To gain an understanding of the definition of reaction rate, the variables affecting the rate of reaction, and the kinetics of homogeneous reactions with respect to concentration dependency and temperature dependency
- To learn about the interpretation of batch reactor data obtained for both constant volume and variable volume batch reactors for determining the kinetics of homogeneous reactions of various types
- To learn the basic concepts of design of ideal reactors in particular batch reactor, plug flow reactor and mixed flow reactor
- To understand the size comparison of single reactors, multiple reactor systems, recycle reactor and autocatalytic reactions
- To gain knowledge on design for reactions in parallel and series reactions carried out in batch, plug flow and mixed flow reactors. Also, to understand the concept of product distribution in parallel and series reactions
- To study the effects of temperature and pressure on reaction kinetics and equilibrium conversion from a thermodynamic point of view
- To understand the design of reactors for non-isothermal, adiabatic and non-adiabatic operations for carrying out single reactions
- To understand how exothermic reactions are carried out in mixed flow reactors as a special case.

UNIT-I:

Overview of chemical reaction engineering: classification of reactions, variables affecting the rate of reaction definition of reaction rate. Kinetics of homogenous reactions-concentration dependent term of rate equation, Temperature dependent term of rate equation, searching for a mechanism, predictability of reaction rate from theory.

UNIT-II:

Interpretation of batch reactor data: constant volume batch reactor:- Analysis of total pressure data obtained in a constant-volume system, the conversion, Integral method of analysis of data– general procedure, irreversible unimolecular type first order reactions, irreversible bimolecular type second order reactions, irreversible trimolecular type third order reactions, empirical reactions of nth order, zero-order reactions, overall order of irreversible reactions from the half-life, fractional life method, irreversible reactions in parallel, homogenous catalyzed reactions, autocatalytic reactions, irreversible reactions in series.

UNIT-III:

Constant volume batch reactor– first order reversible reactions, second order reversible reactions, reversible reactions in general, reactions of shifting order, Differential method of analysis of data.

Varying volume batch reactor: Definition of € and relations of C_A and X_A interms of €, differential method of analysis, integral method of analysis, zero order, first order, second order, nth order reactions, temperature and reaction rate, the search for a rate equation.

UNIT-IV:

Introduction to reactor design: general discussion, symbols and relationship between C_A and X_A; Ideal reactors for a single reaction- Ideal batch reactor, Steady-state mixed flow reactor, Steady-state plug reactors.

Design for single reactions: Size comparison of single reactors, Multiple- reactor systems, Recycle reactor, Autocatalytic reactions.

UNIT-V:

Design for parallel reactions: Introduction to multiple reactions, qualitative discussion about product distribution, quantitative treatment of product distribution and of reactor size. Irreversible first order reactions in series, quantitative discussion about product distribution, quantitative treatment: plug flow or batch reactor, mixed flow reactor, first-order followed by zero-order reaction, zero order followed by first order reaction.

UNIT-VI:

Temperature and Pressure effects: single reactions- heats of reaction from thermodynamics, heats of reaction and temperature, equilibrium constants from thermodynamics, equilibrium conversion, general graphical design procedure, optimum temperature progression, heat effects, adiabatic operations, non-adiabatic operations, comments and extensions. Exothermic reactions in mixed flow reactors-A special problem, multiple reactions.

Outcomes:

After completion of the course, students would be able to:

- Analyze the experimental data obtained from ideal reactors and determine the kinetics of homogeneous reactions of various types for both constant volume and variable volume conditions.
- Design ideal reactors for carrying out homogeneous reactions.
- Compare the performance of various types of reactors including multiple reactor systems and recycle reactors.
- Design suitable reactors for carrying out reactions in parallel and reactions in series.
- Analyze the effects of temperature and pressure on equilibrium constants and equilibrium conversions.
- Design reactors for adiabatic and non-adiabatic operations.

Text Book:

1. Chemical Reaction Engineering, Octave Levenspiel, 3rd Ed. John Wiley & Sons, 1999.

References Books:

1. Elements of Chemical Reaction Engineering, H.S. Fogler, 2nd Edition. PHI, 1992.
2. Chemical Engineering Kinetics, J. M. Smith, 3rd Edition. McGraw- Hill, 1981.
3. Elementary Chemical Reactor Analysis, Aris. R., Prentice-Hall, Englewood Cliffs, 1969.
4. Modeling of Chemical Kinetics and Reactor Design, Coker, A.K., Gulf Professional Publishing, 2001.
5. Fundamentals of Chemical Reaction Engineering, Davis, M.E., and R.J. Davis, McGraw-Hill, 2002.

III Year - II Semester

L	T	P	C
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PROCESS DYNAMICS & CONTROL

Learning objectives:

- To understand and be able to describe quantitatively the dynamic behavior of process systems.
- To learn the fundamental principles of control theory including different types of controllers and control strategies.
- To estimate the stability limits for a system, with or without control.
- To calculate and use the frequency response of a system.
- To describe quantitatively the behavior of simple control systems and to design control systems.
- To get exposure to advanced control strategies.
- To design and tune a control loop and to apply this knowledge in the industry/laboratory.
- To design different types of control valves.

UNIT-I:

Introduction to process dynamics and control, Response of First Order Systems - Physical examples of first order systems

Response of first order systems in series, higher order systems: Second order and transportation lag.

UNIT-II:

Control systems Controllers and final control elements, Block diagram of a Petrochemical rector control system.

UNIT-III:

Closed loop transfer functions, Transient response of simple control systems.

UNIT-IV:

Stability Criterion, Routh Test, Root locus, Transient response from root locus, Application of root locus to control systems Introduction to frequency response, Control systems design by frequency response.

UNIT-V:

Advanced control strategies, Cascade control, Feed forward control, ratio control, Smith predictor, dead time compensation, internal model control.

UNIT -VI:
Controller tuning and process identification. Control valves.

Outcomes:
At the completion of the course students should be able to:

- Describe a process, how it works and what the control objectives are.
- Describe processes with appropriate block diagrams.
- Numerically model a process.
- Identify the stability limits of a system.
- Apply the advance control strategies.
- Tune process controllers.
- Experimentally determine the dynamic behavior of a process.
- Design and operate control valves.

Text Book:

1. Process Systems Analysis and Control by D.R. Coughanowr, 2nd ed. McGraw Hill, 1991

Reference Books:

1. Chemical Process Control, G. Stephanopolous, Prentice Hall, 1984
2. Coulson and Richardson's Chemical Engineering, Volume 3, 3rd Edition: Chemical and Biochemical Reactors and Process Control, Richardson J. F. et.al, Elsevier India, 2006.
3. Automatic Process Control, Donald P. Eckman, John wiley, Reprint 2011.
4. Instrumentation and Control Systems, K.Padmaraju, Y.J. Reddy, McGraw Hill Education, 2016.
5. Process Dynamics and Control, Dale Seaborg, Thomas F. Edgar, Duncan Mellichamp, 2nd edition, Wiley India Pvt. Ltd., 2006.
6. Principles of Process Control. Patranabis, 3rd Edition McGraw-Hill Education Pvt. Ltd., 2012.
7. Industrial Process Control Systems, 2nd Edition, Dale R. Patrick, Stephon, W. Fardo, CRC Press, 2009.
8. Modern Control Systems, 11th Edition Dorf, Pearson, 2008.
9. Modern Control Engineering, Katsuhiko Ogata, 5th Edition, Prentice Hall, 2010.
10. Principles and Practices of Automatic Process Control, Carlos A. Smith, Armando B. Corripio, 3rd International Edition, John Wiley and Sons, 2005.
11. Process control: Concepts, Dynamics & Control, S. K. Single, PHI Learning, 2009.
12. Process control, Peter Harriott, Tata McGraw-Hill 1964. (10th reprint 2008).
13. Computer-Aided Process Control, S. K. Singh, PHE Learning, 2004.
14. Essentials of process control, William L. Luyben, Michacl L. Luyben, McGraw-Hill, 1997.

III Year - II Semester

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ELECTRONICS INSTRUMENTATION
(OPEN ELECTIVE)

Learning Objectives:

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UNIT-I:
Introduction:
(a) **Measurement Errors:** Gross errors and systematic errors, Absolute and relative errors, Accuracy, Precision, Resolution and Significant figures.
(b) **Voltmeters and Multimeters:** Introduction Multi range voltmeter, Extending voltmeter ranges, Loading, AC voltmeter using Rectifiers – Half wave and full wave, Peak responding and True RMS voltmeters.

UNIT-II:
Digital Instruments:
Digital Voltmeters – Introduction, DVM's based on V – T, V – F and Successive approximation principles, Resolution and sensitivity, General specifications, Digital Multi-meters, Digital frequency meters, Digital measurement of time.

UNIT-III:
Oscilloscopes: Introduction, Basic principles, CRT features, Block diagram and working of each block, Typical CRT connections, Dual beam and dual trace CROs, Electronic switch.
Special Oscilloscopes: Delayed time-base oscilloscopes, Analog storage, Sampling and Digital storage oscilloscopes.

UNIT-IV:
Signal Generators: Introduction, Fixed and variable AF oscillator, Standard signal generator, Laboratory type signal generator, AF sine and Square wave generator, Function generator, Square and Pulse generator, Sweep frequency generator, Frequency synthesizer.

UNIT-V:
Measurement of resistance, inductance and capacitance: Whetstone's bridge, Kelvin Bridge; AC bridges, Capacitance Comparison Bridge, Maxwell's bridge, Wein's bridge, Wagner's earth connection

UNIT-VI:
Transducers & Miscellaneous: Introduction, Electrical transducers, Selecting a transducer, Resistive transducer, Resistive position transducer, Strain gauges, Resistance thermometer, Thermistor, Inductive transducer, Differential output transducers, LVDT,Piezoelectric transducer, Photoelectric transducer, Photovoltaic transducer, Semiconductor photo devices, Temperature transducers-RTD, Thermocouple.
Display devices: Digital display system, classification of display, Display devices, LEDs, LCD displays.Bolometer and RF power measurement using Bolometer. Introduction to Signal conditioning.

Outcomes:

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Text Books:

1. Electronic Instrumentation, H. S. Kalsi, TMH, 2004.
2. Electronic Instrumentation and Measurements, David A Bell, PHI / Pearson Education, 2006.

Reference Books:

1. Principles of measurement systems, John P. Beately, 3rd Edition, Pearson Education, 2000.
2. Modern electronic instrumentation and measuring techniques, Cooper D & A D Helfrick, PHI, 1998.
3. Electronic and Electrical measurements and Instrumentation, J. B. Gupta, S. K. Kataria & Sons, Delhi.
4. Electronics & electrical measurements, A K Sawhney, Dhanpat Rai & sons, 9th edition.

III Year - II Semester

L	T	P	C
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BIG DATA ANALYTICS
OPEN ELECTIVE

Learning Objectives:

- Optimize business decisions and create competitive advantage with Big Data analytics
- Introducing Java concepts required for developing map reduce programs
- Derive business benefit from unstructured data
- Imparting the architectural concepts of Hadoop and introducing map reduce paradigm
- To introduce programming tools PIG & HIVE in Hadoop echo system.

UNIT-I:
Data structures in Java: Linked List, Stacks, Queues, Sets, Maps; Generics: Generic classes and Type parameters, Implementing Generic Types, Generic Methods, Wrapper Classes, Concept of Serialization.

UNIT-II:
Working with Big Data: Google File System, Hadoop Distributed File System (HDFS) – Building blocks of Hadoop (Namenode, Datanode, Secondary Namenode, JobTracker, TaskTracker), Introducing and Configuring Hadoop cluster (Local, Pseudo-distributed mode, Fully Distributed mode), Configuring XML files.

UNIT-III:
Writing MapReduce Programs: A Weather Dataset, Understanding Hadoop API for MapReduce Framework (Old and New), Basic programs of Hadoop MapReduce: Driver code, Mapper code, Reducer code, RecordReader, Combiner, Partitioner.

UNIT-IV:
Hadoop I/O: The Writable Interface, WritableComparable and comparators, Writable Classes: Writable wrappers for Java primitives, Text, BytesWritable, NullWritable, ObjectWritable and GenericWritable, Writable collections, Implementing a Custom Writable: Implementing a RawComparator for speed, Custom comparators.

UNIT-V:
Pig: Hadoop Programming Made Easier
Admiring the Pig Architecture, Going with the Pig Latin Application Flow, Working through the ABCs of Pig Latin, Evaluating Local and Distributed Modes of Running Pig Scripts, Checking out the Pig Script Interfaces, Scripting with Pig Latin.

UNIT-VI:
Applying Structure to Hadoop Data with Hive:
Saying Hello to Hive, Seeing How the Hive is Put Together, Getting Started with Apache Hive, Examining the Hive Clients, Working with Hive Data Types, Creating and Managing Databases and Tables, Seeing How the Hive Data Manipulation Language Works, Querying and Analyzing Data.

Outcomes:

- Preparing for data summarization, query, and analysis.
- Applying data modeling techniques to large data sets
- Creating applications for Big Data analytics
- Building a complete business data analytic solution

Text Books:

1. Big Java 4th Edition, Cay Horstmann, Wiley John Wiley & Sons, INC
2. Hadoop: The Definitive Guide by Tom White, 3rd Edition, O'reilly
3. Hadoop in Action by Chuck Lam, MANNING Publ.
4. Hadoop for Dummies by Dirk deRoos, Paul C.Zikopoulos, Roman B.Melnyk,Bruce Brown, Rafael Coss

Reference Books:

1. Hadoop in Practice by Alex Holmes, MANNING Publ.
2. Hadoop MapReduce Cookbook, Srinath Perera, Thilina Gunarathne

Software Links:

1. Hadoop:http://hadoop.apache.org/
2. Hive: https://cwiki.apache.org/confluence/display/Hive/Home
3. Piglatin: http://pig.apache.org/docs/r0.7.0/tutorial.html

III Year - II Semester

L	T	P	C
4	0	0	3

ALTERNATIVE ENERGY SOURCES FOR AUTOMOBILES (OPEN ELECTIVE)

Learning Objectives: To impart the necessity of finding alternative energy sources for automobiles. To understand merits and demerits, performance characteristics of various sources of fuels and their comparison.

- To introduce the use and the application of different fuel types and characteristics. The student will be able to understand Solar photo-voltaic conversion and working principles.
- To expose the student about energy from bio-mass performance characteristics.
- To expose the students to study and understand basic principles of hydrogen energy and thermo-chemical production.
- To learn various factors to be considered in hydrogen fuel usage, and to study performance. Design and study of future possibilities of electric automobiles.
- To learn various factors to be considered in hydrogen fuel usage, study of performance. Design and study of future possibilities of electric automobiles.
- To study the use of turbines in automobiles and Design of turbochargers for automobiles.

UNIT-I:

Introduction: Need for non-conventional energy sources. Energy alternative: solar, photo-voltaic, Hydrogen, Bio mass. Electrical - their merits and demerits.

Solar photo-voltaic conversion, Collection and storage of solar energy, collection devices, flat plate collectors, concentrating type collectors, principles and working of photo-voltaic Conversion, Applications to automobiles.

UNIT-II:

Energy from Bio mass: Photosynthesis, photosynthetic oxygen production, energy plantation. Bio gas production from organic waste, description and types of Bio gas plants, Application and limitations - Merits and demerits performance characteristics and their comparison.

UNIT-III:

Hydrogen Energy: Properties of Hydrogen, sources of Hydrogen, Thermodynamics of water splitting Production of Hydrogen, Electrolysis of water. Thermal decomposition of water. Thermo-chemical production, Biochemical production.

UNIT-IV:

Hydrogen fuel, Storage and Transportation methods, Applications to engines modifications necessary, precautions and safety measures - Performance characteristics in Engine and their comparison.

Electric Automobiles: Design considerations, limitations. opportunities for improvement Batteries, problems. future possibilities , capacities, types , material requirement.

UNIT-V:
Applicability of electric cars, major parts, battery charging, HVAC, requirements, comparative use of fuel and energy. Availability of energy for recharging. impacts on use of fuel and energy. Impact on urban air quality, impact on price, material requirement Traction motors and types.

UNIT-VI:
Hybrid vehicle, benefits, types of HEVs, hybrid maintenance and service.
Use of turbines in cars, arrangement, control merits and de-merits, Design of turbochargers for automobiles, their usefulness on the performance, use of fuel cells in Automobiles.

Outcomes:

- The students completing the course will be able to understand the ever increasing quality of life. This phenomenon imposes high demand on conventional fossil fuels. Hence search for alternate fuels is a continuous phenomenon.
- The students will have an overview of various alternate fuels along with their merits and limitations.

Text Books :

1. G.D. Rai /Non-conventional sources of energy Khanna Pub.
2. William Hamilton /Electric Automobiles/PHI
3.Erjavec and Arias/ Alternative Fuel Technology /Cengage Learning

Reference Books :

1. S.P. Sukhatme /Solar Energy/ Tata McGraw Hill .
2. S. Rao & B.B. Larulekar /Energy Technology/ Khamma Lab
3. Frank Kreith & Jan F. Krieder/Principles of Solar Engineering/McGraw Hill.
4. J.A. Duffie&W.A. Beckman /Solar Energy -thermal Process/McGrawHil1

III Year - II Semester

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WASTE WATER MANAGEMENT
OPEN ELECTIVE

Learning Objectives:

- Outline planning and the design of waste water collection ,conveyance and treatment systems for a community/town/city
- Provide knowledge of characterization of waste water generated in a community
- Impart understanding of treatment of sewage and the need for its treatment
- Summarize the appurtenance in sewage systems and their necessity
- Teach planning and design of septic tank and imhoff tank and the disposal of the effluent from these low cost treatment systems
- Effluent disposal method and realize the importance of regulations in the disposal of effluents in rivers

UNIT-I:

Introduction to Sanitation-Systems of sanitation- relative merits and demerits - collection and conveyance of waste water - classification of sewerage systems-Estimation of sewage flow and storm water drainage- fluctuations-types of sewers- Hydraulics of sewers and storm drains-design of sewers- appurtenances in sewerage- cleaning and ventilation of sewers

UNIT-II:

Pumping of wastewater: Pumping stations-location- components- types of pumps and their suitability with regard to wastewaters.

House Plumbing: Systems of plumbing-sanitary fittings and other accessories-one pipe and two pipe systems-Design of building drainage

UNIT-III:

Sewage characteristics-Sampling and analysis of waste water-Physical, chemical and Biological examination-measurement of BOD & COD- BOD equations

Treatment of sewage: Primary treatment- Screens-grit chambers- grease traps- floatation-sedimentation-design of preliminary and primary treatment units.

UNIT-IV:

Secondary treatment: Aerobic and anaerobic treatment process -comparison.

Suspended growth process: Activated sludge process, principles, design and operational problems, modifications of Activated sludge processes, Oxidation ponds, Aerated Lagoons.

Attached Growth process: Trickling Filters-mechanism of impurities removal-classification-design -operation and maintenance problems. RBCs. Fluidized bed reactors

UNIT-V:

Miscellaneous Treatment Methods: Nitrification and Denitrification- Removal of phosphates-UASB- Membrane reactors- Integrated fixed film reactors. Anaerobic Processes: Septic Tanks, Imhoff tanks- working principles and Design-disposal of septic tank effluent-FAB Reactors

UNIT-VI:

Bio-solids (sludge) management: Characteristics- handling and treatment of sludge-thickening-anaerobic digestion of sludge

Disposal of sewage: Methods of disposal- disposal into water bodies- Oxygen sag Curve-Disposal into sea-disposal on land- sewage sickness

Outcomes:

By the end of successful completion of this course, the students will be able to:

- Plan and design the sewerage systems
- Characterization of sewage
- Select the appropriate appurtenances in the sewerage systems
- Select the suitable treatment flow for sewage treatment
- Identify the critical point of pollution in a river for a specific amount of pollutant disposal into the river

Text Book:

1. Waste water Engineering Treatment and Reuse by Metcalf & Eddy, Tata McGraw- Hill edition.
2. Elements of Environmental Engineering by K.N. Duggal, S.Chand & Company Ltd. New Delhi, 2012.
3. Environmental Engineering by Howard S.Peavy , Donald R. Rowe, Teorge George Tchobanoglus- Mc-Graw-Hill Book Company, New Delhi, 1985
4. Wastewater Treatment for pollution control and Reuuse, by soli.J Areivala, sham R Asolekar, Mc-GrawHill, New Delhi; 3rd Edition
5. Industrial water & wastewater management by KVSG MuraliKrishna

Reference Book:

1. Environmental Engineering-II: Sewage disposal and Air pollution Engineering , by Garg, S.K.,: Khanna publishers
2. Sewage treatment and disposal by Dr.P.N.Modi & Sethi.
3. Environmental Engineering, by Ruth F. Weiner and Robin Matthews- 4th Edition Elsevier, 2003
4. Environmental Engineering by D. Srinivasan, PHI Learning private Limited , New Delhi,2011.

III Year - II Semester

L	T	P	C
4	0	0	3

FUNDAMENTALS OF LIQUEFIED NATURAL GAS
(OPEN ELECTIVE)

Learning Objectives:
The course introduces the student different processes, transportation and storageof liquefied Natural gas (LNG). The students will be able to-

- Gain basic knowledge of LNG and its prospective.
- Learn different liquefaction technologies of LNG.
- Gain knowledge on different functional units on receiving terminals
- Study marine transportation of LNG and its re-gasification at the terminals.
- Understand HSE procedures employed in LNG industry.

UNIT-I:
Introduction: Overview of LNG industry: History of LNG industry – Base load LNG – Developing an LNG Project – World and Indian Scenario – Properties of LNG

UNIT-II:
Liquefaction Technologies: Propane precooled mixed refrigerant process – Description of Air products C_3MR LNG process – Liquefaction – LNG flash and storage.
Cascade process: Description of Conoco-Phillips optimized cascade process – Liquefaction – LNG flash and storage.

Other Liquefaction Processes: Description of Linde MFC LNG process- Precooling and Liquefied Petroleum Gas (LPG) recovery – Liquefaction and subcooling- Trends in LNG train capacity – strategy for grassroots plant- offshore LNG production.

UNIT-III:
Supporting Functional Units in LNG Plants: Gas pretreatment: Slug catcher – NGL stabilization column – Acid gas removal unit – Molecular sieve dehydrating unit – Mercury and sulfur removal unit – NGL recovery – Nitrogen rejection – Helium recovery.

UNIT-IV:
Receiving Terminals: Receiving terminals in India – Main components and description of marine facilities – storage capacity – Process descriptions.
Integration with adjacent facilities – Gas inter changeability – Nitrogen injection – Extraction of C_{2+} components.

UNIT-V:
LNG Shipping Industry & Major Equipment in LNG Industry:
LNG Shipping Industry: LNG fleet – Types of LNG ships – Moss – Membrane – prismatic; Cargo measurement and calculations.
Major equipment in LNG industry – Cryogenic heat exchangers: Spiral – Wound heat exchangers – Plate-fin heat exchangers – Cold boxes; Centrifugal compressors – Axial compressors – Reciprocating compressers.

LNG pumps and liquid expanders – Loading Arms and gas turbines.

UNIT-VI:

Vaporizers: Submerged combustion vaporizers- Open rack vaporizers – Shell and tube vaporizers: direct heating with seawater, and indirect heating with seawater.

Ambient air vaporizers: Direct heating with ambient air – Indirect heating with ambient air.

LNG tanks.

Safety, Security and Environmental Issues:

Safety design of LNG facilities – Security issues for the LNG industry – Environmental issues – Risk based analysis of an LNG plant.

Outcomes: Upon successful completion of this course, the students will be able to

- Screen and apply latest technologies and techniques in the LNG industry.
- Carry out preliminary design of LNG heat exchangers and vaporizers.
- Carry out preliminary design and operate a plant for liquefaction of natural gas safely.
- Plan and carry out preliminary design and operate re-gasification terminals.

Text Book:

1. LNG: Basics of Liquified Natural Gas, I Edition, Stanley Huang, Hwa Chiu and Doug Elliot, PETEX, 2007
   https://ceonline.austin.utexas.edu/petexonline/file.php/1/ebook_demos/lng/HTML/index.html

Reference Books:

1. Marine Transportation of LNG (Liquefied) and related products, Richard G. Wooler, Gornell Marine Press, 1975.
2. Marine Transportation of Liquefied Natural Gas, Robert P Curt, Timothy D. Delaney, National Maritime Research Centre, 1973.
3. Natural Gas by Sea: The Development of a New Technology, Roger Rooks, Wither by, 1993.
4. Natural Gas: Production, Processing and Transport, Alexandre Rojey, Editions OPHRYS, 1997.
5. LNG: A Nontechnical Guide, Michael D'Tusiani, Gordon Shearer, PennWell Books, 2007.
6. Natural Gas Transportation, Storage and Use, Mark Fennell , Amazon Digital Services, Inc., 2011.
7. Liquefied Natural Gas, Walter Lowenstein Lom, Wiley 1974.
8. Liquefied Natural Gas, C. H. Gatton, Noyes, 1967.
9. Liquefied Gas Handling Principles on Ships and in Terminals, 3rd Edition, McGuire and White, Witherby Publishers, 2000.
10. Liquefied Natural Gas Technology, John McDermott, Noyes Data Corporation, 1973.

III Year - II Semester

L	T	P	C
4	0	0	3

COMPUTATIONAL FLUID DYNAMICS
(OPEN ELECTIVE)

Learning Objectives:

- Understanding the governing equations of fluid dynamics.
- The difference between conservation and non-conservations form of equations.
- Various methods available for solutions of partial differential equations.
- Use of boundary conditions for solutions of these equations.
- Understanding the role of finite elemental methods for solutions of fluid dynamics problems.
- Understanding the concept of stability.
- Understanding various softwares available for solving fluid dynamics problems.

UNIT-I:
Basic Philosophy of CFD: Governing equations of Fluid Dynamics, Incompressible Inviscid flows sources and vortex panel methods.

UNIT-II:
Mathematical properties of fluid dynamic equations – Discretization of partial differential equations, Courant-Friedrichs-Lewy (CFL) condition: Stabiloity of numerical solution of simple convection equation for one-dimentional flows, Introduction to Finite-Difference and Finite-Volume methods.

UNIT-III:
Transformations and Grids, Explicit finite Differential methods – Some selected applications to inviscid and viscous flows.

UNIT-IV:
Boundary layer equations and methods of solution

UNIT-V:
Implicit time dependent methods for inviscid and viscous compressible flows, with a discussion of the concept of Numerical dissipation

UNIT-VI:
Introduction to finite element methods in computational fluid dynamics – Weighted residual formulation – Weak formulation – Piece wise defined shape functions – Numerical integration – Partial construction of a weak formulation – Examples.

Outcomes: The students will be able to

- Use of finite difference method and finite volume method for practical applications.
- Use of software tools available for arriving at some problems of interest.
- Distinguish different flow regimes while performing numerical analysis.
- Use of source and vortex panel method of inviscid flow to practical problems.
- Arrive at pressure and flow distribution for complicated flow systems.

Text Books:

1. Computational Fluid Dynamics: An Introduction, John F. Wendt, John David Anderson, Springer, 2009.
2. Computational Fluid Dynamics – The Basics with Applications (1-5 Chapters), John D.Anderson, Jr.McGraw – Hill, Inc., New York, 1995.

Reference Books:

1. Numerical Heat Transfer and Fluid flow, S.V. Patankar, Taylor & Francis, 1980.
2. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Versteeg, H.K., and Malalasekera W., 2nd Edition, Prentice Hall, 2007.
3. Muralidhar, K. Sundarajan, T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 1995.

III Year - II Semester

L	T	P	C
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MASS TRANSFER OPERATIONS LAB-II

Learning Objectives:

The student will be able to learn to:

- Understand the basic concepts of Liquid-Liquid equilibrium, Drying, Adsorption.
- Acquaint with the experimental procedures for the bimodal solubility curve, adsorption isotherms and drying rate curves
- Gain experience in the operations of different equipment adapted to humidification, drying, membrane separation processes.
- Estimate mass transfer coefficient for wetted wall tower
- Understand basic principles of membrane separation process like Reverse osmosis and ultra-filtrations.

Experiments:

1. Liquid-Liquid equilibria
2. Binodal solubility curve
3. Batch drying
4. Continuous drying
5. Solid-liquid extraction(Leaching operation)
6. Single stage adsorption
7. Reverse Osmosis
8. Ultra Filtration

Outcomes:

The students will be able to:

- Conduct experiments; analyze and interpret data related to mass transfer.
- Visualize and understand mass transfer operations.
- Work in teams accommodating the contributions of team members having a variety of skills and perspectives.
- Identify, formulate and solve mass transfer problems.
- Attain proficiency in written, graphical and communications.
- Use techniques, skills and modern engineering tools necessary for engineering practice.

III Year - II Semester

L	T	P	C
0	0	3	2

INSTRUMENTATION, PROCESS DYNAMICS & CONTROL LAB

Learning Objectives:

- To calibrate and determine the time lag of various first and second order instruments.
- To determine the response in single and two capacity systems with and with-out interaction.
- To understand the advanced control methods used for complex processes in the industries. Different experiments like Flow, level and cascade control can be configured and studied.
- To study the open loop (Manual control) and the on/off controller, Proportional controller, PI controller, PD controller, PID controller, Tuning of controller (Open loop and close loop methods), and to study the stability of the system (Bode plot).
- To understand the control valve operation and its flow characteristics.
- To determine the damping coefficient and response of U-tube manometer.

Experiments:

1. Calibration and determination of time lag of various first and second order instruments.
   Major equipment - First order instrument like Mercury-in-Glass thermometer and overall second order instrument like Mercury-in-Glass thermometer in a thermal well.
2. Experiments with single and two capacity systems with and without interaction.
   Major equipment- Single tank system, Two-tank systems (Interacting and Non-Interacting).
3. Level control trainer
   Major equipment - Level control trainer set up with computer.
4. Temperature control trainer
   Major equipment -Temperature control trainer with computer.
5. Cascade control
   Major equipment -Cascade control apparatus with computer.
6. Experiments on proportional, reset, rate mode of control etc.
   Major equipment – PID control apparatus
7. Control valve characteristics
   Major equipment – Control valve set up.
8. Estimation of damping coefficient for U-tube manometer
   Major equipment - U-tube manometer.

Outcomes:

The student will be able to

- Estimate the dynamic characteristics of first and second order systems.
- Apply the advanced control methods used for complex processes in the industries.
- Screen and suggest controllers like On/Off, P, PI, PD and PID for process systems.
- Identify the stability of the system.

III Year - II Semester

L	T	P	C
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CHEMICAL REACTION ENGINEERING LAB

Learning Objectives:

- To determine the order of reaction and rate constant using batch reactor, CSTR, and PFR and analyze the data by differential and integral methods.
- To determine the activation energy and specific reaction rate constant of a reaction of a known order using a batch reactor.
- To determine the rate constant and to study the effect of residence time on conversion in CSTR and PFR.
- To compare the experimental and theoretical values of space time and volumes of reactors for CSTRs in series.
- To determine the RTD and dispersion number for packed bed and tubular reactors using tracer technique.

Experiments:

1. Determination of the order of a reaction using a batch reactor and analyzing the data by (a) differential method (b) integral method.
2. Determination of the activation energy of a reaction in a batch reactor.
3. To determine the effect of residence time on conversion and to determine the rate constant in a CSTR.
4. To determine the specific reaction rate constant of a reaction of a known order in batch reactor.
5. To determine the order of the reaction and the rate constant in a tubular reactor.
6. CSTRs in series- comparison of experimental and theoretical values of space times and volumes of reactors.
7. Mass transfer with chemical reaction (solid-liquid system) –determination of mass transfer coefficient.
8. Axial mixing in a packed bed. Determination of RTD and dispersion number for a packed-bed and tubular reactors using tracer technique.

Outcomes: The students will be able to:

- Design experiments for the determination of the order of the reaction and reaction rate constant for new reaction systems by using batch, CSTR and PFR.
- Analyze and interpret given reaction rate data using various methods.
- Calculate the effect of flow rate, concentration of reactants on conversion in reactors (CSTR/PFR) in series.
- Compare the effect of residence time on conversion for CSTR and PFR.
- Use the experimental kinetic data for re-actor design.

III Year - II Semester

L	T	P	C
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SUMMER INTERNSHIP (4-6 WEEKS)

Learning Objectives: The main objective of the internship is to gain up-to-date, practical experience in the real-working situation, in contrast to information gained during studies concerning mainly theoretical background of petrochemical and chemical engineering.

The students are guided (through the Industry representative) to learn the following aspects:

- Application of the engineering skills, learned in class room, in real world.
- Working as a team to deliver the results along with senior engineering professionals, technicians, managers etc.
- Working safely in industrial environment.
- Result oriented approach in plant operation, troubleshooting and engineering work.
- Present and / or report the work / project outcomes to various disciplines, departments & interest groups with confidence.

Every Student should undergo summer training (summer internship program) in a petroleum refinery/petrochemical complex/ fertilizer industry/ chemical processing industry for 4-6 weeks and submit a report.

Outcomes: The students shall be able to carry out the following tasks independently:

- Work safely in Industrial environment.
- Work with various interest groups, disciplines, professionals, managers, technicians etc.
- Polish the engineering skills by applying the knowledge in day-to-day operations, trouble-shooting and minor-modifications.
- Build relations between University and Industry that will help mutual cooperation over long-term.
- Develop/strengthen the basic skills of interviewing, analysis, report writing, communication, decision-making, and problem solving.

III Year - II Semester

L	T	P	C
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(MC)
MINI PROJECT-II

Learning Objectives:

- To develop innovative and original ideas
- To promote team work

Three / four member teams will be formed to carry out the mini project which is a mandatory courses. Under the guidance of an instructor / faculty each team is given a project in the following subjects at the beginning of II Semester of III year of the 4 – year B. Tech. Program.

Mass Transfer Operations, Chemical Reaction Engineering, Petroleum Refinery Engineering, Petrochemical Engineering and Waste Water Treatment.

The project involves process and mechanical design calculations an equipment / process/system and constructing a working model based on the above calculations. Finally a report will be submitted in a standard format along with the model. The model and report will be assessed by the concerned instructor / faculty for the completion of the mini project –II

Outcomes:

After successful completion of the mini project, students will be able to

- Practice acquired knowledge within the chosen area of technology for project development.
- Identify, discuss and justify the technical aspects of the chosen project with a comprehensive and systematic approach.
- Work as an individual or in a team in development of technical projects.
- Communicate and report effectively project related activities and findings.

IV Year - I Semester

L	T	P	C
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TRANSPORT PHENOMENA

Learning Objectives:

The students will be able to learn:

- The estimation of transport properties like mass diffusivity, thermal conductivity and viscosity.
- To identify and solve various momentum transport problems based on shell momentum balance approach.
- To identify and solve various heat transport problems based on shell energy balance approach.
- Concepts of concentration distribution in solids and in laminar flow based on shell mass balance approach.
- The derivation of the equation of continuity & equation of motion in Cartesian coordinates and curvilinear coordinates.
- The development of unsteady state velocity, temperature and concentration profiles for laminar flow conditions.
- Basic concepts of turbulent flow transport.

UNIT-I:

Viscosity and the mechanisms of momentum transfer: Newton's law of viscosity (molecular momentum transport), generalization of Newton's law of viscosity, pressure and temperature dependence of viscosity, molecular theory of the viscosity of gases at low density, molecular theory of the viscosity of liquids.

Thermal conductivity and the mechanisms of energy transport: Fourier's law of heat conduction (molecular energy transport), temperature and pressure dependence of thermal conductivity, and theory of thermal conductivity of gases at low density.

Diffusivity and the mechanisms of mass transport: Fick's law of binary diffusion (molecular mass transport), temperature and pressure dependence of diffusivities, theory of diffusion in gases at low density. Momentum-Heat-Mass transfer analogies.

UNIT-II:

Shell momentum balances and velocity distributions in laminar flow: shell momentum balances and boundary conditions, flow of a falling film, flow through a circular tube, flow through annulus, flow of two adjacent immiscible fluids, creeping flow around a sphere.

UNIT-III:

Shell energy balances and temperature distributions in solids and laminar flow: shell energy balances; boundary conditions, heat conduction with an electrical heat source, heat conduction with a nuclear heat source, heat conduction with a viscous heat source, heat conduction with a Petrochemical heat source, heat conduction through composite walls, heat conduction in a cooling fin, forced convection, free convection.

UNIT-IV:

Concentration distributions in solids and laminar flow: shell mass balances; boundary conditions, diffusion through a stagnant gas film, diffusion with a heterogeneous Petrochemical reaction, diffusion with a homogeneous Petrochemical reaction, diffusion into a falling liquid film (gas absorption), diffusion into a falling liquid film (solid dissolution), diffusion and Petrochemical reaction inside a porous catalyst.

UNIT-V:

The equations of change: Derivation of the equation of continuity in Rectangular and Polar coordinates, the equation of motion, the equation of energy, the equation of continuity of a component in multi component mixture (in rectangular coordinates only), the equations of change in terms of the substantial derivative.

Use of equations of changes to solve one dimensional steady state problems of momentum, heat and component transfer

UNIT –VI:

Unsteady state one-dimensional transport of momentum, heat and mass transfer.

Introduction to Turbulent transport, Time smoothing of equations of change, Models for turbulent flux (explanation of equations only).

Outcomes:

After completion the course, the students will be able to:

- Predict diffusivity, thermal conductivity and viscosity at low and high pressure.
- Derive momentum flux and velocity distribution for typical geometries.
- Derive heat flux and temperature distribution for typical geometries.
- Derive mass flux and concentration distribution for typical geometries.
- Derive unsteady state velocity profile, temperature profile and concentration profile.
- Derive equation of change for turbulent transport.
- Analyze the momentum, heat and transport problems involved in process equipment.

Text Books:

1. Transport Phenomena by Bird R.B., Stewart W.C., Lightfoot F.N., 2nd ed. John Wiley, 1960.

Reference Books:

1. Transport Processes: Momentum, Heat and Mass, C. J. Geankoplis, PHI, Allyn and Bacon Inc., 2nd Revised Edition, 1983.
2. Transport Phenomena for Engineers by L. Theodore, International text Book Company, 1971.
3. Transport Phenomena- A Unified Approach, Robert S. Brodkey, Harry C. Hershay, McGraw-Hill International Edition, 1988.
4. Transport Phenomena and Unit Operations-A combined Approach, Richard G. Griskey, John Wiley, 2002.
5. Mass Transport Phenomena, Christie J. Geankoplis, Ohio State Univ Bookstore, 1984.
6. Modeling in Transport Phenomena: A Conceptual Approach, Ismail Tosun, Elsevier, 2002.

IV Year - I Semester

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PLANT DESIGN FOR CHEMICAL ENGINEERS

Learning Objectives:

- To get an overview of plant design and to study the general design considerations
- To understand the development of design database-process creation, process design, process flow diagrams, piping & instrument diagrams.
- To learn the general procedure for flow sheet synthesis and development.
- To understand the basic concepts of materials handling equipment and design.
- To learn the basic theory of heat transfer in heat exchangers and design of heat exchangers.
- To understand the selection of suitable separation process.
- To learn about reactor design procedure and selection of reactor and catalysts.

UNIT-I:

Overview of plant design: General overall design considerations-Process design development-Flow sheet development-Computer aided design-Cost estimation

General design considerations: Environmental protection-Plant location-Plant layout-Plant operation & control.

UNIT-II:

Development of design: Development of design database-Process creation-Process design-Process flow diagrams-Process design-Piping & instrument diagrams.

Flow sheet synthesis and development: General procedure-Process information-input/output structure-Function diagrams-Operations diagrams-Process flow sheet - Algorithmic flow sheet generation.

UNIT-III:

Materials-handling equipment & design: Basic concepts-Piping in fluid transports processes-Pumping of fluids-Compression and expansion of fluids-Compression and expansion of fluids-Agitations and mixing of fluids-Flow measurement- Storage & containment of fluids-Transport of solids-handling of solids.

UNIT-IV:

Heat transfer equipment design: Basic theory of heat transfer in exchangers-Determination of heat transfer coefficients and pressure drops-Selection of heat exchanger type-Design of key heat exchanger types-Optimum design of heat exchangers. General methods for design of exchangers

UNIT-V:

Separation equipment design: Selection/Guidelines for suitable separation processes-Equipment for Distillation, Absorption, Stripping, Extraction, Adsorption and filtration.

UNIT-VI:

Reactor equipment design: Reactor principles, Devalopment of reactor rate exoressions, reaction, reactor performance and catalyst equipment-Selection of catalysts-Types of reactors-Selection of reactors-Design of reactor systems-Procedure for reactor design.

Outcomes: At the end of the course, the students will

- Be thorough in the basic principles of plant design and the general design considerations.
- Carry out process design, Develop flow diagrams, piping and instrumentation diagrams, including flow sheet synthesis and development.
- Be able to design equipment pertaining to materials handling, heat transfer, separation processes, and reactors, both catalytic and non-catalytic.

Text Book:

1. Plant Design & Economics for Chemical Engineers, Max Peteres, Klaus D. Timmerhaus, Ronald West, 5th Edition, Tata McGraw-Hill, 2011.

Reference Books:

1. Chemical Engineering Design, R.Sinnot and Gavin Towler, 5th Edition, Butterworth-Heinmann, 2009.
2. Applied Process Design for Chemical & Petro Chemical Plants, E.E Ludwizg, Vol-1,2 & 3, Gulf professional publishing, 3rd Edition, Elsevzier,2001.
3. Chemical Process Equipment Selection & Design, J.R. Couper, W.R.Penny, J.R. Fair, & S. M. Walas, Revised 2nd Edition, Butterworth-Heinemann, 2010.
4. Introduction to Process Engineering and Design, S.B.Thakore and B.I.Bhatt, Tata McGraw-Hill, 2007.
5. Chemical Processing Engineering: Design & Economics, H.Silla, Marcel Dekkar, Inc., 2003.
6. A Guide to Chemical Engineering Process Design & Economics, Gael D.Ulrich, Process Publishing, 1984.
7. Process Engineering and Design Using Visual Basic, Arun Datta, CRC Press, 2008.

IV Year - I Semester

L	T	P	C
4	0	0	3

CHEMICAL REACTION ENGINEERING – II

Learning Objectives:

- To understand the basics of non-ideal flow and the concepts of RTD and conversion in non-ideal flow
- To learn the basics of diagnosing reactor ills
- To get acquainted with the dispersion model, the tanks-in-series model and the convection model for laminar flow and their applications in petrochemical reactions and conversions
- To understand the effects of earliness of mixing, segregation and RTD on conversions for a self-mixing fluid and mixing of two immiscible fluids
- To gain an overview of catalysis, catalysts, catalytic reaction mechanisms and rate limiting step
- To understand the basic concepts of heterogeneous reactions and to study the effect of mass and heat transfer resistance on the overall rate for reactions with porous catalyst particles
- To learn the experimental methods for finding rates in solid-catalyzed reactions
- To gain an insight into deactivating catalysts, mechanism of deactivation, rate and performance equations involving deactivation
- To understand the kinetics of fluid-fluid reactions and fluid-particles
- To study the shrinking core model for spherical particles of unchanging and changing sizes
- To learn about determining the rate controlling step in non-catalytic fluid particle reactions

UNIT-I:

Basics of non-ideal flow: E, the age distribution of fluid, the RTD, conversion in non-ideal flow reactors, diagonizing reactors ills (qualitative discussion only).

UNIT-II:

The dispersion model- axial dispersion, correlations for axial dispersion, Petrochemical reaction and dispersion.

The tanks in series model- pulse response experiments and the RTD, Petrochemical conversion.

The convection model for laminar flow- the convective model and its RTD, Petrochemical conversion in laminar flow reactors.

UNIT-III:

Earliness of mixing, segregation and RTD- self-mixing of a single fluid, mixing of two miscible fluids.

Catalysis and catalytic reactors- catalysts, steps in a catalytic reactions, synthesizing a rate law, mechanism and rate limiting step. (From chapter 6, Fogler).

UNIT-IV:

Heterogeneous reactions I- introduction.Solid catalyzed reaction-I**:** pore diffusion resistance combined with surface kinetics, porous catalyst particles, heat effects during reaction, performance equations for reactors containing porous catalyst particles.

UNIT-V:

Solid catalyzed reactions-II: Experimental methods for finding rates.Catalyst deactivation kinetics, the rate and performance equations.

UNIT-VI:

Fluid-fluid reactions: kinetics- the rate equation.

Fluid-particle reactions: kinetics- selection of a model, shrinking core model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles, extensions, determination of rate controlling step.

Outcomes:

A student on completion of the course would be able to:

- Carry out RTD studies on non-ideal flow reactors and determine the conversions obtained.
- Fit the experimental data to suitable RTD model like dispersion model, tanks-in-series model and the convection model and to predict the conversions from these models.
- Predict the effect of earliness of mixing, segregation and RTD on conversion.
- Determine the kinetics of solid catalyzed reactions, fluid-fluid and fluid-particle reactions.
- Carry out experiments for determining the rates of solid-catalyzed reactions.
- Determine the rate of deactivation in solid-catalyzed reactions.
- Determine the rate controlling step in fluid-particle reactions.

Text Book:

1. Chemical Reaction Engineering by Octave Levenspiel 3rd ed. Wiley Eastern Ltd.
2. Elements of Chemical Reaction Engineering, H.S. Fogler, 2nd Edition. PHI, 1992.

Reference Books:

1. Chemical Engineering Kinetics, J. M. Smith, 3rd Edition. McGraw- Hill, 1981.
3. Elementary Chemical Reactor Analysis, Aris. R., Prentice-Hall, Englewood Cliffs, 1969.
4. Modeling of Chemical Kinetics and Reactor Design, Coker, A.K., Gulf Professional Publishing, 2001.
5. Fundamentals of Chemical Reaction Engineering, Davis, M.E., and R.J. Davis, McGraw-Hill, 2002.
6. Chemical Reactor Theory: An Introduction, Denbigh K.G., and J.C.R. Turner, 3rd Ed., Cambridge University Press, 1984.
7. Chemical Reactor Analysis and Design, Froment, G.B., and K.B. Bischoff, 2nd Ed., Wiley, 1990.
8. An Introduction to Chemical Engineering Kinetics and Reactor Design, C.G. Hill Jr., John Wiley, 1977.
9. Chemical Reaction Engineering: A First Course, Metcalfe, I.S., Oxford University Press, 1997.
10. Chemical Reaction Engineering and Kinetics, Missen, R.W., C.A.Mims and B.A. Saville, Wiley, 1999.
11. The Engineering of Chemical Reactions, Schmidt, L.D., Oxford University Press, New York 1998.
12. Chemical reactor design, Peter Harriott, Marcel Dekkar, 2002.
13. Reaction Kinetics for Chemical Engineers, Stanley M.Walas. Uni Publishers, 1989.

IV Year - I Semester

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PROCESS MODELLING AND SIMULATION

Learning Objectives:

- Understand various aspects and classification associated to mathematical models in process engineering
- Learn the art of developing process models for fluid flow operations, heat transfer operations, mass transfer operations and reaction engineering.
- Deeper understanding of process plant simulation models with special reference to modular and equation oriented solving approaches and solution methodologies.
- Realize industrial applications of process modelling and simulation in sectors such as biomass pyrolysis, refinery engineering, and petrochemical engineering.

UNIT-I:

Introduction: Definitions and targets associated to Process Modelling, Synthesis, Simulation and Analysis – Process Plant Simulation.

Modelling Aspects: Deterministic Vs Stochastic Processes - Physical Modelling – Mathematical Modelling – Chemical Systems Modelling – Controlled System – Principles of Similarity

UNIT-II:

Classification of Mathematical Modelling: Independent and dependent variables and parameters – Classification based on variation of independent variables – Classification based on the state of the process – Classification based on the type of the process – Boundary Conditions – Black Box principle – Artificial Neural Networks.

UNIT-III:

Models in Fluid-flow operations: The continuity equation – Flow through a packed bed column – Laminar flow in a narrow slit – Flow of film on the outside of a circular tube – Choice of coordinate systems for the falling film problem – Annular flow with inner cylinder moving axially – Flow between coaxial cylinders and concentric spheres – Creeping flow between two concentric spheres – Parallel-disc viscometer – Momentum fluxes for creeping flow into a slot.

Models in heat transfer operations: Steady state heat conduction through a hollow cylindrical pipe – Unsteady state steam heating of a liquid – Unsteady state heat loss through a maturing tank – Counter-current cooling of tanks – Heat transfer through extended surfaces – Temperature distribution in a transverse cooling fin of triangular cross section – Unsteady-state heat transfer in a tubular gas preheater – Heat loss through pipe flanges – Heat transfer in a thermometer system – Unsteady state heat transfer by conduction.

UNIT-IV:

Models in Mass-transfer Operations: State single stage solvent extraction – Steady state two stage solvent extraction – Steady state two stage cross current solvent extraction – Unsteady state single stage solvent extraction – Unsteady state mass balance in a stirred tank – Unsteady state mass balance in a mixing tank – Unsteady state mass transfer (Fick's second law of diffusion) – Steady state N countercurrent solvent extraction – Multistage gas absorption (Kremser-Brown Equation) - Multistage distillation.

Models in reaction engineering: Chemical reaction with diffusion in a tubular reactor – chemical reaction with heat transfer in a packed bed reactor – Gas absorption accompanied by chemical reaction.

UNIT-V:

Modular approaches and equation solving approach: Modular approaches to process simulation – The equation solving approach.

Decomposition of Networks: Tearing algorithms – Algorithms based on the signal flow graph – Algorithms based on reduced Digraph.

Convergence promotion and physical and thermodynamic properties: Newton's method – Direct substitution – Wegstein's method – Dominant eigenvalue method – General dominant eigenvalue method – Quasi-Newton Methods – Criterion for accleration – Sources, databanks, Modularity and Routing for Physical and thermodynamic properties estimation.

UNIT-VI:

Specific purpose simulation and dynamic simulation: Auto-thermal ammonia synthesis reactor – Thermal cracking operation – Design of shell and tube heat exchanger – Pyrolysis of Biomass

Introduction to Professional simulation packages for Process Modelling and Simulation: HYSYS/ASPEN/UNISIM Design/CHEMCAD/PRO-II and Fluent/FEMLAB

Outcomes: After completion of the course, the students will be able to

- Analyze a process plant model from various classification perspectives.
- Apply prior knowledge in chemical engineering and mathematics to develop and solve process models in various unit operations such as fluid flow operations, heat transfer operations, mass transfer operations and reaction engineering.
- Apply process plant simulation model solving procedures to achieve solutions for the analysis of process plants.
- Have critical understanding with respect to tear streams for the solution of large process plant simulation models.
- Learn and apply process simulation software for process plant simulation and analysis.

Text book:

1. Process Plant Simulation by B. V. Babu, Oxford University Press, 1st Edition, 2004.

Reference Books:

1. Modelling and Analysis of Chemical Engineering Processes by K. Balu and K. Padmanabhan, I. K. International Pvt Ltd., New Delhi, 2007
2. Chemical Process Modelling and Computer Simulation by Amiya K. Jana, PHI Learning Private Limited, New Delhi, 2011
3. Process Simulation and Control Using ASPEN, PHI Learning Private Limited, New Delhi, 2012
4. Process Modelling, Simulation and Control for Chemical Engineers by W. L. Luyben, McGraw Hill, 2nd Edition, 1999

IV Year - I Semester

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ELECTIVE - I
PETROLEUM PRODUCTION ENGINEERING

Learning Objectives:
The students are expected to get knowledge of

- Fundamental concepts in petroleum production engineering.
- Reservoir fluids, efficient flow to the surface without damaging the reservoir dynamics/drive mechanisms.
- Various surface equipment for process oil and gas after flow from wells.
- Sick well identification and remedial stimulation operations.
- Application of suitable artificial lifts on reservoir energy depletion.
- Crisis management.

UNIT-I:
Petroleum production system- Properties of Oil & Natural gas

UNIT-II:
Reservoir deliverability- Well bore performance –Choke performance.

UNIT-III:
Separation-Design and selection of equipment of well fluids

UNIT-IV:
Artificial lift methods: Sucker rod pumping- Gas lift & other lift systems

UNIT-V:
Production stimulation: Well problem identification- Matrix acidizing- Hydraulic fracturing

UNIT-VI:
Safety & crisis management during Drilling/Production

Outcomes:
After the course, the students will be able to

- Determine the well head pressure, down hole pressure and operating oil/ gas flow rates of the reservoir
- Identify formation damage and find remedial methods to bring the well back into production.
- Screen, design and operate artificial lifts on reservoir pressure depletions.
- Handle in case of any crisis at drilling/production installations.
- Process oil and gas before supply to refinery/consumers.
- Contribute to reservoir management as production engineersto prolong the reservoir life with optimum production.

Text Books:

1. Petroleum Production Engineering: A Computer Assisted Approach, BoyunGuo, William C. Lyons, Ali Ghalambor, Elesevier Science & Technology Books, 2007.
2. Petroleum Production Systems, M.J. Economides, A.Daniel Hill &C.E.Economides, Prentice Hall, 1994.

Reference Books:

1. Production Technology I-II, Institute of Petroleum Engineering, Herriot Watt University.
2. The Technology of Artificial Lift Method, Vol. 1, Brown E., Pennwell Books, 1977.

IV Year - I Semester

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ELECTIVE - I
FLUIDIZATION ENGINEERING

Learning Objectives:
The students will be able to learn:

- Base concepts of fluidization and its advantages and disadvantages.
- Various industrial applications of fluidized bed.
- Different regimes of fluidization and flow maps.
- Geldeart classification of particles.
- Estimation of minimum fluidization velocity.
- Davidson model and K-L model.
- Basic concepts of turbulent and fast fluidized bed.
- Vertical & horizontal movement of solids.
- Estimation of gas interchange coefficients.
- Heat and mass transfer from the bubbling bed model.

UNIT-I:
Introduction: The phenomenon of fluidization-Liquid like behaviour of a fluidized bed-Comparison with other contacting methods-Advantages and disadvantages of fluidized beds.

UNIT-II:
Industrial applications of fluidized beds: Coal gasification-Gasoline from other petroleum fractions; Gasoline from natural and synthesis gases-Heat exchange-Coating of metal objects with plastics-Drying of solids-Synthesis of phthalic anhydride-Acrylonitrile-Polymerization of olefins-FCCU-Fluidized combustion of coal-Incineration of solid waste- Activation of carbon-Gasification of waste- Bio-fluidization.

UNIT-III:
Fluidization and mapping of regimes: Minimum fluidization velocity-Pressure drop vs. Velocity diagram-Effect of temperature and pressure on fluidization-Geldart classification of particles- Terminal velocity of particles- Transport disengaging height-Turbulent fluidization-Pneumatic transport of solids-Fast fluidization-Solid circulation systems- Voidage diagram-Mapping of regimes of fluidization.

UNIT-IV:
Bubbles in dense bed: Single rising bubbles- Davidson model for gas flow at bubbles-Evaluation of models for gas flow at bubbles.
Bubbling fluidized beds: Experimental findings- Estimation of bed Voidages- Physical models: Simple Two phase model; K-L model.

UNIT-V:
High velocity fluidization: Turbulent fluidized bed- Fast fluidization- Pressure drop in turbulent and fast fluidization.
Solids movement, mixing, segregation and staging: Vertical movement of solids-Horizontal movement of solids; Staging of fluidized beds.

UNIT-VI:
Gas dispersion and gas interchange in bubbling beds: Dispersion of gas in beds- Gas interchange between bubble and emulsion- Estimation of gas interchange coefficients.

Particle to gas mass transfer: Experimental Interpolation of mass transfer coefficients- Heat transfer- Experimental heat transfer from the bubbling bed model.

Outcomes:

After completion of the course, the students will be able to:

- Identify the appropriate industrial application of a fluidized bed.
- Determine the flow regimes of fluidization and construct the flow maps.
- Analyze fluidization behavior using Davidson model and K-L model
- Find gas interchange coefficients.
- Evaluate of heat transfer coefficients and mass transfer coefficients using bubbling bed model.
- Determine pressure drop in a turbulent and fast fluidized bed.

Text Books:

1. Fluidization Engineering, Kunii Diazo and Octave Levenspiel, 2nd Edition, John Wiley & Sons Inc, 1991.
2. Fluidized Bed Technology: Principles and Applications, J.R. Howard, Taylor and Francis, 1989.

Reference Books:

1. Fluidization Fundamentals and Application, Howard Littman et al., American Institute of Chemical Engineers, 1970.
2. Handbook of Fluidization and Fluid Particle Systems, Wen-Ching Yang, CRC Press, 2003.

IV Year - I Semester

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ELECTIVE - I
PROCESS INTENSIFICATION

Learning Objectives

- Understand the basic principles and mechanisms adopted in process intensification methodologies
- Understand various principles associated to various unit operations and unit processes
- Study case studies available in petrochemical, fine chemical, pharmaceutical, carbon capture and bioprocess engineering to understand the role of process intensification to improve process performance

UNIT-I:

History of Process Intensification: Rotating boilers – Rotating non-pipe – Separators – Reactors – Rotating heat transfer devices

Overview of Process Intensification: Definition of Process Intensification (PI) – Advantages of PI – Obstacles to PI

UNIT-II:

Mechanisms Involved in Process Intensification: Mechanisms involved in heat transfer intensification – Mechanisms involved in mass transfer intensification – Electrically enhanced process intensification – Microfluidics – Pressure

Compact and Micro-heat exchangers & Process Intensification: Plate, Printed-circuit, Chart-flow, Polymer film, Foam and mesh heat exchangers – Micro-heat exchangers – Small channels – Nanofluids.

UNIT-III:

Reactor Process Intensification: Spinning disc reactors – Oscillatory baffled reactors – Micro-reactors – Field enhanced reactors – Reactive separators – Membrane reactors – Misclleaneous reactor types

UNIT-IV:

Separation process Intensification: Distillation (Dividing wall columns, Compact heat exchanger inside the column, cyclic distillation, Hi Gee) – Centrifuges – Membranes – Drying – Precipitation and Crystallization – Mop fan – Electrolysis

Intensified Mixing: Inline mixers – Spinning disc mixer – Induction heated mixer

UNIT-V:

Process intensification in Petrochemicals: Catalytic plate reactor applicability in refineries – Stripping and gas clean up – Intensified methane reforming – Reactive distillations for methyl and ethyl acetate – Microreactors for methanol production from formaldehyde – Degussa PI route for Hydrogen peroxide production – HEX reactor for olefin hydroformylation – Spinning disc reactors for polymerization – Reactive distillation for Akzo Nobel Chemicals

UNIT-VI:

Process intensification in fine chemicals and pharmaceuticals: Pencillin extraction – Continuous reactor PI by Astra Zeneca – Micro-reactor for barium sulphate production – Spinning disc reactor for barium sulphate production – Spinning disc reactor for producing

drug intermediates – Continuous flow microwave reactor – Ultrasound and intensification of micro-encapsulation – Scaling up coflore flow reactor in chiral amines production

Process intensification in Bioprocessing and Biofuels: Transesterification of vegetable oils – Microreactor for conversion of bio-ethanol to ethylene – Base chemicals produced from biomass

Process intensification for carbon capture: Intensification of post combustion carbon capture processes – Intensification of other carbon capture processes.

Outcomes: After the completion of the course, the students will be able to

- Apply the basic principles and mechanisms that are responsible for process intensification.
- Analyze various modifications to process equipment and designs with which process intensification becomes a reality in unit operations and unit processes.
- Analyze various case studies available in petrochemical, fine chemical, bioprocesses and carbon capture.
- Correlate textbook reported methodologies with Computational Fluid Dynamics and experimental process intensification.

Text books:

1. Process intensification: engineering for efficiency, sustainability and flexibility by D. Reay, C. Ramshaw and A. Harvey, Butterworth-Heinemann, 1st Edition, Burlington, 2008
2. Re-engineering the chemical processing plant: process intensification, A. Stankiewicz and J.A. Moulijn (Editors), Marcel Dekker, New York, 2004.

IV Year - I Semester

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ELECTIVE - I
OPTIMIZATION TECHNIQUES

Learning objectives

- Understand various components of an optimization model to represent real time scenarios in process engineering.
- Classification of process models into multi-variable linear and non-linear programming formulations.
- Understand the basic concepts associated to classical optimization, direct and indirect optimization methods.
- Understand various mathematical methods adopted for the optimization of linear programming, non-linear programming, geometric and integer programming.
- Evaluate the strengths, opportunities and features of various mathematical methods applicable for linear programming, non-linear programming, geometric and integer programming.
- Understand procedures adopted in genetic algorithms in comparison with the classical optimization methods.

UNIT-I:

Introduction to optimization: Introduction-Design vector- Design constraints-Constraint surface- Objective function-Objective function surfaces-Classification of optimization problems-Optimization techniques-Engineering optimization literature-Solution of optimization problems using MATLAB.

Classical optimization techniques: Single-Variable optimization, Multivariable optimization with no constraints-Multivariable optimization with equality constraints-Multivariable optimization with inequality constraints-Convex programming problem.

UNIT-II:

Linear programming:

Simplex method: Applications of linear programming-Standard form of a linear programming problem-Geometry of linear programming problems-Definitions and theorems-Solution of a system of linear Simultaneous equations-Pivotal reduction of a general system of equations-Motivation of the simplex method-Simplex algorithm-Two phases of the simplex method-MATLAB solution of LP problems.

Nonlinear programming-I: One dimensional minimization methods:

Elimination methods: Unrestricted search- Exhaustive search- Dichotomous search-Interval halving method-Fibonacci method-Golden section method-Comparison of elimination methods.

Interpolation methods: Quadratic interpolation method-Cubic interpolation method-Direct root methods-Practical considerations-MATLAB solution of one-dimensional minimization problems.

UNIT-III:

Nonlinear programming-II:

Unconstrained optimization techniques: Classification of unconstrained minimization methods- General approach- Rate of convergence- Scaling of design variables.

Direct search methods: Random search methods- Grid search method- Univariate method-Pattern directions- Powell's method-Simplex method.

Indirect search (descent) methods: Gradient of a function- Steepest descent (Cauchy) method- Conjugate gradient (Fletcher–Reeves) method- Newton's method- Marquardt method- Quasi-Newton methods- Davidon–Fletcher–Powell method- Broyden-Fletcher-Goldfarb-Shanno method- Test functions-MATLAB Solution of unconstrained optimization problems.

UNIT-IV:

Nonlinear programming-III:

Constrained optimization techniques: Characteristics of a constrained problem

Direct methods: Random search methods-Complex method-Sequential linear programming-Basic approach in the methods of feasible directions-Zoutendijk's method of feasible directions-Rosen's gradient projection method-Generalized reduced gradient method-Sequential quadratic programming.

Indirect methods: Transformation techniques-Basic approach of the penalty function method-Interior penalty function method-Convex programming problem, Exterior penalty function method-Extrapolation techniques in the interior penalty function method-Augmented lagrange multiplier method-Checking the convergence of constrained optimization problems-Test problems-MAT LAB solution of constrained optimization problems.

UNIT-V:

Geometric programming: Introduction-Polynomial-Unconstrained minimization problem-Solution of an unconstrained geometric programming program using differential calculus-Solution of an unconstrained geometric programming problem using arithmetic–Geometric inequality.

Dynamic programming: Multistage decision processes-Concept of sub-optimization and principle of optimality-Computational procedure in dynamic programming-Example illustrating the calculus method of solution.

Modern methods of optimization: Genetic, Simulated Annealing, Ant-Colony algorithms.

UNIT-VI:

Applications of Optimization: Fluid Flow and Heat Transfer, Separation Processes, Chemical Reaction Engineering.

Outcomes:

After completing the course, the students will be able to have the following skills:

- Formulate a mathematical model for process engineering scenarios with demarcation of decision variables, dependent variables, objective function, equality and inequality constraints.
- Classification of the formulated mathematical model into either linear or non-linear or geometric or integer programming.
- Application of various mathematical methods for formulated linear/non-linear/geometric/dynamic programming models.
- Identification of most appropriate mathematical method for solving optimization models.
- Application of genetic algorithm for non-linear programming model and evaluate its performance in comparison with any classical deterministic optimization method for the non-linear programming model.

Text Books:

1. Engineering Optimization: Theory and Practice, Singiresu S. Rao, 4th Edition, John Wiley & Sons, 2009.
2. Optimization of Chemical Processes, T. F. Edgar and Himmelblau D, Mc-Graw. Hill,2001.
3. Optimization for Engineering Design: Algorithms and Examples, Kalyanmoy Deb, PHI,2009.

Reference Books:

1. Optimization Concepts and Applications in Engineering, Ashok Belegundu, Tirupathi R. Chandrupatla, Cambridge University Press, 2011.
2. Practical Optimization: Algorithms and Engineering Applications, Andreas Antoniou, Wu-shing Lu, Springer, 2007.

IV Year - I Semester

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ELECTIVE - II
PIPELINE ENGINEERING

Learning Objectives: Imparting knowledge of the following topics:

- Understanding of well fluids for proper designing of flow lines/trunk pipe lines.
- Obtaining the permissions to laying of pipe line as per the State/DGMS regulations.
- Operation and maintenance of gas compressors
- Handling of flammable fluids like gas, oil condensate to check the accident free operation.
- Protection from internal/external corrosion of pipe lines by suitable methods.
- Operations and maintenance of flow lines or trunk pipe lines.

UNIT-I:

Elements of pipeline design: Introduction to pipelines-Fluid properties – Environment - Effects of pressure and temperature - Route selection - standards, codes, regulations and recommended practices - Environmental and hydrological considerations – Economics - Materials / Construction – Operation - Pipeline protection - Pipeline integrity monitoring.

Pipeline route selection, survey and geotechnical guidelines: Introduction - Preliminary route selection - Key factors for route selection - Engineering survey - Legal survey - Construction / As-built survey - Geotechnical design.

Introduction to hydrodynamics around offshore pipelines, including the definition of the different wave theories: current and prediction of the forces acting on an offshore pipeline.

Stress assessment of pipelines, including definition of stress on pipelines and an introduction to fatigue analysis.

UNIT-II:

Natural gas transmission: General flow equation – Steady state - Impact of gas molecular weight and compressibility factor on flow capacity - Flow regimes - Widely used steady-state flow equations – Summary of the impact of different gas and pipeline parameters on the gas flow efficiency – Thermodynamic principles and flow properties of the different flow transported by pipelines -Pressure drop calculation for pipeline in series and parallel – Pipeline gas velocity – Erosional velocity – Optimum pressure drop for design purposes – Pipeline packing – Determining gas leakage using pressure drop method – Wall thickness / pipe grade – Temperature profile – Optimization process – Gas transmission solved problems.

UNIT-III:

Gas compression: Types of compressors – Compressor drivers – Compressor station configuration – Thermodynamics of isothermal and adiabatic gas compression – Temperature change in adiabatic gas compression – Thermodynamics of polytropic gas compression – Gas compressors in series – Centrifugal compressor horsepower – Enthalpy / Entropy charts (Mollier diagram) – Centrifugal compressor performance curve- Reciprocation compressors.

Coolers : Gas coolers – Air-cooled heat exchangers –Heat transfer equations for coolers – Fan air mass flow rate – Required fan power – Gas pressure drop in coolers – Iterative procedure for calculations based on unknown T_2.

UNIT-IV:

Liquid flow and pumps: Fully developed laminar flow in a pipe – Turbulent flow – Centrifugal pumps – Retrofitting for centrifugal pumps (Radial-flow) – Pump station control – Pump station piping design.

Transient flow in liquid and gas pipelines: Purpose of transient analysis – Theoretical fundamentals and transient solution technique – Applications – Computer applications.

UNIT-V:

Pipeline mechanical design: Introduction to material science including the properties of steel and other materials used for pipeline fabrication-Process of pipeline material selection -Codes and standards – Location classification – Pipeline design formulae – Expansion and flexibility – Joint design for pipes of unequal wall thickness – Valve assemblies – Scraper traps – Buoyancy control – Crossings – Depth of cover – Aerial markings – Warning signs - Manufacturing process, including welding standards, procedures and non-destructive testing (NDT) techniques for qualifications

Offshore Pipeline construction: Construction – Commissioning.

- Introduction to different approaches of pipeline design for offshore and onshore
- Introduction to the different pipeline configurations, including pipe-in-pipe, bundles, etc
- Introduction to flexible pipelines – principles and concepts
- Introduction to hydrodynamics around offshore pipelines, including the definition of the different wave theories: current and prediction of the forces acting on an offshore pipeline
- Stress assessment of pipelines, including definition of stress on pipelines and an introduction to fatigue analysis
- Stages of pipeline construction
- Hydro-testing
- Commissioning operations
- Procurement
- Quality assurance
- Methods of offshore pipeline installation

UNIT-VI:

Materials selection: Elements of design – Materials designation standards (suggest following inclusions)

- Introduction to materials : atomic structure, crystal structure, imperfections, diffusion, mechanical properties, dislocations and strengthening mechanisms, phase diagrams, phase transformations, solidification, corrosion. & Introduction to material usage in hydrocarbon pipelines.
- Structural steels - C-Mn ferrite-pearlite structural steels, specifications and influence of composition, heat treatment and microstructure on mechanical properties
- Pipeline Steels - Effect of processing grain refinement, thermomechanical treatment and accelerated cooled steels (TMCP). Effect of composition, inclusions, grain size and production route on mechanical properties
- Corrosion Resistant Materials - Stainless steels - austenitic, ferritic, martensitic and duplex stainless steels - compositions, microstructures, properties. Other corrosion resistant alloys, copper and nickel based alloys, clad material

Pipeline protection, Instrumentation and Pigging: Pipeline coating – Cathodic protection – Cathodic protection calculations for subsea pipelines and structures. – Internal corrosion – Flow meters and their calibration – Sensors – Pigs. Pipeline anomalies and defects- Failure modes and a description of how pipelines fail -Introduction to principles and applications of the in-line inspection techniques and existing tools- Principles and application of NDT techniques used to detect and evaluate pipeline defect and damage-- Introduction to pipeline engineering critical assessment (ECA)

Outcomes: The students will be able to

- Become a specialist in pipeline designing, pipe line maintenance.
- Repair and maintenance of pipeline in short time to avoid production loss.
- Plan for suitable corrosion protection methods to improve the life of the pipeline.
- Be a good public relations officer to deal with public in acquiring the land & also during repair & maintenance operations.

Text Books:

1. Pipeline Design and Construction: A Practical Approach, M. Mahitpour, H. Golshan and M.A. Murray, 2nd Edition, ASME Press, 2007.
2. Pipeline Engineering, Henry Liu, Lewis Publishers (CRC Press), 2003.

Reference Books:

1. Piping Calculation Manual, E. Shashi Menon, McGraw-Hill, 2004.
2. Piping and Pipeline Engineering: Design, Construction, Maintenance Integrity and Repair, George A. Antaki, CRC Press, 2003.
3. Pipeline Planning and Construction Field Manual, E. Shashi Menon, Gulf Professional Publishing, 2011.
4. Pipeline Rules of Thumb Handbook, E. W. McAllister, 7th Edition, 2009.
5. Liquid Pipeline Hydraulics, E. Shashi Menon, Mareel Dekker, Inc., 2004.
   Gas Pipeline Hydraulics, E. Shashi Menon, Taylor & Francis, 2005.

IV Year - I Semester

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ELECTIVE - II
FLUID CATALYTIC CRACKING TECHNOLOGY

Learning Objectives:

- Basic understanding of FCC Technology
- Know-how on Operating & Design parameters of FCC, in particular to Reactor – Regeneration System.
- Role of Catalyst formulations in optimizing FCC operation for different product demand scenarios.
- Explore different Flue Gas control & treatment technologies for meeting environmental regulations.

UNIT-I:

Introduction: Process overview – History- Role in petroleum refining – Process description - commercial FCC Designs.

UNIT-II:

Fundamentals: Reactions- Feed stock and feed stock characterization- Yields and products – Kinetics – Product properties- Catalyst – Heat balances – Mass balances and test runs – Hydrogen balance – Pressure balance.

UNIT-III:

Riser/Reactor design and operations: Feed injection section – Riser – Riser termination- Reactor vessel- Catalyst stripper – Operating considerations.

Regenerator design: Coke combustion – Vessel design – Air distributor- Catalyst distribution – Cyclones–Air blower- carbon burning kinetics- Regenerator heat removal- Air heaters– Operating considerations.

UNIT-IV:

Flue gas systems: Flue gas flows and properties- Flue gas systems- Flue gas control valves- Orifice chamber- Third stage separators- Turbo expanders- Water sprays- Flue gas coolers- Electrostatic precipitators- SO_x removal - NO_X removal – Design and operating considerations.

Cyclones: FCC Cyclones systems- Cyclone design- Cyclone performance- Operating considerations.

UNIT-V:

Fluidization and stand pipe flow: Fluidization fundamentals- Fluidization in FCC in operations- Catalyst densities – Stand pipe - Slide valves.

Product recovery: Reactor transfer line- Main fractionator- Gas recovery unit- Treating- Operating considerations.

UNIT-VI:

Catalyst technology, selection and monitoring: Early catalysts- Catalyst technology- Catalyst manufacture- Catalyst testing and evaluation- Catalyst monitoring- Catalyst additives.

Economics: Role of FCC in Refinery Economics, Economics & technical challenges in switching between Petrochemical / Diesel Centric FCC operations.

Outcomes:

After completion of the course, students will able to apply/ acquire/appreciate:

- Characterization of VGO & Residue Feeds and its influence on FCC design, operation, product yield & quality.
- Technical alternatives available for energy recovery from FCC Flue Gas, cleaning of pollutants such as Particulates, SOx, NOx etc. from FCC Flue Gas.
- Unit Operations involved in recovery of valuable liquid products from FCC Reactor effluent vapor.
- Design of Reaction systems that can withstand high temperature & high erosion environment.
- Catalytic technology that is designed for high temperature, Oxidation / reduction cycles, high activity and selectivity.

Text Book:

1. Fluid Catalytic Cracking Technology and Operation, Joseph W. Wilson, Pennwell Publications Company, 1997.

Reference Book:

1. Fluid Catalytic Cracking Hand Book, Reza Sadeghbeigi, 2nd Edition, Gulf Professional Publishing 2000.

IV Year - I Semester

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ELECTIVE - II
PROCESS INTEGRATION

Learning Objectives:

- Understanding of fundamental concepts and basic objectives of process integration for minimizing raw material utilization, waste generation and utility requirements in process industries.
- Mastering the art of process integration of heat exchange, mass exchange, reactive mass exchange and combined heat and mass exchange networks using graphical, algebraic and mathematical techniques.
- Understanding the basic principles and concepts associated to heat integration and combined heat and power integration.
- Formulating process synthesis problems to target pollution prevention.
- Understanding various applicable case studies to realize the potential of process integration in re-engineering the operational efficiencies and trends in chemical process industries.

UNIT-I:

Introduction: Alternatives for debottlenecking and water reduction in acrylonitrile process – traditional approaches to process development and improvement – Definitions for Process Synthesis, Analysis – Why integration ? – Categories in Process Integration

Overall mass targeting: Targeting for minimal discharge of waste and minimal purchase of utilizes – mass integration strategies to attain targets

UNIT-II:

Graphical techniques for direct recycle strategies: Problem statement – Source-sink mapping diagram and lever rules – Selection of sources, sinks and recycle routes – Direct recycle targets through material recycle pinch diagram – Design rules from the material recycle pinch diagram – multicomponent source-sink mapping diagram.

Graphical approach for the Synthesis of mass exchange networks: Design of individual mass exchangers – Cost of mass exchangers – Problem statement – Mass exchange pinch diagram – Screening of multiple external MSAs and constructing the pinch diagram without process MSA – Wastewater treatment example.

UNIT-III:

Algebraic approach for targeting direct recycle: Problem statement – Algebraic targeting approach and procedure – Case study involving acetic acid usage in vinyl acetate plant.

Algebraic approach to the targeting of mass exchange networks: Composition-interval diagram (CID) – Table of exchangeable loads – Mass exchange cascade diagram – Example of cleaning of aqueous waste.

UNIT-IV:

Heat integration: Synthesis of heat exchanger networks (HEN) – Heat exchange pinch diagram – Minimum utility targeting using algebraic procedure – Case study – Screening of multiple utilities using the Grand Composite representation.

Combined heat and power integration: Heat pumps – Heat Engines – Heat Engines and Thermal Pinch diagram – Heat pumps and thermal pinch diagram – Cogeneration targeting.

UNIT-V:

Overview of Optimization: Mathematical programming – Classification of Optimization problems – Formulation of optimization models – Use of 0-1 Binary variables – Enumerating multiple solutions using integer cuts – Modeling discontinuous functions and what if scenarios using integer variables.

Mathematical approach for direct recycle: Problem statement – Problem representation – Optimization formulation – Interaction between direct recycle and the process

UNIT-VI:

Mathematical techniques for the synthesis of mass and heat exchange networks: Synthesis of HENs – Synthesis of MENs.

Mathematical techniques for mass integration: Source interception – Sink representation – Incorporation of process model in mass integration.

Outcomes: After completion of the course, the students will be able to

- Apply process integration principles for the synthesis of heat exchange, mass exchange, reactive mass exchange and combined heat and mass exchange networks using graphical techniques, algebraic techniques and mathematical programming techniques.
- Apply the principles of heat integration and combined heat and power integration to minimize utility consumption in a conventional chemical process industry scenario.
- Formulate process synthesis models for pollution prevention in process industries.
- Design process networks with minimal wastewater/waste generation, minimal utilities and minimal raw material utilization.
- Develop mathematical models and solve them using optimization techniques for waste minimization, raw material effective utilization and utility minimization in chemical process industries.
- Analyze case study based approach that would facilitate formulation of techniques and methodologies for complex tasks in industrial process systems to target environmental pollution control engineering.

Textbooks:

1. Process Integration by Mahmood M. El-Halwagi, Elsevier, 1st Edition, 2006.
2. Chemical Process Design and Integration by R. Smith, John Wiley & Sons, 8th Edition, Chichester, 2005.

IV Year - I Semester

L	T	P	C
4	0	0	3

ELECTIVE - II
COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING

Learning Objectives:
The students will be able to learn:

- Classification of chemical engineering process simulation models based on mathematical approaches.
- Handling Software Packages such as EXCEL, MATLAB, FEM LAB to solve chemical engineering problems.
- How to analyse and interpret results provided by SOFTWARE modeling approaches.
- Solution dependence and sensitivity on process parameter specifications.

UNIT-I:
Introduction: Algebraic equations-Process simulation- Differential equations.
Review of numerical methods and their application in fluid flow, heat transfer, phase equilibria& mass transfer operations.
Equations of state: Mathematical formulation –Solving equations of state using Excel & Solver- Solving equations of state using MATLAB with a few examples.

UNIT-II:
Vapor liquid equilibrium: Flash and phase separation, Isothermal flash–Development of equations, Example using Excel, Thermodynamic parameters-Example using MATLAB, Non ideal Liquids–Test of thermodynamic model.
Chemical reaction equilibrium: Chemical equilibrium expression- Example of Hydrogen for fuel cells, Solution using Excel & MATLAB; Chemical equilibria with two or more equations- Multiple Equations- Solutions Using MATLAB.

UNIT-III:
Mass balances with recycle streams: Mathematical formulation-Example without recycle-Example with recycle; Comparison of sequential and simultaneous solution methods-Example of process simulation using Excel for simple mass balances.

UNIT-IV:
Mass transfer operations: Multi component distillation with shortcut methods-Multi component distillation with rigorous plate-to-plate methods- Packed bed absorption & Gas plant production separation.

UNIT-V:
Chemical reactors: Mathematical formulation of reactor problems plug flow reactor and batch reactor, continuous stirred tank reactor-Using MATLAB to solve ordinary differential equations- Isothermal plug flow reactor, Non isothermal plug flow reactor- Using FEM LAB to solve ordinary differential equations- Isothermal plug flow reactor, Non isothermal plug flow reactor-Reactor problems with mole changes and variable density-Chemical reactors with mass transfer limitations- Continuous stirred tank reactors-Transient continuous stirred tank reactors.

UNIT-VI:

Transport Processes in One Dimension: Applications in chemical engineering– Mathematical formulations- Flow of a Newtonian fluid in a pipe- Flow of a non-newtonian fluid in a pipe- Transient heat transfer- Linear adsorption.

Fluid flow in two and three dimensions: Mathematical foundation of fluid flow- Entry flow in a pipe-Entry flow of a non-newtonian fluid-flow in microfluidic devices-Turbulent flow in a pipe-Start Up flow in a pipe-Flow through an orifice-Flow in a serpentine mixer-Boundary conditions-Non dimensionalization.

Outcomes: The students shall be able to do the following tasks:

- Identify suitable software package (EXCEL, MATLAB , FEM LAB etc.,) to solve a given chemical engineering modeling problem.
- Attain proficiency to write code and utilize tools available in various softwares to solve the given problem.
- Debug and troubleshoot code for the generation of solution.
- Interpretation of software based simulation results from prior chemical engineering knowledge.
- Parametric analysis and case studies for process system analysis.

Text Book:

1. Introduction to Chemical Engineering Computing, B.A. Finlayson, John Wiley &Sons.,Inc, 2006.

Reference Books:

1. Applied Mathematical Methods for Chemical Engineers, Norman W. Loney, 2nd Edition, Taylor & Francis, 2007.
2. Mathematical Methods in Chemical Engineering, ArvindVerma, M. Morbidelli, Oxford University Press, 1997.

IV Year - I Semester

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INTELLECTUAL PROPERTY RIGHTS AND PATENTS

Learning Objectives:

- To know the importance of Intellectual property rights, which plays a vital role in advanced Technical and Scientific disciplines.
- Imparting IPR protections and regulations for further advancement, so that the students can familiarize with the latest developments.

UNIT-I:

Introduction to Intellectual Property Rights (IPR): Concept of Property - Introduction to IPR – International Instruments and IPR - WIPO - TRIPS – WTO -Laws Relating to IPR - IPR Tool Kit - Protection and Regulation - Copyrights and Neighboring Rights – Industrial Property – Patents - Agencies for IPR Registration – Traditional Knowledge –Emerging Areas of IPR - Layout Designs and Integrated Circuits – Use and Misuse of Intellectual Property Rights.

UNIT-II:

Copyrights and Neighboring Rights: Introduction to Copyrights – Principles of Copyright Protection – Law Relating to Copyrights - Subject Matters of Copyright – Copyright Ownership – Transfer and Duration – Right to Prepare Derivative Works –Rights of Distribution – Rights of Performers **–** Copyright Registration – Limitations – Infringement of Copyright – Relief and Remedy – Case Law - Semiconductor Chip Protection Act.

UNIT-III:

Patents: Introduction to Patents - Laws Relating to Patents in India – Patent Requirements – Product Patent and Process Patent - Patent Search - Patent Registration and Granting of Patent - Exclusive Rights – Limitations - Ownership and Transfer — Revocation of Patent – Patent Appellate Board - Infringement of Patent – Compulsory Licensing — Patent Cooperation Treaty – New developments in Patents – Software Protection and Computer related Innovations.

UNIT-IV:

Trademarks: Introduction to Trademarks – Laws Relating to Trademarks – Functions of Trademark – Distinction between Trademark and Property Mark – Marks Covered under Trademark Law - Trade Mark Registration – Trade Mark Maintenance – Transfer of rights - Deceptive Similarities - Likelihood of Confusion - Dilution of Ownership – Trademarks Claims and Infringement – Remedies – Passing Off Action.

UNIT-V:

Trade Secrets: Introduction to Trade Secrets – General Principles - Laws Relating to Trade Secrets - Maintaining Trade Secret – Physical Security – Employee Access Limitation – Employee Confidentiality Agreements – Breach of Contract –Law of Unfair Competition – Trade Secret Litigation – Applying State Law.

UNIT-VI:

Cyber Law and Cyber Crime: Introduction to Cyber Law – Information Technology Act 2000 - Protection of Online and Computer Transactions - E-commerce - Data Security –

Authentication and Confidentiality - Privacy - Digital Signatures – Certifying Authorities - Cyber Crimes - Prevention and Punishment – Liability of Network Providers.

- Relevant Cases Shall be dealt where ever necessary.

Outcomes:

- IPR Laws and patents pave the way for innovative ideas which are instrumental for inventions to seek Patents.
- Students get an insight on Copyrights, Patents and Software patents which are instrumental for further advancements.

References:

1. Intellectual Property Rights (Patents & Cyber Law), Dr. A. Srinivas. Oxford University Press, New Delhi.
2. Deborah E.Bouchoux: Intellectual Property, Cengage Learning, New Delhi.
3. PrabhuddhaGanguli: Intellectual Property Rights, Tata Mc-Graw –Hill, New Delhi
4. Richard Stim: Intellectual Property, Cengage Learning, New Delhi.
5. Kompal Bansal &Parishit Bansal Fundamentals of IPR for Engineers, B. S. Publications (Press).
6. Cyber Law - Texts & Cases, South-Western's Special Topics Collections.
7. R.Radha Krishnan, S.Balasubramanian: Intellectual Property Rights, Excel Books. New Delhi.
8. M.Ashok Kumar and MohdIqbal Ali: Intellectual Property Rights, Serials Pub.

IV Year - I Semester

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PROCESS EQUIPMENT DESIGN AND DRAWING LAB

Learning Objectives:

The student will be trained in the following fundamentals:

- Understanding of standard symbology used to represent various pipes, valves and fittings and their use in development of P &ID (Piping & Instrument Diagram)
- Understanding of standard symbology used to represent various instruments, sensing elements, impulse lines, local & digital (DCS) instruments, pneumatic /electronic signals, controllers, control valves, complex control loops etc.
- Understanding of standard symbology used to represent process equipment.
- Preparation of standard Process Flow Diagrams using AUTOCAD / Microsoft Visio with required details for Process Design.
- Preparation of standard Piping and Instrument Diagrams (P&IDS) using AUTOCAD / Microsoft Visio, with required details for design of piping, instrument systems.
- Process & Mechanical design and drawing of Heat & Mass Transfer & Storage Equipment.

Experiments

1. Drawing of flow sheet symbols.
2. Drawing of instrumentation symbols.
3. Drawing of piping & instrumentation diagrams.
4. Drawing of flow diagram of a process.
5. Process and Mechanical design of following equipment:
    a) Double pipe heat exchanger
    b) Shell and tube heat exchanger (sensible heat & phase change)
    c) Absorber
    d) Distillation column with Auxiliaries
    e) Cylindrical and Spherical Storage Vessels.
    f) Different types of Reactors

Outcomes:

The students shall be able to carry out the following tasks independently:

- Create & use standard symbols for pipes, valves, fittings along with auxiliary details such as insulation, heat tracing and ultimately create pipeline numbering /specification system with details such as line size, metallurgy, rating, service, external (insulation / heat tracing) condition etc., suitable for given application.
- Create & use standard (ISA / ASME) symbols for sensing elements, instruments, signals & control loops, control valves etc.
- Draw standard Process Flow Diagram (PFD) in AUTOCAD / Microsoft Visio using the steady state Simulation output (flow diagram and Heat & Material balance) with flagged stream numbers & basic stream conditions such flow, phase, pressure & temperature conditions.
- Draw a detailed Piping & Instrumentation Diagram (P&ID) in AUTOCAD / Micro Visio as per the standard / specified details with piping specifications, instrumentation starting from sensing element to complete control loops, basic details of the

equipment including nozzles, design conditions of the equipment, standard symbology to represent minor piping such as drains, instrument lead-lines etc.

- Carryout process and mechanical design & drawing of (a) Shell & tube and Double Pipe Exchangers (b) Distillation columns & absorber and (c) Cylindrical & Spherical storage vessels.

Text Book:

1. Ludwig's Applied Process Design for Chemical and Petrochemical Plants, Vol 1 – 3, 4th Edition, A. Kaynode Coker, Elsevier – GPP, 2010
2. Joshi's Process Equipment Design by V.V. Mahajani, S.B. Umarji, 4th Edition, Macmillan Publishers, 2009.

IV Year - I Semester

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SIMULATION LAB

Learning Objectives: The students will be trained in the following fundamentals:

- Characterization of Petroleum fractions by combining hydrocarbon light-ends (represented by pure components) and heavy- ends (represented by distillation cuts) to generate pseudo-components i.e., input data
- Application & understanding of suitable Thermodynamic models for predicting the properties of various hydrocarbons, sour systems & electrolytes.
- Creation of suitable flow chart with pipe segments, valves, mixers, splitters, flash drums, two / three phase separators, reactors, columns, heat exchanges, columns and various other unit operations for the give application.
- Steady state simulation of the plant /equipment & hydraulic systems for (a) performance prediction / adequacy check called "rating" and (b) and for design purpose called 'sizing"
- Generate output date files with stream data (heat & material balance), equipment duty / design features, hydraulic capacity etc.

The following experiments have to be conducted using C/C++/ Simulink /MATLAB/UNISIM:

1. Benzene-Toluene distillation Column
2. Ethylbenzene-Styrene distillation Column
3. Flash Distillation
4. Non isothermal CSTR
5. Crude Distillation Unit
6. Hydraulic Sizing including two-phase systems
7. Thermal sizing and rating of Shell & tube heat exchanger
8. Interacting system- two tank liquid level
9. Non interacting system-two tank liquid level
10. Plug flow reactor
11. Double Pipe Heat Exchanger
12. Amine Absorber for CO_2 and H_2S.

Outcomes:

The students shall be able to carry out the following tasks independently:

- Create input file for given raw data (pure components & distillation cuts) by appropriate pseudo-cut, thermodynamic model selection for hydrocarbon & sour applications
- Create additional components suitable for usage of Utility streams (Steam, Boiler Feed water, Air etc.) as appropriate for the requirement.
- Simulate a process plant using a basic process flow diagram /scheme by building a simulation flow chart /environment and converging the model (a) reflecting the actual plant operating conditions, while rating and /or troubleshooting and (b) meeting the desired objectives, while designing or sizing.
- Use techniques to converge of recycle loops with minimal iterations and apply suitable accuracy margins for convergence.
- Use three-phase separation / decant techniques for moisture bearing hydrocarbons as appropriate.

- Use appropriate tray efficiencies (from literature) for various distillation applications and optimizing reflux ratio / Reboiler duties / number of trays for a given product specifications.
- Size /rate the pipeline& pumping systems for single /two phase applications and evaluate multiphase pipelines for slug /dump conditions etc.
- Carryout detailed thermal sizing or rating of shell & tube exchangers as per TEMA specifications and API guidelines.
- Generate Heat & Material Balance of the streams with required physical & chemical properties from converged simulation.
- Generate sized equipment data sheets as per the industry standards with required information for detailed design/ manufacture.

IV Year - II Semester

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INDUSTRIAL SAFETY & HAZARD MANAGEMENT

Learning Objectives:

- To educate in HSE in handling and storage of hazardous chemicals and in safe operation of unit operations/ unit processes like reactions, distillations, compression/expansion, and absorption/desorption etc.
- To learn the principles of designing equipment eliminating the possibilities of fire, explosion, toxic releases etc.
- To learn how to overcome hazardous situations during installation, pre-commissioning, commissioning, normal operation and/or during execution of any maintenance work.
- To learn various techniques and measures available to investigate industrial accident.

UNIT-I:

Introduction: Safety programs - Engineering ethics - Accident and loss statistics - Acceptable risk - Public perceptions - The nature of the accident process - Inherent safety- Four significant disaters.

Toxicology: How toxicants enter biological organisms - How toxicants are eliminated from biological organisms - Effects of toxicants on biological organisms - Toxicological studies - Threshold limit values.

UNIT-II:

Industrial hygiene: Government of India regulations and OSHA - Industrial hygiene identification - Evaluation - Control.

Source models: Introduction to source models - Flow of liquid through a hole - Flow of liquid through a hole in a tank - Flow of liquids through pipes - Flow of vapor through holes - Flow of gases through pipes - Flashing liquids - Liquid pool evaporation or boiling - Realistic and worst-Case releases.

UNIT-III:

Toxic release and dispersion models: Parameters affecting dispersion - Neutrally buoyant dispersion models - Pasqual-Gifford model - Dense gas dispersion-Case Study, Release mitigation.

UNIT-IV:

Fires and explosions: Classification of fires - The fire triangle - Distinction between fires and explosions – Definitions - Flammability characteristics of liquids and vapors - Limiting oxygen concentration and Inerting - Flammability diagram - Ignition energy – Autoignition – Auto oxidation - Adiabatic compression - Ignition sources - Sprays and mists – Explosions. Case Study.

Designs to prevent fires and explosions: Inerting - Static electricity - Controlling static electricity - Explosion-Proof equipment and instruments – Ventilation - Sprinkler systems - Miscellaneous designs for preventing fires and explosions.

UNIT-V:

Introduction to reliefs: Relief concepts – Definitions - Location of reliefs - Relief types - Relief scenarios - Data for sizing reliefs - Relief systems.

Relief sizing: Conventional spring-Operated reliefs in liquid service - Conventional spring-Operated reliefs in vapor or gas service - Rupture disc reliefs in liquid service - Rupture disc reliefs in vapor or gas service - Deflagration venting for dust and vapor explosions - Venting for fires external to process vessels - Reliefs for thermal expansion of process fluids.

UNIT-VI:

Hazards identification: Process hazards checklists - Hazards surveys - Hazards and operability studies - Safety reviews - Other methods.

Risk assessment: Review of probability theory - Event trees - Fault trees - QRA and LOPA.

Accident investigations: Learning from accidents - Layered investigations - Investigation process - Investigation summary - Aids for diagnosis - Aids for recommendations, Case Histories

Outcomes:

After the course, the students will become knowledgeable in the following:

- Accessing the various hazards involved in handling hydrocarbons in Oil & Gas sector. Visualization of all possible safety issues at all the phases of industry by applying the techniques like HAZOP, QRA etc.
- Steps to be followed during design stages to overcome possible safety threats.
- Measurement and monitoring of safety index.
- Fire preventing/Firefighting systems.
- Accident investigation process-Root causes analysis.

Text Book:

1. Chemical Process Safety: Fundamentals with Applications, Daniel A. Crowl, Joseph F. Louvar, 3rd Edition, Prentice Hall, 2011.

Reference Books:

1. Safety and Accident Prevention in Chemical Operations, H.H.Fawcett and W.S.Wood, 2nd Edition, John Wiley & Sons, New York 1982.
2. Guidelines For Process Safety: Fundamentals in General Plant Operations, Center for Chemical Process Safety of the American Institute of Chemical Engineers, 1995.
3. ILO – OSH 2001.
4. Government of India: The Factories Act 1948, amended 1954, 1970, 1976 and 1987; The manufacture, storage and import of hazardous chemicals rules, 1989; The Explosives Act 1884; The Petroleum Act 1934; National policy on safety, Health and environment at workplace, Government of India; Constitutional provisions of occupational safety and health, The Constitution of India.
5. HAZOP and HAZAN, Trevor A. Keltz, 3rd Edition, Gulf Publications, 1986
6. What Went Wrong?: Case Histories of Process Plant Disasters, Trevor A. Keltz, 4th Edition, 1985.

IV Year - II Semester

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PROCESS ENGINEERING ECONOMICS

Learning Objectives:

- To understand the various terms and activities related to economics which can be useful during economical evaluation of any chemical process industries.
- To understand the concepts and calculations involving time value of money, present and future worth of property
- To have the knowledge about capital recovery, depreciation and depreciation calculations
- To understand the methodology of cost estimation including fixed and variable costs by considering the concept of cost indices.
- To understand the concept of balance sheet, profit and loss accounting and income statement
- To understand the concept of profitability evaluation of project and select the best process alternative based on its economic evaluation
- To understand the concept of rate of return and payout time, and replacement of existing facilities
- To have knowledge of the economic balance in evaporation, fluid flow, heat and mass transfer, cyclic operations, reactors and inventory in process operations
- To learn about the economic analysis of a complete process
- To learn about multivariable input-output analysis for analyzing the production of chemical products

UNIT-I:

Introduction: The process industries – capital and interest – economics and the process engineer.

Value of Money – Equivalence: Value of money – equations for economic studies – equivalence – example problems – the bond problem.

UNIT-II:

Amortization: Capital recovery – depreciation – straight-line method, sinking-fund method, fixed percentage method – interest in depreciation calculations – depreciation accounting – depletion

Capital Requirements for Process Plants: Cost indices – equipment costs – the Williams six-tenths Factor – service facilities – buildings and other non-process items – capital requirements for complete plants-approximate cost estimates-detailed cost estimates – total and process investment – the balance sheet – sources of capital.

UNIT-III:

Costs, Earnings, Profits and Returns: Variable costs – fixed costs-explanation of individual items of fixed costs-interest as an Item of cost – using cost data-cost studies-the Income statement-income statement ratio – profits and earnings-a discussion of theoretical economy and accounting-analysis of the income statement – economic production charts – capacity factors – incremental costs – differential analysis of economic production charts

Economics of Selecting Alternates: Annual cost method – present worth method – equivalent alternates.

UNIT-IV:

Rates of Return and Payout Time – Replacements: Rate-of-return method – payout-time method – effect of source of capital – nonproductive investments and taxes – consideration of capacity factor – replacement of existing facilities – irreducible factors in economic analyses.

Economic Balance: Economic balance in evaporation – economic vessel design – economic balance in fluid flow, heat transfer and mass transfer - economic balance with two variables, combined operation-combined operations with one variable- combined operations with two variables, combined operations with alternates

UNIT-V:

Economic Balance in Cyclic Operations: Batch operations (fixed cycle time) – batch operations (variable cycle time) – multiple equipment units – semicontinuous operations.

Economic Balance in Yield and Recovery: Economic analysis for variable feed and product grades, variable recovery – economic balance for waste stream concentrations – economic balance for yield in process operations-yield in a batch reactor (catalytic or noncatalytic)-yield in continuous multistage reactors (noncatalytic)- yield in a flow reactor (catalytic)

UNIT-VI:

Economic Balance and Inventory in Process Operations: Semicontinuous operations – batch operations – non-repetitive operations – process inventory considerations – the general case of inventory – general summary of economic balance.

Economic Analysis of A Complete Process: Operating plants-appraised value-earning value-stock and bond value – proposed plants-capital requirements-estimated annual returns – evaluation – reliability of cost estimates.

Outcomes:

After the course work, the students will be able to:

- Understand with various aspects related to economics and can apply them for economic evaluation of chemical process and decide its economic feasibility
- Analyze cash flow sequences and solve problems involving time value of money
- Calculate profitability, rate of return of investments and cost estimation.
- Read and understandcorporate financial statements (Balance sheet, income statement, cash flow statement).
- Choose projects/equipment from a set of possible alternatives.
- Assess the impact of depreciation, taxation and other economic factors on the project's feasibility.
- Develop policies for assets replacement.
- Assess alternative financing modes.
- Make financially prudent decisions in everyday life.
- Calculate optimal sizes of new chemical processes and subsequent expansion of capacity.
- Describe multivariable input-output analysis.

Text Book:

1. Process Engineering Economics, H.E. Schweyer, McGraw-Hill, New York,1955.

Reference Books:

1. Plant Design and Economics for Chemical Engineers, M. S. Peters and K. D. Timmerhaus, McGraw Hill, 4th Ed., 1991.
2. Cost and Optimization Engineering, F.C. Jelen, McGraw-Hill, International ed., 1997.
3. Process Engineering Economics, James R. Couper, Marcel Dekkar, Inc., 2003
4. Introduction to Process Economics, F.A. Holland, F. A. Watson, J. K. Wilkinson, 2nd Edition, John Wiley & Sons, 1983.
5. Schaum's outlines of engineering economics, Jose Sepulveda, William Souder, Byron Gottfried, McGraw-Hill, 1984.
6. Process Engineering Economics, James Process Engineering Economics, James R. Couper, Marcel Dekkar, Inc., 2003.

IV Year - II Semester

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MULTICOMPONENT DISTILLATION

Learning Objectives:

The students will be imparted knowledge in the following topics:

- VLE calculations like determination bubble point and dew point for multicomponent systems using K-values and relative volatility.
- Different shortcut procedures to calculate the equilibrium stages for given separation.
- Various rigorous calculations methods like Lewis Matheson method, Thiele –Geddes method, BP method, Tridiagonal Matrix method.
- Multicomponent flash vaporization, steam distillation and differential distillation.
- Basic concepts and details of azeotropic distillation and extractive distillation.
- Concepts for tray design and tray column sizing.
- Different packing types, packing hydraulics .
- Calculations for packing efficiency, concept of HTU and HETP concepts.

UNIT-I:

Introduction to distillation: Vapor liquid equilibrium (VLE)- K-Values and relative volatility-ideal and non-ideal systems-effect of temperature, pressure and composition on K-values and volatility-Phase diagrams-Calculations of bubble points and dew points-Azeotropes- Key fractionation concepts – Approximate material balance.

UNIT-II:

Short Cut Methods for Stage and Reflux Requirements: Pseudobinary systems-Hengstebeck method; Emperical Methods: Various methods for calculation of minimum reflux ratio- Feneske equation for minimum number of stages- FUG method-Erbar and Maddox method-Krkbride equation for feed plate location-Distribution of non-key components: Hengstebeck and Geddes method.

UNIT-III:

Rigorous Distillation Calculations: Basic concepts –Rigorous computational methods-Lewis-Matheson method and its variations-Thiele- Geddes method and its variations-B.P.method - Tridiagonal matrix method- Computations using computer programming.

UNIT-IV:

Multicomponent single stage operations: Flash vaporization- Raleigh distillation and steam distillation.

Azeotropic and extraction distillation: Concepts- Configurations and case studies.

UNIT-V:

Tray design and operations: The common tray types-Tray capacity limits-Tray hydraulic parameters- Flow regimes on trays.

Tray column sizing & tray efficiency: Tray design and tray efficiency fundamentals-Predictions of tray efficiency.

UNIT-VI:

Packing design and operations: Packing types- Classifications-Packing objectives- Packing hydraulics- Comparing tray and packing-Sizing of packed column.

Packing efficiency & predictions: The transfer unit concept-The HETP concept – Factors affecting HETP – HETP Predictions- Mass transfer models – Rules of thumb – Data interpolation.

Outcomes:

After the completion of the course the student will be able to:

- Determine bubble point and dew point for multicomponent mixtures using K-values and relative volatility.
- Determine minimum reflux ratio, minimum no. of stages, feed tray location, and distribution of key components using various shortcut methods.
- Determine the number of stages in multi-stage multicomponent towers by various rigorous calculation methods.
- Make calculations of multicomponent single stage operations like flash vaporization, differential distillation and steam distillation.
- Carry out the design of azeotropic distillation and extractive distillation systems.
- Design a tray and packed columns accounting efficiency terms.

Text Books:

1. Distillation Design, Henry Kister, McGraw-Hill, 1992.
2. Distillation, Mathew Van Winkle, McGraw-Hill, 1967.

Reference Books:

1. Fundamentals of Multicomponent Distillation, C. D. Holland, McGraw-Hill, 1997.
2. Distillation Principles and Processes, Sydney Young, White Mule Press, 2011.
3. Elements of Fractional Distillation, C.S. Robinson, E. R. Gilliland, 4th Edition, 1950.
4. Distillation Design in Practice, L. M. Rose, Elsevier, 1985.
5. Distillation Tray Fundamentals, M. J. Lockett, Cambridge University Press, 2009.

IV Year - II Semester

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ELECTIVE III
NATURAL GAS ENGINEERING

Learning Objectives:

- To know and apply various correlations for the evaluations of natural gas properties.
- To evaluate gas reservoir deliverability and wellbore performance
- To estimate choke performance and well deliverability using nodal analysis
- To know various process technologies, operating and design parameters deployed for the natural gas separation, dehydration and acid gas removal.
- To understand various supplementary equipment associated to natural gas compression, metering and transportation.
- To understand various principles associated to troubleshooting in natural gas wells.

UNIT-I:

Introduction: Natural gas constituents - Utilization of natural gas- Natural gas industry (World and India)- Natural gas reserves -Types of natural gas resources.

Properties of natural gas: Specific gravity – Pseudo critical properties – Viscosity – Compressibility factor – Gas density – Formation volume factor and expansion factor – Compressibility of natural gas – Real gas pseudo pressure and real gas normalized pressure.

UNIT-II:

Gas reservoir deliverability: Introduction – Analytical methods – Empirical methods – Construction of inflow performance relation curve.

Wellbore performance: Introduction – Single phase gas well – Mist flow in gas wells.

UNIT-III:

Choke performance: Introduction – Sonic and subsonic flow – Dry gas flow through chokes – Wet gas flow through chokes

Well deliverability: Introduction – Nodal analysis – Analysis with wellhead node.

UNIT-IV:

Separation: Separation of gases and liquids – Stage separation – Flash calculation – Low temperature separation.

Dehydration of natural gas: Water content of natural gas streams- Dehydration systems- Glycol dehydrator design.

Removal of acid gases: Iron – Sponge sweetening – Alkanol amine sweetening – Glycol / Amine process –Sulfinol process.

UNIT-V:

Compression: Types of compressors – Selection of reciprocating compressors – Selection of centrifugal compressors – Selection of rotary blowers.

Volumetric measurement: Measurement with orifice meters – Displacement metering – Turbine meter – Elbow meter – Natural gas liquid measurement.

Transportation: Pipeline design – Sizing pipelines and pipeline wall thickness.

UNIT-VI:

Liquid loading on gas wells: Turners methods – Guo's methods – Comparison of methods.

Hydrate control: Hydrate forming conditions – Preventing hydrate formation.

Pipeline cleaning: Pigging system – Selection of pigs – Major applications – Pigging procedure.

Outcomes:

- Evaluate the properties of natural gas as functions of independent parameters such as temperature and pressure.
- Interpret and analyze data available for natural gas reservoirs and predict well bore performance and production capacities using various correlations.
- Ability to apply nodal analysis for natural gas well analysis.
- Identify the role of operating and design parameters to achieve desired targets during natural gas separation, dehydration and acid gas removal.
- Evaluate the technical requirements associated to natural gas transportation, volumetric measurement and transportation.

Have practical knowledge with respect to the troubleshooting of natural gas production from gas wells.

Text Books:

1. Natural Gas Engineering Handbook, Bojun Guo and Ali Ghalambor, Gulf publishing company, 2005.
2. Gas Production Operations, H.Dale Beggs, OGCC Publications, 1984.

Reference Books:

1. Handbook of Natural Gas Engineering, D.L.Katz, McGraw-Hill, 1959.
2. Natural Gas Production Engineering, Chi U. Ikoku, Krieger Publishing Company, 1992.
3. Troubleshooting Natural Gas Processing: Well head to Transmission, Norman P. Lieberman, Pennwell Publishing Company, 1997.
4. Practical Natural Gas Engineering, R.V.Smith, 2nd Edition, PennWell, 1990.

IV Year - II Semester

L	T	P	C
4	0	0	3

ELECTIVE III
PREVENTION OF POLLUTION THROUGH PROCESS INTEGRATION

Learning Objectives:

- Understanding basic objectives of process integration and their application for pollution control and prevention.
- Mastering the art of process integration of heat exchange, mass exchange, reactive mass exchange and combined heat and mass exchange networks using graphical, algebraic and mathematical techniques.
- Formulating process synthesis problems to target pollution prevention.
- Understanding various applicable case studies to realize the potential of pollution prevention through process integration.

UNIT-I

Introduction: Environmental problem and pollution prevention – Definitions of Process Synthesis, Analysis, Optimization and Integration – Can flowsheets provide Global insights – Mass and energy integration as branches of process integration.

Modelling of Mass-exchange units for environmental applications: Definition of mass exchanger – Equilibrium – Interphase mass transfer – Types and sizes of mass exchanger – Minimizing cost of mass exchange system

UNIT-II

Graphical approach for synthesis of mass exchange networks: Network Vs Unit – Problem scope, significance and complexity – mass exchange network synthesis unit – Targeting approach – Corresponding Composite scales – Pinch diagram – Constructing process pinch diagrams without process MSAs – Trade off fixed versus operating costs

Graphical techniques for mass integration with mass exchange interception: The source-sink mapping diagram – Mass integration applicability for yield enhancement, debottlenecking and wastewater minimization in acrylonitrile plant

UNIT-III

Algebraic approach for synthesis of mass exchange networks: Composition – interval diagram (CID) – Table of exchangeable loads (TEL) – mass exchange cascade diagram – Dephenolization of aqueous wastes – Synthesis of MENs with minimum number of exchangers – Feasibility criteria at the pinch – Network synthesis – Trading off fixed versus operating costs using mass-load paths

UNIT-IV

Mathematical programming based approach for the Synthesis of Mass-exchange networks: Problem statement with challenges – Synthesis of MSA induced WINs – Developing strategies for segregation, mixing and direct recycle - Case study of chloroethanol interception in an ethyl chloride process

UNIT-V

Synthesis of reactive mass-exchange networks: Corresponding composition scales for reactive mass exchange – Synthesis approach

Combining heat integration with mass integration: Synthesis of Heat exchanger networks – Synthesis of combined heat and reactive mass exchange networks – Case study of ammonia removal from gaseous emissions and ammonium nitrate plant.

UNIT-VI

Synthesis of heat-induced separation network for condensation of volatile compounds from air: Problem statement – System configuration – Integration of heat and mass objectives – Design approach – Dilute waste streams as special case – Case study for removal of methyl ethyl ketone

Synthesis of membrane systems: Reverse osmosis membrane systems – Modelling of HFRO units – Synthesis of RO Networks – Short cut method for the synthesis of RONs.

Outcomes: After completion of the course, the students will be able to

- Apply process integration principles for the synthesis of heat exchange, mass exchange, reactive mass exchange and combined heat and mass exchange networks using graphical techniques, algebraic techniques and mathematical programming techniques.
- Formulate process synthesis models for pollution prevention in process industries.
- Process networks with minimal wastewater/waste generation, minimal utilities and minimal raw material utilization.
- Design reverse osmosis membrane networks for pollution control and potable water generation applications.
- Analyze case study based approach that would facilitate formulation of techniques and methodologies for complex tasks in industrial process systems to target environmental pollution control engineering.

Textbooks:

1. Pollution Prevention through Process Integration: Systematic Design Tools, M. M. El-Halwagi, Academic Press, 1st Edition, 1997.
2. Chemical Process Design and Integration by R. Smith, John Wiley & Sons, 8th Edition, Chichester, 2005.

IV Year - II Semester

L	T	P	C
4	0	0	3

ELECTIVE III
NANOTECHNOLOGY

Learning Objectives:

Imparting Knowledge in the following:

- Properties of Nano-materials
- Characterization of nano-materials
- Synthesis approaches for nano-materials from chemistry perspective
- Synthesis technologies for nano-materials from process perspective
- Applications of nano-science, nano-technology and nano-materials

UNIT-I:

The big world of Nano-materials: History and scope, can small things make a big difference? Classification of Nano structured material, fascinating nano structures.

Unique properties of nano-materials: micro structures and defects in nano crystalline materials, effects of nano dimensions on materials behavior.

UNIT-II:

Synthesis Routes: Bottom-up approaches, Top-down approaches, Consolidation of nano powders.

UNIT-III:

Applications of Nano-materials: Nano electrons, micro and nano electro mechanical systems, nano sensors, nano crystal, food and agriculture industry, cosmetics, consumers goods, structure and engineering automotive industry, water treatment, and environment, nano medical applications, textiles, paints, energy, defenses and space applications, structure applications.

UNIT-IV:

Tools to characterize Nano- materials: X-ray diffraction (XRD), Small Angle X-ray Scattering (SAXS), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), Field Ion Microscopy (FIM), 3-Dimensional Atom Probe (3-DAP), Nano-indentation.

UNIT-V:

Classification of Nano-materials; Inter molecular forces in organic polymerics, Aqueous, Biological, Vander-waal, Electro static, Double layer forces in acid phase and acid base systems.

UNIT-VI:

Depletion interactions, Hydro phobic forces layering, Mesoscale thermodynamics of Nano scale particles. Gibbs treatment of interfaces, Mesoscale fluid dynamics, thin films.

Outcomes:

A students shall be able to do the following tasks:

- Applying sound knowledge of chemistry specific approaches for nano-material synthesis.
- Using knowledge of various nano-particle fabricating technologies.
- Exploring prominent applications of nano-technology in petroleum refinery engineering and petrochemical peoduction.

- Devising principles of various characterization methods for nano-technology.
- Identifying and Quantifying various intermolecular forces that exist at the nano-scale.
- Developing working knowledge of thermodynamics at the nano-scale.

Text Books:

1. Text book of Nano-Science and Nano-Technology, Murthy B.S., Shankar P., Baldev Raj, B. B. Rath and James Murday, Universities Press India Limited, Hyderabad, 2013(Units-I –IV).
2. Nano Materials & Introduction to synthesis, properties and application, Dieter Vollath, wiley vch, 2006 (Units-V–VI).

Reference Book:

1. Introduction to Nano-science and Nanotechnology, K.K. Chattopadhyay and A. N. Banerjee, PHI, 2009.

IV Year - II Semester

L	T	P	C
4	0	0	3

ELECTIVE III
DESIGN AND ANALYSIS OF EXPERIMENTS

Learning Objectives:

- The general philosophy of designing and carrying experiments and analyzing the data generated from experiments.
- Factorial and fractional factorial designs and their relevance to simultaneously increase experimentation efficiency and reduce cost.
- Mathematical methodologies for the efficient analysis of the data generated from experimentation to instill confidence in the data for utilization towards industrial process modeling and simulation efforts.
- Linear and non-linear regression analysis.
- Overview of various software packages for statistical design and analysis of experiments.

UNIT-I:
Introduction to probability, Probability laws, Baye's theorem, Probability distributions, Parameters and statistics

UNIT-II:
Normal and t-distributions, Central limit theorem, Random sampling and declaration of independence significance tests

UNIT-III:
Randomization and blocking with paired comparisons significance tests and confidence interval for means, variances, proportions and frequencies.

UNIT-IV:
Analysis of variance, Experiments to compare k-treatment means

UNIT-V:
Two-way factorial designs, blocking, Yate's algorithm
Fractional factorial designs at two levels, Concept of design resolution

UNIT-VI:
Simple modeling with least squares (Regression analysis), Matrix versions of normal equations

Outcomes:

A student with sound knowledge in this course shall be able to do the following tasks:

- Design an experiment with minimal experimental runs and maximum diversity in the data obtained.
- Analyze obtained data for its consistency to represent the natural phenomena associated in the experiment

- Improve experimental approaches by rigorous data analysis
- Utilization of probability and statistical knowledge to define and refine experimental data consistency.
- Develop process models using linear and non-linear regression for experimental data. Analyze the competence of regressed models to represent experimental data.

Text Book:

1. Statistics for Experimenters, G.E.P. Box, William G. Hunter and J.S. Hunter, John Wiley & Sons. 1978.

Reference Books:

1. Design and Analysis of Experiments, D.C. Montgomery, 2nd Edition John Wiley and Sons, 1984.
2. Design of Experiments in Chemical Engineering: A Practical Guide, Zivorad R. Lazic, Wiley – VCH, 2005.

IV Year - II Semester

L	T	P	C
0	0	0	2

SEMINAR
(PRESENTATION OF SUMMER INTERNSHIP REPORT)

Learning Objectives:

- To give a clear, organized and accurate oral presentation of Summer Training/Internship Report.
- To provide verbally/ through power point presentation of condensed large amounts of technical information into concise, condensed analysis.
- Sharing the practical knowledge obtained during training with fellow students.

A summer internship report is a documentation of a student's work—a record of the original work done by the student in the summer internship of 6- 8 week duration.

The presentation of the summer training report by the candidates should be conducted by a committee constituted by the Head of the Department for evaluation.

Summer training report of the students shall be evaluated for 50 marks by the committee appointed by the university.

Outcomes: Students will extend their abilities to:

- Get themselves good clarity in the technical topics being presented.
- Develop good communication skills.
- Practice the behaviors of effective speakers.
- Assess strengths in speaking and set goals for future growth.

IV Year - II Semester

L	T	P	C
0	0	0	10

PROJECT REPORT

Learning Objectives:
The students are guided to learn the following aspects:

- Understanding & evaluating the usage / commercial /environmental aspect of a Petroleum Product / process from a demand / supply or regulation point of view.
- Understanding & evaluating the technology aspects of various alternatives available, called "Best Available Technologies (BAT)", through literature & references and select a suitable process with optimum capacity.
- Carrying-out the basic design of the process using steady state simulation and generate PFD heat & material balance and utility consumption summary.
- Preparing Material Selection drawing based on 20 year equipment life. Carrying-out preliminary equipment design, with mechanical details, of all major equipment and preparing equipment data sheets.
- Preparation of Equipment Layout & Plot Plan drawing.
- Preliminary cost estimation of the plant (CAPEX) and OPEX via utility / chemical / catalyst consumption.
- Presentation & Project management skills.

The project work may consist of any one of the following:

a) The project work should consist of a comprehensive design project of one of the Petroleum Refinery Units/ a Petrochemical plant/ Organic ChemicalPlant in the form of a report with the following chapters:
   1. Introduction
   2. Physical and chemical properties and uses
   3. Literature survey for different processes
   4. Selection of the process
   5. Material and energy balances
   6. Specific equipment design, (Process as well as mechanical design with drawing), including computer programs wherever possible, of heat transfer equipment or separation equipment or reactors
   7. General equipment specifications
   8. Plant location and layout
   9. Materials of construction
   10. Health and safety factors
   11. Preliminary cost estimation
   12. Bibliography.

b) Modeling & Simulation of any petroleum refining unit/petrochemical process.

c) Any experimental work with physical interpretations.

Outcomes:
The students shall be able to independently carryout the following tasks:

- Preparation of Project Feasibility Reports for Petroleum /Petrochemical Plants.
- Gather & use various sources such as market data, literature, customer feed-backs etc. to evaluate the Best Available Technologies in the market and select suitable process meeting the site conditions, environmental regulations, product quality etc.
- Simulation of Overall Plant including estimation utility consumptions.
- Generation of PFD (Process Flow Diagrams), MSD (Material Selection Diagrams) and Heat & material balance reports.

- Sizing of all plant equipment and preliminary cost estimation using cost indexes, charts& literature.
- Preliminary cost estimation of piping, instrumentation, electrical equipment, civil works & construction as % of Equipment cost, to determine Installation cost of the plant.
- Preliminary utility, catalyst & chemical consumption estimation and using this data estimating the operating cost.
- Manage a comprehensive project in a planned manner, within specified time and present the salient features of the result to the audience with confidence and clarity.