COURSE STRUCTURE AND SYLLABUS
for

B.TECH. CHEMICAL ENGINEERING
R19 – Regulation

(Applicable for batches admitted from 2019-2020)

DEPARTMENT OF PETROLEUM ENGINEERING
&
PETROCHEMICAL ENGINEERING,
UNIVERSITY COLLEGE OF ENGINEERING KAKINADA (A),
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
KAKINADA - 533 003, ANDHRA PRADESH, INDIA

I YEAR I SEMESTER							
S. No.	**Course Code**	**Course Title**	**POs**	**L***	**T**	**P**	**C**
1	BS	Mathematics – I		3	0	0	3
2	BS	Engineering Physics		3	0	0	3
3	PCC	Introduction to Chemical Engineering		3	0	0	3
4	ES	Programming for Problem Solving		3	0	0	3
5	ES	Engineering Drawing		1	0	3	2.5
6	BS	Engineering Physics Lab		0	0	3	1.5
7	BS	Physics Virtual Lab		0	0	2	0
8	ES	Programming for Problem Solving - Laboratory		0	0	3	1.5
9	HS	English Communication Skills – Laboratory - I		0	0	2	1
10	PR	Engineering Exploration Project		0	0	2	1
11	*MC	Constitution of India		3	0	0	0
		Total		16	0	15	19.5

I YEAR II SEMESTER							
S. No.	**Course Code**	**Course Title**	**POs**	**L***	**T**	**P**	**C**
1	HS	Communicative English		3	0	0	3
2	BS	Mathematics – II		3	0	0	3
3	BS	Mathematics – III		3	0	0	3
4	BS	Chemistry – I (Physical Chemistry)		3	0	0	3
5	ES	Engineering Mechanics		3	0	0	3
6	ES	Engineering Workshop & IT Workshop		0	0	3	1.5
7	BS	Chemistry - I Laboratory (Physical Chemistry)		0	0	3	1.5
8	HS	English Communication Skills Laboratory -II		0	0	3	1.5
9	*MC	Environmental Science		3	0	0	0
10	*MC	Physical Fitness Activities		0	0	2	0
11	MOOCS (NPTEL/SWAYAM) for Honors/Minor						
			Total	18	0	11	19.5

*contact clock hours

II YEAR I SEMESTER							
S. No.	**Course Code**	**Course Title**	**POs**	**L***	**T**	**P**	**Credits**
1	BS	Mathematics-IV		3	0	0	3
2	ES	Basic Electrical & Electronics Engineering		3	0	0	3
3	ES	Materials Science & Engineering		3	0	0	3
4	PCC	Chemistry – II (Organic Chemistry)		3	0	0	3
5	PCC	Chemical Process Principles		3	0	0	3
6	PCC	Mechanical Unit Operations		3	0	0	3
7	ES	Basic Engineering (Mech. + Elec.) Laboratory		0	0	3	1.5
8	PCC	Organic Chemistry – Laboratory		0	0	3	1.5
9	PCC	Mechanical Unit Operations – Laboratory		0	0	3	1.5
10	*MC	Essence of Indian Traditional Knowledge		3	0	0	0
11	*MC	Physical Fitness Activities		0	0	2	0
12	MOOCS (NPTEL/SWAYAM) for Honors/Minor Degree						
		Total Credits					**22.5**

II YEAR II SEMESTER							
S. No.	**Course Code**	**Course Title**	**POs**	**L***	**T**	**P**	**Credits**
1	ES	Elements of Mechanical Engineering		2	0	0	2
2	HSSMS	Managerial Economics & Financial Accounting		3	0	0	3
3	PCC	Momentum Transfer		3	0	0	3
4	PCC	Chemical Engineering Thermodynamics-I		3	0	0	3
5	PCC	Process Instrumentation		2	0	0	2
6	PCC	Process Heat Transfer		3	0	0	3
7	PCC	Momentum Transfer – Laboratory		0	0	3	1.5
8	PCC	Process Heat Transfer – Laboratory		0	0	3	1.5
9	HSSMS	Socially Relevant Project		0	0	1	0.5
10	*MC	Physical Fitness Activities		0	0	2	0
11	MOOCS (NPTEL/SWAYAM) for Honors/Minor Degree						
		Total Credits					**19.5**

*contact clock hours

III YEAR I – SEMESTER							
S. No.	**Course Code**	**Course Title**	**POs**	**L***	**T**	**P**	**Credits**
1	PCC	Chemical Engineering Thermodynamics-II		3	0	0	3
2	PCC	Chemical Reaction Engineering – I		3	0	0	3
3	PCC	Mass Transfer Operations – I		3	0	0	3
4	PCC	Process Dynamics & Control		3	0	0	3
5	PEC	PROFESSIONAL ELECTIVE – I i. Petroleum Refinery Engineering ii. Air Pollution and Control		3	0	0	3
6	PCC	Petroleum Analysis – Laboratory		0	0	3	1.5
7	PCC	Mass Transfer Operations – Laboratory		0	0	3	1.5
8	PCC	Instrumentation, Process Dynamics & Control – Laboratory		0	0	3	1.5
9	PCC	Socially Relevant Project		0	0	1	0.5
10	*MC	Physical Fitness Activities		0	0	2	0
11	PT	Industrial Visits (Local & Outside)					
12	MOOCS (NPTEL/SWAYAM) for Honors/Minor Degree						
		Total Credits					**20**

*contact clock hours

III Year II – Semester							
S. No.	**Course Code**	**Course Title**	**POs**	**L***	**T**	**P**	**Credits**
1	PCC	Mass Transfer Operations- II		3	0	0	3
2	PCC	Chemical Reaction Engineering – II		3	0	0	3
3	OEC	OPEN ELECTIVE – I (for other Branches) i. Chemical Process Safety ii. Fundamentals of Petroleum Refining iii. Renewable Energy Sources		3	0	0	3
4	PEC	PROFESSIONAL ELECTIVE – II i. Solid Waste Management ii. Green Process Technologies		3	0	0	3
5	PEC	PROFESSIONAL ELECTIVE – III i. General Chemical Technology ii. Industrial Biotechnology		3	0	0	3
6	PCC	Chemical Reaction Engineering – Laboratory		0	0	3	1.5
7	PCC	Mathematical methods – Laboratory		0	0	3	1.5
8	**HSS	Universal Human Values 2: Understanding Harmony		3	0	0	3
9	*MC	Employability Skills – I: Python Programming		1	0	1	0
10	PT	Summer Internship (4 or 6 Weeks)					
11	MOOCS (NPTEL/SWAYAM) for Honors/Minor Degree						
		Total Credits					**21**

*contact clock hours

**There is a provision for the Universities/Institutions to implement AICTE mandatory course "Universal Human Values 2: Understanding Harmony" under Humanities and social science Elective in seventh semester/Suitable semester as a 3 credit course, within 160 credit framework. for 3 credits in R19 regulation

IV YEAR I – SEMESTER							
S. No.	**Course Code**	**Course Title**	**POs**	**L***	**T**	**P**	**Credits**
1	PCC	Transport Phenomena		3	0	0	3
2	PCC	Plant Design and Economics for Chemical Engineers		3	0	0	3
3	PEC	PROFESSIONAL ELECTIVE – IV i. Process Modelling and Simulation ii. Fluidization Engineering		3	0	0	3
4	PEC	PROFESSIONAL ELECTIVE – V i. Optimization Techniques for Chemical Engineers ii. Industrial Safety & Hazard Management		3	0	0	3
5	OEC	OPEN ELECTIVE – II (for other Branches) i. Hazard Operability and Fault Tree Analysis in Process Plants ii. Heat Integration and Pinch Analysis iii. Design of Experiments and Analysis.		3	0	0	3
6	PCC	Process Equipment Design & Drawing – Laboratory		0	0	3	1.5
7	PCC	Process Simulation – Laboratory		0	0	3	1.5
8	PROJ	Presentation/Seminar (SIP Report)		0	0	0	1
9	PROJ	Project (Industrial/In-house) (Phase-1)		0	0	0	2
10	*MC	IPR & Patenting		3	0	0	0
11	*MC	Employability Skills – II: Data Science		1	0	1	0
12	MOOCS (NPTEL/SWAYAM) for Honors/Minor Degree						
		Total Credits					**21**

*contact clock hours

IV YEAR II – SEMESTER							
S. No.	**Course Code**	**Course Title**	**POs**	**L***	**T**	**P**	**Credits**
1	PEC	PROFESSIONAL ELECTIVE – VI i. Nanotechnology ii. Petroleum Production Engineering		3	0	0	3
2	PEC	PROFESSIONAL ELECTIVE – VII i. Natural Gas Engineering ii. Computational Fluid Dynamics		3	0	0	3
3	OEC	OPEN ELECTIVE – III (for Chemical Engineering) i. NPTEL-Data Analysis & Decision making ii. NPTEL- E-Business iii. NPTEL- Innovation, Business Models & Entrepreneurship		3	0	0	3
4	PROJ	Project (Industrial / In-house) (Phase-2)					8
5	*MC	Physical Fitness Activities		0	0	2	0
6	MOOCS (NPTEL/SWAYAM) for Honors/Minor Degree						
		Total Credits					**17**

*contact clock hours

TOTAL CREDITS = 39 + 42 + 41 + 38 = 160

Suggested course list (Department/NPTEL/SWAYAM) for UG R19 regulation for Honors degree in Chemical Engineering.

Dept. of PE & PCE**	
S. No	**Course Name**
1	Fundamentals of Bio Process Engineering
2	Fuels and Combustion
3	Carbon capture
4	Chemical engineering in Drugs and Pharmaceutical Industries
5	Air pollution monitoring and its applications
6	Process plant equipment operation, control & reliability
7	Multi Component Distillation
8	Super critical fluid extraction
9	Energy conservation in process industries

NPTEL/SWAYAM Portal	
S.No.	**Course Name**
1	Aspen Plus® simulation software - a basic course for beginners
2	Transport Phenomena of Non-Newtonian Fluids
3	Flow Through Porous Media
4	Chemical Process Intensification
5	Introduction to Polymer Physics-IITG
6	Technologies for Clean and Renewable Energy Production
8	Trace and ultra-trace analysis of metals using atomic absorption spectrometry
9	Colloids and Surfaces

** If there are no courses available for Chemical Engineering in the NPTEL/SWAYAM portal in respective semesters, then student can choose the courses offered by the Department of PE & PCE.

Suggested course list for UG R19 regulation for **B. Tech Minor Degree in Chemical Engineering** from SWAYAM/ NPTEL portal.

S. No.	Course Name
1	Mechanical Unit Operations
2	Introduction to Polymer Physics-IITR
3	Fluid and Particle Mechanics
4	Fluidization Engineering
5	Chemical Engineering Thermodynamics
6	Aspen Plus® simulation software - a basic course for beginners
7	Transport Phenomena of Non-Newtonian Fluids
8	Polymers: concepts, properties, uses and sustainability
9	Material & Energy Balance Computations
10	Principles and Practices of Process Equipment and Plant Design

I Year- I Semester

L	T	P	C
3	0	0	3

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

Course Objectives:

- This course will illuminate the students in the concepts of calculus.
- To enlighten the learners in the concept of differential equations and multivariable calculus.
- To equip the students with standard concepts and tools at an intermediate to advanced level mathematics to develop the confidence and ability among the students to handle various real world problems and their applications.

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

- utilize mean value theorems to real life problems (L3)
- solve the differential equations related to various engineering fields (L3)
- familiarize with functions of several variables which is useful in optimization (L3)
- Apply double integration techniques in evaluating areas bounded by region (L3)
- students will also learn important tools of calculus in higher dimensions. Students will become familiar with 2- dimensional and 3-dimensional coordinate systems (L5)
- Conclude the use of special function in multiple integrals (L4)

UNIT I: Sequences, Series and Mean value theorems: **(10 hrs)**

Sequences and Series: Convergences and divergence – Ratio test – Comparison tests – Integral test – Cauchy's root test – Alternate series – Leibnitz's rule.

Mean Value Theorems (without proofs): Rolle's Theorem – Lagrange's mean value theorem – Cauchy's mean value theorem – Taylor's and Maclaurin's theorems with remainders.

UNIT II: Differential equations: **(15 hrs)**

Linear differential equations – Bernoulli's equations – Exact equations and equations reducible to exact form – Non-homogeneous equations of higher order with constant coefficients with non-homogeneous term of the type e^{ax}, sin ax, cos ax, polynomials in x^n, e^{ax} V(x) and x^nV(x) – Method of Variation of parameters
Applications: Orthogonal trajectories – Electrical circuits (RL, RC, RLC) – Simple Harmonic motion.

UNIT III: Partial differentiation: **(10 hrs)**

Introduction – Homogeneous function – Euler's theorem – Total derivative – Chain rule – Jacobian – Functional dependence – Taylor's and Mc Laurent's series expansion of functions of two variables.
Applications: Maxima and Minima of functions of two variables without constraints and Lagrange's method (with constraints).

UNIT IV: Multiple integrals: **(8 hrs)**

Double and Triple integrals – Change of order of integration – Change of variables.
Applications: Finding Areas and Volumes.

UNIT V: Special functions: **(5 hrs)**

Introduction to Improper Integrals-Beta and Gamma functions- Properties - Relation between Beta and Gamma functions- Evaluation of improper integrals.

Text Books:

1. **B. S. Grewal,** Higher Engineering Mathematics, 43rd Edition, Khanna Publishers.
2. **B. V. Ramana,** Higher Engineering Mathematics, 2007 Edition, Tata Mc. Graw Hill Education.

Reference Books:

1. **Erwin Kreyszig,** Advanced Engineering Mathematics, 10th Edition, Wiley-India.
2. **Joel Hass, Christopher Heil and Maurice D. Weir,** Thomas calculus, 14th Edition, Pearson.
3. **Lawrence Turyn,** Advanced Engineering Mathematics, CRC Press, 2013.
4. **Srimantha Pal, S C Bhunia,** Engineering Mathematics, Oxford University Press.

I Year- I Semester

L	T	P	C
3	0	0	3

ENGINEERING PHYSICS

(for non-circuital branches like ME, CE, Chemical etc)

Course Objectives:

Physics curriculum which is re-oriented to the needs of non-circuital branches of graduate engineering courses offered by JNTUniversity:kakinada that serves as a transit to understand the branch specific advanced topics. The course is designed to:

- *Impart concepts of mechanics required to identify forces and moments in mechanical systems by vector representation-extend Newton's second law for inertial and non-inertial frames of reference- study different types of harmonic oscillatory motions.*
- *Tap the Simple harmonic motion and its adaptability for improved acoustic quality of concert halls- impart concepts of flaw detection techniques using ultrasonics.*
- *Study the structure- property relationship exhibited by solid materials within the elastic limit.*
- *Impart knowledge in basic concepts of LASERs along with its Engineering applications- Familiarize types of sensors for various engineering applications*
- *Explore the knowledge of magnetic and dielectric materials and their utility in appliances.*

UNIT-I **(10hrs)**

MECHANICS: Basic laws of vectors and scalars, rotational frames-conservative and non – conservative forces , F = - grad V, Newton's laws in inertial and linear accelerating non-inertial frames of reference, rotating frame of reference with constant angular velocity, Harmonic oscillator ; damped harmonic motion ; Forced oscillations and resonance.

Outcome:

The students will be able to

- Identify forces and moments in mechanical systems using scalar and vector techniques
- extend Newton's second law for inertial and non-inertial frame of reference
- explain simple harmonic motion and damped harmonic motions

UNIT-II **(10hrs)**

ACOUSTICS & ULTRASONICS: Introduction – Reverberation - Reverberation time - Sabine's formula (Derivation using growth and decay method)–absorption coefficient and its determination- factors affecting acoustics of buildings and their remedies.

Production of ultrasonics by Magnetostriction and piezoelectric methods – Detection of ultrasonics - acoustic grating - Non-Destructive Testing- pulse echo system through transmission and reflection modes - Applications.

Dr.G.Padmaja Rani | Dr.P.Dakshina Murthy | Dr.V.R.K.Murthy | Dr.S.V.S.Ramana Reddy

Dr.R.Padmasuvarna | Dr.K.Samatha

Outcome:

The students will be able to

- explain how sound is propagated in buildings
- analyze acoustic properties of typically used materials in buildings
- recognize sound level disruptors and their use in architectural acoustics
- Use of ultrasonics in flaw detection using NDT technique

UNIT-III **(9hrs)**

ELASTICITY:, stress, strain, Hooke's law, stress-strain curve, generalized Hooke's law with and without thermal strains for isotropic materials, different types of moduli and their relations, bending of beams – Bending moment of a beam – Depression of cantilever.

Outcome:

The students will be able to

- Understand the elasticity and plasticity concepts
- Study different types of moduli and their relation
- Analyze the concepts of shearing force and moment of inertia

UNIT-IV **(9hrs)**

LASERS & SENSORS: Characteristics–Spontaneous and Stimulated emission of radiation – population inversion - Einstein's coefficients & Relation between them and their significance - Pumping Mechanisms - Ruby laser – Helium Neon laser – Applications.

SENSORS (qualitative description only): Different types of sensors and applications; Strain and Pressure sensors- Piezoelectric, magnetostrictive sensors, Temperature sensor - bimetallic strip, pyroelectric detectors.

Outcome:

The students will be able to

- **Understand** the basic concepts of LASER light Sources
- Study Different types of laser systems
- Identify different types of sensors and their working principles

UNIT-V **(10hrs)**

MAGNETISM & DIELECTRICS: Introduction – Magnetic dipole moment – Magnetization-Magnetic susceptibility and permeability – Origin of permanent magnetic moment – Bohr Magneton - Classification of magnetic materials (Dia, Para and Ferro) – Domain concept of Ferromagnetism - Hysteresis – soft and hard magnetic materials – Applications of Ferromagnetic materials.

Introduction - Dielectric polarization – Dielectric polarizability, Susceptibility and Dielectric constant-types of polarizations: Electronic and Ionic (Quantitative), Orientational polarizations (qualitative)-Lorentz internal field – Claussius_Mossoti equation- Frequency dependence of polarization - Applications of dielectrics.

Outcome:

The students will be able to

- **explain** the concept of dielectric constant and polarization in dielectric materials.
- **summarize** various types of polarization of dielectrics .
- **interpret** Lorentz field and Claussius_Mosotti relation in dielectrics.
- **classify** the magnetic materials based on susceptibility and their temperature dependence.
- **explain** the applications of dielectric and magnetic materials .
- **Apply** the concept of magnetism to magnetic devices.

Dr.G.Padmaja Rani | Dr.P.Dakshina Murthy | Dr.V.R.K.Murthy | Dr.S.V.S.Ramana Reddy

Dr.R.Padmasuvarna | Dr.K.Samatha

I Year- I Semester

L	T	P	C
3	0	0	3

INTRODUCTION TO CHEMICAL ENGINEERING

Learning Objectives:

- To introduce the concepts that will enable the transition from science to chemical engineering.
- Explanation of role of Chemical Engineers in everyday life and the importance of Chemical Engineering.
- To learn the various Unit Operations and Unit Processes used in Chemical industries.
- To learn the role of Chemical Engineers in environmental and safety aspects in process industries.

UNIT – I:

Introduction, Chemical Engineering in everyday life, Lab scale to plant scale, Versatility of a Chemical/Petrochemical Engineer, Role of Chemical Engineers in Petroleum refinery, Chemical, Petrochemical, Nanotechnology, Energy and environment.

Batch Processing, Transition from batch to continuous processing, Case study: Any chemical industry, Role of basic sciences in Chemical Engineering (Introduction) (Text Book 1 & 2)

UNIT – II:

Introduction & Basic concepts of analysis of processes, unit operations, basic laws, units and dimensions, partial pressure, vapour pressure. Solutions, concentration measurements, humidity and saturation. Material and Energy balances, Design & control of chemical systems.

Flow of fluids: Introduction, nature of fluid, viscosity, velocity profile, flow field, types of fluid motion, laminar and turbulent flow, flow of a fluid past a solid surface, Reciprocating, rotary, and centrifugal pumps. (Text Book 2 & 3)

UNIT –III:

Heat transfer: Conduction, convection (omit correlations for calculation of heat transfer coefficients, heat transfer with change in phase) and radiation.

Heat transfer equipment (double pipe & Shell and tube heat exchanger), evaporation, long tube vertical type and forced circulation type evaporators, multiple effect evaporation, methods of feeding. (Text Book 1 & 3)

UNIT-IV:
Mass transfer: Introduction, Laws of diffusion, contact patterns, classification of separation processes and applications, basic definitions of separation processes, VLE, LLE, boiling point diagram. (Text Book 3)

Basic Concepts in Mass transfer Operations: Distillation, Extraction & leaching, crystallization, drying, absorption. (Text book 2 & 3).

UNIT – V:
Introduction to mechanical operations: Size reduction, filtration, basic differences between agitation and mixing. Introduction to environmental pollution: types and their effect. Safety in chemical process industries with case studies.

Types of reactions and reactors. Introduction to Process plant design & Economics (Text Book 1, 2 & 3).

Outcomes:
The student will be able to explain:

- The role of Chemical Engineers in everyday life and the importance of Chemical Engineering.
- The role of various Unit Operations and Unit Processes in Chemical industries.
- The role of Chemical Engineers in environmental and safety aspects in process industries.

Text Books:

1. Chemical Engineering-An Introduction, Morton M.Denn, Cambridge University Press, 2013.
2. Introduction to Chemical Engineering, S. Pushpavanam, PHI learning Pvt. Ltd., 2012.
3. Introduction to Chemical Engineering, Walter L. Badger, Julius T, Banchero, TMH Publications, 2008.

Reference Book:

1. Unit operations in Chemical Engineering, W.L. McCabe and J.C. Smith and Peter Harriott, McGraw Hill, 5th Ed. 1993.

I Year- I Semester

L	T	P	C
3	0	0	3

PROGRAMMING FOR PROBLEM SOLVING

Objectives:

The objectives of this course are to make the student familiar with problem solving using computers, development of algorithms, usage of basic flowchart symbols and designing flowcharts.

The students can also understand programming language basic concepts, reading and displaying the data, earn the programming skills using selection, iterative control structures, functions, arrays, pointers and files. After completion of this course the student is expected to analyze the real life problem and write programs in C language to solve the problems.

Course Outcomes:

After completion of this course

- Student will be able to develop efficient algorithm for solving a problem.
- Use various constructs of C programming language efficiently.
- Student will be able to develop programs using modular approach such as functions. And also able to develop programs to perform matrix and mathematical applications.
- Student will be able to understand dynamic memory management and problems using pointers and solving the problems.
- Student will be able to develop programs for real life applications using structures and also learn about handling the files for storing the data permanently.

UNIT I: Problem Solving: Problem solving aspects, Problem solving techniques, Computer as a Problem solving tool, Algorithms-definition, features, criteria. Flowchart-definition, basic symbols, sample flowcharts. Top down design, Implementation of program verification, The efficiency of algorithms, Analysis of algorithms, computational complexity of algorithm, order(O) notation, Worst case & Average case Analysis.

UNIT II: Basics of C programming language: Introduction to C, structure of a C program, basic data types and sizes, constants, variables, unary, binary and ternary operators, expressions, type conversions, conditional expressions, precedence and order of evaluation, Input and Output statements, Sample Programs.

SELECTION-DECISION MAKING CONDITIONAL CONTROL STRUCTURES: simple-if, if-else, nested if-else, if-else ladder and switch-case.

ITERATIVE: while-loop, do-while loop and for loop control structures, goto, break and continue statements. Sample Programs.

UNIT III: FUNCTIONS-basics, parameter passing, storage classes extern, auto, register, static, scope rules, block structure, user defined functions, standard library functions, recursive functions, Recursive solutions for Fibonacci series, towers of Hanoi, header files, C Preprocessor, example c programs

ARRAYS-concepts, declaration, definition, accessing elements, storing elements, 1-D arrays, 2-D arrays and character arrays, Multidimensional arrays, array applications: Matrix operations, checking the symmetricity of a Matrix, Passing 1-D arrays, 2-D arrays to functions, Strings and String Manipulations

UNIT IV: POINTERS-pointers concepts, initialization of pointer variables, pointers and function arguments, passing by address-dangling memory, address arithmetic, character pointers and functions, pointers to pointers, pointers and multi-dimensional arrays, dynamic memory management functions, command line arguments

UNIT V: ENUMERATED, STRUCTURE AND UNION TYPES: Derived types-structures- declaration, definition and initialization of structures, accessing structures, nested structures, arrays of structures, structures and functions, pointers to structures, self referential structures, unions, typedef, bit-fields, program applications

FILEHANDLING: Concept of a file, text files and binary files, Formatted I/O, File I/O operations

Text Books:

1. How to Solve it by Computer, R. G. Dromey, Pearson Education, 2019
2. Programming in C, Ashok N Kamthane, Amit Ashok Kamthane, 3rd Edition, Pearson Education, 2019

Reference Books:

1. The C programming Language by Dennis Richie and Brian Kernighan
2. Programming in C, Reema Thareja, OXFORD
3. C Programming, A Problem Solving Approach, Forouzan, Gilberg, Prasad, Cengage

TEXT BOOKS:

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

REFERENCE BOOKS:

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

Course Outcome: After undergoing this course, the student learnt the scales, various engineering curves and drawing the 2D and 3D objects.

HEAD
Mechanical Engineering Department
University College of Engineering
J.N.T. University Kakinada
KAKINADA

I Year- I Semester

L	T	P	C
1	0	3	2.5

ENGINEERING DRAWING

Course Objective: 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. scales

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

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

Scales: Plain scales, diagonal scales and vernier scales

Unit II

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

Orthographic Projections: Reference plane, importance of reference lines, projections of points in various quadrants, projections of lines, line parallel to both the planes, line parallel to one plane and inclined to other plane.

Unit III

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

Part-A: Projections of straight lines inclined to both the planes.

Part-B: determination of true lengths of a line inclined to both the planes, angle of inclination and traces.

Unit IV

Objective: The objective is to make the students draw the projections of the plane inclined to both the planes and projections of Prism & Cylinder with axis inclined to one plane

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

Projections of Solids – Prisms & Cylinders with the axis inclined to one of the plane.

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 plane and 3D views to 2D and vice-versa

Pyramids & Cones with the axis inclined to one of the plane.

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

HEAD
Mechanical Engineering Department
University College of Engineering
J.N.T. University Kakinada
KAKINADA

I Year- I Semester

L	T	P	C
0	0	3	1.5

ENGINEERING PHYSICS LAB
(Any 10 of the following listed 15 experiments)

LIST OF EXPERIMENTS:

1. Determination of Rigidity modulus of a material- Torsional Pendulum.
2. Determination of Young's modulus by method of single cantilever oscillations.
3. Determination of Acceleration due to Gravity and Radius of Gyration - Compound Pendulum.
4. Verification of laws of vibrations in stretched strings – Sonometer.
5. Determenation of spring constant of springs using coupled oscillators.
6. Magnetic field along the axis of a current carrying coil – Stewart and Gee's apparatus
7. Study the variation of B versus H by magnetizing the magnetic material (B-H curve).
8. Measurement of magnetic susceptibility by Quincke's method.
9. Determination of ultrasonic velocity in liquid (Acoustic Grating)
10. Determination of dielectric constant by charging and discharging method
11. Determination of wavelength of Laser by diffraction grating
12. Determination of particle size using Laser.
13. Determeination of Pressure variation using strain Gauge sensor.
14. Determination of Moment of Inertia of a Fly Wheel.
15. Determination of Velocity of sound –Volume Resoantor.

1. Dr.G.Padmaja Rani	**Chairman**	
2. Dr.P.Dakshina Murthy	**Member**	
3. Dr.V.R.K.Murthy	**External Member**	
4. Dr.S.V.S.Ramana Reddy	**External Member**	
5. Dr.K.Samatha	**External Member**	
6. Dr.R.Padmasuvarna	**External Member**	

I Year- I Semester

L	T	P	C
0	0	2	0

PHYSICS VIRTUAL LAB

LIST OF EXPERIMENTS

1. Hall Effect
2. Crystal Structure
3. Brewster's angle
4. Numerical Aperture of Optical fiber
5. Photoelectric Effect
6. LASER – Beam Divergence and Spot size
7. Michelson's interferometer
8. Black body radiation
9. Flywheel – moment of inertia
10. AC Sonometer
11. Resistivity by four probe method
12. Newton's rings –Refractive index of liquid

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

1. Dr.G.Padmaja Rani	**Chairman**	
2. Dr.P.Dakshina Murthy	**Member**	
3. Dr.V.R.K.Murthy	**External Member**	
4. Dr.S.V.S.Ramana Reddy	**External Member**	
5. Dr.K.Samatha	**External Member**	
6. Dr.R.Padmasuvarna	**External Member**	

I Year- I Semester

L	T	P	C
0	0	3	1.5

PROGRAMMING FOR PROBLEM SOLVING – LABORATORY

Exercise 1
a) Write a C Program to calculate the area of a triangle.
b) Write a C program to find the largest of three numbers using ternary operator.
c) Write a C Program to swap two numbers without using a temporary variable.

Exercise 2
a) Write a C program to find the 2's complement of a binary number.
b) Write a C program to find the roots of a quadratic equation.
c) Write a C program, which takes two integer operands and one operator from the user, performs the operation and then prints the result. (Consider the operators +,-,*, /, % and use Switch Statement)

Exercise 3
a) Write a C program to find the sum of individual digits of a positive integer and, also, find the reverse of the given number.
b) Write a C program to generate the first *n* terms of the Fibonacci sequence.
c) Write a C program to generate all the prime numbers between 1 and n, where n is a value supplied by the user.

Exercise 4
a) Write a C Program to print the multiplication table of a given number.
b) Write a C Program to read a decimal number and find its equivalent binary number.
c) Write a C Program to check whether the given number is Armstrong number or not.

Exercise 5
a) Write a C program to interchange the largest and smallest numbers in the given array.
b) Write a C program to implement a liner search on a given set of values.
c) Write a C program to implement binary search on a given set of values.

Exercise 6
a) Write a C program to implement sorting of an array of elements.
b) Write a C program to input two m x n matrices, check the compatibility and perform addition and multiplication of them.

Exercise 7
Write a C program that uses functions to perform the following operations:
i. To insert a sub-string into given main string at a given position.
ii. To delete n characters from a given position in a given string.
iii. To replace a character of string either from beginning or ending or at a specified location.

Exercise 8
Write a C program that uses functions to perform the following operations using Structure:
i) Reading a complex number
ii) Writing a complex number
iii) Addition of two complex numbers
iv) Multiplication of two complex numbers

M.V.S.S.N. Ravi Kumar — L. Suneelatha — 25.06.2019

Exercise 9

Write C Programs for the following string operations without using the built in functions
- to concatenate two strings
- to append a string to another string
- to compare two strings

Exercise 10

a) Write C Program to find the number of characters in a given string including and excluding spaces.
b) Write C Program to copy the contents of one string to another string without using string handling functions.
c) Write C Program to find whether a given string is palindrome or not.
d) Write a C program to find both the largest and smallest number of an array of integers using call by value and call by reference.

Exercise 11

Write a C program using recursion for the following:
a) To display sum of digits of given number
b) To find the factorial of a given integer
c) To find the GCD (greatest common divisor) of two given integers.
d) To find Fibonacci sequence

Exercise 12

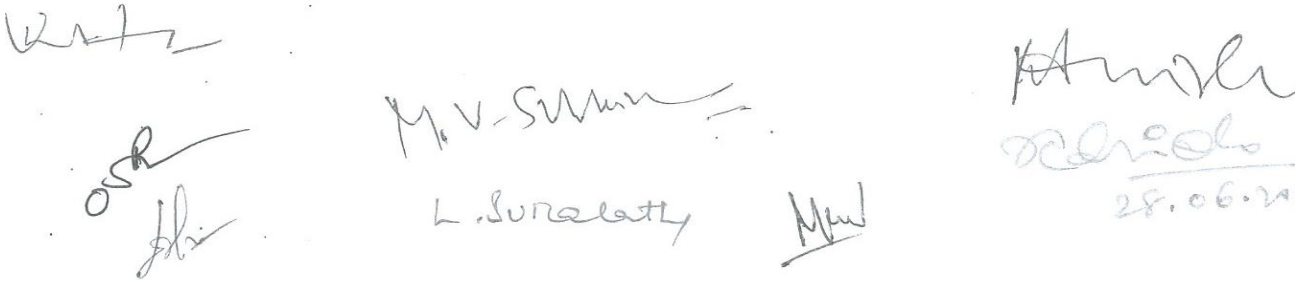
a) Write C Program to reverse a string using pointers
b) Write a C Program to compare two 2D arrays using pointers
c) Write a C program consisting of Pointer based function to exchange value of two integers using passing by address.

Exercise 13

Examples which explores the use of structures, union and other user defined variables

Exercise 14

a) Write a C program which copies one file to another.
b) Write a C program to count the number of characters and number of lines in a file.
c) Write a C Program to merge two files into a third file. The names of the files must be entered using command line arguments.



I Year- I Semester

L	T	P	C
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ENGLISH COMMUNICATION SKILLS LABORATORY - 1

Topics:

UNIT I:
Pronunciation: Vowels, Consonants, Phonetic Transcription

UNIT II:

Past tense markers, word stress-di-syllabic words, Poly-Syllabic words

UNIT III:

Rhythm & Intonation

UNIT IV:

Contrastive Stress (Homographs)

UNIT V:

Word Stress: Weak and Strong forms
Stress in compound words

Prescribed text book: "**Infotech English**", Maruthi Publications.

References:

1. Exercises in Spoken English Part 1,2,3,4, OUP and CIEFL.
2. English Pronunciation in use- Mark Hancock, Cambridge University Press.
3. English Phonetics and Phonology-Peter Roach, Cambridge University Press.
4. English Pronunciation in use- Mark Hewings, Cambridge University Press.
5. English Pronunciation Dictionary- Daniel Jones, Cambridge University Press.
6. English Phonetics for Indian Students- P. Bala Subramanian, Mac Millan Publications.

P. Rajendra / Convenor
28/06/2019

28/6/19

I Year- I Semester

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ENGINEERING EXPLORATION PROJECT

Learning Objectives:

- To get in-depth understanding of role of chemical engineering in a process industry.
- To get familiarity with organizational structure, work environment & culture, anatomy of chemical processes and equipment involved in a process industry.
- To interact with the teams of engineers and operating personnel in a process industry.
- To know the challenges in design, operation and production of a process industry.

Methodology:

The total students of a class are divided into small groups. Each group would be sent to a process industry for 7 days. Preferably on each Saturday in a week of 6-8 students along with a Faculty member. The host process industry provides a mentor (an experienced engineer). The students are expected to study all aspects of the industry under the guidance of the mentors (Faculty and Industry). At the end of the 7 day program each student should submit a report, which will be evaluated by a two-member team of faculty nominated by the Head of the Department.

Outcomes:

The students will be able:

- To understand the professional activities in process industry.
- To judge the importance and relevance of various subjects in curriculum.
- To know the possible career options in a process industry.

I Year- I Semester

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3	0	0	0

CONSTITUTION OF INDIA
(MC)

Learning Objectives:

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution

UNIT – I:

History of Making of the Indian Constitution: History, Drafting Committee, (Composition& Working), **Philosophy of the Indian Constitution:** Preamble, Salient, Features.

UNIT – II:

Contours of Constitutional Rights &Duties: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT – III:

Election Commission: Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

UNIT – IV:

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, **Executive:** President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT – V:

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation.Pachayati raj: Introduction, PRI: ZilaPachayat.Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level:

Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.

Course Outcomes:
After the completion of the course, student will be able to

CO1 Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.

CO2 Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.

CO3 Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.

CO4 Discuss the passage of the Hindu Code Bill of1956.

Text Books:

1. The Constitution of India, 1950 (Bare Act), Government Publication
2. Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, Dr. S. N. Busi, 2015

References:

1. Indian Constitution Law, 7th Edn. M. P. Jain, Lexis Nexis, 2014.
2. Introduction to the Constitution of India, Lexis Nexis, D.D. Basu, 2015.

I Year- II Semester

L	T	P	C
3	0	0	3

COMMUNICATE ENGLISH

Introduction

The course is designed to train students in receptive (listening and reading) as well as productive and interactive (speaking and writing) skills by incorporating a comprehensive, coherent and integrated approach that improves the learners' ability to effectively use English language in academic/ workplace contexts. The shift is from *learning about the language* to *using the language*. On successful completion of the compulsory English language course/s in B.Tech., learners would be confident of appearing for international language qualification/proficiency tests such as IELTS, TOEFL, or BEC, besides being able to express themselves clearly in speech and competently handle the writing tasks and verbal ability component of campus placement tests. Activity based teaching-learning methods would be adopted to ensure that learners would engage in actual use of language both in the classroom and laboratory sessions.

Course Objectives

- Facilitate effective listening skills for better comprehension of academic lectures and English spoken by native speakers
- Focus on appropriate reading strategies for comprehension of various academic texts and authentic materials
- Help improve speaking skills through participation in activities such as role plays, discussions and structured talks/oral presentations
- Impart effective strategies for good writing and demonstrate the same in summarizing, writing well organized essays, record and report useful information
- Provide knowledge of grammatical structures and vocabulary and encourage their appropriate use in speech and writing

Learning Outcomes

At the end of the module, the learners will be able to

- understand social or transactional dialogues spoken by native speakers of English and identify the context, topic, and pieces of specific information
- ask and answer general questions on familiar topics and introduce oneself/others
- employ suitable strategies for skimming and scanning to get the general idea of a text and locate specific information
- recognize paragraph structure and be able to match beginnings/endings/headings with paragraphs
- form sentences using proper grammatical structures and correct word forms

P. Rajendra Kashyap 28/06/19 (28/6/19) 28/6/19

Unit 1:

Lesson-1: A Drawer full of happiness from "**Infotech English**", Maruthi Publications

Lesson-2: Deliverance by Premchand from "**The Individual Society**", Pearson Publications. (Non-detailed)

Listening: Listening to short audio texts and identifying the topic. Listening to short audio texts and identifying the context and specific pieces of information to answer a series of questions both in speaking and writing.

Speaking: Asking and answering general questions on familiar topics such as home, family, work, studies and interests. Self introductions and introducing others.

Reading: Skimming text to get the main idea. Scanning to look for specific pieces of information.

Reading for Writing: Paragraph writing (specific topics) using suitable cohesive devices; linkers, sign posts and transition signals; mechanics of writing - punctuation, capital letters.

Vocabulary: Technical vocabulary from across technical branches (20) GRE Vocabulary (20) (Antonyms and Synonyms, Word applications) Verbal reasoning and sequencing of words.

Grammar: Content words and function words; word forms: verbs, nouns, adjectives and adverbs; nouns: countables and uncountables; singular and plural basic sentence structures; simple question form - wh-questions; word order in sentences.

Pronunciation: Vowels, Consonants, Plural markers and their realizations

Unit 2:

Lesson-1: Nehru's letter to his daughter Indira on her birthday from "**Infotech English**", Maruthi Publications

Lesson-2: Bosom Friend by Hira Bansode from "**The Individual Society**", Pearson Publications. (Non-detailed)

Listening: Answering a series of questions about main idea and supporting ideas after listening to audio texts, both in speaking and writing.

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Speaking: Discussion in pairs/ small groups on specific topics followed by short structured talks. Functional English: Greetings and leave takings.

Reading: Identifying sequence of ideas; recognizing verbal techniques that help to link the ideas in a paragraph together.

Reading for Writing: Summarizing - identifying main idea/s and rephrasing what is read; avoiding redundancies and repetitions.

Vocabulary: Technical vocabulary from across technical branches (20 words) GRE Vocabulary Analogies (20 words) (Antonyms and Synonyms, Word applications)

Grammar: Use of articles and zero article; prepositions.

Pronunciation: Past tense markers, word stress-di-syllabic words

Unit 3:

Lesson-1: Stephen Hawking-Positivity 'Benchmark' from "**Infotech English**", Maruthi Publications

Lesson-2: Shakespeare's Sister by Virginia Woolf from "**The Individual Society**", Pearson Publications. (Non-detailed)

Listening: Listening for global comprehension and summarizing what is listened to, both in speaking and writing.

Speaking: Discussing specific topics in pairs or small groups and reporting what is discussed. Functional English: Complaining and Apologizing.

Reading: Reading a text in detail by making basic inferences - recognizing and interpreting specific context clues; strategies to use text clues for comprehension. Critical reading.

Reading for Writing: Summarizing - identifying main idea/s and rephrasing what is read; avoiding redundancies and repetitions. Letter writing-types, format and principles of letter writing. E-mail etiquette, Writing CV's.

Vocabulary: Technical vocabulary from across technical branches (20 words) GRE Vocabulary (20 words) (Antonyms and Synonyms, Word applications) Association, sequencing of words

Grammar: Verbs - tenses; subject-verb agreement; direct and indirect speech, reporting verbs for academic purposes.

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Pronunciation: word stress-poly-syllabic words

Unit 4:

Lesson-1: Liking a Tree, Unbowed: Wangari Maathai-biography from "**Infotech English**", Maruthi Publications

Lesson-2: Telephone Conversation-Wole Soyinka from "**The Individual Society**", Pearson Publications. (Non-detailed)

Listening: Making predictions while listening to conversations/ transactional dialogues without video (only audio); listening to audio-visual texts.

Speaking: Role plays for practice of conversational English in academic contexts (formal and informal) - asking for and giving information/directions. Functional English: Permissions, Requesting, Inviting.

Reading: Studying the use of graphic elements in texts to convey information, reveal trends/patterns/relationships, communicative process or display complicated data.

Reading for Writing: Information transfer; describe, compare, contrast, identify significance/trends based on information provided in figures/charts/graphs/tables. Writing SOP, writing for media.

Vocabulary: Technical vocabulary from across technical branches (20 words) GRE Vocabulary (20 words) (Antonyms and Synonyms, Word applications) Cloze Encounters.

Grammar: Quantifying expressions - adjectives and adverbs; comparing and contrasting; degrees of comparison; use of antonyms

Pronunciation: Contrastive Stress

Unit 5:

Lesson-1: Stay Hungry-Stay foolish from "**Infotech English**", Maruthi Publications

Lesson-2: Still I Rise by Maya Angelou from "**The Individual Society**", Pearson Publications. (Non-detailed)

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Listening: Identifying key terms, understanding concepts and interpreting the concepts both in speaking and writing.

Speaking: Formal oral presentations on topics from academic contexts - without the use of PPT slides. Functional English: Suggesting/Opinion giving.

Reading: Reading for comprehension. RAP Strategy Intensive reading and Extensive reading techniques.

Reading for Writing: Writing academic proposals- writing research articles: format and style.

Vocabulary: Technical vocabulary from across technical branches (20 words) GRE Vocabulary (20 words) (Antonyms and Synonyms, Word applications) Coherence, matching emotions.

Grammar: Editing short texts – identifying and correcting common errors in grammar and usage (articles, prepositions, tenses, subject verb agreement)

Pronunciation: Stress in compound words

Prescribed text books for theory for Semester-I:
1. **"Infotech English"**, Maruthi Publications. (Detailed)
2. **"The Individual Society"**, Pearson Publications. (Non-detailed)

Prescribed text book for Laboratory for Semesters-I & II:
1. **"Infotech English"**, Maruthi Publications. (with Compact Disc)

Reference Books

- Bailey, Stephen. *Academic writing: A handbook for international students*. Routledge, 2014.
- Chase, Becky Tarver. *Pathways: Listening, Speaking and Critical Thinking*. Heinley ELT; 2nd Edition, 2018.
- Skillful Level 2 Reading & Writing Student's Book Pack (B1) Macmillan Educational.
- Hewings, Martin. *Cambridge Academic English (B2)*. CUP, 2012.

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I Year- II Semester

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MATHEMATICS – II
(Linear Algebra and Numerical Methods)

Course Objectives:

- To instruct the concept of Matrices in solving linear algebraic equations
- To elucidate the different numerical methods to solve nonlinear algebraic equations
- To disseminate the use of different numerical techniques for carrying out numerical integration.
- To equip the students with standard concepts and tools at an intermediate to advanced level mathematics to develop the confidence and ability among the students to handle various real world problems and their applications.

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

- develop the use of matrix algebra techniques that is needed by engineers for practical applications (L6)
- solve system of linear algebraic equations using Gauss elimination, Gauss Jordan, Gauss Seidel (L3)
- evaluate approximating the roots of polynomial and transcendental equations by different algorithms (L5)
- apply Newton's forward & backward interpolation and Lagrange's formulae for equal and unequal intervals (L3)
- apply different algorithms for approximating the solutions of ordinary differential equations to its analytical computations (L3)

Unit I: Solving systems of linear equations, Eigen values and Eigen vectors: **(10 hrs)**

Rank of a matrix by echelon form and normal form – Solving system of homogeneous and non-homogeneous equations linear equations – Gauss Elimination for solving system of equations – Eigen values and Eigen vectors and their properties.
Applications: Free vibration of a two-mass system.

Unit-II: Cayley-Hamilton theorem and Quadratic forms: **(10 hrs)**

Cayley-Hamilton theorem (without proof) – Finding inverse and power of a matrix by Cayley-Hamilton theorem – Reduction to Diagonal form – Quadratic forms and nature of the quadratic forms – Reduction of quadratic form to canonical forms by orthogonal transformation.

4

Singular values of a matrix, singular value decomposition (Ref. Book – 1).

UNIT III: Iterative methods: **(8 hrs)**

Introduction – Bisection method – Secant method – Method of false position – Iteration method – Newton-Raphson method (One variable and simultaneous Equations) – Jacobi and Gauss-Seidel methods for solving system of equations – Power Method for finding Largest Eigenvalue –Eigenvector.

UNIT IV: Interpolation: **(10 hrs)**

Introduction – Errors in polynomial interpolation – Finite differences – Forward differences – Backward differences – Central differences – Relations between operators – Newton's forward and backward formulae for interpolation – Interpolation with unequal intervals – Lagrange's interpolation formula – Newton's divide difference formula.

UNIT V: Numerical integration and solution of ordinary differential equations: **(10 hrs)**

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) – Milne's Predictor and Corrector Method.

Text Books:

1. **B. S. Grewal,** Higher Engineering Mathematics, 43^{rd} Edition, Khanna Publishers.
2. **B. V. Ramana,** Higher Engineering Mathematics, 2007 Edition, Tata Mc. Graw Hill Education.

Reference Books:

1. **David Poole,** Linear Algebra- A modern introduction, 4^{th} Edition, Cengage.
2. **Steven C. Chapra,** Applied Numerical Methods with MATLAB for Engineering and Science, Tata Mc. Graw Hill Education.
3. **M. K. Jain, S. R. K. Iyengar and R. K. Jain,** Numerical Methods for Scientific and Engineering Computation, New Age International Publications.
4. **Lawrence Turyn,** Advanced Engineering Mathematics, CRC Press.

I Year- II Semester

L	T	P	C
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MATHEMATICS-III (Vector Calculus, Transforms and PDE)
(Common to ALL branches of First Year B.Tech.)

Course Objectives:

- To familiarize the techniques in partial differential equations
- To furnish the learners with basic concepts and techniques at plus two level to lead them into advanced level by handling various real world applications.

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

- interpret the physical meaning of different operators such as gradient, curl and divergence (L5)
- estimate the work done against a field, circulation and flux using vector calculus (L5)
- apply the Laplace transform for solving differential equations (L3)
- find or compute the Fourier series of periodic signals (L3)
- know and be able to apply integral expressions for the forwards and inverse Fourier transform to a range of non-periodic waveforms (L3)
- identify solution methods for partial differential equations that model physical processes (L3)

Unit –I: Vector calculus: **(10 hrs)**

Vector Differentiation: Gradient – Directional derivative – Divergence – Curl – Scalar Potential.

Vector Integration: Line integral – Work done – Area – Surface and volume integrals – Vector integral theorems: Greens, Stokes and Gauss Divergence theorems (without proof).

Unit –II: Laplace Transforms: **(10 hrs)**

Laplace transforms of standard functions – Shifting theorems – Transforms of derivatives and integrals – Unit step function – Dirac's delta function – Inverse Laplace transforms – Convolution theorem (with out proof).

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

Unit –III: Fourier series and Fourier Transforms: **(10 hrs)**

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.

Fourier Transforms: Fourier integral theorem (without proof) – Fourier sine and cosine integrals – Sine and cosine transforms – Properties – inverse transforms – Finite Fourier transforms.

Unit –IV: PDE of first order: **(8 hrs)**

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 V: Second order PDE and Applications: **(10 hrs)**

Second order PDE: Solutions of linear partial differential equations with constant coefficients – RHS term of the type $e^{ax+by}, \sin(ax+by), \cos(ax+by), x^m y^n$.

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

Text Books:

1. **B. S. Grewal,** Higher Engineering Mathematics, 43rd Edition, Khanna Publishers.
2. **B. V. Ramana,** Higher Engineering Mathematics, 2007 Edition, Tata Mc. Graw Hill Education.

Reference Books:

1. **Erwin Kreyszig,** Advanced Engineering Mathematics, 10th Edition, Wiley-India.
2. **Dean. G. Duffy,** Advanced Engineering Mathematics with MATLAB, 3rd Edition, CRC Press.
3. **Peter O' Neil,** Advanced Engineering Mathematics, Cengage.
4. **Srimantha Pal, S C Bhunia,** Engineering Mathematics, Oxford University Press.

I Year- II Semester

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CHEMISTRY – 1 (PHYSICAL CHEMISTRY)

Learning objectives:

- To understand the basic concepts of distribution law, phase rule, chemical kinetics, solutions.
- To explain the equilibrium existing between the different phases of a heterogeneous system.
- To study of chemical kinetics explains the rates at which chemical reactions occur and also explains theories of reaction rates.
- To understand total vapor pressure of ideal or non-ideal mixtures of two volatile liquids.
- To study fundamentals of spectroscopy to understand qualitative and quantitative analysis of substances.
- To understand mechanism by which components are separated on GC and HPLC techniques, spectro-photometry and separation techniques.

UNIT-I:

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

UNIT-II:

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.

UNIT-III: Spectroscopic and separation techniques

Part A : Spectrophotometry: General features of absorption spectroscopy, Beer-Lambert's law and its limitations, absorbance, transmittance and molar absorptivity; Single and double beam spectrophotometers.

Part B: Separation Techniques:

Solvent extraction: Principle and process, Batch extraction, continuous extraction and counter current extraction, application-determination of iron (III).

High performance liquid chromatography (HPLC): principles and applications.

Gas liquid chromatography (GLC): principles and applications.

UNIT-VI:

Chemical Kinetics: Introduction to chemical kinetics – theories of reaction rates –collision theory – modified collision theory –arhenius theory – absolute 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-V:

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.

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.

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 refineries.
- Understand the various reactions 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. Puri, B. R., Sharma L. R., Pathama M. S., Principles of Physical Chemistry, Vishal Publishing company, 2008.
2. Manas Chanda, Atomic Structure and the Chemical Bond, 4th Edition, Tata-McGraw-Hill, 2000.
3. Bahl, B. S., G. D. Tuli and Arun Bahl, Essentials of Physical Chemistry, 24th Revised Version, Chand & Co, Latest edition.

Reference Books:

1. Peter Atkins, Julia de Paula, Physical Chemistry, 9th Edition, Oxford University Press, 2011.
2. Laidler, K. J., Chemical kinetics, 2nd Edition, McGraw-Hill, 1965.
3. Macmillan, Kapoor, K. L., A textbook of physical chemistry, 2000.
4. John A. Dean, Van Nostrand Reinhold, Chemical separation methods, 1969.
5. Kour, H., An introduction to chromatography, Pragati Publishers, 2007.
6. Sastry, M. N., Separation methods, Himalaya Publications, 3rd Edition, 2005.

28/6/19

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28.06.2019

I Year- II Semester

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ENIGINEERING MECHANICS

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, , Lami's Theorm, Equations of Equilibrium of Coplanar Systems, Graphical method for the equilibrium, Triangle law of forces, converse of the law of polygon of forces condition of equilibrium, Equations of Equilibrium for Spatial System of forces, Numerical examples on spatial system of forces using vector approach, Analysis of plane trusses.

UNIT – III

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

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.

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 – IV

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.

Rectilinear and Curvilinear motion of a particle: Kinematics and Kinetics- D'Alembert's Principle, Work Energy method and applications to particle motion- Impulse momentum method.

UNIT – V

Objectives: The students are to be exposed to rigid motion kinematics and kinetics

Rigid body Motion: Kinematics and kinetics of translation, Rotation about fixed axis and plane motion, Work Energy method and Impulse momentum method.

Dr. K. Meera Saheb	Dr. B. Balakrishna	Dr. A. Gopala Krishna	Dr.A.SwarnaKumari
Dr. N. Mohan Rao	Dr. K. Mallikarjuna Rao	Dr.A.V.Sitarama Raju	Dr. P. Ramesh Babu
Dr. N. Ramanaiah	Dr.G.Madhusudan Reddy	Dr.Ch. Rajesh	

TEXT BOOK:

1. Engg. Mechanics - S.Timoshenko & D.H.Young., 4th Edn - , Mc Graw Hill publications.

REFERENCES:

1. Engineering Mechanics statics and dynamics – R.C.Hibbeler, 11th Edn – Pearson Publ.
2. Engineering Mechanics , statics – J.L.Meriam, 6th Edn – Wiley India Pvt Ltd.
3. Engineering Mechanics , dynamics – J.L.Meriam, 6th Edn – Wiley India Pvt Ltd.
4. Engineering Mechanics , statics and dynamics – I.H.Shames, – Pearson Publ.
5. Mechanics For Engineers , statics - F.P.Beer & E.R.Johnston – 5th Edn Mc Graw Hill Publ.
6. Mechanics For Engineers, dynamics - F.P.Beer & E.R.Johnston –5th Edn Mc Graw Hill Publ.
7. Theory & Problems of engineering mechanics, statics & dynamics – E.W.Nelson, C.L.Best & W.G. McLean, 5th Edn – Schaum's outline series - Mc Graw Hill Publ.
8. Engineering Mechanics , Fedinand . L. Singer , Harper – Collins.
9. Engineering Mechanics statics and dynamics , A Nelson , Mc Graw Hill publications
10. Engineering Mechanics, Tayal. Umesh Publ.

Course outcomes:

CO1. To Learn the principles (Axioms) of statics, able to find resultant & resolution of system of forces and resultant force.
CO2. Explore the concepts of constraints, free body diagram and action-reaction.
CO3. Estimate the geometric parameters like centroid, center of gravity and moment of inertia and identify their application.
CO4. Learn the analysis of frames and trusses and know the importance of friction.
CO5. Able to determine solution to dynamic problems through D'Alembert equilibrium equations, Impulse-Momentum and work– energy method

Dr. K. Meera Saheb Dr. B. Balakrishna Dr. A. Gopala Krishna Dr.A.SwarnaKumari

Dr. N. Mohan Rao Dr. K. Mallikarjuna Rao Dr.A.V.Sitarama Raju Dr. P. Ramesh Babu

Dr. N. Ramanaiah Dr.G.Madhusudan Reddy Dr.Ch. Rajesh

I Year- II Semester

L	T	P	C
0	0	3	1.5

ENGINEERING WORKSHOP & IT WORKSHOP

ENGINEERING WORKSHOP:

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

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

Trade:

1.Carpentry
1. T-Lap Joint
2. Cross Lap Joint
3. Dovetail Joint
4. Mortise and Tenon Joint

2.Fitting
1. Vee Fit
2. Square Fit
3. Half Round Fit
4. Dovetail Fit

3.Black Smithy
1. Round rod to Square
2. S-Hook
3. Round Rod to Flat Ring
4. Round Rod to Square headed bolt

4.House Wiring
1. Parallel / Series Connection of three bulbs
2. Stair Case wiring
3. Florescent Lamp Fitting
4. Measurement of Earth Resistance

5.Tin Smithy
1. Taper Tray
2. Square Box without lid
3. Open Scoop
4. Funnel

IT WORKSHOP

Objectives:

- **PC Hardware:** Identification of basic peripherals, Assembling a PC, Installation of system software like MS Windows, device drivers, etc. Troubleshooting of PC Hardware and Software issues.
- **Internet & World Wide Web:** Different ways of hooking the PC on to the internet from home and workplace and effectively usage of the internet, web browsers, email, newsgroups and discussion forums. Awareness of cyber hygiene (protecting the personal computer from getting infected with the viruses), worms and other cyber attacks.
- **Productivity Tools:** Understanding and practical approach of professional word documents, excel spread sheets, power point presentations and personal web sites using the Microsoft suite office tools.

Course Outcomes:

List of Exercises:

(Faculty to consolidate the workshop manuals using the textbook and references)

Task 1: Identification of the peripherals of a computer - Prepare a report containing the block diagram of the computer along with the configuration of each component and its functionality. Describe about various I/O Devices and its usage.

Task 2: Practicing disassembling and assembling components of a PC

Task 3: Installation of Device Drivers, MS windows, Linux Operating systems and Disk Partitioning

Task 4: Introduction to Memory and Storage Devices, I/O Port, Assemblers, Compilers, Interpreters, Linkers and Loaders.

Task 5: Demonstration of Hardware and Software Troubleshooting

Task 6: Demonstrating Importance of Networking, Transmission Media, Networking Devices- Gateway, Routers, Hub, Bridge, NIC, Bluetooth Technology, Wireless Technology, Modem, DSL, and Dialup Connection.

Task 7: Awareness of various threats on the Internet and its solutions

Task 8: Demonstration and Practice on Microsoft Word

Task 9: Demonstration and Practice on Microsoft Excel

Task 10: Demonstration and Practice on Microsoft Power Point

Task 11: Demonstration and Practice on LaTeX

TEXT BOOK:

1 Computer Fundamentals, Anita Goel, Pearson India Education, 2017
2 PC Hardware Trouble Shooting Made Easy, TMH

REFERENCE BOOK:

1. Scott Mueller's Upgrading and Repairing PCs, 18/e, Scott. Mueller, QUE, Pearson,2008
2. Comdex Information Technology, Vikas Gupta, Dreamtech.
3. Essential Computer and IT Fundamentals for Engineering and Science Students, Dr. N.B. Venkateswarlu
4. Information Technology Workshop, 3e, G Praveen Babu, M V Narayana BS Publications

28.06.2019

I **C**
1.5

I Year- II Semester

L	T	P	C
0	0	3	1.5

ENGLISH COMMUNICATION SKILLS LABORATORY - II

Learning objectives:

Physical Chemistry Laboratory is intended to:

- Understand the concepts learned in theoretical, physical chemistry.
- Emphasize in acquiring accurate data.
- Make data and error analysis.
- Correlate the data to theory.
-

List of Experiments

1. Determination of density and surface tension of liquids against air at various temperatures using capillary rise method.
2. Measurement of dielectric 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. Study of kinetics of the reduction of methylene blue by ascorbic acid.
6. i. Determination of molecular weight by vapor pressure method.
   ii. Determination of latent heat of vaporization.
7. Kinetics of inversion of using a polarimeter.
8. Determination of vapour liquid equilibrium of binary mixtures.
9. Ternary Liquid Equilibria: determination of binomial curve.
10. Chromatographic methods: Paper chromatography, thin layer chromatography.
11. Adsorption of acetic acid by charcoal.
12. Photo-catalytic degradation of pigment by TiO_2

Out comes:

A student who successfully completes this laboratory course 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 physico-chemical measurement techniques.

28/6/19

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28.6.2019

UNIT I:
Oral Activity: JAM, Hypothetical Situations, Self/Peer Profile
Common Errors in Pronunciation, Neutralising Accent

UNIT II:
Oral Activity: Telephonic Etiquette, Role Plays
Poster Presentations

UNIT III:
Oral Activity: Oral Presentation skills, Public speaking
Data Interpretation

UNIT IV:
Oral Activity: Group Discussions: Do's and Don'ts- Types, Modalities

UNIT V:
Oral Activity: Interview Skills: Preparatory Techniques, Frequently asked questions, Mock Interviews.
Pronunciation: Connected speech (Pausing, Tempo, Tone, Fluency etc.,)

References:

1. Exercises in Spoken English Part 1,2,3,4, OUP and CIEFL.
2. English Pronunciation in use- Mark Hancock, Cambridge University Press.
3. English Phonetics and Phonology-Peter Roach, Cambridge University Press.
4. English Pronunciation in use- Mark Hewings, Cambridge University Press.
5. English Pronunciation Dictionary- Daniel Jones, Cambridge University Press.
6. English Phonetics for Indian Students- P. Bala Subramanian, Mac Millan Publications.
7. Technical Communication- Meenakshi Raman, Sangeeta Sharma, Oxford University Press.
8. Technical Communication- Gajendrea Singh Chauhan, Smita Kashiramka, Cengage Publications.

P. Rajendra Karmarkar 28/06/19

28/6/19

28/6/19

I Year- II Semester

L	T	P	C
3	0	0	0

ENVIRONMENTAL SCIENCE
(MC)

Learning Objectives:
The objectives of the course are 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 Environmental Management: 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.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

I Year- II Semester

L	T	P	C
0	0	2	0

PHYSICAL FITNESS ACTIVITIES
(MC)

I Year- II Semester

L	T	P	C
0	0	0	3

MOOCS (NPTEL/ SWAYAM) FOR HONORS/MINORS DEGREE

Learning Objectives:
The students will be able to:

- Avail the expertise in a specific subject from nation-wide reputed faculty, through MOOC (Massive Open Online Course)
- Develop the ability for self-actualization and in getting opportunity for life-long learning

There shall be a Discipline Centric Elective Course through Massive Open Online Course (MOOC) as Program Elective course. The student shall register for the course (Minimum of 12 weeks) offered by SWAYAM/NPTEL through online with the approval of Head of the Department. The Head of the Department shall appoint one mentor for each of the MOOC subjects offered. The student needs to register the course in the SWAYAM/NPTEL portal. During the course, the mentor monitors the student's assignment submissions given by SWAYAM/NPTEL.
The student needs to submit all the assignments given and needs to take final exam at the center. The student has to earn a certificate by passing the exam. The student will be awarded the credits given in curriculum only by submission of the certificate. In case if student does not pass subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered again through SWAYAM/NPTEL in the next semester with the recommendation of Head of the Department and shall be passed in the examination.
The list of MOOCS courses is given in the appendix (to do honors in chemical engineering, the eligible student has to choose the subjects in chemical engineering from the list to fulfill the criteria of 20 credits). In order to get minor degree, a student has to select and do the courses in any one discipline other than chemical engineering to fulfil the criteria of 20 credits.
The total 20 credits for honors or minor degree should be obtained from the second semester to the end of eighth semester. A candidate can take a 3-credit course in each semester during the above mentioned period.
It may be noted that, each student is to get minimum 8.0 SGPA without any backlogs in each semester to do honors and minors degree.

Outcomes:
The students are able to:

- Overcome the digital divide in acquiring fast developing technologies / knowledge and be part of digital revolution.
- Acquire subject specific expert knowledge from National Resource Pool.
- Understand his /her academic / professional priorities for future development.

II Year- I Semester

L	T	P	C
3	0	0	3

MATHEMATICS – IV

Course Objectives:

- To familiarize the complex variables.
- To familiarize the students with the foundations of probability and statistical methods.
- To equip the students to solve application problems in their disciplines.

Course Outcomes: At the end of the course students will be able to

- apply Cauchy-Riemann equations to complex functions in order to determine whether a given continuous function is analytic (L3)
- find the differentiation and integration of complex functions used in engineering problems (L5)
- make use of the Cauchy residue theorem to evaluate certain integrals (L3)
- apply discrete and continuous probability distributions (L3)
- design the components of a classical hypothesis test (L6)
- infer the statistical inferential methods based on small and large sampling tests (L4)

UNIT-I: Functions of a complex variable and Complex integration: **(10 hrs)**

Introduction – Continuity – Differentiability – Analyticity – Properties – Cauchy-Riemann equations in Cartesian and polar coordinates – Harmonic and conjugate harmonic functions – Milne – Thompson method.
Complex integration: Line integral – Cauchy's integral theorem – Cauchy's integral formula – Generalized integral formula (all without proofs).

UNIT-II: Series expansions and Residue Theorem: **(10 hrs)**

Radius of convergence – Expansion in Taylor's series, Maclaurin's series and Laurent series. Types of Singularities: Isolated – pole of order m – Essential – Residues – Residue theorem (without proof) – Evaluation of real integral of the type $\int_{-\infty}^{\infty} f(x)dx$

UNIT – III: Probability and Distributions: **(10 hrs)**

Review of probability and Baye's theorem – Random variables – Discrete and Continuous random variables – Distribution function – Mathematical Expectation and Variance – Binomial, Poisson, Uniform and Normal distributions.

8

UNIT – IV: Sampling Theory: **(8 hrs)**

Introduction – Population and samples – Sampling distribution of Means and Variance (definition only) – Central limit theorem (without proof) – Introduction to t, χ^2 and F-distributions – Point and Interval estimations – Maximum error of estimate.

UNIT – V: Tests of Hypothesis: **(10 hrs)**

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 two means (Large and Small samples) – Tests on proportions.

Text Books:

1. **B. S. Grewal,** Higher Engineering Mathematics, 43rd Edition, Khanna Publishers.
2. **Miller and Freund's,** Probability and Statistics for Engineers, 7/e, Pearson, 2008.

Reference Books:

1. **S. C. Gupta and V. K. Kapoor**, Fundamentals of Mathematical Statistics, 11/e, Sultan Chand & Sons Publications, 2012.
2. **Jay l. Devore,** Probability and Statistics for Engineering and the Sciences, 8th Edition, Cengage.
3. **Shron L. Myers, Keying Ye, Ronald E Walpole,** Probability and Statistics Engineers and the Scientists, 8th Edition, Pearson 2007.
4. **Sheldon, M. Ross**, Introduction to probability and statistics Engineers and the Scientists, 4th Edition, Academic Foundation, 2011

II Year- I Semester

L	T	P	C
3	0	0	3

BASIC ELECTRICAL & ELECTRONICS ENGINEERING

Preamble:
This course covers the topics related to analysis of various electrical circuits, operation of various electrical machines and electronic components to perform well in their respective fields.

Course objectives:

- To learn the basic principles of electrical circuital law's and analysis of networks.
- To understand principle of operation and construction details of DC machines & Transformers.
- To understand principle of operation and construction details of alternator and 3-Phase induction motor.
- To study operation of PN junction diode, half wave, full wave rectifiers and OP-AMPs.
- To learn operation of PNP and NPN transistors and feedback amplifier.

Unit - I

Electrical Circuits

Basic definitions – types of network elements – Ohm's Law – Kirchhoff's Laws – inductive networks – capacitive networks – series – parallel circuits – Mesh and Node Analysis -star-delta and delta-star transformations- simple Numerical Problems.

Unit - II

DC Machines

Principle of operation of DC generator – EMF equation – open circuit characteristics of separately excited DC shunt Generator - types of DC machines – Principle of operation of DC Motor - torque equation – three point starter – speed control methods of DC motor – Swinburne's Test- simple Numerical Problems.

Unit - III

AC Machines:

Transformers

Principle of operation and construction of single phase transformers – EMF equation – Losses – OC & SC tests w.r.t. efficiency and regulation only - simple Numerical Problems.

Dr.Ch.Saibabu (Member)	Dr.S.SivanagaRaju (Member)	Dr.R.SrinivasaRao (Member)	Dr.V.V.N.Murthy (Member)	Dr.B.Sarvesh (Member)	Dr.K.S.Rama Rao (Member)
r.K.Ramasudha (Member)	Dr.D.Suryanarayana (Member)	Dr.D.M.Vinod Kumar (Member)	Sri K.Praveen Kumar (Member)	Dr.M.Siva Kumar (Member)	Dr.K.Sri Kumar (Chairman)

AC Rotating Machines

Principle of operation and construction of alternators – types of alternators –Regulation of alternator by synchronous impedance method- principle of operation of 3-Phase induction motor – slip-torque characteristics – efficiency. simple Numerical Problems.

Unit IV

Rectifiers and Linear ICs

PN junction diodes and their characteristics – Rectifiers- half wave and bridge rectifiers - simple Numerical Problems. Characteristics of operation amplifiers (OP-AMP) – application of OP-AMPs (inverting, non-inverting, integrator and differentiator)

Unit V

Transistors

Operation of PNP and NPN junction transistors, transistor as an amplifier – single stage and frequency response of CE amplifier – concepts of feedback amplifier..

Course Outcomes:

The student should be able to:

- Analyse various electrical networks.
- Understand operation of DC generators,3-point starter and DC machine testing by Swinburne's Test.
- Analyse performance of single-phase transformer.
- Explain operation of 3-phase alternator and 3-phase induction motors.
- Analyse operation of half wave, full wave bridge rectifiers and OP-AMPs and Explain single stage CE amplifier and concept of feedback amplifier.

Text Books:

1. Electrical Technology by Surinder Pal Bali, Pearson Publications.
2. Electronic Devices and Circuits by R.L. Boylestad and Louis Nashelsky, 9th edition, PEI/PHI 2006.

Reference Books:

1. Electrical Circuit Theory and Technology by John Bird, Routledge Taylor &Francis Group
2. Basic Electrical Engineering by M.S.Naidu and S.Kamakshiah, TMH Publications
3. Fundamentals of Electrical Engineering by Rajendra Prasad, PHI Publications,2nd edition
4. Basic Electrical Engineering by Nagsarkar, Sukhija, Oxford Publications,2nd edition
5. Industrial Electronics by G.K. Mittal, PHI

Dr.Ch.Saibabu (Member)	Dr.S.SivanagaRaju (Member)	Dr.R.SrinivasaRao (Member)	Dr.V.V.N.Murthy (Member)	Dr.B.Sarvesh (Member)	Dr.K.S.Rama Rao (Member)
Dr.K.Ramasudha (Member)	Dr.D.Suryanarayana (Member)	Dr.D.M.Vinod Kumar (Member)	Sri K.Praveen Kumar (Member)	Dr.M.Siva Kumar (Member)	Dr.K.Sri Kumar (Chairman)

II Year- I Semester

L	T	P	C
3	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

Introduction: Engineering Materials – Classification – levels of structure. Crystal Geometry and Structure Determination: Space lattice and Unit cell. Bravais lattices, crystal systems with examples. Lattice coordinates, Miller indices, Bravais indices for directions and places: crystalline and non-crystalline solids; ionic, covalent and metallic solids; packing efficiency, coordination number; structure determination by Bragg's X-ray diffraction and powder methods.

UNIT -II

Crystal Imperfection: Point defects, line defects-edge and screw dislocation, Berger's circuit and Berger's vectors, dislocation reaction, dislocation motion, multiplication of dislocations during deformation.

Role of dislocation on crystal properties; surface defects, dislocation density and stress required to move dislocations.

UNIT -III

Basic thermodynamic functions: phase diagrams and phase transformation: Primary and binary systems-general types with examples; tie line& lever rule, non- equilibrium cooling: phase diagrams of Fe-Fe3-C, Pb-Sn, Cu-Ni systems.

Phase transformations in Fe-Fe3-C steels, Time-Temperature-Transformation (TTT) curves for eutectoid steels and plain carbon steels;

effect of alloying elements on properties of steels; types of steels, alloys and other metals used in chemical industry.

UNIT -IV

Elastic, an elastic and plastic deformations in solid materials; rubber like elasticity, visco elastic behavior (models); shear strength of real and perfect crystals, work hardening mechanisms, cold working, hot working; dynamic recovery, recrystallization, grain growth, grain size and yield stress, Brief description of heat treatment in steels.

Magnetic materials: Terminology and classification, magnetic moments due to electron spin, ferro-magnetism and related phenomena, domain structure, hysteresis loop, soft and hard magnetic materials.

UNIT- V

Fracture in ductile and brittle materials, creep: mechanism of creep and methods to reduce creeping in materials, creep rates and relations. Fatigue-mechanisms and methods to improve fatigue resistance in materials. Composite materials: types; stress-strain relations in composite materials, applications.

Oxidation and Corrosion: Mechanisms of oxidation, oxidation resistant materials, principles and types of corrosion, protection against corrosion.

Outcomes:

After the course, the students will be able to:

- Equipped with knowledge to understand material selection diagram, evaluation of equipment life and prediction of life of the equipment.
- Acquiring the abilities to carryout reliability studies.
- Ready to carryout equipment failure analysis and propose the remedial measures

Text books:

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

Reference Books:

1. Elements of Materials Science, L.R. Van Vlack,
2. Science of Engineering Materials, vols. 1&2, ManasChanda, McMillan Company of India Ltd.
3. Materials Science and Engineering, Bala Subramaniam, R., Callister's, Wiley, 2010

II Year- I Semester

L	T	P	C
3	0	0	3

CHEMISTRY – II (ORGANIC CHEMISTRY)

Course Objectives:
The students will be imparted the knowledge of

- Organic reactants, intermediates and their stability- effect of intermediates, steric inhibition and mechanism of the reaction.
- The static and dynamic aspects of three-dimensional shapes of molecules-a foundation for understanding structure and reactivity.
- 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.
- Coal-its constituents - aromatic compounds and their extraction methods.
- 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: **8hrs**

Structure and Bonding: Hybridization, polar effects: inductive effect, electromeric effect, resonance, hyper conjugation, steric inhibition – Examples.

UNIT-II: **8 hrs**

Isomerism: Positional, functional, stereo-Isomerism-*E-Z* nomenclature, optical isomerism - enantiomers, diastereomers, optical isomerism in lactic acid and tartaric acid, symmetry and chirality - Fischer projection (CIP rules), racemization and resolution, conformational analysis of ethane, ethylene glycol, 1,2-dihaloethanes, propane, *n*-butane and cyclohexane.

UNIT-III: **10 hrs**

Preparation and Reactions of Alkanes, Alkenes and Alkynes:
Part-A: Preparation of hydrocarbons [alkanes, alkenes and alkynes], Halogenation of alkanes, alkenes and alkynes.
Part B: Addition of HBr to alkene in the presence and absence of peroxide, Hydroboration oxidation, Allylic halogenation using *N*-Bromo succinimide (NBS), Catalytic hydrogenation (homogenous and heterogenous catalysis).

UNIT-IV: **10 hrs**

Chemistry of Aromatic Compounds: Sources of aromatic compounds: aromatics from coal (at high temperature and low temperature), coal gas manufacture and recovery of aromatics, fractional distillation of coal tar,

preparation methods of aromatics from petroleum products (catalytic reforming, high temperature cracking), preparation, properties and reactivity of aromatic hydrocarbons, aromatic heterocyclic compounds – (preparation, properties and uses of pyrrole, furan, thiophene, pyridine and quinoline).
Dyes - preparation and uses of azo-dye from phenol and β-naphthol.

UNIT-V: **10 hrs**

Named Reactions: Mechanism and applications of following organic reactions:
(a) Friedel-Craft reaction (b) Reimer-Tiemann reaction (c) Claisen rearrangement
(d) Beckmann rearrangement (e) Dienone phenol rearrangement (f) Aldol condensation (g) Perkin reaction (g) Benzoin condensation (h) Claisen condensation (i) Reformatsky reaction (j) Diels-Alder reaction (l) 1,3-dipolar cycloaddition (Click Chemistry).

Course 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.
- Have knowledge of isomerism, particularly stereoisomerism and the complexity of organic molecules.
- • Be able to conduct a chemical reaction whether it is on lab scale or industrial scale with complete understanding of its mechanism.
- • Be able to understand reactions taking place via free radical mechanism particularly in petroleum refining processes.
- will have knowledge of aromatic compounds which are precursors for a number of industrial organic products like drugs, dyes.

Text Books:
1. Morrison, R. T., R. N. Boyd and Saibal, Kranti Bhattacharjee, Organic Chemistry,
Pearson, 2011.

Reference Books:
1. Francis A Carey, Principles of Organic Chemistry, Latest edition.
2. John Murray, Organic Chemistry, Latest edition.
3. Arun Bahl and B. S. Bahl, Advanced Organic Chemistry, S. Chand Publishers, 2010.

II Year- I Semester

L	T	P	C
3	0	0	3

CHEMICAL PROCESS PRINCIPLES

Learning Objectives:
The subject of chemical process calculations is intended to make the students understand mainly the calculations involved in material and energy balances across 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 in chemical processes.
- 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 relations: Basis of calculations, Methods of expressing compositions of mixtures and solutions, density and specific gravity, Baume and API gravity scales, Units and inter conversions

Behavior of Ideal gases: Kinetic theory of gases, Application of ideal gas law, Gaseous mixtures, Gases in chemical reactions.

UNIT-II
Material balances: Tie components, Yield, Material Balance with and without reaction, Conversion. Material balance calculations in simple drying, dissolution and crystallization processes. Processes involving chemical reactions. Processes involving recycles, bypass, purge and other complexities.

UNIT-III
Energy Balances: 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 nonpolar liquids enthalpy and its evaluation.
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-IV

VLE: Liquefaction and liquid state, vaporization, boiling point, Effect of temperature on vapor pressure, Antoine equation, Vapor pressure plots (ternary), Estimation of critical properties, Vapor pressure of immiscible liquids and ideal solutions, Raoult's law, Non-volatile solutes.

Humidity and Saturation: Relative and percentage saturation or dew point, wet bulb and dry bulb temperature, Use of humidity charts for engineering calculations

UNIT-V

Combustion Calculations: Introduction to 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 Books:

1. Chemical Process Principles, Part -I, Material and Energy Balances, Hougen O A, Watson K. M. and Ragatz R.A., 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. Elementary Principles of Chemical Processes, R. M. Felder and R. W. Rousseau, 3rd Ed., Wiley, 1999.
2. Handbook Chemical Engineering Calculations, N. Chopey, 3rd Edition, Mc-Graw Hill, 2004.
3. Stoichiometry, Bhatt, B. I., Thakore S. B., 5th Ed., Tata Mc-Graw Hill Education 2010.

II Year- I Semester

L	T	P	C
3	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 size, shape and specific surface estimation.
- 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 contacting equipment namely gravity settlers, thickeners, classifiers, clarifiers, sedimenters and cyclones.
- Understand the working principle of electrostatic precipitation and flotation and their relevance to industry.

UNIT-I

Properties, handling and mixing of particulate solids: Solid particles, properties estimation, storage of solids and mixing of solids, types of mixers, mixers for non-cohesive solids and cohesive solids.

UNIT-II

Size reduction: Principles, criteria for commination, characteristics of commination, 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-III

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-IV

Classification of filtration in terms of pressure, solid removal mode and 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. Filtration efficiency.

UNIT-V

Agitation and mixing of liquids: circulation velocities, power consumption in agitated vessels, types of impellers,

Standard Turbine Design, Blending of liquids, suspension of solid particles, dispersion operations.

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.
- Industrial case studies associated with mechanical unit operations.
- Conceptual design of equipment in mechanical unit operations.

Text Book:

1. Unit Operations in Chemical Engineering, McCabe, W.L., J.C.Smith and Peter Harriott, McGraw Hill, 7th 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- I Semester

L	T	P	C
0	0	3	1.5

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:

Course Objectives:

- To obtain Open Circuit Characteristics of DC shunt generator.
- To predetermine the efficiency of dc shunt machine using Swinburne's test.
- To control speed of dc shunt motor using Armature voltage and Field control methods.
- To predetermine the efficiency and regulation of single-phase transformer with O.C and S.C tests.
- To obtain performance characteristics of a 3-phase induction motor.
- To find out regulation of an alternator by synchronous impedance method.

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

1. Open Circuit Characteristics of separately excited DC Shunt Generator
2. Swinburne's test on D.C. Shunt machine (predetermination of efficiency of a given D.C. shunt machine working as motor and generator).
3. Speed control of D.C. Shunt motor by Armature Voltage control and Field control methods
4. OC and SC tests on single phase transformer (predetermination of efficiency and regulation at given power factors).
5. Brake test on 3-phase Induction motor (determination of performance characteristics)
6. Regulation of alternator by Synchronous impedance method.

Dr.Ch.Saibabu (Member)	Dr.S.SivanagaRaju (Member)	Dr.R.SrinivasaRao (Member)	Dr.V.V.N.Murthy (Member)	Dr.B.Sarvesh (Member)	Dr.K.S.Rama Rao (Member)
Dr.K.Ramasudha (Member)	Dr.D.Suryanarayana (Member)	Dr.D.M.Vinod Kumar (Member)	Sri K.Praveen Kumar (Member)	Dr.M.Siva Kumar (Member)	Dr.K.Sri Kumar (Chairman)

Course Outcomes:

The students should be able to

- Determine the Open Circuit Characteristics of a DC shunt generator.
- Predetermine the efficiency of a DC shunt machine
- Control the speed of dc shunt motor using Armature voltage and Field control methods.
- Estimate the efficiency and regulation for different load conditions and power factors of single phase transformer with OC and SC test.
- Analyze the performance characteristics of a three-phase induction motor.
- Determine the regulation of an alternator by synchronous impedance method.

Dr.Ch.Saibabu (Member)	Dr.S.SivanagaRaju (Member)	Dr.R.SrinivasaRao (Member)	Dr.V.V.N.Murthy (Member)	Dr.B.Sarvesh (Member)	Dr.K.S.Rama Rao (Member)
Dr.K.Ramasudha (Member)	Dr.D.Suryanarayana (Member)	Dr.D.M.Vinod Kumar (Member)	Sri K.Praveen Kumar (Member)	Dr.M.Siva Kumar (Member)	Dr.K.Sri Kumar (Chairman)

II Year- I Semester

L	T	P	C
0	0	3	1.5

ORGANIC CHEMISTRY – LABORATORY

Learning objectives:
Organic Chemistry Laboratory is intended to:

- Understand the concepts learned in theoretical organic chemistry.
- Emphasize in acquiring accurate data.
- Develop the ability to prepare organic compounds independently.
- Understand the importance of the purity of organic compounds.

List of Experiments

1. Systematic qualitative analysis of organic compounds.
   a. Colour, odour and solubility.
   b. Melting point/ boiling point.
   c. Preliminary test: Aliphatic/aromatic compounds, saturation and unsaturation.
   d. Detection of extra elements such as nitrogen, sulphur and halogen by Lassaigne's test
   e. Functional group test: Phenols, amides/urea, carbohydrates, amines, carboxylic acids, aldehydes and ketones, alcohols, esters, aromatic and halogenated hydrocarbons, nitro compounds and anilides.
   f. Recrystallisation and sublimation.

Minimum **FIVE** unknown organic compounds to be analyzed systematically.

2. Preparation of benzanilide from aniline.
3. Preparation of urea oxalate derivative from urea.
4. Preparation of phenyl - azo – β - napthol from aniline.
5. Preparation of dibenzalacetone from benzaldehyde.
6. Preparation of benzil from benzoin.
7. Preparation of paraacetmol.
8. Preparation of Nylon - 6, 6.
9. Preparation of methyl orange.

Out comes:
A student who successfully completes this laboratory course should be able to:

- Understand and practice proper laboratory safety procedures.
- Gain familiarity with organic compounds.
- Identify, analyze and synthesize organic compounds.
- Understand basic organic reaction mechanism.
- Understand how the dyes are helpful for textile, paint, leather, paper, food and petrochemical industries.

II Year- I Semester

L	T	P	C
0	0	3	1.5

MECHANICAL UNIT OPERATIONS LABORATORY

Learning Objective: The course will equip students with the practical knowledge of different mechanical unit operations & operational conditions of different equipment.

1. To determine the time of grinding in a ball mill for producing a product with 80 % passing a given screen.
2. To verify the laws of crushing using any size reduction equipment like crushing rolls or vibrating mills and to find out the working index of the material.
3. To find the effectiveness of hand screening and vibrating screen of a given sample.
4. To achieve beneficiation of a ore using froth flotation technique.
5. To obtain batch sedimentation data and to calculate the minimum thickener area under given conditions.
6. To determine the specific cake resistance and filter medium resistance of a slurry in plate and frame filter press.
7. To separate a mixture of particles by Jigging.
8. To calculate separation efficiency of particles in a mixture using cyclone separator.
9. To determine reduction ratio of a given sample in a pulverizer.
10. To determine reduction ratio of a given sample in .a grinder Major equipment – Disk Grinder

Outcome: Student will be able to

- Develop knowledge on various mechanical separation operations used in a chemical industry.
- Develop knowledge on estimation of particle size, power requirement and surface area.
- Understand the process of froth floatation and sedimentation techniques.

II Year- I Semester

L	T	P	C
3	0	0	0

ESSENCE OF INDIAN TRADITIONAL KNOWLEDGE
(MC)

Learning Objectives:
To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the Importance of roots of knowledge system.

- The course aim of the importing basic principle of third process reasoning and inference sustainability is at the course of Indian traditional knowledge system
- To understand the legal framework and traditional knowledge and biological diversity act 2002 and geographical indication act 2003.
- The courses focus on traditional knowledge and intellectual property mechanism of traditional knowledge and protection.
- To know the student traditional knowledge in different sector.

UNIT-I:
Introduction to traditional knowledge: Define traditional knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, the physical and social contexts in which traditional knowledge develop, the historical impact of social change on traditional knowledge systems. Indigenous Knowledge (IK), characteristics, traditional knowledge vis-à-vis indigenous knowledge, traditional knowledge Vs western knowledge traditional knowledge vis-à-vis formal knowledge

Learning Outcomes:
At the end of the unit, the student will able to:

- Understand the traditional knowledge.
- Contrast and compare characteristics importance kinds of traditional knowledge.
- Analyze physical and social contexts of traditional knowledge.
- Evaluate social change on traditional knowledge.

UNIT-II:
Protection of traditional knowledge: the need for protecting traditional knowledge Significance of TK Protection, value of TK in global economy, Role of Government to harness TK.

Learning Outcomes:
At the end of the unit, the student will able to:

- Know the need of protecting traditional knowledge.
- Apply significance of tk protection.
- Analyze the value of tk in global economy.
- Evaluate role of government

UNIT-III:

Legal framework and TK: A: The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, Plant Varieties Protection and Farmers Rights Act, 2001 (PPVFR Act); B:The Biological Diversity Act 2002 and Rules 2004, the protection of traditional knowledge bill, 2016. Geographical indications act 2003.

Learning Outcomes:

At the end of the unit the student will able to:

- Understand legal framework of TK.
- Contrast and compare the ST and other traditional forest dwellers
- Analyze plant variant protections
- Evaluate farmers right act

UNIT-IV:

Traditional knowledge and intellectual property: Systems of traditional knowledge protection, Legal concepts for the protection of traditional knowledge, Certain non IPR mechanisms of traditional knowledge protection, Patents and traditional knowledge, Strategies to increase protection of traditional knowledge, global legal FORA for increasing protection of Indian Traditional Knowledge.

Learning Outcomes:

At the end of the unit, the student will able to:

- Understand TK and IPR
- Apply systems of TK protection.
- Analyze legal concepts for the protection of TK.
- Evaluate strategies to increase the protection of TK.

UNIT-V:

Traditional knowledge in different sectors: Traditional knowledge and engineering, Traditional medicine system, TK and biotechnology, TK in agriculture, Traditional societies depend on it for their food and healthcare needs, Importance of conservation and sustainable development of environment, Management of biodiversity, Food security of the country and protection of TK.

Learning Outcomes:

At the end of the unit, the student will able to:

- Know TK in different sectors.
- Apply TK in engineering.
- Analyze TK in various sectors.
- Evaluate food security and protection of TK in the country.

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

1. Understand the concept of Traditional knowledge and its importance
2. Know the need and importance of protecting traditional knowledge

3. Know the various enactments related to the protection of traditional knowledge.
4. Understand the concepts of Intellectual property to protect the traditional knowledge

Reference Books:

1. Traditional Knowledge System in India, by Amit Jha, 2009.
2. Traditional Knowledge System and Technology in India by Basanta Kumar Mohanta and Vipin Kumar Singh, Pratibha Prakashan 2012.
3. Traditional Knowledge System in India by Amit Jha Atlantic publishers, 2002
4. "Knowledge Traditions and Practices of India" Kapil Kapoor, Michel Danino

E-Resources:

1. https://www.youtube.com/watch?v=LZP1StpYEPM
2. https://nptel.ac.in/courses/121106003/

II Year- I Semester

L	T	P	C
0	0	2	0

PHYSICAL FITNESS ACTIVITIES
(MC)

II Year- I Semester

L	T	P	C
0	0	0	3

MOOCS (NPTEL/ SWAYAM) FOR HONORS/MINORS DEGREE

Learning Objectives:
The students will be able to:

- Avail the expertise in a specific subject from nation-wide reputed faculty, through MOOC (Massive Open Online Course)
- Develop the ability for self-actualization and in getting opportunity for life-long learning

There shall be a Discipline Centric Elective Course through Massive Open Online Course (MOOC) as Program Elective course. The student shall register for the course (Minimum of 12 weeks) offered by SWAYAM/NPTEL through online with the approval of Head of the Department. The Head of the Department shall appoint one mentor for each of the MOOC subjects offered. The student needs to register the course in the SWAYAM/NPTEL portal. During the course, the mentor monitors the student's assignment submissions given by SWAYAM/NPTEL.
The student needs to submit all the assignments given and needs to take final exam at the center. The student has to earn a certificate by passing the exam. The student will be awarded the credits given in curriculum only by submission of the certificate. In case if student does not pass subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered again through SWAYAM/NPTEL in the next semester with the recommendation of Head of the Department and shall be passed in the examination.
The list of MOOCS courses is given in the appendix (to do honors in chemical engineering, the eligible student has to choose the subjects in chemical engineering from the list to fulfill the criteria of 20 credits). In order to get minor degree, a student has to select and do the courses in any one discipline other than chemical engineering to fulfil the criteria of 20 credits.
The total 20 credits for honors or minor degree should be obtained from the second semester to the end of eighth semester. A candidate can take a 3-credit course in each semester during the above mentioned period.
It may be noted that, each student is to get minimum 8.0 SGPA without any backlogs in each semester to do honors and minors degree.

Outcomes:
The students are able to:

- Overcome the digital divide in acquiring fast developing technologies / knowledge and be part of digital revolution.
- Acquire subject specific expert knowledge from National Resource Pool.
- Understand his /her academic / professional priorities for future development.

II Year- II Semester

L	T	P	C
2	0	0	2

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.

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: Classification of boilers, essentialities of boilers, selection of different types of boilers, study of boilers, boiler mountings and accessories.

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-V:

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.

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.

II Year- II Semester

L	T	P	C
3	0	0	3

MANAGERIAL ECONOMICS & FINANCIAL ACCOUNTING

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:

Theories of Production and Cost Analyses:

Theories of 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(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, Business Cycles : Meaning and Features – Phases of a Business Cycle. Features and

Evaluation of Sole Trader, Partnership, Joint Stock Company – State/Public Enterprises and their forms.

UNIT – IV:

Introduction to Accounting & Financing Analysis:
Introduction to Double Entry System, Journal, Ledger, Trail Balance and Preparation of Final Accounts with adjustments – Preparation of Financial Statements-Analysis and Interpretation of Financial Statements-Ratio Analysis – Preparation of Funds flow and cash flow analysis (Problems)

UNIT – V:

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)

Course Outcome:

- 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.

References:

1. Varshney R.L, K.L Maheswari, Managerial Economics, S. Chand & Company Ltd,
2. JL Pappas and EF Brigham, Managerial Economics, Holt, R & W; New edition edition
3. N.P Srinivasn and M. Sakthivel Murugan, Accounting for Management, S. Chand & Company Ltd,
4. Maheswari S.N, AnIntroduction to Accountancy, Vikas Publishing House Pvt Ltd
5. I.M Pandey, Financial Management , Vikas Publishing House Pvt Ltd
6. V. Maheswari, Managerial Economics, S. Chand & Company Ltd,

II Year- II Semester

L	T	P	C
3	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 with 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 flow like including various types of pumps, compressors and blowers, Venturimeter transportation and metering methods, Orifice Meters
- 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 in pipelines such as fittings and valves and their relevance towards variation in pressure drop correlations in pipes
- Understand the knowledge related to various fluid flow measuring devices (Venturi, Orifice, Rotameter, hot wire anemometer 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.

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-III

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-IV

Transportation and Metering of fluids- Pipes, fittings and valves, Pumps: positive displacement and centrifugal pumps.

Measurement of flowing fluids: full bore meters, insertion meters; Venturi meter, Rotameter, Orifice meter, Hot wire anemometer, Pitot tube, and Other flow metering devices.

UNIT-V

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

Compressors, fans, blowers, steam ejectors and jets

Outcomes:

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

- Analyze fluid flow in circular and non-circular conduits.
- Do calculations associate 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. Unit Operations of Chemical Engineering, McCabe,W.L., J.C.Smith & Peter Harriot McGraw-Hill, 7th Edition, 2001.
2. Transport Processes and Unit Operations, Christie J. Geankoplis, 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, Vol-1: Fluid flow, Heat Transfer and Mass Transfer, J. M. Coulson and J. F. Richardson, 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
3	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 chemical 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.

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
2	0	0	2

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 of instruments.

Industrial Thermometers**:** Mercury in glass thermometer - Bimetallic thermometer - Pressure spring thermometer, Thermo-electricity – types of thermocouples – Thermocouple lead wires. Resistance-thermometers: RTD and bridge circuits (2 wire, 3 wire and 4 wire - method) -Radiation receiving elements- pyrometers.

UNIT II

Pressure measurement: 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 III

Head, density and specific gravity, 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. Viscosity measurement.

Composition analysis, spectroscopic analysis by absorption, emission, mass and color measurement spectrometers, gas analysis by thermal conductivity, analysis of moisture, gas chromatography, refractometer.

UNIT IV

Open channel meters, viscosity meters, quantity meters, flow of dry materials, Recording instruments, indicating and signaling instruments, transmission of instrument readings, control center, instrumentation diagram

UNIT V

Distributed control system (DCS) working and architecture of DCS- elements of DCS, human measuring interface, engineering work station, communication media and protocol.

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 Books:

1. Industrial Instrumentation, Donald P. Eckman, Wiley eastern, 1950.
2. Modern Distributed Control Systems, Dr Moustafa Elshafei, Create space independent publishing platform, 1st ed. 2016.

Reference Books:

1. Principles of Industrial Instrumentation, Patranabis, 2nd Edition, Tata McGraw-Hill, 1996.
2. Instruments for measurements and control by Holbrock W.C. Van Nostrand East West.
3. Hand book Instrumentation, Considine, McGraw Hill.

II Year- II Semester

L	T	P	C
3	0	0	3

PROCESS HEAT TRANSFER

Learning Objectives:

- This course is designed to introduce 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.
- Further the students will be trained to acquire skills to carry out the detailed process design of shell and tube heat exchangers such as number tubes, selection of shell and tube material, estimate number of baffles and also provide necessary information regarding TEMA classification. Design of double pipe heat exchangers, both counter current and co-current

UNIT-I

Introduction & Conduction: Nature of heat flow, conduction, convection, natural and forced convection, and radiation. Steady state: 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.

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 in 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. Analogy between transfer of momentum and heat, heat transfer to liquid metals, heating and cooling of fluids in forced convection outside tubes.

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

UNIT-IV

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

Radiation: Properties and definitions, black body radiation, real surfaces, and the grey body. Absorption of radiation by opaque solids, radiation between surfaces, radiation and shielding, combined heat transfer by conduction, convection and radiation.

UNIT-V

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).

Evaporators: Types of Evaporators, performance of tubular evaporator. Capacity and economy, methods of feeding, multiple effect evaporators, vapor recompression.

Outcomes:

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.
3. Heat Transfer, Holman, J.P., 9th Edition, Tata McGraw-Hill, 2008

Reference Books:

1. Process Heat Transfer, D.Q. Kern, Tata- McGraw-Hill, 1997.
2. Schaum's Outline of Heat Transfer, Donald Pitts and L. E. Sisson, 2nd Edition, McGraw-Hill, 1998.
3. A Text Book on Heat Transfer, Sukhatme, P., 5th Edition, Universities Press (India) Pvt. Ltd., 2005.
4. Heat Transfer: Principles and Applications, Binay Dutta, K., PHI Learning, 2009.
5. 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
0	0	3	1.5

MOMENTUM TRANSFER - LABORATORY

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	1.5

PROCESS HEAT TRANSFER - LABORATORY

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 rod.
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.

Outcomes:

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

L	T	P	C
0	0	1	0.5

SOCIALLY RELEVANT PROJECTS
(HSSMS)

Learning Objectives:
The students will be able to:

- Identify socially relevant projects.
- Work as a team to develop the project.

After identifying a socially relevant project, a team of students will develop a prototype project for execution. A few of the projects are suggested below.

1. Swachh Bharath Programme
2. Blood Donation Service activity
3. Health & Environment
4. Visit to Orphanage
5. Energy Saving Project (conventional)
6. Road Safety Program
7. Save Girl Child
8. Safety at home
9. Social Forestry
10. Self-defense for Women

Outcomes:
The students are able to:

- Assess the needs and problems of society.
- Design and implement the system in the project.
- Develop a sense of social and civic responsibility.
- Acquire leadership qualities to work in a team.
- Develop competence required for working together and sharing responsibility.

II Year- II Semester

L	T	P	C
0	0	2	0

PHYSICAL FITNESS ACTIVITIES
(MC)

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

MOOCS (NPTEL/ SWAYAM) FOR HONORS/MINORS DEGREE

Learning Objectives:
The students will be able to:

- Avail the expertise in a specific subject from nation-wide reputed faculty, through MOOC (Massive Open Online Course)
- Develop the ability for self-actualization and in getting opportunity for life-long learning

There shall be a Discipline Centric Elective Course through Massive Open Online Course (MOOC) as Program Elective course. The student shall register for the course (Minimum of 12 weeks) offered by SWAYAM/NPTEL through online with the approval of Head of the Department. The Head of the Department shall appoint one mentor for each of the MOOC subjects offered. The student needs to register the course in the SWAYAM/NPTEL portal. During the course, the mentor monitors the student's assignment submissions given by SWAYAM/NPTEL.
The student needs to submit all the assignments given and needs to take final exam at the center. The student has to earn a certificate by passing the exam. The student will be awarded the credits given in curriculum only by submission of the certificate. In case if student does not pass subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered again through SWAYAM/NPTEL in the next semester with the recommendation of Head of the Department and shall be passed in the examination.
The list of MOOCS courses is given in the appendix (to do honors in chemical engineering, the eligible student has to choose the subjects in chemical engineering from the list to fulfill the criteria of 20 credits). In order to get minor degree, a student has to select and do the courses in any one discipline other than chemical engineering to fulfil the criteria of 20 credits.
The total 20 credits for honors or minor degree should be obtained from the second semester to the end of eighth semester. A candidate can take a 3-credit course in each semester during the above mentioned period.
It may be noted that, each student is to get minimum 8.0 SGPA without any backlogs in each semester to do honors and minors degree.

Outcomes:
The students are able to:

- Overcome the digital divide in acquiring fast developing technologies / knowledge and be part of digital revolution.
- Acquire subject specific expert knowledge from National Resource Pool.
- Understand his /her academic / professional priorities for future development.

III Year- I Semester

L	T	P	C
3	0	0	3

CHEMICAL ENGINEERING THERMODYNAMICS –II

Learning Objectives:
The students will be able to learn:

- The sensible and latent heat effects.
- The heat effects of industrial reactions.
- The residual and excess property relations.
- The concept of fugacity and partial molar properties.
- The VLE calculations using Raoult's law, modified Raoult's law, Henry's law activity coefficient models, generalized gamma/phi formulation and
  K-values.
- The VLE calculations from equation of state.
- The estimation of reaction equilibrium constant and equilibrium conversion for liquid phase reactions, gas phase reactions and industrial reactions.
- The 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 relations, 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, VLE for partially miscible mixtures.

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–V:

Chemical Reaction Equilibria: The reaction coordinate, application of equilibrium criterion to chemical 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:

The students are able to:

- Calculate the sensible and latent heat effects.
- Determine the heat effects of industrial reactions.
- Apply residual and excess property relations.
- Apply the concept of fugacity and estimate partial molar properties.
- Calculate the VLE data using Raoult's law, modified Raoult's law, Henry's law activity coefficient models, generalized gamma/phi formulation and
  K-values.
- Calculate the VLE data using equation of state.
- Estimate the reaction equilibrium constant and equilibrium conversion for liquid phase reactions, gas phase reactions and industrial reactions.
- Apply the phase rule for reacting and non-reacting systems.

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
3	0	0	3

CHEMICAL REACTION ENGINEERING – I

Learning Objectives:
The students will be able to learn:

- 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
- 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
- The basic concepts of design of ideal reactors in particular batch reactor, plug flow reactor and mixed flow reactor
- The size comparison of single reactors, multiple reactor systems, recycle reactor and autocatalytic reactions
- The 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
- The effects of temperature and pressure on reaction kinetics and equilibrium conversion from a thermodynamic point of view
- The design of reactors for non-isothermal, adiabatic and non-adiabatic operations for carrying out single reactions
- The exothermic reactions 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 uni-molecular type first order reactions, irreversible bimolecular type second order reactions, irreversible tri-molecular 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, 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 in terms 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 – III:

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 – IV:

Design for parallel reactions: Introduction to multiple reactions, qualitative discussion about product distribution, quantitative treatment of product distribution and of reactor size.
Design for series reactions: 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 – V:

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:

The students are able to:

- Apply the reaction rate concepts.
- Interpret the batch reactor data for determination of reaction kinetics for various reaction.
- Design the different types of reactors.
- Perform the size comparison of single, multiple reactor systems & recycle reactor.
- Design different reactors for parallel and series reactions.
- Analyze the effects of temperature and pressure on reaction kinetics and equilibrium conversion from a thermodynamic point of view.
- Design the reactors for non-isothermal, adiabatic and non-adiabatic operations for carrying out single reactions
- Apply the Concept of exothermic reactions in mixed flow reactors as a special case.

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- I Semester

L	T	P	C
3	0	0	3

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.

Mass Transfer Coefficients: Mass Transfer Coefficients in Laminar Flow, Mass Transfer Coefficients in Turbulent Flow, 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.

Fundamental of Distillation-I: 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:
Fundamental of 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 - Savarit method-Distillation in packed towers.
Absorption and Stripping-I: 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.

UNIT – V:
Absorption and Stripping-II: 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.
Equipment for Gas-Liquid Operations: Gas dispersed, sparged vessels (bubble columns), mechanical agitated equipment (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 towers vs packed towers.

Outcomes:
The students are able to:

- Estimate the diffusivities and diffusion rates of gases and liquids for diffusion through solids, liquids and gases.
- Estimate the mass transfer coefficients using mass transfer theories for laminar flow and turbulent flow.
- Calculate interphase mass transfer coefficients.
- Calculate the number of equilibrium stages using McCabe-Thiele and enthalpy concentration methods.
- Calculate the number of equilibrium stages using Kremser equation and graphical methods for absorption and stripping.
- Design stage wise and continuous gas-liquid contact towers for distillation, absorption and stripping
- Design equipment for Gas-Liquid Operations in general.

Text Books:

1. Mass Transfer Operations, R.E. Treybal, 3rd Edition. 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. Design of Equilibrium Stage Processes, B.D.Smith, McGraw-Hill, 1963.
5. Staged Cascades in Chemical Processing, P.L.T.Brian, Prentice-Hall, 1972.
6. Equilibrium-Stage Separation Operations in Chemical Engineering, E.J.Henley and J.D.Seader, John Wiley & Sons, 1981.
7. Transport Processes and Unit Operations, Christie J. Geankoplis, 4th Edition, PHI, 2009.
8. Separation Processes, C.J. King, 2nd Edition, McGraw- Hill, 1980.

III Year- I Semester

L	T	P	C
3	0	0	3

PROCESS DYNAMICS & CONTROL

Learning objectives:

The student will be able to learn:

- The basic procedure to derive transfer functions for first order, pseudo second order and second order systems.
- How Laplace transforms can be used to get solutions of transfer function equations for different types of systems.
- The importance of underdamped second order systems in relation to the real-life situations.
- To calculate the overall transfer function and thus offset calculation from the control system block diagram.
- The behavior and logic of different types of advanced controllers and their strategies.
- The concept of stability, stability criterion and frequency response analysis for sinusoidal forcing functions.
- The behavior and tuning of a controller and the calculation of controller parameters.
- The inherent and effective characteristics of different types of control valves and the usage of valve positioners to induce linear characteristic into a non-linear control valve.

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.

UNIT – II:

Higher order systems, Second order and transportation lag, Control systems, Controllers and final control elements.

Block diagram of a chemical rector control system. Closed loop transfer functions, Transient response of simple control systems.

UNIT - III:

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

UNIT-IV:

Control systems design by frequency response. Advanced control strategies, Cascade control, feed forward control, ratio control, Smith predictor, dead time compensation, internal model control.

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

Outcomes:
The students are able to:

- Derive transfer functions for first order, pseudo second order and second order systems.
- Apply Laplace transforms to get solutions of transfer function equations for different types of systems.
- Correlate the underdamped second order systems to the real-life situations.
- Calculate the overall transfer function and thus offset calculation from the control system block diagram.
- Implement the principals of advanced controllers and their strategies.
- Apply the concept of stability, stability criterion and frequency response analysis for sinusoidal forcing functions.
- Tune the process controllers.
- Determine the dynamic behavior of a process experimentally.
- Design and operate control valves.

Text Book:

1. Process Systems Analysis and Control, D.R. Coughanowr, 3rd Ed. McGraw Hill, 2008.

Reference Books:

1. Chemical Process Control, G. Stephanopoulos, 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, Mc Graw 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. Modern Control Engineering, Katsuhiko Ogata, 5th Edition, Prentice Hall, 2010.
8. Principles and Practices of Automatic Process Control, Carlos A. Smith, Armando B. Corripio, 3rd International Edition, John Wiley and Sons, 2005.

III Year- I Semester

L	T	P	C
3	0	0	3

PETROLEUM REFINERY ENGINEERING
(PROFESSIONAL ELECTIVE – I)

Learning Objectives:

The students will be able to learn:

- The overview of petroleum refining.
- The 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 into various products and 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.
- The impact of refinery operations on environment.

UNIT-I:

Introduction: Overall refinery operations, Global and Indian scenarios.

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.

Thermal & catalytic cracking processes: Visbreaking - Hydrovisbreaking, Thermal cracking - Catalytic cracking- Fluid Catalytic cracking and Hydrocracking- Delayed coking; Feed stocks – Feed and product treating – Catalysts - Process variables – Product Recoveries - Yield estimation - Latest developments for all the above processes.

UNIT-IV:

Hydro processing: Naphtha - Distillate (Kerosene/ Diesel/ Cycle oils)- Gas oil and Resid hydro processing — Different hydro-processing technologies for feed stock and product treatment.

Lube Oil Refining: Lubricant base oil processes- Deasphalting -Solvent Extraction.

UNIT-V

Catalytic reforming and isomerization: Catalytic reforming processes – Isomerization Processes -Feed stocks -Feed preparation – Yields for the above processes.

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.

Impact on environment: Pollution due to petroleum processes and operations-its control.

Outcomes:

The students are able to:

- Emphasize different operations in petroleum refining.
- Estimate the properties of crude oils and petroleum fractions and their significance in meeting the fuel specifications.
- Apply various processes and production steps involved in primary separation of crude oil into various products and intermediate product streams.
- Assess different processes and production steps involved to convert low value heavy fuels to high value lighter liquids.
- Apply 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.
- Assess the pollution in petroleum refining to apply suitable treatment technologies.

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. Petroleum Refining Processes, Rakesh Rathi, SBS, Publishers, 2007.
4. Practical Advances in Petroleum Processing, Chang S. Hsu and Paul Robinson, Vol. 1 & 2, Springer, 2006.
5. Thermal and Catalytic Processes in Petroleum Refining, Serge Raseev, Marcel Dekkar, Inc., 2003.
6. Fundamentals of Petroleum Refining, Mohammed A. Fahim, Taher A. Al-Sahhaf, AmalElkilani, Elsevier Science, 2009.
7. Handbook of Petroleum Processing, David S. J. Jones, Peter P. Pujado, Springer, 2006.
8. Refining Processes Handbook, Surinder Parkash, Gulf Professional Publishing, 2003.
9. Petroleum Refining, Andrew Campbell, Rarebooksclub.com, 2012.

III Year- I Semester

L	T	P	C
3	0	0	3

AIR POLLUTION AND CONTROL
(PROFESSIONAL ELECTIVE – I)

Learning objectives:
The students will be able to learn:

- The fundamentals of air pollution with a background on historical perspective on air pollution.
- Classification of major air pollutants; their sources and effects (environmental, economic and health), sampling of air pollutants and their analysis.
- Principles of the dispersion of air pollutants in the atmosphere.
- The details of air pollution control equipment and their design aspects with reference to sulphur dioxide, nitrogen oxide, organic vapors etc.
- Details of air pollution legislation and role of citizens in air pollution control.

UNIT-I:
Introduction: Sources, nature and type of pollutants, emission factors
Meterology: Meteorological factors in pollution, plume behavior and characteristics, chill index, equivalent ambient temperature, chimney design considerations, plume rise, effective stack height, element of air pollution modeling, acid rain problem.

UNIT-II:
Health effects of pollution: Effect of air pollution on humans, plants, animals and materials. Global problems of air pollution - air pollution measurements - Ringleman's chart.

UNIT-III:
Thermodynamics and kinetics of air pollution: Applications in the removal of gases like SOx, NOx, CO and HC - air-fuel ratio – computation and control of products of combustion - automobile pollution, odour pollution control - flares.

UNIT-IV:
Air pollution control: Sampling and analysis of particulate matter and gaseous pollutants - removal of particulate matters - principles and design of settling chambers - solid traps, cyclone separators - fabric filters - scrubbers and electro-static precipitators.

UNIT-V:

General methods of control: Removal of sulfur -dioxide, oxides of nitrogen and organic vapors from gaseous emissions - environmental criteria for setting up of industries and developing green belts.

Outcomes:

The students are able to:

- Apply knowledge about the nature, origin of air pollution and impact of the air pollution on human beings, plants and materials.
- Undertake the sampling and analysis of pollutants (Monitoring of air pollutants)
- Apply the thermodynamic aspects of air pollution control methods.
- Apply the updated engineering technologies to control air pollution.
- Assess various pollution control technologies to control of specific air pollutants like Sox, Nox, organic vapors etc.
- Interpret the legislations according to the design and operational requirements.

Text book:

1. Air pollution, M. N. Rao and H. V. N. Rao, McGraw Hill Publications, 1989.

Reference books:

1. Pollution control in Process Industries, S. P. Mahajan, Tata McGraw Hill Publishing Company Ltd, New Delhi, 1985.
2. Environmental Pollution Control Engineering, C. S. Rao, 2nd edition, New age International Publishers, 2006

III Year- I Semester

L	T	P	C
0	0	3	1.5

PETROLEUM ANALYSIS – LABORATORY

Learning Objectives:

The students will be able to learn:

- Objectives of analyses of crude oil and its products.
- The tests for Reid vapor pressure, viscosity, smoke point, flash point & fire point, aniline point, cloud & pour point, softening point, calorific value.
- The distillation characteristics (ASTM curves) of crude oil, diesel, gasoline and kerosene.
- The tests on water content of different petroleum products.
- The tests on Corrosiveness of petroleum products.
- The operation of laboratory equipment.

List of experiments:

1. Determination of distillation characteristics of Gasoline / Diesel / Kerosene.
2. Determination of Reid Vapor Pressure of Crude oil / Gasoline.
3. Determination of viscosity of diesel and lubricating oils.
4. Determination of smoke point of kerosene.
5. Determination of carbon residue of petroleum products.
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 cloud & pour points of petroleum products.
11. Detection of corrosiveness of petroleum products.

Outcomes:

The students will be able to:

- Handle various apparatus/equipment for petroleum analyses
- Carry out the tests for Reid vapor pressure, viscosity, smoke point, flash point & fire point, aniline point, cloud & pour point, softening point, calorific value.
- Determine the distillation characteristics (ASTM curves) of crude oil, diesel, gasoline and kerosene.
- Do the tests on water content of different petroleum products.
- Carry out the tests on corrosiveness of petroleum products.

III Year- I Semester

L	T	P	C
0	0	3	1.5

MASS TRANSFER OPERATIONS – LABORATORY

Learning Objectives:
The students will be able to learn:

- The experimental methods related to estimation of diffusivity coefficients for solids and vapors.
- The experimental procedures for the determination of mass transfer coefficients.
- Handling different types of mass transfer equipment.
- The experimental methods for VLE, steam distillation and differential distillation.
- The experimental determination of HETP values for a given packing.
- The experimental determination of mass transfer coefficients for surface evaporation and wetted wall column.
- The experimental determination of stage efficiency of cross current leaching

List of Experiments:

1. Estimation of diffusivity coefficients: vapors
2. Estimation of diffusivity coefficients: liquids
3. Steam distillation
4. Differential distillation
5. Vapor Liquid Equilibria
6. Liquid Liquid Equilibria
7. Ternary Liquid Equilibria
8. Cross current leaching
9. Evaluation of mass transfer coefficients:
    (a) Surface evaporation
    (b) Wetted wall column

Outcomes:
The student will be able to:

- Apply Fick's law for estimating the mass transfer rates and diffusion coefficients.
- Estimate the diffusivity coefficients for solids and vapors.
- Determine the mass transfer coefficients experimentally.
- Understand the challenges of handling mass transfer equipment.
- Generate and validate the VLE data.
- Compare and validate the HETP values for various column packings.
- Compare and validate the mass transfer coefficients for surface evaporation and wetted wall column.
- Use techniques, skills, and modern engineering tools necessary for engineering practice.
- Estimate the stage efficiency of cross current leaching.

	L	T	P	C
III Year- I Semester	**0**	**0**	**3**	**1.5**

INSTRUMENTATION, PROCESS DYNAMICS & CONTROL – LABORATORY

Learning Objectives:

The students will be able to learn:

- Calibration and determination of the time lag of various first and second order instruments.
- The determination of the response in single and two capacity systems with and with-out interaction.
- The advanced control methods used for complex processes in the industries. Different experiments like Temperature, level and pressure control can be configured and studied.
- The experimental procedures for 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).
- The control valve operation and its flow characteristics.
- The determination of the damping coefficient and response of U-tube manometer.

Experiments:

1. Determination of time constant & transportation lag for mercury in glass thermometer with and without thermal well.
2. Sinusoidal response of mercury in glass thermometer with and without thermal well.
3. Study of dynamic response of single tank liquid level system.
4. Study of dynamic response of two tank non-interacting liquid level system.
5. Study of dynamic response of two tank interacting liquid level system.
6. Determination of damping coefficient for U-tube:
7. Study of control valve characteristics and determine valve flow coefficient for the following valves:
   a) Equal percentage valve
   b) Quick opening valve
   c) Linear valve
8. Determination of hysteresis for the following valves:
   a) Equal percentage valve
   b) Quick opening valve
   c) Linear valve
9. Temperature control trainer:

a) Open loop response
b) On-off control
c) P-control
d) PID-control
e) Auto tuning

10. Level control trainer:
    a) Open loop response
    b) On-off control
    c) P-control
    d) PID-control
    e) Auto tuning
11. Pressure control trainer:
    a) Open loop response
    b) On-off control
    c) P-control
    d) PID-control
    e) Auto tuning

Outcomes:

The students are able to:

- Calibrate and determine the time lag of various first and second order instruments.
- Perform experiments to find the response in single and two capacity systems with and with-out interaction.
- Apply the advanced control methods used for complex processes in the industries.
- Perform different experiments like Temperature, level and pressure control.
- Carry out experiments on 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).
- Operate the control valve and assess its flow characteristics.
- Estimate the damping coefficient and response of U-tube manometer.

III Year- I Semester

L	T	P	C
0	0	1	0.5

SOCIALLY RELEVANT PROJECT

Learning Objectives:
The students will be able to:

- Identify socially relevant projects based on chemical engineering
- Work as a team to develop the project.

After identifying a socially relevant project, a team of students will develop a prototype project for execution. A few of the projects are suggested below.

Some of the Socially Relevant Projects:

1. Development of a prototype plant for the conversion of plastics
2. Development of a water purification system for villages
3. Development of a waste water treatment system for villages
4. Utilization of coringa leaves
5. Development of natural pesticides
6. Home biogas plant based on spoiled carbohydrate materials
7. Development of solar powered cycle.
8. Utilization of solar hot water in the manufacture of chemicals
9. Production of fruit jams
10. Production of cellulose from banana plant waste.

Outcomes:
The students are able to:

- Assess the needs and problems of society.
- Design and implement the system in the project.
- Develop a sense of social and civic responsibility.
- Acquire leadership qualities to work in a team.
- Develop competence required for working together and sharing responsibility.

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

PHYSICAL FITNESS ACTIVATES
(MC)

III Year- I Semester

L	T	P	C
0	0	0	0

INDUSTRIAL VISITS
(LOCAL & OUTSIDE)

Learning Objectives:
The students will be able to be aware of industrial environment, culture, requirements, nature of jobs and to develop accordingly.

Visits to Industries:
During the semester, all the students are required to visit minimum 6 major industries like petroleum refineries, petrochemical, fertilizer and organic and inorganics 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.

Evaluation of the report:
The reports of the industrial visits will be evaluated by a committee appointed by Head of the Department.

Outcomes:
The students are able to:

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

III Year- I Semester

L	T	P	C
0	0	0	3

MOOCS (NPTEL/ SWAYAM) FOR HONORS/MINORS DEGREE

Learning Objectives:
The students will be able to:

- Avail the expertise in a specific subject from nation-wide reputed faculty, through MOOC (Massive Open Online Course)
- Develop the ability for self-actualization and in getting opportunity for life-long learning

There shall be a Discipline Centric Elective Course through Massive Open Online Course (MOOC) as Program Elective course. The student shall register for the course (Minimum of 12 weeks) offered by SWAYAM/NPTEL through online with the approval of Head of the Department. The Head of the Department shall appoint one mentor for each of the MOOC subjects offered. The student needs to register the course in the SWAYAM/NPTEL portal. During the course, the mentor monitors the student's assignment submissions given by SWAYAM/NPTEL.
The student needs to submit all the assignments given and needs to take final exam at the center. The student has to earn a certificate by passing the exam. The student will be awarded the credits given in curriculum only by submission of the certificate. In case if student does not pass subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered again through SWAYAM/NPTEL in the next semester with the recommendation of Head of the Department and shall be passed in the examination.
The list of MOOCS courses is given in the appendix (to do honors in chemical engineering, the eligible student has to choose the subjects in chemical engineering from the list to fulfill the criteria of 20 credits). In order to get minor degree, a student has to select and do the courses in any one discipline other than chemical engineering to fulfil the criteria of 20 credits.
The total 20 credits for honors or minor degree should be obtained from the second semester to the end of eighth semester. A candidate can take a 3-credit course in each semester during the above mentioned period.
It may be noted that, each student is to get minimum 8.0 SGPA without any backlogs in each semester to do honors and minors degree.

Outcomes:
The students are able to:

- Overcome the digital divide in acquiring fast developing technologies / knowledge and be part of digital revolution.
- Acquire subject specific expert knowledge from National Resource Pool.
- Understand his /her academic / professional priorities for future development.

III Year - II Semester

L	T	P	C
3	0	0	3

MASS TRANSFER OPERATIONS-II

Learning Objectives:

The students will be able to learn:

- Equilibrium separations based on liquid-liquid contact along with data analysis from equilibrium diagrams represented in triangular and rectangular coordinates.
- The details of single and multistage counter current contactors for liquid-liquid extraction.
- The basic concepts of leaching for single and multistage operations.
- The basic concepts in humidification and dehumidification.
- The design aspects of humidification equipment and cooling towers.
- The basic concepts of drying and design aspects of equipment for batch and continuous drying.
- Basic concepts of adsorption and construction of adsorption isotherms.
- Design aspects of different types of adsorbers like fixed bed, moving bed and fluidized bed.
- The principles of ion exchange, techniques and applications.
- Details of different pressure driven, concentration driven, electro potential driven membrane separation processes and different types of synthetic 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.

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.

Drying equipment: Batch and continuous drying equipment, material and energy balances of continuous driers, rate of drying for continuous direct heat driers.

UNIT – IV:

Adsorption: 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.

Adsorption equipment: 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.

Ion-Exchange: Principles of ion exchange, techniques and applications, ion-movement theory, ion exclusion.

UNIT – V:

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, nano filtration, ultrafiltration, microfiltration, pervaporation, dialysis, membrane extraction, electro-dialysis. Types of synthetic membranes – micro porous, asymmetric, thin-film composite, electrically charged and inorganic membranes. Membrane modules - industrial applications. Brief introduction to cryogenic separations.

Outcomes:

The students are able to:

- Analyze 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.
- Apply the basic concepts for design of ion exchange systems
- 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, 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, Kaushik Nath, 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. Liquid Extraction, Robert E. Treybal, 2nd edition, McGraw Hill, 1963.
4. Principles of Mass Transfer and Separation Processes, Binay K. Datta, PHI Learning Private Ltd., 2009.
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-Stage Separation Operations in Chemical Engineering, E.J. Henley and J.D. Seader, John Wiley & Sons, 1981.
8. Transport Processes and Unit Operations, Christie J. Geankoplis, 4th Edition, PHI, 2009.
9. Separation Processes, C.J. King, 2nd edition, McGraw- Hill, 1980.

III Year II Semester

L	T	P	C
3	0	0	3

CHEMICAL REACTION ENGINEERING – II

Learning Objectives:

The student will be able to learn:

- The basics of non-ideal flow and the concepts of RTD and conversion in non-ideal flow.
- The basics of diagnosing reactor ills.
- The dispersion model, the tanks-in-series model and the convection model for laminar flow and their applications in chemical reactions and conversions.
- The effects of earliness of mixing, segregation and RTD on conversions for a self-mixing fluid and mixing of two immiscible fluids.
- The details of catalysis, catalysts, catalytic reaction mechanisms and rate limiting step.
- 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.
- The experimental methods for finding rates in solid-catalyzed reactions.
- The details of deactivating catalysts, mechanism of deactivation, rate and performance equations involving deactivation.
- The kinetics of fluid-fluid reactions and fluid-particles.
- The shrinking core model for spherical particles of unchanging and changing sizes.
- 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, diagnosing reactors ills (qualitative discussion only).

UNIT – II:

The dispersion model- axial dispersion, correlations for axial dispersion, chemical reaction and dispersion.

The tanks in series model- pulse response experiments and the RTD, chemical conversion.

The convection model for laminar flow- the convective model and its RTD, chemical 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 reaction, synthesizing a rate law, mechanism and rate limiting step. (From chapter 6, Fogler).

UNIT – IV:

Solid catalyzed reaction-I: Introduction, pore diffusion resistance combined with surface kinetics, porous catalyst particles, heat effects during reaction, performance equations for reactors containing porous catalyst particles.

Solid catalyzed reactions-II: Experimental methods for finding rates; catalyst deactivation kinetics, the rate and performance equations.

UNIT – V:

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:

The students are 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 and carry out experiments for determining the rates of solid-catalyzed reactions.
- Determine the rate of deactivation in solid-catalyzed reactions.
- Apply the general rate equations of fluid-fluid reactions with the concentration profiles to design the equipment.
- Determine the rate controlling step in fluid-particle reactions.

Text Books:

1. Chemical Reaction Engineering, Octave Levenspiel, 3rd Ed. Wiley Eastern Ltd., 1998.
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.
2. Elementary Chemical Reactor Analysis, Aris. R., Prentice-Hall, Englewood Cliffs, 1969.
3. Modeling of Chemical Kinetics and Reactor Design, Coker, A.K., Gulf Professional Publishing, 2001.
4. Fundamentals of Chemical Reaction Engineering, Davis, M.E., and R.J. Davis, McGraw-Hill, 2002.
5. Chemical Reactor Analysis and Design, Froment, G.B., and K.B. Bischoff, 2nd Ed., Wiley, 1990.
6. An Introduction to Chemical Engineering Kinetics and Reactor Design, C.G. Hill Jr., John Wiley, 1977.
7. Chemical Reaction Engineering and Kinetics, Missen, R.W., C.A. Mims and B.A. Saville, Wiley, 1999.
8. The Engineering of Chemical Reactions, Schmidt, L.D., Oxford University Press, New York 1998.
9. Chemical reactor design, Peter Harriott, Marcel Dekkar, 2002.
10. Reaction Kinetics for Chemical Engineers, Stanley M.Walas. Uni Publishers, 1989.

III Year- II Semester

L	T	P	C
3	0	0	3

CHEMICAL PROCESS SAFETY
(OPEN ELECTIVE – I)

Learning Objectives:

The students will be able to learn:

- HSE aspects 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.
- The principles of designing equipment eliminating the possibilities of fire, explosion, toxic releases etc.
- The prevention/elimination of hazardous situations during installation, pre-commissioning, commissioning, normal operation and/or during execution of any maintenance work.
- The 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 disasters.

UNIT-II:

Toxicology: How toxicants enter biological organisms - How toxicants are eliminated from biological organisms - Effects of toxicants on biological organisms - Toxicological studies - Threshold limit values.
Industrial hygiene: Government of India regulations and OSHA - Industrial hygiene identification - Evaluation - Control.

UNIT-III:

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 – auto ignition – auto oxidation - adiabatic compression - ignition sources - sprays and mists – explosions - case studies.

UNIT-IV:

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-V:

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.

Outcomes:

The students are able to:

- Access 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.
- Apply procedures to maintain the industrial hygiene.
- Design various stages of operations without safety risk.
- Measure and monitor safety indices.
- Provide methods to prevent fires and explosions.
- Operate liquid and gas relief systems.

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. HAZOP and HAZAN, Trevor A. Keltz, 3rd Edition, Gulf Publications, 1986
5. What Went Wrong? Case Histories of Process Plant Disasters, Trevor A. Keltz, 4th Edition, 1985.
6. Lees' Loss Prevention in the Process Industries, Sam Mannan, Volume 1-3,4th edition, Elsevier Publishers, 2012.

III Year- II Semester

L	T	P	C
3	0	0	3

FUNDAMENTALS OF PETROLEUM REFINING
(OPEN ELECTIVE – I)

Learning Objectives:

The students are able to learn:

- Properties of crude oils and Petroleum fractions and their significance in meeting the fuel specifications.
- The chemistry of petroleum.
- The primary distillation of crude oil.
- The catalytic cracking, hydrocracking and alkylation.
- The catalytic reforming and isomerization.
- The details of residue reduction, hydrogen, hydrotreating, sulfur processes and asphalt production.

UNIT-I:

Introduction: The evolution of petroleum refining-Indian and world scenarios

Crude oil characteristics: crude oil composition-distillation curves-fractions-cutting crudes-gravities-sulphur content.

Products from crude oil: Properties and specifications.

The chemistry of petroleum: hydrocarbons-naphthenes-olefins and aromatics

UNIT-II:

Distillation: The simple still-the distilling column-reflux and reboil-cut points and setting cut points-desalting.

Vacuum distillation**:** The cracking phenomenon-effects of low pressure-vacuum flashing- adjusting the distillation curve.

UNIT-III:

Catalytic cracking: The process-the reaction section-catalysts-the regenerator-the fractionator-yields-process variables.

Hydrocracking: The process-hardware and the reactions.

Alkylation**:** The chemical reaction-the process-yields-process variables-poly plants.

UNIT-IV:

Catalytic reforming: The history-chemical reactions-semi regenerative reformers-regeneration-continuous catalytic reforming-process variables

Isomerization**:** Butane isomerization- C5/C6 isomerization.

UNIT-V:

Residue reduction: Thermal cracking and visbreaking-coking.

Hydrogen, hydro treating and Sulphur plants: Hydro treating-hydrogen sources-sulphur facilities.

Asphalt: composition-asphaltic crude oils-asphalt products.

Outcomes:

The students are able to:

- Assess different crude oils and evaluate petroleum fractions according to specifications.
- Apply the chemistry of petroleum in assessing different petroleum processes.
- Distinguish between atmospheric distillation and vacuum distillation units in petroleum refining.
- Differentiate the secondary processes like the catalytic cracking, hydrocracking, alkylation, catalytic reforming and isomerization.
- Know the necessity of residue reduction, and asphalt production while treating different crude oils.
- Realize the importance of hydrotreating of petroleum fractions and Supporting processes like production of hydrogen and sulfur.

Text Books:

1. Petroleum refining: In non-technical language, William L. Leffler, 4th edition, PennWell Corporation, 2008.

References 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.
3. Petroleum Refining, Andrew Campbell, Rarebooksclub.com, 2012.

III Year- II Semester

L	T	P	C
3	0	0	3

RENEWABLE ENERGY SOURCES
(OPEN ELECTIVE – I)

Learning objectives:
The students are able to learn:

- The depletion rate of conventional energy resources and importance of renewable energy sources.
- The alternate viable energy sources to meet the energy requirements.
- The details of solar energy, bio energy, wind energy, ocean energy, geothermal energy and hydrogen energy as alternate sources.
- The construction and operation of biogas plants for domestic and industrial applications (combined heat and power applications, transportation fuel).
- The application of methanol, ethanol and compressed biogas (CBG) as transporting fuels.

UNIT – I:
Principle of Renewable Energy: Comparison of Renewable and Conventional energy sources – Ultimate energy sources - natural energy currents on earth - primary supply to end use - Spaghetti & Pie diagrams -Energy planning - Energy Efficiency and Management.

UNIT – II:
Solar Radiation: Extra-terrestrial solar radiation - terrestrial solar radiation - solar thermal conversion-Solar Thermal Central Receiver system - Photovoltaic energy conversion - solar cell (theoretical analysis only).

UNIT – III:
Wind energy: Planetary and local winds - Vertical axis and Horizontal axis wind mills - principles of wind power - maximum power – actual power - wind turbine operation (theoretical analysis only).

UNIT – IV:
Energy from Oceans: Ocean temperature differences - principles of OTEC plant operations - wave energy - devices for energy extraction - tides - Simple single pool tidal system.
Geothermal Energy: Origin and types
Bio energy: Classification - anaerobic digestion for biogas - biogas digester – use of biogas for combined heat and power application (theoretical analysis only) – Methanol, ethanol and compressed biogas (CBG) as transportation fuels.

UNIT – V:

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.

Outcomes:

The students will be able to:

- Assess the depletion rate of conventional energy resources and importance of renewable energy sources.
- Identify the alternate viable energy sources to meet the energy requirements.
- Apply the solar energy, bio energy, wind energy, ocean energy, geothermal energy and hydrogen energy as alternate sources wherever necessary as per the economics.
- Design, construct and operate the biogas plants for domestic and industrial applications.
- Test and implement the application of methanol, ethanol and compressed biogas (CBG) as automotive fuels.

Text books:

1. Renewable Energy Sources, John W. Twidell & Anthoney D. Weir, 2nd edition, Taylor & Francis
2. Non-Conventional Energy Sources, G.D.Rai, Khanna Publishers

Reference books:

1. Power Plant Technology, EL-Wakil, McGraw-Hill Publications.
2. Renewable Energy Sources: Their impact on global warming and pollution, Tasneem Abbasi, S. A. Abbasi, PHI Publishers.
3. Solar Energy, S.P. Sukhatme, Tata McGraw Hill.
4. Energy Technology, S. Rao & B.B. Larulekar, Khamma Lab.
5. Principles of Solar Engineering, Frank Kreith & Jan F. Krieder, McGraw Hill.
6. Solar Energy -thermal Process, J.A. Duffie &W.A. Beckman, McGraw Hil1.

III Year- II Semester

L	T	P	C
3	0	0	3

SOLID WASTE MANAGEMENT
(PROFESSIONAL ELECTIVE – II)

Learning Objectives:

The students are able to learn:

- The methods of collection and characterization of solid wastes.
- The principles of treatment of solid wastes.
- The impact of solid wastes on the health of the living beings.
- The methods of processing of solid wastes.
- The criterion for selection of technology for the safe disposal of solid wastes.

UNIT – I:

Introduction to solid waste management: Goals and objectives of solid waste management, classification of solid waste – Factors influencing generation of solid waste – Sampling and characterization – Future changes in waste composition, Major legislation, Monitoring responsibilities, Terms related to ISWM like WTE, ULB, TLV etc., Measurement of NPK and Calorific value.

UNIT – II:

Basic elements in solid waste management: Elements and their inter relationship – principles of solid waste management – onsite handling, storage and processing of solid waste.

Collection of solid waste: Type and methods of waste collection systems, analysis of collection system – optimization of collection routes – alternative techniques for collection system.

UNIT – III:

Transfer, Transport and Transformation of waste: Need for transfer operation, compaction of solid waste – transport means and methods, transfer station types and design requirements.

Unit operations used for separation and transformation**:** Shredding – materials separation and recovery, source reduction and waste minimization

UNIT – IV:

Processing and Treatment**:** Processing of solid waste – waste transformation through combustion and composting, Market yard wastes and warming composting and vermin composting, Anaerobic methods for

materials recovery and treatment – Energy recovery – biogas generation and cleaning – Incinerators.

UNIT – V:

Disposal of solid waste: Methods of disposal, Landfills: Site selection, design and operation, drainage and leachate collection systems – designated waste landfill remediation. Case studies.

Outcomes:

The students will be able to:

- Characterize the solid wastes.
- Design the collection systems of solid wastes.
- Design the treatment of safe disposal of solid wastes.
- Design and operate the landfill system for municipal solid wastes.
- Design a composting or anaerobic digestion facility.

Text Books:

1. Integrated solid waste management, George Technologies, McGraw Hill Publication, 1993

Reference Books:

1. Solid waste engineering, Vesilind, P.A., Worrell, W., Reinhart, D., Cenage learning, New Delhi, 2004
2. Solid and hazardous waste management, P M Cherry, CBS Publishers and Distributors, New Delhi, 2016
3. Solid waste engineering, William A Worrell, P Aarue Vesilind, Cenage learning, New Delhi, 2016

III Year- II Semester

L	T	P	C
3	0	0	3

GREEN PROCESS TECHNOLOGIES
(PROFESSIONAL ELECTIVE – II)

Learning objectives:
The students will be able to learn:

- The fundamentals of green chemistry and green processes.
- The application of novel techniques such as ultrasound and microwave for the development of green process technologies.
- The application of methods involving ionic liquids, super critical CO_2 and electrochemical process in the green process technologies.
- The implementation of photocatalytic engineering, bio-catalysis and bio-processes in the green process technologies.

UNIT – I:
Tools for Green Process Engineering: Green Process Engineering design and methodology: A multi criteria approach – process optimization strategies – Representation and modeling of processes.

UNIT – II:
Technologies and Innovative Methods for Intensification – I: Process intensification by miniaturization – multifunctional reactors – Ultrasound in Process Engineering: New Look at Old Problems.

UNIT – III:
Technologies and Innovative Methods for Intensification – II: Microwaves: a potential technology for green process development – intensification by means of formulation.

UNIT – IV:
A new generations processes -I: Supercritical CO_2 as the key solvent for sustainable processes – Ionic liquids – water as solvent and solvent-free reactions - Electrochemical Processes for a Sustainable Development.

UNIT-V:
A new generations processes -II: - Photocatalytic Engineering – Biocatalysis and Bioprocesses - Catalysis contribution to a sustainable chemistry

Outcomes:
The students are able to:

- Apply the fundamentals of green chemistry and green processes.
- Implement the novel techniques such as ultrasound and microwave for the development of green process technologies.
- Develop the methods such as ionic liquids, super critical CO_2 and electrochemical process in the green process technologies.

- Implement the photocatalytic engineering, bio-catalysis and bio-processes in the green process technologies.

Text book:

1. Green Process Engineering : From the concepts to Industrial applications, Martine Poux, Patrick Cognet and Christophe Gourdon, CRC Press, 2010

Reference Book:

1. Green Chemistry and Green Engineering: Processing, Technologies, Properties and Applications, Shrikaant Kulkarni, Neha Kanwar Rawat, A. K. Haghi, CRC Press, 2021.

III Year- II Semester

L	T	P	C
3	0	0	3

GENERAL CHEMICAL TECHNOLOGY
(PROFESSIONAL ELECTIVE – III)

Learning objectives:
The students are able to learn:

- The importance of chemical process industries over the other manufacturing industries.
- The details of chemical process equipment, the application of thermodynamics, the chemical process principles.
- The corrosion and the safety aspects in the chemical manufacturing processes.
- The overview of chemical properties of inorganic chemicals and the manufacturing processes.
- The applications of materials which the engineers are likely to use during their professional career.

UNIT – I:
Introduction: Objectives, unit processes and unit operations. General Fundamentals
Chloro-Alkali Industries: Manufacture of soda ash, caustic soda and chlorine
Nitrogen industries: manufacture of ammonia, urea, nitric acid, ammonium nitrate.
Phosphate Industries: Phosphoric Acid, calcium phosphate and super phosphate

UNIT – II:
Sulfur and sulfuric acid: Sources of sulphur and sulphuric acid, Manufacture of sulfur by Frasch process & from fuel gases and DCDA process for sulfuric acid manufacture.
Cement: Types, compounds in cement, manufacture, special cements-pozzolans, high alumina, silicates, polymer concrete, magnesium oxy chloride cements.

UNIT – III:
Industrial gases: production of water gas, producer gas, Nitrogen, hydrogen and oxygen.
Nuclear industries: Uranium and thorium fission, nuclear fuels.
Pulp and paper industry: Methods of pulping, production of sulphate and sulphite pulp, production of paper by wet process.

UNIT – IV:
Sugar and starch industry: Manufacture of cane sugar, production of starch from maize.
Fermentation industry: Manufacture of alcohol from molasses, manufacture of penicillin.

Rubbers: Classification of rubbers, natural rubber, monomers of synthetic rubber, manufacture of SBR.

UNIT – V:

Synthetic Fibers: Classification, manufacture of nylon - 66, polyester fiber, viscose rayon fiber.

Oils, soaps and detergents: Definitions, constitution of oils, extraction and expression of vegetable oils, refining and hydrogenation of oils, continuous process for the production of fatty acids and soap, production of detergents.

Plastic Industry: Classification of plastics outlines and manufacture of phenols, formaldehyde, vinyl chloride and vinyl acetate, manufacture of phenol-formaldehyde resin and polyvinyl resins.

Outcomes:

The students are able to:

- Assess the importance of chemical process industries over the other manufacturing industries.
- Apply the details of chemical process equipment, thermodynamics, and the chemical process principles in a process industry.
- Study the corrosion aspects so as to select the suitable materials of construction for handling, storage and processing of various chemicals.
- Implement safety measures at various stages of processing plants.
- Judge and troubleshoot during any critical issues that may crop-up in operation of process plants.

Text book:

1. Dryden's Outlines of Chemical Technology for 21st Century, M. Gopal Rao, and M. Sittig, 3rd edition, East West Press, 2010.

Reference books:

1. Shreve's Chemical Process Industries, G. T. Austin, McGraw Hill, 5th edition (1984)
2. A Text Book of Chemical Technology (Volume II), by G. N. Pandey, Vikas Publishers.

III Year- II Semester

L	T	P	C
3	0	0	3

INDUSTRIAL BIOTECHNOLOGY
(PROFESSIONAL ELECTIVE – III)

Learning Objectives:

The students are able to learn:

- The importance of biochemical engineering sciences and biotechnology.
- The principles of animal biotechnology
- The application of animal cell culture, the monoclonal antibodies, the transgenic animal and the gene therapy.
- The basic concepts of plant biotechnology.
- The ethical, social, technical and economical aspects of various industries based on biotechnology.
- Application of biotechnology in various sectors like drugs, specialty chemicals, pharmaceuticals, agriculture, electronics, and defence etc.

UNIT – I:

Fundamentals of biochemical engineering sciences- Bio technology – Ancient and modern.

Exploitation of microbes-Large scale process, Commercial exploitation - Micro gravity biotechnology (Space biotechnology).

UNIT – II:

Animal biotechnology: Application of animal cell culture-Monoclonal antibodies -Transgenic animal and gene therapy.

UNIT – III:

Plant biotechnology: Plant Cell-Tissue and organ culture processes – Engineering perspectives.

Large scale separation processes: ATPS-Gradient elution and affinity interaction.

UNIT – IV:

Techno economics of biotechnology industries and Legal, social and ethical aspects of biotechnology.

UNIT – V:

Fermentation economics-isolation of microorganisms of potential industrial interest -Market potential, Recovery costs.

Outcomes:

The students are able to:

- Appreciate the scope and relevance of biochemical engineering and biotechnology in various applications.

- Apply the principles of animal biotechnology, animal cell culture, monoclonal antibodies, transgenic animal and gene therapy in diverse applications.
- Apply the concepts of biotechnology in the design of various processing units.
- Gain comprehensive understanding of ethical, social, technical and economical aspects of various industries based on biotechnology.
- Extend the application of biotechnology in various novel and critical sectors.

Text Books:

1. Introduction to Environmental Biotechnology, A. K. Chatterji, 3rd edition, PHI Publishers, 2011.
2. Text book of Biotechnology, H. K. Das, John Wiley, 2004.

Reference Books:

1. Environmental Biotechnology, Alan Scragg, 2nd edition, Oxford Press, 2005.
2. Concepts in Biotechnology, Balasubramanium, 2nd Edition, University Press, 2004.
3. Molecular Biotechnology, Bernard R. Glick and J.J.Pasternack, AS M Press, 2010.
4. Fundamentals of Biochemical Engineering, Bailey Ollis, 2nd Edition, McGraw-Hill, 1986
5. Introduction to Biotechnology, Ray V.Herren, Delmar Cengage learning, 2012.

III Year- II Semester

L	T	P	C
0	0	3	1.5

CHEMICAL REACTION ENGINEERING – LABORATORY

Learning Objectives:

The students are able to learn:

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

List of 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. Determination of the effect of residence time on conversion and the rate constant in a CSTR.
4. Determination of the specific reaction rate constant of a reaction of a known order in batch reactor.
5. Determination of 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. Determination of mass transfer coefficient for solid-liquid reaction system).
8. 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 reactor design.

III Year- II Semester

L	T	P	C
0	0	3	1.5

MATHEMATICAL METHODS – LABORATORY

Learning Objectives:

The students will be able to learn:

- The application of MATLAB to solve various rigorous and iterative problems related to various chemical engineering topics.
- The what-if analysis for the variations in the parameters using mathematical methods.

List of problems:

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. Compressibility factor variation from Vanderwaals equation
5. Isothermal compression of gas using Redlich-Kwong Equation of state
6. Thermodynamic properties of steam from Redlich-Kwong Equation
7. Solution of Stiff Ordinary Differential Equations
8. Iterative Solution of ODE boundary value problem
9. Shooting method for solving two-point boundary value problems
10. Expediting the solution of systems of nonlinear algebraic equations
11. Solving differential algebraic equations –DAEs
12. Method of lines for Partial Differential Equations
13. Estimating model parameters involving ODEs using fermentation data

Outcome:

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

Textbook:

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

III Year-II Semester

L	T	P	C
3	0	0	3

UNIVERSAL HUMAN VALUES 2: UNDERSTANDING HARMONY (HSMC)

Human Values Courses

This course also discusses their role in their family. It, very briefly, touches issues related to their role in the society and the nature, which needs to be discussed at length in one more semester for which the foundation course named as "H-102 Universal Human Values 2: Understanding Harmony"is designed which may be covered in their III or IV semester.

During the Induction Program, students would get an initial exposure to human values through Universal Human Values – I. This exposure is to be augmented by this compulsory full semester foundation course.

Universal Human Values 2: Understanding Harmony

Course code: HSMC (H-102)

Credits: L-T-P-C 2-1-0-3 or 2L:1T:0P 3 credits

Pre-requisites: None. Universal Human Values 1 (desirable)

1. OBJECTIVE:

The objective of the course is four fold:

1. Development of a holistic perspective based on self-exploration aboutthemselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

2. COURSE TOPICS:

The course has 28 lectures and 14 practice sessions in 5 modules:

Module 1: Course Introduction - Need, Basic Guidelines, Content and Process for Value Education

1. Purpose and motivation for the course, recapitulation from Universal Human Values-I
2. Self-Exploration–what is it?- Its content and process; 'Natural Acceptance' and ExperientialValidation- as the process for self-exploration
3. Continuous Happiness and Prosperity- A look at basic Human Aspirations
4. Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario

6. Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking

Module 2: Understanding Harmony in the Human Being - Harmony in Myself!

7. Understanding human being as a co-existence of the sentient 'I' and the material 'Body'
8. Understanding the needs of Self ('I') and 'Body' - happiness and physical facility
9. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer)
10. Understanding the characteristics and activities of 'I' and harmony in 'I'
11. Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail
12. Programs to ensureSanyam and Health.

Include practice sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease

Module 3: Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship

13. Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship
14. Understanding the meaning of Trust; Difference between intention and competence
15. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship
16. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals
17. Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives

Module 4: Understanding Harmony in the Nature and Existence - Whole existence as Coexistence

18. Understanding the harmony in the Nature
19. Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self-regulation in nature
20. Understanding Existence as Co-existence of mutually interacting units in all-pervasive space
21. Holistic perception of harmony at all levels of existence.

Include practice sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

Module 5: Implications of the above Holistic Understanding of Harmony on Professional Ethics

22. Natural acceptance of human values
23. Definitiveness of Ethical Human Conduct
24. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order
25. Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people-friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems.
26. Case studies of typical holistic technologies, management models and production systems
27. Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations
28. Sum up.

Include practice Exercises and Case Studies will be taken up in Practice (tutorial) Sessions eg. to discuss the conduct as an engineer or scientist etc.

3. READINGS:

3.1 Text Book

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010

3.2 Reference Books

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi

5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj - PanditSunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi - Romain Rolland (English)

4. *MODE OF CONDUCT (L-T-P-C 2-1-0-3 or 2L:1T:0P 3 credits)*

Lectures hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them.

Tutorial hours are to be used for practice sessions.

While analysing and discussing the topic, the faculty mentor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.

In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self-observation, self-reflection and self-exploration. Scenarios may be used to initiate discussion. The student is encouraged to take up" ordinary" situations rather than" extra-ordinary" situations. Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and work in real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials) would also provide support to a student in performing actions commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic humanvalues.

It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses.

This course is to be taught by faculty from every teaching department, including HSS faculty. Teacher preparation with a minimum exposure to at least one 8-day FDP on Universal Human Values is deemed essential.

5. ASSESSMENT:

This is a compulsory credit course. The assessment is to provide a fair

state of development of the student, so participation in classroom discussions, self-assessment, peer assessment etc. will be used in evaluation.

Example:

Assessment by faculty mentor: 10 marks Self-assessment: 10 marks
Assessment by peers: 10 marks
Socially relevant project/Group Activities/Assignments: 20 marks Semester End Examination: 50 marks

The overall pass percentage is 40%. In case the student fails, he/she must repeat the course.

6. OUTCOME OF THE COURSE:

By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind. They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

This is only an introductory foundationalinput. It would be desirable to follow it up by

a) faculty-student or mentor-mentee programs throughout their time with the institution
b) Higher level courses on human values in every aspect of living. E.g. as a professional

III Year-II Semester

L	T	P	C
1	0	1	0

EMPLOYABILITY SKILLS – I: PYTHON PROGRAMMING (MC)

Course objectives:

1. Describe the core syntax and semantics of Python programming language.
2. Discover the need for working with the strings and functions.
3. Illustrate the process of structuring the data using lists, dictionaries, tuples and sets.
4. Indicate the use of regular expressions and built-in functions to navigate the file system.
5. Infer the Object-oriented Programming concepts in Python.

Course Outcomes:

COs	Course Outcomes	Bloom's Level
CO1	Interpret the fundamental Python syntax and semantics and be fluent in the use of Python control flow statements.	L2
CO2	Express proficiency in the handling of strings and functions.	L2
CO3	Determine the methods to create and manipulate Python programs by utilizing the data structures like lists, dictionaries, tuples and sets.	L3
CO4	Identify the commonly used operations involving file systems and regular expressions.	L2
CO5	Articulate the Object-Oriented Programming concepts such as encapsulation, inheritance and polymorphism as used in Python.	L3

UNIT-1:Introduction: History of python, Applications of python, running python scripts, Identifiers, Keywords, Statements and Expressions, Variables, Operators, Precedence and Associativity, Data Types, Indentation, Comments, Reading Input, Print Output, Type Conversions, Control Flow- if, if-elif-else, for, while, break, continue, pass.

UNIT-2: Strings: Creating and Storing Strings, Basic String Operations, Accessing Characters in String by Index Number, String Slicing and Joining, String Methods, Formatting Strings, Lists, Creating Lists, Basic List Operations, Indexing and Slicing in Lists, Built-In Functions Used on Lists, List Methods, The del Statement.

UNIT-3: Dictionaries: Creating Dictionary, Accessing and Modifying key: value Pairs in Dictionaries, Built-In Functions Used on Dictionaries, Dictionary Methods, The del Statement, Tuples and Sets, Creating Tuples, Basic Tuple Operations, Indexing and Slicing in Tuples, Built-In Functions Used on Tuples, Relation between Tuples and Lists, Relation between Tuples and Dictionaries, Tuple Methods, Using zip() Function, Sets, Set Methods, Traversing of Sets, Frozen set.

UNIT-4: Functions: Defining functions, calling functions, Passing Arguments, Keyword Arguments, Default Arguments, Variable-length Arguments, anonymous functions, Scope of the variable in a function-Global and Local Variables. Modules: Creating modules, import statement, from import statement, name spacing.

UNIT-5: Object Oriented Programming in Python: Classes and Objects, Creating Classes in Python, Creating Objects in Python, The Constructor Method, Classes with Multiple Objects, Class Attributes versus Data Attributes, Encapsulation, Inheritance, The Polymorphism. **Error and Exceptions:** Difference between an error and Exception, Handling Exception, try except block, Raising Exceptions, User Defined Exceptions.

Text Books:

1. Python Programming: A Modern Approach, Vamsi Kurama, Pearson.
2. Learning Python, Mark Lutz, Orielly.

Reference Books:

1. Think Python, Allen Downey, Green Tea Press.
2. Core Python Programming, W.Chun, Pearson.
3. Introduction to Python, Kenneth A. Lambert, Cengage.

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 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 fertilizer industry/ chemical processing industry/ petroleum refinery/petrochemical complex for 4-6 weeks and submit a report.

Outcomes:
The students will be able to:

- 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

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MOOCS (NPTEL/ SWAYAM) FOR HONORS/MINORS DEGREE

Learning Objectives:

The students are able to:

- Avail the expertise in a specific subject from nation-wide reputed faculty, through MOOC (Massive Open Online Course)
- Develop the ability for self-actualization and in getting opportunity for life-long learning

There shall be a Discipline Centric Elective Course through Massive Open Online Course (MOOC) as Program Elective course. The student shall register for the course (Minimum of 12 weeks) offered by SWAYAM/NPTEL through online with the approval of Head of the Department. The Head of the Department shall appoint one mentor for each of the MOOC subjects offered. The student needs to register the course in the SWAYAM/NPTEL portal. During the course, the mentor monitors the student's assignment submissions given by SWAYAM/NPTEL.

The student needs to submit all the assignments given and needs to take final exam at the center. The student has to earn a certificate by passing the exam. The student will be awarded the credits given in curriculum only by submission of the certificate. In case if student does not pass subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered again through SWAYAM/NPTEL in the next semester with the recommendation of Head of the Department and shall be passed in the examination.

The list of MOOCS courses is given in the appendix (to do honors in chemical engineering, the eligible student has to choose the subjects in chemical engineering from the list to fulfill the criteria of 20 credits). In order to get minor degree, a student has to select and do the courses in any one discipline other than chemical engineering to fulfil the criteria of 20 credits.

The total 20 credits for honors or minor degree should be obtained from the second semester to the end of eighth semester. A candidate can take a 3-credit course in each semester during the above-mentioned period.

It may be noted that, each student is to get minimum 8.0 SGPA without any backlogs in each semester to do honors and minors degree.

Outcomes:

The students are able to:

- Overcome the digital divide in acquiring fast developing technologies / knowledge and be part of digital revolution.
- Acquire subject specific expert knowledge from National Resource Pool.
- Understand his /her academic / professional priorities for future development.

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.
- Solving of various momentum transport problems based on shell momentum balance approach.
- Solving of various heat transport problems based on shell energy balance approach.
- The 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 steady state and unsteady state velocity, temperature and concentration profiles for laminar flow conditions.

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, with a nuclear heat source with a viscous heat source, with a chemical heat source, heat conduction through composite walls, heat conduction in a cooling fin, forced convection and 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 chemical reaction, with a homogeneous chemical reaction,

diffusion into a falling liquid film (gas absorption and solid dissolution), diffusion and chemical reaction inside a porous catalyst.

UNIT-V:
The equations of change: Derivation of the equation of continuity in Rectangular and Polar coordinates, the equations of motion, energy, and 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 and unsteady state problems of momentum, heat, and mass transfer.

Outcomes:
The students are 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 Book:
1. Transport Phenomena, 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, 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

L	T	P	C
3	0	0	3

PLANT DESIGN AND ECONOMICS FOR CHEMICAL ENGINEERS

Learning Objectives:
The students will be able to learn:

- The development of design database-process creation, process design, process flow diagrams, piping & instrument diagrams and the general procedure for flow sheet synthesis and development.
- The basic concepts of materials handling equipment and design.
- The basic theory of heat transfer in heat exchangers and design of various heat exchangers.
- The selection of a suitable separation process and reactor design procedure and selection of reactor and catalysts.
- The various terms and activities related to economics which can be useful during economical evaluation of any chemical process industries.

UNIT – I:
Development of design: Development of design database -Process creation -Process design -Process flow diagrams- 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.
Plant location -Plant layout -Plant operation & control.

UNIT-II:
Materials handling equipment & design: Basic concepts -Piping in fluid transports processes –selection of pumps and design procedure for pumps - Compression and expansion of fluids. Design of flow meters and belt conveyor systems.

UNIT-III:
Heat transfer equipment design: Basic theory of heat transfer in exchangers -Selection and design of heat exchangers including compact heat exchangers - Kern method, Bell Delaware method, Wills and Johnston method for shell and tube heat exchangers – design of plate and frame, plate and fin and spiral heat exchangers - Pressure drop calculations.

UNIT-IV:
Separation equipment and reactor design**:** Selection/Guidelines for suitable separation processes – design of distillation, absorption and extraction columns. short cut methods. Design of reactor systems - selection of catalysts.

UNIT-V:
Process Economics: Time value of money, depreciation and depletion amortization, rate of returns and pay-out time, economical balancing in cyclic operation - cost, earnings, profit and returns – estimation of capital and operational costs -William sixth term factor - break even analysis.

Outcomes:
The students are able to:

- Apply 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.
- Design equipment pertaining to materials handling, heat transfer, separation processes and catalytic & non-catalytic reactors.

Text Books:

1. Plant Design & Economics for Chemical Engineers, Max Peteres, Klaus
   D. Timmerhaus, Ronald West, 5th Edition, Tata McGraw-Hill, 2011.
2. Introduction to Process Engineering and Design, S.B. Thakore and B.I.
   Bhatt, Tata McGraw-Hill, 2007.

Reference Books:

1. Chemical Engineering Design, R. Sinnot and Gavin Towler, 5th Edition,
   Butterworth-Heinmann, 2009.
2. Applied Process Design for Chemical & Petrochemical 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. Chemical Processing Engineering: Design & Economics, H. Silla, Marcel Dekkar, Inc., 2003.
5. A Guide to Chemical Engineering Process Design & Economics, Gael D. Ulrich, Process Publishing, 1984.
6. Process Engineering and Design Using Visual Basic, Arun Datta, CRC Press, 2008.

IV Year - I Semester

L	T	P	C
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PROCESS MODELLING AND SIMULATION
(PROFESSIONAL ELECTIVE – IV)

Learning Objectives:
The students will be able to learn:

- The various aspects and classification associated to mathematical models in process engineering.
- The art of developing process models for fluid flow operations, heat transfer operations, mass transfer operations and reaction engineering.
- The process plant simulation models with special reference to modular and equation oriented solving approaches and solution methodologies.
- The industrial applications of process modelling and simulation.

UNIT – I:
Mathematical models for chemical engineering systems: Introduction, Use of mathematical models, Scope of coverage, Principles of formation, Fundamental laws, Continuity equation, Energy equation Equations of motion, Transport equations, Equations of state, Equilibrium and Chemical kinetics.

UNIT – II:
Application of mathematical models to chemical engineering systems: series of isothermal, constant hold up CSTRs, CSTRs with variable hold-ups, two heated tanks, gas phase pressurized CSTR, non-isothermal CSTR.
Modelling of single component vaporizer, multi-component flash drum, batch reactor, Reactor with mass transfer, Ideal binary distillation column and Batch distillation with hold up.

UNIT – III:
Methods for solving non-linear equations: Interval Halving method, Newton-Raphson method, False Position method, Wegstein method, solution of linear simultaneous algebraic equations-Gauss elimination method, Gauss Jordon and Gauss – Seidal method.
Numerical integration: Trapezoidal and Simpson's rules.
Numerical solution of ordinary differential equations**:** Euler Algorithm and Runge-Kutta (Fourth-Order) methods.

UNIT – IV:
Computer simulation: Simulation of gravity flow tank, three CSTRs in series with constant hold-up open loop system and three CSTRs in series with constant hold-up closed loop system. Simulation of non-isothermal CSTR, binary distillation column and batch reactor - bubble and dew point calculations in VLE.

UNIT – V:

General Concepts of Simulation for Process Design: Introduction, modular approaches to process simulation- sequential modular approach, simultaneous modular approach, equation solving approach, Partitioning and tearing.

Handling of professional simulation packages for process modelling and simulation: HYSYS/ASPEN/UNISIM Design/CHEMCAD/PRO-II and Fluent/FEMLAB.

Outcomes:

The students are 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, heat transfer & mass transfer operations and reaction engineering.
- Apply process plant simulation models and solving procedures to obtain the solutions for the analysis of process plants.
- Carry out simulation of large process plants using tear streams.
- Apply process simulation software for process plant simulation and analysis.

Text books:

1. Process Modelling, Simulation and Control for Chemical Engineers, W. L. Luyben, McGraw Hill, 2nd Edition, 1999.
2. Process Plant Simulation, B. V. Babu, Oxford University Press, 1st Edition, 2004.

Reference Books:

1. Modelling and Analysis of Chemical Engineering Processes, K. Balu and K. Padmanabhan, I. K. International Pvt. Ltd., New Delhi, 2007.
2. Chemical Process Modelling and Computer Simulation, Amiya K. Jana, PHI Learning Private Limited, New Delhi, 2011.
3. Process Simulation and Control Using ASPEN, PHI Learning Private Limited, New Delhi, 2012.

IV Year - I Semester

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FLUIDIZATION ENGINEERING
(PROFESSIONAL ELECTIVE – IV)

Learning Objectives:
The students will be able to learn:

- The basic concepts of fluidization and its advantages and disadvantages.
- The various industrial applications of fluidized bed.
- The different regimes of fluidization and flow maps.
- The Geldart classification of particles; the estimation of minimum fluidization velocity; the Davidson and K-L models.
- The basic concepts of turbulent and fast fluidized beds.
- The basic concepts of vertical & horizontal movement of solids.
- The estimation of gas interchange coefficients.
- The principles of heat and mass transfer from the bubbling bed model.

UNIT-I:
Introduction: The phenomenon of fluidization -liquid like behavior of a fluidized bed -comparison with other contacting methods -advantages and disadvantages of fluidized beds.
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- activated carbon -gasification of waste - bio fluidization.

UNIT-II:
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-III:
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-IV:
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-V:
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:
The students are 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.
- Calculate 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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OPTIMIZATION TECHNIQUES FOR CHEMICAL ENGINEERS (PROFESSIONAL ELECTIVE – V)

Learning objectives:
The students will be able to learn:

- The various components of an optimization model to represent real time scenarios in process engineering.
- The classification of process models into multi-variable linear and non-linear programming formulations.
- The basic concepts associated to classical optimization, direct and indirect optimization methods.
- The various mathematical methods for the optimization of linear programming, non-linear programming, geometric and integer programming.
- The strengths, opportunities and features of various mathematical methods applicable for linear programming, non-linear programming, geometric and integer programming.
- The 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: 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.

UNIT-III:
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-IV:
Nonlinear programming-II:
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-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.
Modern methods of optimization: Genetic, simulated annealing, ant-colony algorithms.
Applications of optimization: Fluid flow and heat transfer, separation processes, chemical reaction engineering.

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

- Formulate a mathematical model for process engineering scenarios with demarcation of decision variables, dependent variables, objective function, equality and inequality constraints.
- Classify the formulated mathematical model into either linear or non-linear or geometric or integer programming.
- Apply various mathematical methods for formulated linear/non-linear/geometric/dynamic programming models.
- Identify the most appropriate mathematical method for solving optimization models.
- Apply genetic algorithm for non-linear programming model and evaluate its performance in comparison with any classical deterministic optimization method.

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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INDUSTRIAL SAFETY & HAZARD MANAGEMENT
(PROFESSIONAL ELECTIVE – V)

Learning Objectives:
The students will be able to learn:

- The HSE aspects 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.
- The principles of designing equipment eliminating the possibilities of fire, explosion, toxic releases etc.
- The prevention/elimination of hazardous situations during installation, pre-commissioning, commissioning, normal operation and/or during execution of any maintenance work.
- The various techniques and measures available to investigate industrial accidents.

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 disasters.
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 and OSHA regulations - 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:
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 – Auto ignition – Auto oxidation - Adiabatic compression - Ignition sources - Sprays and mists – Explosions. Case Studies.
Design methods 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-IV:
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 and 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-V:
Hazard identification: Process hazards checklists - hazard surveys - hazard and operability studies - safety reviews - other methods.
Risk assessment: Review of probability theory - event & 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:
The students are able to:
- Assess the various hazards involved in handling hydrocarbons in oil & gas sector; Visualize all possible safety issues at all the phases of industry by applying the techniques like HAZOP, QRA etc.,
- Apply the procedures to maintain the industrial hygiene.
- Design various stages of operations without safety risk.
- Measure and monitor safety indices.
- Design methods to prevent fires and explosions.
- Design and operate liquid and gas relief systems.
- Investigate the process accidents systematically.

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 - I Semester

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HAZARD OPERABILITY AND FAULT TREE ANALYSIS IN PROCESS PLANTS
(OPEN ELECTIVE – II)

Learning Objectives:
The students will be able to learn:

- The features and details of HAZOP studies.
- The organization of HAZOP study along with recording, auditing and training for a process plant.
- The advanced HAZOP and specific applications with factors for successful completion of HAZOP.
- The concepts of fault tree analysis.
- The examples for the application of HAZOP & fault tree analysis in process plants
- The case studies of application of HAZOP along with fault tree analysis.

UNIT – I:
Introduction: aims and objectives - essential features of HAZOP study process hazard studies: concept stage hazard review - hazid at front-end engineering design (feed) - detailed design hazard study - construction/design verification - pre-commissioning safety review - project close-out/post start-up review - consideration of inherently safer or less polluting systems - demolition/abandonment reviews - overview of hazard studies.
The HAZOP study method: essential features - the purpose – limitations the detailed HAZOP study procedure: the description and design intention - generating a deviation - identifying causes - evaluating consequences - safeguards (protection) - risk assessment - recommendations/actions – recording - continuing and completing the analysis- an illustration of the HAZOP study process

UNIT – II:
Organizing a HAZOP Study: Defining the scope and objectives of the study and establishing the boundaries - appointing a team leader and selecting the team – preparation
Carrying Out a Study: Pre-meeting with client - planning the meetings - the study meetings - coordinating and reviewing responses - completing and signing off the report(s) - follow-up of actions and management of change.
Recording and Auditing: Background information - section headings - the recording format for the detailed examination - the level of recording - the content - computer recording - auditing a HAZOP study
Training: Team members – scribe - team leader

UNIT – III:
Advanced Aspects of HAZOP Study: HAZOP study of computer-controlled processes - human factors - linking HAZOP studies to LOPA
Specific Applications of HAZOP: Modification of existing operations - repeat designs—HAZOP-by-difference - periodic hazard studies and the HAZOP of an existing plant - operating procedures - pilot plant and laboratory operations - drains, vents, and other interconnections between plants - commissioning and decommissioning - start-up and shutdown - construction and demolition - contract operations
Factors for a Successful HAZOP Study: Throughout the study - before the study - during the study - after the study

UNIT – IV:
Fault Tree Analysis- Basic Concepts: Orientation - failure vs success models -the undesired event concept.
The Basic Elements of Fault Tree: The Fault Tree Model - symbology - the building blocks of the fault tree.
Fault Tree Construction Fundamentals: Faults vs failures - fault occurrence vs. fault existence - passive vs. active components - component fault categories: primary, secondary and command - failure mechanism, failure mode, and failure effect - the "immediate cause" concept - basic rules for fault tree construction.

UNIT – V:
Examples and Case Studies: Pressure tank – power distributions in three motors - case study on HAZOP and fault tree analysis for calculation of safety integrity level on reactor.
The propagation of faults in process plants: Modeling of fault propagation - fault tree synthesis - an interactive, computer-based facility.
Application of HAZOP and fault tree analysis for reactive chemical hazards

Outcomes:
The students are able to:
- Apply the HAZOP procedure in identifying the process risk.
- Organize HAZOP study along with recording, auditing and training for a process plant.
- Carry out the advanced HAZOP with specific applications.
- Apply the concepts of fault tree analysis in identifying the root causes of the process accidents.
- Follow the examples and case studies while designing HAZOP and fault tree procedures for a process accident under study.

Text Books:
1. HAZOP: Guide to Best Practice - Guidelines to Best Practice for the Process and Chemical Industries, Frank Crawley, Brian Tyler, 3rd edition, Elsevier,2015.
2. Fault Tree Handbook, W. E. Vesely, F.F. Goldberg, U.S. Nuclear Regulatory Commission, NUREG-0492, 1998.

Articles:

1. The propagation of faults in process plants: 1. Modeling of fault propagation, Kelly, B.E., & Lees, F.P., Reliability Engineering, 16, 3-38, 1986.
2. The propagation of faults in process plants: 2. Fault tree synthesis, Kelly, B.E., & Lees, F.P., Reliability Engineering, 16, 39-62, 1986.
3. The propagation of faults in process plants: 3. An interactive, computer-based facility, Kelly, B.E., & Lees, F.P., Reliability Engineering, 16, 3-38, 1986.
4. Hazop Study and Fault Tree Analysis for Calculation Safety Integrity Level on Reactor-C.5-01, Oil Refinery Unit at Balikpapan-Indonesia, Ali Musyafa, Adi Soeprijanto, Asian Journal of Applied Sciences, 2017

IV Year - I Semester

L	T	P	C
3	0	0	3

HEAT INTEGRATION AND PINCH ANALYSIS
(OPEN ELECTIVE – II)

Learning Objectives:
The students will be able to learn:

- The concepts of HENs and design of various heat exchange equipment.
- The methodology of heat and power integration.
- The concept of pinch technology for heat integration and energy optimization.
- More specific and complex aspects of pinch analysis and energy economics.
- The concepts of energy integration in distillation trains.

UNIT – I:
Heat Exchanger Networks I – Heat Transfer Equipment: Overall heat transfer coefficients - heat transfer coefficients and pressure drops for shell-and-tube heat exchangers - temperature differences in shell-and-tube heat exchangers - allocation of fluids in shell-and-tube heat exchangers - extended surface tubes - retrofit of heat exchangers – condensers - reboilers and vaporizers - other types of heat exchange equipment - fired heaters

UNIT – II:
Heat Exchanger Networks II – Energy Targets: Composite curves - the heat recovery pinch - threshold problems – non-global minimum temperature difference - process constraints - utility selection – furnaces - cogeneration (combined heat and power generation) - integration of heat pumps

UNIT – III:
Heat Exchanger Networks III – Capital and Total Cost Targets: Number of heat exchange units - heat exchange area targets - number-of-shells target - capital cost targets - total cost targets
Key concepts of pinch analysis: heat recovery and heat exchange - the pinch and its significance

UNIT – IV:
Heat Exchanger Networks IV – Network Design: The pinch design method - design for threshold problems - stream splitting - design for multiple pinches - remaining problem analysis - network optimization - the superstructure approach to heat exchanger network design - retrofit of heat exchanger networks - addition of new heat transfer area in retrofit.
Heat Exchanger Networks V – Stream Data: Process changes for heat integration - the trade-offs between process changes, utility selection, energy cost and capital cost - data extraction

UNIT – V:
Heat Integration of Distillation Columns: The Heat integration characteristics of distillation - the appropriate placement of distillation - use of the grand composite

curve for heat integration of distillation - evolving the design of simple distillation columns to improve heat integration - heat pumping in distillation - capital cost considerations - heat integration characteristics of distillation sequences - heat-integrated distillation sequences based on the optimization of a superstructure

Outcomes:
The students are able to:

- Apply the concepts of HENs and design of various heat exchange equipment.
- Apply the methodology of heat and power integration in the HENs.
- Apply the concept of pinch technology for heat integration and energy optimization.
- Gain an in-depth understanding on more rigorous aspects of pinch analysis and energy economics.
- Apply the concept of energy integration to distillation columns.

Text Books:

1. Robin Smith, Chemical Process Design and Integration, 2nd Edition, John Wiley and Sons Ltd 2005.
2. Ian C Kemp, Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy, Second edition.

Reference Books and Articles:

1. Kern DQ, Process Heat Transfer, McGraw-Hill (1950).
2. Jiri J Klemes, Handbook of Process Integration (PI): Minimisation of Energy and Water Use, Waste and Emissions, 1st Edition.
3. Sinnott RK, Chemical Engineering, Volume 6 Chemical Engineering Design, Butterworth Heinemann (1996).
4. Ahmad S, Linnhoff B and Smith R Cost Optimum Heat Exchanger Networks II Targets and Design for Detailed Capital Cost Models, Comp Chem Eng (1990).
5. Zhu XX, Zanfir M and Klemes J Heat Transfer Enhancement for Heat Exchanger Network Retrofit, Heat Transfer Eng (2000).
6. Ahmad S, Linnhoff B and Smith R Design of Multipass Heat Exchangers: an Alternative Approach, Trans ASME J Heat Transfer (1988).

IV Year - I Semester

L	T	P	C
3	0	0	3

DESIGN OF EXPERIMENTS AND ANALYSIS
(OPEN ELECTIVE – II)

Learning Objectives:
The students will be able to learn:

- The general philosophy of designing and carrying experiments and analyzing the data generated from experiments.
- The factorial and fractional factorial designs and their relevance to simultaneously increase experimentation efficiency at reduced cost.
- The efficient analysis of the data generated from experimentation that can be validated for utilization towards process modeling and simulation.
- The concepts of linear and non-linear regression analysis.
- The use of various software packages for statistical design and analysis of experiments.

UNIT-I:
Introduction to probability, Probability laws, Bayes' 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.
Two-way factorial design, blocking, Yate's algorithm.
Fractional factorial design at two levels, Concept of design resolution.

UNIT-V:
Simple modeling with least squares (Regression analysis), Matrix versions of normal equations.
Software packages: Learn and use a few latest software packages in design of experiments.

Outcomes:
The students are able to:

- Effectively design the experiments for reduced time and resources.
- Rigorously analyze the data generated that can be effectively validated for any future simulation.

- Apply the concepts of linear and non-linear regression analysis for the design of experiments.
- Evaluate the extent of deviation between the experimental and theoretical data.
- Use various software packages for statistical design and analysis of experiments.

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 - I Semester

L	T	P	C
0	0	3	1.5

PROCESS EQUIPMENT DESIGN & DRAWING – LABORATORY

Learning Objectives:
The student will be able to learn:

- The standard symbology used to represent various pipes, valves and fittings and their use in development of P&ID (Piping & Instrument Diagram)
- The 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.
- The standard symbology used to represent process equipment.
- The preparation of standard process flow diagrams using AUTOCAD / Microsoft Visio with required details for process design.
- The preparation of standard Piping and Instrument Diagrams (P&IDS) using AUTOCAD / Microsoft Visio, with required details for design of piping, instrument systems.
- The process and mechanical design of the equipment for storage, heat and mass transfer operations.
- The drawing of detailed diagrams of process equipment for storage, heat and mass transfer operations.

List of 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 are able to:

- 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 / Edraw Max /Microsoft Visio^{R} Flowchart 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) for various types of instruments and accessories in AUTOCAD / Edraw Max /Microsoft Visio^{R} Flowchart.
- Carryout process and mechanical design of (a) Shell & tube and Double Pipe Exchangers (b) Distillation columns & absorber and (c) Cylindrical & Spherical storage vessels.
- Draw the detailed diagrams of process equipment for storage, heat and mass transfer operations.

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, V.V. Mahajani, S.B. Umarji, 4th Edition, Macmillan Publishers, 2009.

IV Year - I Semester

L	T	P	C
0	0	3	1.5

PROCESS SIMULATION – LABORATORY

Learning Objectives:
The students will be able to learn:

- The 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
- The application of suitable thermodynamic models for predicting the properties of various hydrocarbons, sour systems & electrolytes.
- The creation of suitable detailed flow diagrams for process plants.
- The steady state simulation of the plant /equipment & fluid flow systems.
- The generation of output data files like stream data (heat & material balance), equipment duty & design features, hydraulic capacity etc.

List of experiments: (need to be conducted using 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 are able to:

- Characterize the 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
- Apply the suitable thermodynamic models for predicting the properties of various hydrocarbons, sour systems & electrolytes.
- Create the suitable detailed flow diagrams for process plants.
- Perform the steady state simulation of the plant /equipment & fluid flow systems.
- Generate the output data files like stream data (heat & material balance), equipment duty & design features, hydraulic capacity etc.

IV Year - I Semester

L	T	P	C
0	0	0	1

PRESENTATION/SEMINAR
(SUMMER INTERNSHIP PROGRAM REPORT)

Learning Objectives:
The students are able to learn:

- The preparation of the document in a proper format for the submission as summer Training/Internship Report.
- The skills to prepare power point presentation by editing the material from the internship report.
- The oral skills to present the PPT with confidence.
- Sharing the practical knowledge acquired during the 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 4 - 6 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.

Outcomes:
The students are able to:

- Prepare the documents/reports in the desired formats.
- Make the power point presentations very effectively.
- Present the PPTs with confidence in the technical groups/seminars/meetings.
- Enhance written and oral communication skills.
- Share the technical knowledge and experience to colleagues in the plant and elsewhere.

IV Year - I Semester

L	T	P	C
0	0	0	2

PROJECT (INDUSTRIAL / IN-HOUSE) (PHASE – 1)

Learning Objectives:
The students are able to learn to:

- Explore the given/chosen topic in detail by doing literature search from journals articles and books.
- Identify the gaps in the existing research/technology.
- Formulate the problem statement of the project and to work out the methodology of addressing the topic.
- Make some preliminary investigations on the topic experimentally or theoretically or both.
- Make an interim technical report consisting of preliminary investigations for presenting it to a committee.

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 plant/ a chemical process plant 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/chemical process plant.

c) Any experimental work in chemical engineering with physical interpretations.

Note: The interim report is intended as a compilation of literature survey and the results in the preliminary investigations. It is evaluated by a committee for 50 marks (2 credits)

Outcomes:

The students are able to:

- Carry out literature survey for any project.
- Do research work by bridging the gaps in the existing research/technology.
- Write the problem statements of any projects.
- Develop methodology to make calculations.
- Make the interim technical reports for the preliminary investigations.

IV Year - I Semester

L	T	P	C
3	0	0	0

IPR & PATENTING
(MC)

Learning Objectives:

- To acquire detailed knowledge of IPR Laws and its relevance, application and practice in Engineering Discipline, the student has to know the increasingly assumed role of Intellectual Property globally with the rapid pace of technological and scientific innovations created by the human intellect and to understand the TRIPS Agreement and the functions WIPO, WTO to enhance the protection different IPRs and the enforcement of competition law to prevent unfair competition
- To acquire a comprehensive knowledge about Copyright as an exclusive right given by the law to the creators of literary, scientific, dramatic, musical and artistic works and producers of cinematography films and sound recordings, thereby protecting and rewarding creativity and ensure moral and economic rights of Authors of those creative works, which induces others to do the same is the basis for socio- economic development and progress of the society
- To acquire a comprehensive knowledge about Patent as an exclusive right granted for the inventions arising from the human intellect and its considerable commercial value of those scientific inventions having potential for industrial application are being protected for a limited duration to encourage the innovations.
- Study about Trade Marks Law gives an insight about Trade Mark as a statutory right provides protection to the owner of the mark by ensuring the exclusive right to use it, or to authorize another to use the same for consideration which will promote initiative and enterprise worldwide and hinders the efforts of unfair competitors. Trade Secrets and confidential information relating to the business enterprises and why this key strategic asset needs to be protected
- Study of Information Technology Act and Cyber Laws provide a detailed insight to regulate online and digital transactions and promoting E-governance, E-commerce, E-banking with required confidentiality, data security and to prevent cyber-crimes.

UNIT – I:

Introduction to Intellectual Property Rights (IPRs): Concept of Property - Introduction to IPR – IPR Tool Kit – International Instruments and IPR – WIPO - TRIPS – WTO – IPR Laws - IPR Protection and Regulation - Copyrights and Neighbouring Rights – Industrial Property – Patents – Designs - Traditional Knowledge – Geographical Indications - Emerging Areas of IPR.
Law of Unfair Competition – Competition Commission.

UNIT – II:

Copyrights and Neighbouring 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 – Case Law.

UNIT – III:

Patents: Introduction to Patents - Patent Laws in India – Patent Requirements – Product Patent and Process Patent - Patent Search - Registration and Grant of Patent – Exclusive and Monopoly Rights – Limitations - Ownership - Transfer — Revocation of Patent – Patent Appellate Board - Infringement of Patent – Double Patenting — Compulsory Licensing - Patent Cooperation Treaty – New developments - Software Protection and Computer related Innovations.

UNIT – IV:

Trademarks & Trade Secrets: Introduction to Trademarks – Trademark Laws – Functions of Trademark – Marks Covered under Trademark Law - Trade Mark Registration – Maintenance – Transfer - Deceptive Similarities - Infringement – Remedies.

Introduction to Trade Secrets – Laws Relating to Trade Secrets – Safeguarding Trade Secrets – Physical Security – Employee Access Limitation – Confidentiality Agreements – Breach of Contract – Remedies.

UNIT – V:

Cyber Laws and Cyber Crimes: Introduction to Cyber Laws – Information Technology Act 2000 - Protection of Online and Computer Transactions - E-commerce - Data Security – Privacy - Authentication - Confidentiality - Digital Signatures – Certifying Authorities - Cyber Crimes - Prevention - Punishment – Liability of Network Providers.

Outcomes:

After studying these units, the student is expected to be able to assume:

- The significance of innovations, distinguish different kinds of IPRs and know the legislative framework, practice and procedure relating to Patents, Copyrights, Trademarks, Designs, Trade Secrets, Geographical Indications, Traditional Knowledge and certain emerging areas.
- The various components of copyright law, its protection and enforcement to know the application of copyright law, its duration, advantages and issues of 'fair use' and 'plagiarism' in the digital era.
- The Patent law in India and its global instruments and spell out the procedural requirements of novelty, non-obviousness and inventive step involved in obtaining a Patent, its exclusive rights besides assignment and licensing patterns, commercial exploitation and how the patent does benefit the society.
- The conceptual and legal framework relating to Trade Marks and its infringement and gives an insight how the Trademark is commercially

advantageous to its owner to prevent unfair competition and further safeguarding the trade secrets of the business enterprises.

- The importance of E-commerce, data security, online transactions and how the confidentiality and privacy can be safeguarded through the digital signatures and the prevention and punishment of cybercrimes under the law.

Texts Books:

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

L	T	P	C
1	0	1	0

EMPLOYABILITY SKILLS – II: DATA SCIENCE
(MC)

Course Objectives: The main objectives of this course is to

- describe the life cycle of Data Science and computational environments for data scientists using Python
- describe the fundamentals for exploring and managing data with Python
- examine the various data analytics techniques for labeled/columnar data using Python
- demonstrate a flexible range of data visualizations techniques in Python

UNIT I: INTRODUCTION TO DATA SCIENCE AND PYTHON:
Introduction to Data Science and its importance, Data Science and Big data, The life cycle of Data Science, The Art of Data Science, Work with data, data Cleaning, data Munging, data manipulation. Establishing computational environments for data scientists using Python with IPython and Jupyter.
Introduction to Python - Python Introduction- Features, Identifiers, Reserved words, Indentation, Comments. Built-in Data types and their Methods: Strings, List, Tuple, Dictionary, Set. Type Conversion, Operators, Decision Making, Looping, Loop Control statements, Math and Random number functions. User defined functions - function arguments & its types, Essential Python libraries.

UNIT II: FILE, EXCEPTION HANDLING AND OOP:
User defined Modules and Packages in Python- Files: File manipulations, File and Directory related methods - Python Exception Handling. OOPs Concepts -Class and Objects, Constructors – Data hiding- Data Abstraction- Inheritance

UNIT III: INTRODUCTION TO NUMPY
NumPy Basics: Arrays and Vectorized Computation- The NumPy ndarray- Creating ndarrays- Data Types for ndarrays- Arithmetic with NumPy Arrays- Basic Indexing and Slicing - Boolean Indexing-Transposing Arrays and Swapping Axes. Universal Functions: Fast Element-Wise Array Functions- Mathematical and Statistical Methods-SortingUnique and Other Set Logic.

UNIT IV: DATA MANIPULATION WITH PANDAS
Introduction to pandas Data Structures: Series, DataFrame, Essential Functionality: Dropping Entries Indexing, Selection, and Filtering- Function Application and Mapping- Sorting and Ranking. Summarizing and Computing Descriptive Statistics- Unique Values, Value Counts, and Membership. Reading and Writing Data in Text Format.

UNIT V: DATA CLEANING, PREPARATION AND VISUALIZATION

Data Cleaning and Preparation: Handling Missing Data - Data Transformation: Removing Duplicates, Transforming Data Using a Function or Mapping, Replacing Values, Detecting and Filtering Outliers- String Manipulation: Vectorized String Functions in pandas. Using Matplotlib, Plotting with pandas: Line Plots, Bar Plots, Histograms and Density Plots, Scatter or Point Plots.

Text Books:

1. Y. Daniel Liang, "Introduction to Programming using Python", Pearson,2012.
2. Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", O'Reilly, 2nd Edition,2018
3. Jake VanderPlas, "Python Data Science Handbook: Essential Tools for Working with Data", O'Reilly, 2017

Reference Books:

1. Wesley J. Chun, "Core Python Programming", Prentice Hall,2006.
2. Mark Lutz, "Learning Python", O'Reilly, 4th Edition, 2009.

LIST OF EXERCISES:

Software Requirements: Python

1. Write a Program to implement Editing and executing Programs Flow Controls.
2. Write a Program to implement Editing and executing Programs Functions.
3. Write a Program to implement String Manipulations
4. Write a Program to implement Creating and manipulating a Tuple, Lists and Dictionary
5. Write a Program to implement Object Creation and Usage
6. Write a Program to implement Inheritance
7. Write a Program to implement Method Overloading
8. Write a Program to implement Reading and Writing with Text Files and Binary Files
9. Write a Program to implement Combining and Merging Data Sets
10. Write a Program to implement Regular Expressions
11. Write a Program to implement Data Aggregation and GroupWise Operations

IV Year - I Semester

L	T	P	C
0	0	0	3

MOOCS (NPTEL/ SWAYAM) FOR HONORS/MINORS DEGREE

Learning Objectives:

The students are able to:

- Avail the expertise in a specific subject from nation-wide reputed faculty, through MOOC (Massive Open Online Course)
- Develop the ability for self-actualization and in getting opportunity for life-long learning

There shall be a Discipline Centric Elective Course through Massive Open Online Course (MOOC) as Program Elective course. The student shall register for the course (Minimum of 12 weeks) offered by SWAYAM/NPTEL through online with the approval of Head of the Department. The Head of the Department shall appoint one mentor for each of the MOOC subjects offered. The student needs to register the course in the SWAYAM/NPTEL portal. During the course, the mentor monitors the student's assignment submissions given by SWAYAM/NPTEL.

The student needs to submit all the assignments given and needs to take final exam at the center. The student has to earn a certificate by passing the exam. The student will be awarded the credits given in curriculum only by submission of the certificate. In case if student does not pass subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered again through SWAYAM/NPTEL in the next semester with the recommendation of Head of the Department and shall be passed in the examination.

The list of MOOCS courses is given in the appendix (to do honors in chemical engineering, the eligible student has to choose the subjects in chemical engineering from the list to fulfill the criteria of 20 credits). In order to get minor degree, a student has to select and do the courses in any one discipline other than chemical engineering to fulfil the criteria of 20 credits.

The total 20 credits for honors or minors degree should be obtained from the second semester to the end of eighth semester. A candidate can take a 3-credit course in each semester during the above mentioned period.

It may be noted that, each student is to get minimum 8.0 SGPA without any backlogs in each semester to do honors and minors degree.

Outcomes:

The students will be able to:

- Overcome the digital divide in acquiring fast developing technologies / knowledge and be part of digital revolution.
- Acquire subject specific expert knowledge from National Resource Pool.
- Understand his /her academic / professional priorities for future development.

IV Year - II Semester

L	T	P	C
3	0	0	3

NANOTECHNOLOGY
(PROFESSIONAL ELECTIVE – VI)

Learning Objectives:

The students will be able to learn:

- The properties and characterization of nanomaterials.
- The synthesis approaches for nanomaterials from chemistry perspective.
- The synthesis technologies for nanomaterials from process perspective.
- The applications of nanoscience, nanotechnology and nanomaterials in the fields of chemical, medical, textiles, paints, energy, defence and space.
- The working knowledge of thermodynamics in nanotechnology.

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, consumer's 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; Dispersive systems and their classifications, classification of dispersive systems according to size, classification of dispersive systems according to dimension, Inter molecular forces in organic polymerics, aqueous, biological, Vander-waal, electro static, double layer forces in acid phase

and acid base systems. Depletion interactions, Hydro phobic forces layering. Mesoscale thermodynamics of Nano scale particles. Gibbs treatment of interfaces.

Outcomes:
The students are able to:

- Characterize the nanomaterials.
- Synthesize the nanomaterials.
- Develop process technologies for nanomaterials.
- Assess the application of nanoscience, nanotechnology and nanomaterials in the fields of chemical, medical, textiles, paints, energy, defence and space.
- Apply the knowledge of thermodynamics in nanotechnology.

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.
2. Nano- and Biomaterials Compounds, Properties, Characterization, and Applications by Zhypargul Abdullaeva Wiley vch, 2006.
3. Intermolecular and Surface Forces by Jacob N. Israelachvili, Third Edition,2011 Academic Press (Elsevier)

Reference Books:

1. Introduction to Nano-science and Nanotechnology, K.K. Chattopadhyay and A. N. Banerjee, PHI, 2009.
2. Nano Materials & Introduction to Synthesis, Properties and Application, Dieter Vollath, wiley vch, 2006.
3. Interfacial forces in aqueous media, 2nd edition by Carel J. Van Oss, 1994.
4. Surface and Interfacial Forces by Hans-Jürgen Butt and Michael Kappl, 2nd edition, 2009.
5. Colloids and Interfaces in Life Sciences and Bio-nanotechnology, by Willem Norde, 2nd edition, CRC press, 2011.
6. Foundations of Colloid Science by Robert J. Hunter, 2nd Edition, Oxford university press, 2000.
7. Surfaces, Interfaces and Colloids: Principles and Applications, Drew Myers, 2nd Edition, Wiley, 1991.

IV Year - II Semester

L	T	P	C
3	0	0	3

PETROLEUM PRODUCTION ENGINEERING
(PROFESSIONAL ELECTIVE – VI)

Learning Objectives:

The students are able to learn:

- The fundamental concepts in petroleum production.
- The concepts of reservoir deliverability, well bore performance and choke performance.
- The classification and properties of reservoir fluids, Darcy's law and its application to the flow of reservoir fluids.
- The various surface equipment for process oil and gas after flow from wells.
- The application of suitable artificial lifts on reservoir energy depletion.
- Sick well identification and remedial stimulation operations.

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.

Outcomes:

The students are able to:

- Apply the fundamental concepts of petroleum production.
- Apply the concepts of reservoir deliverability, well bore performance and choke performance.
- The classification and properties of reservoir fluids, Darcy's law and its application to the flow of reservoir fluids.

- Design various surface equipment for process oil and gas after flow from wells.
- Apply the suitable artificial lifts on reservoir energy depletion.
- Perform well identification to carry out remedial stimulation operations.

Text Books:

1. Petroleum Production Engineering: A Computer Assisted Approach, Boyun Guo, William C. Lyons, Ali Ghalambor, Elsevier 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 - II Semester

L	T	P	C
3	0	0	3

NATURAL GAS ENGINEERING
(PROFESSIONAL ELECTIVE – VII)

Learning Objectives:
The students will be able to learn:

- The various correlations for the evaluation of natural gas properties.
- The concepts of reservoir deliverability, wellbore performance, and choke performance for a gas reservoir.
- The various process technologies, operating and design parameters deployed for the natural gas separation, dehydration and acid gas removal.
- The various supplementary equipment associated with natural gas compression, metering and transportation.
- The various principles associated in troubleshooting of 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: Analytical methods – Empirical methods – Construction of inflow performance relation curve (IPR curves).
Wellbore performance: Single phase gas well – Mist flow in gas wells.
Choke performance**:** Sonic and subsonic flow – Dry and wet gas flow through chokes.

UNIT-III:
Separation: Separation of gases and liquids – stage separation – flash calculations – low temperature separation.
Dehydration of natural gas: Water content of natural gas streams-dehydration systems- glycol dehydrator design.
Removal of acid gases**:** Alkanol amine sweetening – glycol / amine process –sulfinol process.

UNIT-IV:
Compression: Types of compressors – selection of reciprocating, centrifugal and rotary compressors.

Volumetric measurement: Measurement with orifice meters – displacement metering – turbine meter – elbow meter – mass flow meters (Coriolis meters) – natural gas liquid measurement.
Transportation: Pipeline design – sizing pipelines and pipeline wall thickness.

UNIT-V:
Liquid loading in gas wells: Turner's method – Guo's method – comparison of methods.
Hydrate control: Hydrate forming conditions – methods to prevent hydrate formation.
Pipeline cleaning: Pigging system – selection of pigs – major applications – pigging procedure.

Outcomes:
The students are able to:

- Apply the various correlations for evaluation of natural gas properties.
- Apply the concepts of reservoir deliverability, wellbore performance, and choke performance for a gas reservoir.
- Gain understanding of various process technologies, operating and design parameters deployed for the natural gas separation, dehydration and acid gas removal.
- Design the various supplementary equipment associated with natural gas compression, metering and transportation.
- Apply the various principles associated in troubleshooting of natural 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
3	0	0	3

COMPUTATIONAL FLUID DYNAMICS
(PROFESSIONAL ELECTIVE – VII)

Learning Objectives:

The students will able to learn:

- The governing equations of fluid dynamics.
- The difference between conservation and non-conservation form of equations.
- The various methods available for solutions of partial differential equations.
- The boundary conditions for solution of partial differential equations.
- The role of finite element methods for solving fluid dynamics problems.
- The concept of stability.
- The hands-on operation of various software packages to solve fluid dynamics problems.

UNIT-I:

Governing equations of fluid dynamics, incompressible and 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: stability of numerical solution of simple conduction and convection equations for one-dimensional 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.

Implicit time dependent methods for inviscid and viscid compressible flow, with a discussion of the concept of numerical dissipation.

UNIT-V:

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 are able to:

- Apply the governing equations of fluid dynamics to fluid flow problems.
- Differentiate between conservation and non-conservation form of equations.
- Apply the various methods for solutions of partial differential equations.
- Apply the boundary conditions for solution of partial differential equations.
- Use finite element methods in solving fluid dynamics problems.
- Assess the reasons for stability of flow systems.
- Use various software packages for solving fluid dynamics problems.

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. Computational Fluid Flow and Heat Transfer, Muralidhar, K. Sundarajan, T., Narosa Publishing House, 1995.

IV Year - II Semester

L	T	P	C
3	0	0	3

OPEN ELECTIVE – III (FOR CHEMICAL ENGINEERING)

The students are required to take one of the courses from NPTEL / SWAYAM.

- NPTEL – DATA ANALYSIS & DECISION MAKING
- NPTEL – E-BUSINESS
- NPTEL – INNOVATION, BUSINESS MODELS & ENTREPRENEURSHIP

If the above courses are not available from the list of NPTEL / SWAYAM portal, the student should do the course suggested by the department.

IV Year - II Semester

L	T	P	C
0	0	0	8

PROJECT (INDUSTRIAL / IN-HOUSE) (PHASE-2)

Learning Objectives:
The students are able to learn:

- The evaluation of the usage / commercial /environmental aspect of a product / process from a demand / supply or regulation point of view.
- The evaluation of the technical aspects of various alternatives available, called "Best Available Technologies (BAT)".
- The selection of a suitable process for the optimum capacity.
- The basic design of the process using steady state simulation and generate PFD, heat & material balances and summary of utility consumption.
- The preliminary equipment design, with mechanical details, of all major equipment and preparing equipment data sheets.
- The concepts of plant location.
- The preparation of plant layout & plot plan drawing.
- The preliminary cost estimation of the plant (CAPEX) and OPEX.
- The 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 Chemical Plant 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.

Note: Students are expected to carry out the project after preliminary investigations done in phase-I. Finally, the interim report and the phase-II report should be merged to submit the final project report for evaluation (8 credits).

Outcomes:
The students are able to:

- Prepare the project feasibility reports for process 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.
- Perform simulation of overall plant including estimation of utility consumptions.
- Generate the PFD (Process Flow Diagrams), and heat & material balance report.
- Size all plant equipment and preliminary cost estimation using cost indices, charts & other relevant literature.
- Perform preliminary cost estimation of piping, instrumentation, electrical equipment, civil works & construction as % of equipment cost, to determine Installation cost of the plant.
- Perform preliminary utility, catalyst & chemical consumption estimation.
- Estimate the total operating cost.
- Prepare 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.

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

PHYSICAL FITNESS ACTIVITIES
(MC)

IV Year - II Semester	**L**	**T**	**P**	**C**
	0	**0**	**0**	**3**

MOOCS (NPTEL/ SWAYAM) FOR HONORS/MINORS DEGREE

Learning Objectives:

The students are able to:

- Avail the expertise in a specific subject from nation-wide reputed faculty, through MOOC (Massive Open Online Course)
- Develop the ability for self-actualization and in getting opportunity for life-long learning

There shall be a Discipline Centric Elective Course through Massive Open Online Course (MOOC) as Program Elective course. The student shall register for the course (Minimum of 12 weeks) offered by SWAYAM/NPTEL through online with the approval of Head of the Department. The Head of the Department shall appoint one mentor for each of the MOOC subjects offered. The student needs to register the course in the SWAYAM/NPTEL portal. During the course, the mentor monitors the student's assignment submissions given by SWAYAM/NPTEL.

The student needs to submit all the assignments given and needs to take final exam at the center. The student has to earn a certificate by passing the exam. The student will be awarded the credits given in curriculum only by submission of the certificate. In case if student does not pass subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered again through SWAYAM/NPTEL in the next semester with the recommendation of Head of the Department and shall be passed in the examination.

The list of MOOCS courses is given in the Appendix (to do honors in chemical engineering, the eligible student has to choose the subjects in chemical engineering from the list to fulfill the criteria of 20 credits). In order to get minor degree, a student has to select and do the courses in any one discipline other than chemical engineering to fulfil the criteria of 20 credits.

The total 20 credits for honors or minors degree should be obtained from the second semester to the end of eighth semester. A candidate can take a 3-credit course in each semester during the above mentioned period.

It may be noted that, each student is to get minimum 8.0 SGPA without any backlogs in each semester to do honors and minors degree.

Outcomes:

The students will be able to:

- Overcome the digital divide in acquiring fast developing technologies / knowledge and be part of digital revolution.
- Acquire subject specific expert knowledge from National Resource Pool.
- Understand his /her academic / professional priorities for future development.