COURSE STRUCTURE AND SYLLABUS
for

B.TECH. CHEMICAL ENGINEERING
R20 – Regulations

(Applicable for batches admitted from 2020-2021)

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

University College of Engineering Kakinada (A)
Department of Petroleum Engineering & Petrochemical Engineering
R20 Course Structure

B.TECH. CHEMICAL ENGINEERING

Semester I (First year)							
Sl. No.	Course Title	Category	Course Code	Hours per week			Credits
				L	**T**	**P**	**C**
1	Mathematics - I	BS		3	0	0	3
2	Engineering Physics	BS		3	0	0	3
3	Engineering Mechanics	ES		3	0	0	3
4	Elements of Mechanical Engineering	ES		3	0	0	3
5	Basic Electrical and Electronics Engineering	ES		3	0	0	3
6	Engineering Workshop and IT Workshop	ES		0	0	3	1.5
7	Engineering Physics Laboratory	BS		0	0	3	1.5
8	Basic Engineering (Mechanical & Electrical) Laboratory	ES		0	0	3	1.5
9	Physics Virtual Laboratory	BS		0	0	2	0
MC	Constitution of India	MC		3	0	0	0
			Total credits				**19.5**

Category	**CREDITS**
Basic Science course	7.5
Engineering Science Courses	12.0
Humanities and social science	-
TOTAL CREDITS	**19.5**

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Department of Petroleum Engineering & Petrochemical Engineering
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Semester II (First year)							
Sl. No.	Course Title	Category	Course Code	Hours per week			Credits
				L	**T**	**P**	**C**
1	Mathematics – II	BS		3	0	0	3
2	Physical Chemistry	BS		3	0	0	3
3	Communicative English	HS		3	0	0	3
4	Engineering Drawing	ES		1	0	4	3
5	Programming for problem solving using - C	ES		3	0	0	3
6	English Communication Skills – Laboratory	HS		0	0	3	1.5
7	Physical Chemistry – Laboratory	BS		0	0	3	1.5
8	Programming for problem solving using - C Laboratory	ES		0	0	3	1.5
MC	Professional Ethics and Human Values	HS		2	0	0	0
MC	Physical Fitness Activities			0	0	2	0
				Total credits			**19.5**

Category	**CREDITS**
Basic Science course	7.5
Engineering Science Courses	7.5
Humanities and social science	4.5
TOTAL CREDITS	**19.5**

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B.TECH. CHEMICAL ENGINEERING

Semester III (Second year)							
Sl. No.	Course Title	Category	Course Code	Hours per week			Credits
				L	**T**	**P**	**C**
1	Mathematics – III	BS		3	0	0	3
2	Organic Chemistry for Chemical Engineers	PCC		3	0	0	3
3	Fluid Mechanics for Chemical Engineers	PCC		3	0	0	3
4	Mechanical Unit Operations	PCC		3	0	0	3
5	Material and Energy Balances	PCC		3	0	0	3
6	Organic Chemistry for Chemical Engineers – Laboratory	PCC		0	0	3	1.5
7	Mechanical Unit Operations – Laboratory	PCC		0	0	3	1.5
8	Fluid Mechanics for Chemical Engineers – Laboratory	PCC		0	0	3	1.5
9	Python programming	SC		1	0	2	2
MC	Environmental Science	MC		2	0	0	0
			Total credits				**21.5**

Category	**CREDITS**
Basic Science Course	3.0
Professional Core Courses	16.5
Skill Oriented Course	2.0
TOTAL CREDITS	**21.5**

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Semester IV (Second year)							
Sl. No.	Course Title	Category	Course Code	Hours per week			Credits
				L	**T**	**P**	
1	Management and Organizational Behaviour	HS		3	0	0	3
2	Mathematics -IV	BS		3	0	0	3
3	Mass Transfer Operations – I	PCC		3	0	0	3
4	Chemical Engineering Thermodynamics – I	PCC		3	0	0	3
5	Heat Transfer Operations	PCC		3	0	0	3
6	Mass Transfer Operations – I Laboratory	PCC		0	0	3	1.5
7	Mathematical methods for Chemical Engineers – Laboratory	PCC		0	0	3	1.5
8	Heat Transfer Operations - Laboratory	PCC		0	0	3	1.5
9	Industry Exploration Project	SC		1	0	2	2
					Total credits		**21.5**
Internship during summer vacation							
Honors/Minor courses				**4**	**0**	**0**	**4**

Category	**CREDITS**
Basic Science Courses	3.0
Professional Core Courses	13.5
Engineering Science Courses	-
Skill oriented course*	2.0
Humanities and Social Sciences	3.0
TOTAL CREDITS	**21.5**

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Semester V (Third year)							
S No	Course Title	Category	Code	Hours			Credits
				L	**T**	**P**	
1	Chemical Engineering Thermodynamics-II	PCC		3	0	0	3
2	Instrumentation, Process Dynamics and Control	PCC		3	0	0	3
3	Mass Transfer Operations – II	PCC		3	0	0	3
4	**Open Elective – I** (for other branches) i. Introduction to Chemical Engineering ii. Fundamentals of Petroleum Refining iii. Renewable Energy Sources	OEC		3	0	0	3
5	**Professional Elective – I** i. General Chemical Technology ii. Industrial Pollution and Control iii. Petroleum Refinery Engineering	PEC		3	0	0	3
6	Instrumentation, Process Dynamics and Control – Laboratory	PCC		0	0	3	1.5
7	Mass Transfer Operations – II - Laboratory	PCC		0	0	3	1.5
8	Soft Computing Techniques	SC		1	0	2	2
9	Essence of Indian Traditional Knowledge	MC		2	0	0	0
Summer Internship after second year to be evaluated during V semester				0	0	0	1.5
				Total credits			**21.5**
Honors/Minor courses				**4**	**0**	**0**	**4**

Category	**CREDITS**
Professional core Courses	12
Professional Elective courses	3
Open Elective Course/Job oriented elective	3
Skill advanced course/ soft skill course*	2
Summer Internship	1.5
TOTAL CREDITS	**21.5**

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Semester VI (Third year)							
SNo	Course Title	Category	Code	Hours			Credits
				L	**T**	**P**	
1	Chemical Reaction Engineering	PCC		3	0	0	3
2	Transport Phenomena	PCC		3	0	0	3
3	Plant Design and Economics for Chemical Engineers	PCC		3	0	0	3
4	**Professional Elective – II** i. Process Modelling and Simulation ii. Bio Chemical Engineering iii. Materials Science and Engineering	PEC		3	0	0	3
5	**Open Elective – II** (for other branches) i. Basics of Waste Management ii. Introduction to Petrochemicals iii. Fundamentals of Green Technologies	OEC		3	0	0	3
6	Chemical Reaction Engineering – Laboratory	PCC		0	0	3	1.5
7	Process Equipment Design & Drawing – Laboratory	PCC		0	0	3	1.5
8	Process Simulation – Laboratory	PCC		0	0	3	1.5
9	Data Science	SC		**1**	**0**	**2**	**2**
10	IPR & Patenting	MC		2	0	0	0
						Total credits	**21.5**
	Honors/Minor courses			**4**	0	0	**4**
Industrial/Research Internship (Mandatory) during summer vacation							

Category	**CREDITS**
Professional core courses	13.5
Professional Elective courses	3
Open Elective Course/Job oriented elective	3
Skill advanced course/ soft skill course*	2
Mandatory course (AICTE)	0
Industrial/Research Internship (Mandatory)	-
TOTAL CREDITS	**21.5**

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Semester VII (Fourth year)							
S. No	Course Title	Category	Code	Hours			Credits
				L	**T**	**P**	
1	**Professional Elective – III** i. Process Intensification ii. Optimization Techniques for Chemical Engineers iii. Fluidization Engineering	PEC		3	0	0	3
2	**Professional Elective – IV** i. Petroleum Production Engineering ii. Computational Fluid Dynamics iii. Petroleum Reservoir Engineering	PEC		3	0	0	3
3	**Professional Elective – V** i. Industrial Safety & Hazard Management ii. Nanotechnology iii. Natural Gas Engineering	PEC		3	0	0	3
4	**Open Elective – III** (for other branches) i. Pipeline Engineering ii. Chemical Process Safety iii. Introduction to Separation Processes	OEC		3	0	0	3
5	**Open Elective – IV** (for other branches) i. Hazard Operability and Fault Tree Analysis in Process Plants ii. Heat Integration and Pinch Analysis iii. Introduction to Meta-Analysis and Design of Experiments	OEC		3	0	0	3
6.	Universal Human Values 2: Understanding Harmony	MC		3	0	0	3
7	Cloud Computing	SC		1	0	2	2
Industrial/Research Internship (Mandatory) after third year to be evaluated during VII semester				0	0	0	3
			Total credits				**23**
Honors/Minor courses				**4**		**0**	**4**

Category	**CREDITS**
Professional Elective courses	9
Open Elective Course/Job oriented elective	6
Humanities and Social Science Elective	3
Skill advanced course/ soft skill course*	2
Industrial/Research Internship	3
TOTAL CREDITS	**23**

B.TECH. CHEMICAL ENGINEERING

Semester VIII (Fourth year)							
Sl. No.	Category	Code	Course Title	Hours per week			Credits
				L	**T**	**P**	
1	Major Project	PROJ	Project (internship in industry/Research labs/ Project (in-house)) and seminar.	0	0	0	12
	INTERNSHIP (6 MONTHS)						
Total credits							**12**

APPENDIX – I

Suggested course list (Department/NPTEL/SWAYAM) – 2022, for UG R20 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 technology
4	Chemical Engineering in Drugs and Pharmaceutical Industries
5	Air pollution monitoring and its applications
6	Process plant equipment operation, control & reliability
7	Multicomponent 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	Advanced Thermodynamics
3	Membrane Technology
4	Applied Time-Series Analysis
5	Physico-chemical processes for wastewater treatment
6	Bio-mass Conversion and Bio-refinery
7	Environmental Quality Monitoring & Analysis
8	Polymer Reaction Engineering
9	Process Control - Design, Analysis and Assessment
10	Non-conventional energy Resources

** 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.

APPENDIX – II

Suggested 12 weeks course list (NPTEL/SWAYAM) – 2022, for UG R20 regulation for **Minor Degree in Chemical Engineering** from SWAYAM/ NPTEL portal.

S. No.	Course Name
1	Basic Principles and Calculations in Chemical Engineering
2	Fluid Flow Operations
3	Transport Processes I: Heat and Mass Transfer
4	Membrane Technology
5	Optimization in Chemical Engineering
6	Chemical Engineering Thermodynamics
7	Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems
8	Process Control - Design, Analysis and Assessment
9	Physico-chemical processes for wastewater treatment
10	Process Equipment Design
11	Polymer Reaction Engineering
12	Chemical Process Instrumentation
13	Biomass Conversion and Biorefinery

University College of Engineering Kakinada (A)
Department of Petroleum Engineering & Petrochemical Engineering
B. Tech. Chemical Engineering Syllabus, R20 – Regulation

I Year- I Semester

L	T	P	C
3	0	0	3

MATHEMATICS – I

Learning Objectives:

- To familiarize a variety of well-known sequences and series, with a developing intuition about the behaviour of new ones.
- 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.

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, Problems and applications on the above theorem.

UNIT – II: Differential equations of first order and first degree: (10 hrs)

Linear differential equations – Bernoulli's equations – Exact equations and equations reducible to exact form – Homogeneous and Non-homogeneous differential 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 – Euler-Cauchy equation and Legender's equation.

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 MacLaurin'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 integrals – Change of order of integration – Double integrals in polar coordinates – Change of variables to polar coordinates – Areas enclosed by plane curves – Triple integrals – Volume of solids – Change of variables to spherical and cylindrical co-ordinates.

UNIT – V: Beta and Gamma functions: (5 hrs)
Introduction to Improper Integrals –Beta and Gamma functions – Properties – Relation between Beta and Gamma functions – Evaluation of improper integrals.

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)

Text Books:

1. B. S. Grewal, Higher Engineering Mathematics, 44th 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

Learning Objectives:

- Bridging the gap between the physics in school at 10+2 level and UG level engineering courses.
- To identify the importance of the optical phenomenon i.e. interference, diffraction and polarization related to its Engineering applications
- Understand the mechanism for emission of light, utility of lasers as coherent light sources for low and high energy applications, study of propagation of light through optical fibers and their implications in optical communications.
- Open new avenues of utility for dielectric and magnetic materials as potential sources for micro devices.
- Familiarize the concepts of theoretical acoustics for their practical utility in engineering acoustics. Explanation for the significance of ultrasound and its application in NDT application.
- Enlighten the periodic arrangement of atoms in Crystalline solids by Bragg's law – Learning the structural analysis through X-ray diffraction.

Unit-I: Wave Optics **10hrs**

Interference: Introduction - Principle of superposition –Interference of light - Interference in thin films (Reflection Geometry) and its applications - Colors in thin films- Newton's Rings- Determination of wavelength and refractive index.

Diffraction: Introduction - Fresnel and Fraunhofer diffraction - Fraunhofer diffraction due to single slit, double slit - N-slits (Qualitative) – Grating - Dispersive power and resolving power of Grating (Qualitative).

Polarization: Introduction-Types of polarization - Polarization by reflection, refraction and Double refraction - Nicol's Prism - Half wave and Quarter wave plates.

Unit Outcomes:

The students will be able to

- **Explain** the need of coherent sources and the conditions for sustained interference (L2)
- **Identify** engineering applications of interference (L3)
- **Analyze** the differences between interference and diffraction with applications (L4)
- **Illustrate** the concept of polarization of light and its applications (L2)
- **Classify** ordinary polarized light and extraordinary polarized light (L2)

Unit-II: Lasers and Fiber optics **10hrs**

Lasers: Introduction – Characteristics of laser – Spontaneous and Stimulated emissions of radiation – Einstein's coefficients – Population inversion –Lasing action- Pumping Schemes – Ruby laser – He-Ne laser - Applications of lasers.

Fiber optics: Introduction –Principle of optical fiber- Acceptance Angle- Numerical Aperture- Classification of optical fibers based on refractive index profile and modes –Propagation of electromagnetic wave through optical fiber - Applications.

Unit Outcomes:

The students will be able to

- **Understand** the basic concepts of LASER light Sources (L2)
- **Apply** the concepts to learn the types of lasers (L3)
- **Identifies** the Engineering applications of lasers (L2)
- **Explain** the working principle of optical fibers (L2)
- **Classify** optical fibers based on refractive index profile and mode of propagation (L2)
- **Identify** the applications of optical fibers in various fields (L2)

UNITIII: Dielectric and Magnetic Materials **8hrs**

Dielectric Materials: Introduction - Dielectric polarization - Dielectric polarizability, Susceptibility and Dielectric constant - Types of polarizations - Electronic (Quantitative), Ionic (Quantitative) and Orientation polarizations (Qualitative) - Lorentz internal field - Clausius- Mossotti equation- Piezoelectricity.

Magnetic Materials: Introduction - Magnetic dipole moment - Magnetization- Magnetic susceptibility and permeability - Origin of permanent magnetic moment - Classification of magnetic materials: Dia, para, Ferro, antiferro & Ferrimagnetic materials - Domain concept for Ferromagnetism & Domain walls (Qualitative) - Hysteresis - soft and hard magnetic materials.

Unit Outcomes:

The students will be able to

- **Explain** the concept of dielectric constant and polarization in dielectric materials (L2)
- **Summarize** various types of polarization of dielectrics (L2)
- **Interpret** Lorentz field and Claussius- Mosotti relation in dielectrics(L2)
- **Classify** the magnetic materials based on susceptibility and their temperature dependence (L2)
- **Explain** the applications of dielectric and magnetic materials (L2)
- **Apply** the concept of magnetism to magnetic devices (L3)

Unit-IV: Acoustics and Ultrasonics **10hrs**

Acoustics: Introduction – requirements of acoustically good auditorium– Reverberation – Reverberation time – Sabine's formula (Derivation using growth and decay method) - Absorption coefficient and its determination – Factors affecting acoustics of buildings and their remedial measures.

Ultrasonics: Introduction – Characteristics of Ultrasonic waves – Production of ultrasonic waves by magnetostriction and piezoelectric methods – Detection - Acoustic grating - Non Destructive Testing – pulse echo system through transmission and reflection modes - Applications.

Unit Outcomes:

The students will be able to

- **Explain** how sound is propagated in buildings (L2)
- **Analyze** acoustic properties of typically used materials in buildings (L4)
- **Recognize** sound level disruptors and their use in architectural acoustics (L2)
- **Identify** the use of ultrasonics in different fields (L3)

Unit-V: Crystallography and X-ray diffraction **10hrs**

Crystallography: Space lattice, Basis, Unit Cell and lattice parameters – Bravais Lattice – crystal systems (3D) – coordination number - packing fraction of SC, BCC & FCC - Miller indices – separation between successive (hkl) planes. **X- ray diffraction:** Bragg's law - X-ray Diffractometer – crystal structure determination by Laue's and powder methods.

Unit Outcomes:

The students will be able to

- **Classify** various crystal systems (L2)
- **Identify** different planes in the crystal structure (L3)
- **Analyze** the crystalline structure by Bragg's X-ray diffractometer (L4)
- **Apply** powder method to measure the crystallinity of a solid (L4)

Outcomes:

CO1 **Explain** the need of coherent sources and the conditions for sustained interference (L2). **Identify** applications of interference in engineering (L3). **Analyze** the differences between interference and diffraction with applications (L4). **Illustrate** the concept of polarization of light and its applications (L2). **Classify** ordinary polarized light and extraordinary polarizedlight (L2) The different realms of physics and their applications in both scientific and technological systems are achieved through the study of wave optics.

CO2 **Explain** various types of emission of radiation (L2). **Identify** lasers as tools in engineering applications (L3). **Describe** the construction and working principles of various types of lasers (L1). **Explain** the working principle of optical fibers (L2). **Classify the** optical fibers based on refractive index profiles and modes of propagation (L2). **Identify** the applications of optical fibers in medical, communication and other fields (L2). **Apply** the fiber optic concepts in various fields (L3).

CO3 **Explain** the concept of dielectric constant and polarization in dielectric materials (L2). **Summarize** various types of polarization of dielectrics (L2). **Interpret** Lorentz field and Claussius- Mosotti relation in dielectrics (L2). **Classify** the magnetic materials based on susceptibility and their temperature dependence (L2). **Explain** the applications of dielectric and magnetic materials (L2). **Apply** the concept of magnetism to magnetic devices (L3).

CO4 **Explain** sound waves and its propagation/absorption of construction material used in design of buildings (L2). **Analyze** acoustic parameters of typical materials used in buildings (L4). **Recognize** sound level disruptors and their application in architectural acoustics (L2). **Identify** the use of ultrasonics in diversified fields of engineering (L3)

CO5 **Interpret** various crystal systems (L2) and **Analyze** the characterization of materials by XRD (L4). **Identify** the important properties of crystals like the presence of long-range order and periodicity, structure determination using X-ray diffraction technique (L3). **Analysis** of structure of the crystals by Laue's and Powder techniques (L2).

Text books:

1. Engineering Physics by M. N. Avadhanulu, P.G.Kshirsagar & TVS Arun Murthy S.Chand Publications, 11th Edition 2019.
2. Engineering Physics" by D.K.Bhattacharya and Poonam Tandon, Oxford press (2018).
3. Applied Physics by P.K.Palanisamy ,SciTech publications (2018)

Reference Books:

1. Fundamentals of Physics – Halliday, Resnick and Walker, John Wiley &Sons, 11th Edition (2018)
2. Engineering Physics by M.R.Srinivasan, New Age international publishers (2014).
3. Engineering Physics by B.K. Pandey and S. Chaturvedi, , Cengage Learning(2018)
4. Engineering Physics - Sanjay D. Jain, D. Sahasrambudhe and Girish, University Press(2016)
5. University Physics by H.D.Young and R.A. Freedman,Pearson(2017)

I Year- I Semester

L	T	P	C
3	0	0	3

ENGINEERING MECHANICS

Learning Objectives:

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

UNIT – I:

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

Introduction to Engg. Mechanics – Basic Concepts.

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

Friction: Introduction**,** limiting friction and impending motion, coulomb's laws of dry friction, coefficient of friction, cone of friction

UNIT– II:

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

Equilibrium of Systems of Forces: Free Body Diagrams, 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.

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

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 Ed – 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.

I Year- I Semester

L	T	P	C
3	0	0	3

ELEMENTS OF MECHANICAL ENGINEERING

Learning Objectives:

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

UNIT –I:

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

UNIT–II:

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

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.

University College of Engineering Kakinada (A)
Department of Petroleum Engineering & Petrochemical Engineering
B. Tech. Chemical Engineering Syllabus, R20 – Regulation

I Year- I Semester

L	T	P	C
3	0	0	3

BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

Learning Objectives:

UNIT - 1 Electrical Circuits

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

UNIT - 2 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 - 3 Transformers

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

AC Rotating Machines

Alternators: Construction and Principle of operation of alternators – Regulation of alternator by synchronous impedance method.

3-Phase induction motor : principle of operation of 3-Phase induction motor – slip-torque characteristics – simple Numerical Problems.

UNIT - 4 Rectifiers

Operation of PN junction diodes and their characteristics – Rectifiers: Operation of half wave and full wave rectifiers – relevant wave forms – Derivation of output voltage and efficiency - simple Numerical Problems.

UNIT - 5 Transistors

Operation of PNP and NPN junction transistors, transistor configurations – input output characteristics, transistor as an amplifier in CE arrangement, – frequency response of CE amplifier.

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

CO1 Analyse various electrical networks.

CO2 Understand operation of DC generators,3-point starter and DC machine testing by Swinburne's Test.

CO3 Analyse performance of single-phase transformer.

CO4 Explain operation of 3-phase alternator and 3-phase induction motors.

CO5 Analyse operation of half wave, full wave bridge rectifiers, transistor configurations and frequency response of CE amplifier.

#*Based on suggested Revised BTL*

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

I Year- I Semester

L	T	P	C
0	0	3	1.5

ENGINEERING WORKSHOP AND 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 various threats on the Internet and its solutions
- **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:

Note: Faculty to consolidate the workshop manuals using the textbook and references

Task 1: Identification of the peripherals of a computerand its functionality.

Task 2: Prepare a report containing the block diagram of the computer.

Task 3: Describe about various I/O Devices and its usage.

Task 4: Practicingdisassembling and assembling components of a PC

Task 5: Installation of Device Drivers, MS windows, Linux Operating systems and Disk Partitioning

Task 6: Introduction to Memory and Storage Devices, I/O Port, Assemblers, Compilers, Interpreters, Linkers and Loaders.

Task 7: Demonstration of Hardware Troubleshooting

Task 8: Demonstration of Software Troubleshooting

Task 9: Demonstrating on Importance of Networking, Types of Networks Transmission Media and Various Networking Devices.

Task 10: Search Engines & Netiquette: Students should know what search engines are and how to use the search engines. Usage of search engines like Google, Yahoo, ask.com and others should be demonstrated by student.

Task 11:Awareness of various threats on the Internet and its solutions

Task 12: Demonstration and Practice on Microsoft Word

Task 13: Demonstration and Practice on Microsoft Excel

Task 14: Demonstration and Practice on Microsoft Power Point

TEXT BOOK:

1 Computer Fundamentals, Anita Goel, Pearson India Education, 2017

REFERENCE BOOK:

1. Essential Computer and IT Fundamentals for Engineering and Science Students, Dr. N. B. Venkateswarlu, S. Chand Publishers
2. Comdex Information Technology, Vikas Gupta, Dreamtech.

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

ENGINEERING PHYSICS – LABORATORY

Learning Objectives:

NOTE: (Any 10 of the following listed experiments)
List of Engineering Physics Experiments:

1. Laser: Determination of wavelength using diffraction grating.
2. Young's modulus of given material by Strain gauge method.
3. Study of variation of magnetic field along the axis of a current carrying circular coil by Stewart & Gee's method.
4. Determination of ultrasonic velocity in given liquid (Acoustic grating).
5. Determination of dielectric constant using charging and discharging method.
6. Study the variation of B versus H by magnetizing the magnetic material (B-H curve).
7. Estimation of Planck's constant using photoelectric effect.
8. Determination of Rigidity modulus of material of a wire-dynamic method (Torsional pendulum).
9. Determination of numerical aperture and acceptance angle of an optical fiber.
10. Determination of thickness of thin object by wedge method.
11. Determination of radius of curvature of given plano convex lens by Newton's rings.
12. Determination of wavelengths of different spectral lines in mercury spectrum using diffraction grating in normal incidence configuration.
13. Determination of the resolving power of telescope.
14. Sonometer: Verification of laws of string.
15. Determination of Acceleration due to gravity and Radius of gyration using Compound pendulum.

Outcomes:

Reference:

1. S. Balasubramanian, M.N. Srinivasan "A Text book of Practical Physics"- S. Chand Publishers, 2017.

I Year- I Semester

L	T	P	C
0	0	3	1.5

BASIC ENGINEERING (MECHANICAL & ELECTRICAL) LABORATORY

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

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:

Learning Objectives:
The following experiments are required to be conducted as compulsory experiments from each section:

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.

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

CO1 To obtain Open Circuit Characteristics of DC shunt generator.

CO2 To predetermine the efficiency of dc shunt machine using Swinburne's test.

CO3 To control speed of dc shunt motor using Armature voltage and Field control methods.

CO4 To predetermine the efficiency and regulation of single-phase transformer with O.C and S.C tests.

CO5 To obtain performance characteristics of a 3-phase induction motor.

I Year- I Semester

L	T	P	C
0	0	2	0

PHYSICS VIRTUAL LABORATORY

Learning Objectives:

Note: Any 5 of the following listed 10 experiments

List of Experiments:

1. Hall Effect
2. Brewster's angle
3. Numerical Aperture of Optical fiber
4. Photoelectric Effect
5. Michelson's interferometer
6. Newton's rings –Refractive index of liquid
7. Dispersive power of a prism
8. Resolving power of the prism
9. Magnetic susceptibility by Quincke's method
10. Velocity sound waves by Kundt's tube

Outcomes:

URL: www.vlab.co.in

I Year- I Semester

L	T	P	C
3	0	0	0

CONSTITUTION OF INDIA
(MC)

Learning Objectives:

- To Enable the student to understand the importance of constitution
- To understand the structure of executive, legislature and judiciary
- To understand philosophy of fundamental rights and duties
- To understand the autonomous nature of constitutional bodies like Supreme Court and high court controller and auditor general of India and election commission of India.
- To understand the central and state relation financial and administrative.

UNIT-I:

Introduction to Indian Constitution: Constitution meaning of the term, Indian Constitution - Sources and constitutional history, Features - Citizenship, Preamble, Fundamental Rights and Duties, Directive Principles of State Policy.

Learning outcomes:

After completion of this unit student will

- Understand the concept of Indian constitution
- Apply the knowledge on directive principle of state policy
- Analyze the History, features of Indian constitution
- Evaluate Preamble Fundamental Rights and Duties

UNIT-II:

Union Government and its Administration Structure of the Indian Union: Federalism, Centre- State relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, LokSabha, RajyaSabha, The Supreme Court and High Court: Powers and Functions;

Learning outcomes:-After completion of this unit student will

- Understand the structure of Indian government
- Differentiate between the state and central government
- Explain the role of President and Prime Minister
- Know the Structure of supreme court and High court

UNIT-III:

State Government and its Administration Governor - Role and Position - CM and Council of ministers, State Secretariat: Organisation, Structure and Functions

Learning outcomes:-After completion of this unit student will

- Understand the structure of state government
- Analyze the role Governor and Chief Minister
- Explain the role of state Secretariat
- Differentiate between structure and functions of state secretariat

UNIT-IV:

A.Local Administration - District's Administration Head - Role and Importance, Municipalities - Mayor and role of Elected Representative - CEO of Municipal Corporation PachayatiRaj: Functions PRI: ZilaPanchayat, Elected officials and their roles, CEO ZilaPanchayat: Block level Organizational Hierarchy - (Different departments), Village level - Role of Elected and Appointed officials - Importance of grass root democracy

Learning outcomes:-After completion of this unit student will

- Understand the local Administration
- Compare and contrast district administration role and importance
- Analyze the role of Myer and elected representatives of Municipalities
- Evaluate Zillapanchayat block level organisation

UNIT-V

Election Commission: Election Commission- Role of Chief Election Commissioner and Election Commissionerate State Election Commission:, Functions of Commissions for the welfare of SC/ST/OBC and women

Learning outcomes:- After completion of this unit student will

- Know the role of Election Commission apply knowledge
- Contrast and compare the role of Chief Election commissioner and commissiononerate.
- Analyze role of state election commission
- Evaluate various commissions of viz SC/ST/OBC and women

Outcomes:

At the end of the semester/course, the student will be able to have a clear knowledge on the following:

- Understand historical background of the constitution making and its importance for building a democratic India.
- Understand the functioning of three wings of the government ie., executive, legislative and judiciary.
- Understand the value of the fundamental rights and duties for becoming good citizen of India.
- Analyze the decentralization of power between central, state and local self-government.
- Apply the knowledge in strengthening of the constitutional institutions like CAG, Election Commission and UPSC for sustaining democracy.
    1. Know the sources, features and principles of Indian Constitution.
    2. Learn about Union Government, State government and its administration.
    3. Get acquainted with Local administration and Pachayati Raj.
    4. Be aware of basic concepts and developments of Human Rights.
    5. Gain knowledge on roles and functioning of Election Commission

References:

1. Durga Das Basu, Introduction to the Constitution of India, Prentice – Hall of India Pvt. Ltd.. New Delhi
2. SubashKashyap, Indian Constitution, National Book Trust

3. J.A. Siwach, Dynamics of Indian Government & Politics
4. D.C. Gupta, Indian Government and Politics
5. H.M.Sreevai, Constitutional Law of India, 4th edition in 3 volumes (Universal Law Publication)
6. J.C. Johari, Indian Government andPolitics Hans
7. J. Raj IndianGovernment and Politics
8. M.V. Pylee, Indian Constitution Durga Das Basu, Human Rights in Constitutional Law, Prentice – Hall of India Pvt. Ltd.. New Delhi
9. Noorani, A.G., (South Asia Human Rights Documentation Centre), Challenges to Civil Right), Challenges to Civil Rights Guarantees in India, Oxford University Press 2012

E-resources:

1. nptel.ac.in/courses/109104074/8
2. nptel.ac.in/courses/109104045/
3. nptel.ac.in/courses/101104065/
4. www.hss.iitb.ac.in/en/lecture-details
5. www.iitb.ac.in/en/event/2nd-lecture-institute-lecture-series-indian-constitution

I Year- II Semester

L	T	P	C
3	0	0	3

MATHEMATICS – II

Learning 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.

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 linear equations – Gauss Elimination method – Eigen values and Eigen vectors and properties (article-2.14 in text book-1).
Applications: Fee vibration of two mass system.

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

Cayley-Hamilton theorem (without proof) – Applications – Finding the 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.
Singular values of a matrix, singular value decomposition (text book-3).

UNIT – III: Iterative methods: (8 hrs)

Introduction – Solutions of algebraic and transcendental equations: Bisection method – Secant method – Method of false position – Iteration method – Newton-Raphson method (One variable and simultaneous Equations)
Solutions of system of equations – Jacobi and Gauss -Seidel methods
Evaluation of largest eigen value – eigen vector using Power Method .

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 differentiation and integration, Solution of ordinary differential equations with initial conditions: (10 hrs)
Numerical differentiation using interpolating polynomial – Trapezoidal rule – Simpson's 1/3rd and 3/8th rule – Solution of initial value problems 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.

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 the approximate 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 numerical integral techniques to different Engineering problems (L3)
- apply different algorithms for approximating the solutions of ordinary differential equations with initial conditions to its analytical computations (L3)

Text Books:

1. B. S. Grewal, Higher Engineering Mathematics, 44th Edition, Khanna Publishers.
2. B. V. Ramana, Higher Engineering Mathematics, 2007 Edition, Tata Mc. Graw Hill Education.
3. David Poole, Linear Algebra- A modern introduction, 4th Edition, Cengage.

Reference Books:

1. Steven C. Chapra, Applied Numerical Methods with MATLAB for Engineering and Science, Tata Mc. Graw Hill Education.
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publications.
3. Lawrence Turyn, Advanced Engineering Mathematics, CRC Press.

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Department of Petroleum Engineering & Petrochemical Engineering
B. Tech. Chemical Engineering Syllabus, R20 – Regulation

I Year- II Semester

L	T	P	C
3	0	0	3

PHYSICAL CHEMISTRY

Course 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 fundamentals of spectroscopy, their applications and understand mechanism by which components are separated on GC and HPLC techniques and separation techniques.
- 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.

UNIT-I: **8hrs**

Chemical Equilibria: Thermodynamic derivation of equilibrium constant, equilibrium constants expressed in different units, relation between K_p and K_c, Lechatelier-Braun principle (effect of temperature and catalyst).

Distribution Law: Nernst Distribution Law – Thermodynamic deduction of distribution law – Limitations – Modification when change in molecular state–Determination of Equilibrium Constant – Applications

UNIT-II: **8 hrs**

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 – (lead silver system) and three component system (Na_2SO_4-NaCl-H_2O system) – applications.

UNIT-III: Spectroscopic and separation techniques **10 hrs**

Part A : Spectroscopic techniques: Flame photometer, Atomic absorption spectroscopy (AAS), and Atomic emission spectroscopy (AES) – Instrumentation and applications

Part B: Separation Techniques: Introduction and classification

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

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

Gas liquid chromatography (GLC): principles and applications.

UNIT-IV: **10 hrs**

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: **10 hrs**

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

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., Pathania 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.

I Year- II Semester

L	T	P	C
3	0	0	3

COMMUNICATIVE 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.

Learning 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

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 prose, prose and conversation.

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 - who-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.
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.
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)

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

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

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

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I Year- II Semester	**L**	**T**	**P**	**C**
	1	**0**	**4**	**3**

ENGINEERING DRAWING

Learning Objectives:

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

UNIT – I:

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

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

Curves: Parabola, Ellipse and Hyperbola by general 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. To make the students draw the projections of the lines inclined to both the planes.

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

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

UNIT – V:

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

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

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

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

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

PROGRAMMING FOR PROBLEM SOLVING USING – C

Learning Objectives:

UNIT – I:
Problem Solving: Problem solving aspects, problem solving techniques, computer as a problem solving tool, Characteristics of Complex problem Solving methods, Collective Problem Solving, Collaborative Problem Solving, Software Development Life Cycle, algorithms-definition, features, criteria, Flowchart definition, basic symbols, sample flowcharts, Top down design, Implementation of program verification.

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, Header files, C pre-processors, sample programs. **Selection or Branching:** Simple if, if-else, nested if, if-else ladder and switch-case, goto, break and continue statements. **Iterative or Looping:** While loop, Do-while loop and for loop, sample programs.

UNIT – III:
Functions: Basics, Parameter passing, storage classes, scope rules, block structure, user-defined functions, standard library functions, Recursive functions, Recursive solutions for Fibonacci series and Towers of Hanoi. **Arrays:** Declaration, definition, Accessing elements, types of Arrays, Array applications, Matrix operations, passing 1-D Arrays and 2-D Arrays to functions.
Strings: Basics, string operations, string manipulation functions.

UNIT – IV:
Pointers: Basics, Initialization of Pointer variables, Pointers and function arguments, passing by Address Dangling memory, Address Arithmetic, character pointers and functions. Pointer to Pointer, Pointers and Multi-Dimensional Arrays, Dynamic Memory Management functions, Command-line Arguments.
Notations: The efficiency of algorithms, Analysis of Algorithms, computational complexity of algorithms, order(O), notation, Worst-case and Average-case analysis.

UNIT – V:

Enumerated, Structure and Union Types: Derived Types, Structure declaration, definition and initialization, accessing Structures, nested Structures, Arrays of Structures, Structures and Functions, Pointers to Structures, Self-referential Structures, Unions, typedef, bit-fields, program applications.

File Handling: Concepts of Files, Text files and Binary Files, formatted I/O, File I/O operations.

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

- **CO1** Develop efficient algorithm for solving a problem.
- **CO2** Experiment with various constructs of C programming language efficiently.
- **CO3** Develop programs using modular approach such as functions and also able to develop programs to perform matrix and mathematical applications.
- **CO4** Examine dynamic memory management, problems using pointers and solving the problems.
- **CO5** Develop programs for real-life applications using Structures and also learn about handling the files for storing the data permanently.

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.

C Programming, A Problem Solving Approach, Forouzan, Gilberg, Prasad, Cengage.

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

ENGLISH COMMUNICATION SKILLS – LABORATORY

Learning Objectives:

TOPICS

UNIT I:

Vowels, Consonants, Pronunciation, Phonetic Transcription, Common Errors in Pronunciation,

UNIT II:

Word stress-di-syllabic words, poly-syllabic words, weak and strong forms, contrastive stress (Homographs)

UNIT III:

Stress in compound words, rhythm, intonation, accent neutralization.

UNIT IV:

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

UNIT V:

Newspapers reading; Understanding and identifying key terms and structures useful for writing reports.

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.
   English Phonetics for Indian Students- P. Bala Subramanian, Mac Millan Publications.

I Year- II Semester

L	T	P	C
0	0	3	1.5

PHYSICAL CHEMISTRY – LABORATORY

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. Determination of critical solution temperature of phenol and water system.
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. Determination of specific rotation using 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 (Freundlich adsorption isotherm).

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.

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

PROGRAMMING FOR PROBLEM SOLVING USING - C LABORATORY

Learning Objectives:

- Understand Algorithm and Syntax create Mathematical Operations in C.
- Handle Strings and Files in C.
- Understand Arrays, Pointers and Recursion in C.
- Implement Dynamic and Modular programming in C
- Learn Functions and Storage classes in C.

List of Exercises:

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 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 to implement simple calculator using 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 it's 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 Towers of Hanoi.

Exercise 6:

a. Write a C program to implement sorting an array of elements.
b. Write a C program to implement matrix addition and multiplication.
c. Write a C program to print the upper case matrix using Arrays.

Exercise 7:
Write a C program that uses functions to perform the following operations.
a. To insert a sub string into given main string at a given position.
b. To delete n characters from a given position in a given string.
c. To replace a character of a 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:
a. Reading a complex number
b. Writing a complex number
c. Addition of two complex numbers
d. Multiplication of two complex numbers

Exercise 9:
Write a C program for the following string operations without using the built-in functions.
a. To concatenate two strings
b. To append a string to another string
c. To compare two strings

Exercise 10:
a. Write a C program to find the number of characters in a given string including and excluding spaces.
b. Write a C program to copy the contents of one string to another string without using string handling functions.
c. Write a C program to find whether a given string is palindrome or not.

Exercise 11:
Write a C program using recursion for the following:
a. To display sum of digits of a 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 a 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:
a. 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.
b. Write a C program to implement student details using Structures.

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.

Exercise 15:

Write a C program to implement Different Storage classes.

a. Auto
b. Static
c. Register
d. External

Course Outcomes:

CO1 Examine C syntax, structure and be fluent in the use of C keywords and looping.

CO2 Demonstrate proficiency in handling Strings and File Systems.

CO3 Construct Matrixes creation and operations Programs using Arrays, structures like Dynamic programming.

CO4 Interpret the concepts of Recursion Programming as used in C.

CO5 Construct C programs using Pointers and Functions, various call by reference.

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I Year- II Semester

L	T	P	C
2	0	0	0

PROFESSIONAL ETHICS AND HUMAN VALUES (MC)

Learning Objectives:

- To create an awareness on Engineering Ethics and Human Values.
- To instill Moral and Social Values and Loyalty
- To appreciate the rights of others.
- To create awareness on assessment of safety and risk

Unit I: Human Values:

Morals, Values and Ethics-Integrity-Work Ethic-Service learning – Civic Virtue – Respect for others –Living Peacefully –Caring –Sharing –Honesty -Courage-Cooperation–Commitment – Empathy –Self Confidence Character –Spirituality.

Learning outcomes:

1. Learn about morals, values & work ethics.
2. Learn to respect others and develop civic virtue.
3. Develop commitment
4. Learn how to live peacefully

Unit II: Engineering Ethics:

Senses of 'Engineering Ethics-Variety of moral issued –Types of inquiry –Moral dilemmas –Moral autonomy –Kohlberg's theory-Gilligan's theory-Consensus and controversy –Models of professional roles-Theories about right action-Self-interest -Customs and religion –Uses of Ethical theories –Valuing time –Cooperation –Commitment.

Learning outcomes:

1. Learn about the ethical responsibilities of the engineers.
2. Create awareness about the customs and religions.
3. Learn time management
4. Learn about the different professional roles.

Unit III: Engineering as Social Experimentation

Engineering As Social Experimentation –Framing the problem –Determining the facts –Codes of Ethics –Clarifying Concepts –Application issues –Common Ground -General Principles –Utilitarian thinking respect for persons

.**Learning outcomes:**

1. Demonstrate knowledge to become a social experimenter.
2. Provide depth knowledge on framing of the problem and determining the facts.
3. Provide depth knowledge on codes of ethics.
4. Develop utilitarian thinking

UNIT IV: Engineers Responsibility for Safety and Risk:

Safety and risk –Assessment of safety and risk –Risk benefit analysis and reducing risk-Safety and the Engineer-Designing for the safety-Intellectual Property rights (IPR).

Learning outcomes:

1. Create awareness about safety, risk & risk benefit analysis.
2. Engineer's design practices for providing safety.
3. Provide knowledge on intellectual property rights.

UINIT V: Global Issues

Globalization –Cross-culture issues-Environmental Ethics –Computer Ethics – Computers as the instrument of Unethical behavior –Computers as the object of Unethical acts –Autonomous Computers-Computer codes of Ethics –Weapons Development -Ethics and Research –Analyzing Ethical Problems in research.

Learning outcomes:

1. Develop knowledge about global issues.
2. Create awareness on computer and environmental ethics
3. Analyze ethical problems in research.
4. Give a picture on weapons development.

Course outcomes:

Students will be able to:

- Identify and analyze an ethical issue in the subject matter under investigation or in a relevant field
- Identify the multiple ethical interests at stake in a real-world situation or practice
- Articulate what makes a particular course of action ethically defensible
- Assess their own ethical values and the social context of problems
- Identify ethical concerns in research and intellectual contexts, including academic integrity, use and citation of sources, the objective presentation of data, and the treatment of human subjects
- Demonstrate knowledge of ethical values in non-classroom activities, such as service learning, internships, and field work
- Integrate, synthesize, and apply knowledge of ethical dilemmas and resolutions in academic settings, including focused and interdisciplinary research.

Text Books:

1. "Engineering Ethics includes Human Values" by M.Govindarajan, S.Natarajan and, V.S.SenthilKumar-PHI Learning Pvt. Ltd-2009
2. "Engineering Ethics" by Harris, Pritchard and Rabins, CENGAGE Learning, India Edition, 2009.
3. "Ethics in Engineering" by Mike W. Martin and Roland Schinzinger –Tata McGraw-Hill–2003.
4. "Professional Ethics and Morals" by Prof.A.R.Aryasri, Dharanikota Suyodhana-Maruthi Publications.
5. "Professional Ethics and Human Values" by A.Alavudeen, R.Kalil Rahman and M.Jayakumaran-LaxmiPublications.
6. "Professional Ethics and Human Values" by Prof.D.R.Kiran-
7. "Indian Culture, Values and Professional Ethics" by PSR Murthy-BS Publication

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

PHYSICAL FITNESS ACTIVITIES
(MC)

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II Year- I Semester

L	T	P	C
3	0	0	3

MATHEMATICS – III

Learning 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.

UNIT – I: Laplace Transforms: (10 hrs)

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

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

UNIT – II: 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 (article-22.5 in text book-1) – inverse transforms – Convolution theorem (without proof) – Finite Fourier transforms.

UNIT – III: Partial Differential Equations 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 – IV: Second order PDE and Applications: (10 hrs)

Second order PDE: Solutions of linear partial differential equations with constant coefficients – Non-homogeneous 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.

UNIT – V: Vector calculus: (10 hrs)

Differentiation of vectors – Scalar and vector point functions – Gradient – Directional derivative – Divergence – Curl – Scalar potential.

Integration of vectors – Line integral – Circulation – Work done – Surface integral – Flux – Volume integral – Vector integral theorems: Greens, Stokes and Gauss Divergence theorems (without proof) and their applications.

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

- 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)
- 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)

Text Books:

1. B. S. Grewal, Higher Engineering Mathematics, 44th 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.

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II Year- I Semester

L	T	P	C
3	0	0	3

ORGANIC CHEMISTRY FOR CHEMICAL ENGINEERS

Learning 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).

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**

FLUID MECHANICS FOR CHEMICAL ENGINEERS

Learning Objectives:

The students will be able to learn:

- The fluid flow in circular and non-circular conduits as well as the flow past solids.
- The calculations associated to the estimation of friction factor and pressure drop in the circular conduits.
- The basic concepts of fluidization and to estimate pressure drop in packed and fluidized beds.
- The Bernoulli's equation for the transport of acidic, alkaline, hydrocarbon and miscellaneous incompressible fluids in pipelines.
- The pressure drops and energy requirements associated to compressible fluid flow in circular and rectangular ducts.
- Principles of fluid flow in various types of pumps, fans and blowers.
- The concepts of various flow measuring devices.

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:

The students are able to:

- Analyze fluid flow in circular and non-circular conduits as well as the flow past solids.
- Do calculations associate to the estimation of friction factor and pressure drop in the circular conduits.
- Apply basic concepts of fluidization and to estimate pressure drop in packed and fluidized beds.
- Do calculations involve 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.
- 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- I Semester

L	T	P	C
3	0	0	3

MECHANICAL UNIT OPERATIONS

Learning Objectives:

The students will be able to learn:

- The fundamentals associated with liquid agitation and mixing.
- The principles of particle size, shape and specific surface estimation.
- About particulate solids handling and mixing
- The principles of size reduction and screening
- The concept of filtration
- The functioning of various prominent solid fluid contacting equipment namely gravity settlers, thickeners, classifiers, clarifiers, sedimenters and cyclones.

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:

The students are able to:

- Apply the fundamentals associated with liquid agitation and mixing.
- Estimate the particle size, shape and specific surface.
- Apply principles of particulate solids handling and mixing in different process industries.
- Emphasize the size reduction and screening operations.
- Calculate rate of filtration.
- Design various solid fluid contacting equipment such as: gravity settlers, thickeners, classifiers, clarifiers, sedimenters and cyclones.

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. Mechanical Operations for Chemical Engineers, Narayanan, C.M., and Bhattacharya, Khanna Publishers, 1990.

II Year- I Semester

L	T	P	C
3	0	0	3

MATERIAL AND ENERGY BALANCES

Learning Objectives:
The students will be able to learn:

- Unit conversions in process calculations.
- The elementary material balances in physical and chemical processes.
- The elementary energy balances in reactive and non-reactive processes.
- Formulation of combined material and energy balances for combustion of fuels.
- The relevance of thermodynamics in process calculations.
- The complex process calculations using MS Excel/MATLAB.

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:

The students are able to:

- Apply the unit conversions fundamentals in process calculations.
- Formulate and solve elementary material balances in physical and chemical processes.
- Formulate and solve elementary energy balances in reactive and non-reactive processes.
- Apply the concepts and solve the combined material and energy balances in combustion calculations.
- Impart the thermodynamics in process calculations.
- Conceptualize an integrated methodology that encompasses the knowledge in other subjects (Physical Chemistry, Thermodynamics and Mathematics) and MS Excel/MATLAB for a systematic and structured approach towards chemical process calculations.

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.
4. Stoichiometry and Process Calculations, K. V. Narayanana and B. Lakshmikutty, PHI Learning Private Ltd., 2017
5. Principles of Chemical Engineering processes: Material and Energy balances, Nayef Ghasem and R. Henda, 2nd Edition, CRC Press, 2015

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

ORGANIC CHEMISTRY FOR CHEMICAL ENGINEERS – LABORATORY

Course 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 azo-dye from phenol and β-naphthol.
5. Preparation of dibenzalacetone from benzaldehyde.
6. Preparation of benzil from benzoin.
7. Preparation of paracetamol.
8. Preparation of Nylon - 6, 6.
9. Preparation of methyl orange.mana
10. Preparation of benzoic acid from acetophenone (iodoform reaction)
11. Extraction of caffeine from tea (powder).

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 Objectives:

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 through 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 an ore using froth flotation technique.
5. To obtain batch sedimentation data to compute rate of sedimentation 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

Outcomes:

The students are able to:

- Develop knowledge on various mechanical separation operations used in a chemical and mineral process industries.
- Develop knowledge on estimation of particle size, power requirement and surface area for solid particles like coal.
- Understand the processes of froth floatation and sedimentation.
- Study and verification of crushing and grinding laws.
- Design batch and continuous filters.
- Calculate and verify the efficiency of cyclone separator.

II Year- I Semester

L	T	P	C
0	0	3	1.5

FLUID MECHANICS FOR CHEMICAL ENGINEERS – LABORATORY

Learning Objectives:

The students will be able to learn:

- The discharge coefficient of orifice, venture & notches.
- The point velocity using pitot tube
- Measure the average velocities and flowrates using various devices.
- Estimate the skin and form frictional losses in pipes and fittings,
- Verify the Bernoulli's and Ergun equations in packed and fluidized beds,
- Verify Newton's law of viscosity.
- Estimate of mechanical efficiency of centrifugal pump.
- Hands-on experience and communication skills will be achieved.
- Verify Stoke's law and to determine terminal velocity.
- The determination of discharge coefficient of orifice, venture & notches.
- The friction factors in pipes.
- The pressure drop calculations 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:

The students are able to:

- Determine the discharge coefficient of orifice, venturi, notches,
- Measure the point velocity using pitot tube
- Measure the average velocities and flowrates using various devices.
- Estimate the skin and form frictional losses in pipes and fittings,
- Verify the Bernoulli's and Ergun equations in packed and fluidized beds,
- Verify Newton's law of viscosity.
- Estimate of mechanical efficiency of centrifugal pump.
- Hands-on experience and communication skills will be achieved.
- Verify Stoke's law and to determine terminal velocity.

University College of Engineering Kakinada (A)
Department of Petroleum Engineering & Petrochemical Engineering
B. Tech. Chemical Engineering Syllabus, R20 – Regulation

II Year- I Semester

L	T	P	C
1	0	2	2

PYTHON PROGRAMMING
(SOFT SKILL COURSE)

OBJECTIVES:

- Introduction to Scripting Language
- Exposure to various problems solving approaches of computer science

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

CO	Course Outcome	Knowledge Level (K)#
CO1	**Understand** and comprehend the basics of python programming. Demonstrate the principles of structured programming and be able to describe, design, implement, and test structured programs using currently accepted methodology	K2
CO2	**Demonstrate** the principles of structured programming and be able to describe, design, implement, and test structured programs using currently accepted methodology. Explain the use of the built-in data structures list, sets, tuples and dictionary	K3
CO3	**Understand** of functions and its applications, Modules.	K3
CO4	**Identify** real-world applications using oops, files and exception handling provided by python.	K3
CO5	**Formulate** and implement a program to solve a real-world problem using GUI and Turtle graphics.	K3

- *#Based on suggested Revised BTL*
- **Mapping of course outcomes with program outcomes**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M				M			M			H
CO2	H				H		M				H	
CO3	M	M			H				H			
CO4	M			M			H				M	H
CO5		L		H			M				L	

- **(Please fill the above with Levels of Correlation, viz., L, M, H)**

UNIT – I:

Introduction: History of Python, Need of Python Programming, Applications Basics of Python Programming Using the REPL(Shell), Running Python Scripts, Variables, Assignment, Keywords, Input-Output, Indentation.

UNIT – II:

Types, Operators and Expressions: Types - Integers, Strings, Booleans; Operators- Arithmetic Operators, Comparison (Relational) Operators, Assignment Operators, Logical Operators, Bitwise Operators, Membership Operators, Identity Operators, Expressions and order of evaluations Control Flow- if, if-elif-else, for, while, break, continue, pass

UNIT – III:

Data Structures Lists - Operations, Slicing, Methods; Tuples, Sets, Dictionaries, Sequences. Comprehensions.

UNIT – IV:

Functions - Defining Functions, Calling Functions, Passing Arguments, Keyword Arguments, Default Arguments, Variable-length arguments, Anonymous Functions, Fruitful Functions(Function Returning Values), Scope of the Variables in a Function - Global and Local Variables.

Modules: Creating modules, import statement, from. Import statement, name spacing,

Python packages, Introduction to PIP, Installing Packages via PIP, Using Python Packages

UNIT – V:

Object Oriented Programming OOP in Python: Classes, 'self variable', Methods, Constructor Method, Inheritance, Overriding Methods, Datahiding,

Error and Exceptions: Difference between an error and Exception, Handling Exception, try except block, Raising Exceptions, User Defined Exceptions

Brief Tour of the Standard Library - String Pattern Matching,GUI Programming, Turtle Graphics

TEXT BOOKS

1. Python Programming: A Modern Approach, VamsiKurama, 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

Python Programming Lab (R20)

Exercise 1 - Basics

a) Running instructions in Interactive interpreter and a Python Script
b) Write a program to purposefully raise Indentation Error and Correct it

Exercise 2 - Operations

a) Write a program to compute distance between two points taking input from the user (Pythagorean Theorem)
b) Write a program add.py that takes 2 numbers as command line arguments and prints its sum.

Exercise - 3 Control Flow

a) Write a Program for checking whether the given number is a even number or not.

b) Using a for loop, write a program that prints out the decimal equivalents of 1/2, 1/3, 1/4, . . . , 1/10

c) Write a program using a for loop that loops over a sequence. What is sequence?

d) Write a program using a while loop that asks the user for a number, and prints a countdown from that number to zero.

Exercise 4 - Control Flow - Continued

a) Find the sum of all the primes below two million.
Each new term in the Fibonacci sequence is generated by adding the previous two terms. By starting with 1 and 2, the first 10 terms will be:

1, 2, 3, 5, 8, 13, 21, 34, 55, 89,...

b) By considering the terms in the Fibonacci sequence whose values do not exceed four million, find the sum of the even-valued terms.

Exercise - 5 - DS

a) Write a program to count the numbers of characters in the string and store them in a dictionary data structure
b) Write a program to use split and join methods in the string and trace a birthday with a dictionary data structure.

Exercise - 6 DS - Continued

a) Write a program combine_lists that combines these lists into a dictionary.

b) Write a program to count frequency of characters in a given file. Can you use character frequency to tell whether the given file is a Python program file, C program file or a text file?

Exercise - 7 Files

a) Write a program to print each line of a file in reverse order.
b) Write a program to compute the number of characters, words and lines in a file.

Exercise - 8 Functions

a) Write a function ball_collide that takes two balls as parameters and computes if they are colliding. Your function should return a Boolean representing whether or not the balls are colliding.

Hint: Represent a ball on a plane as a tuple of (x, y, r), r being the radius

If (distance between two balls centers) <= (sum of their radii) then (they are colliding)

b) Find mean, median, mode for the given set of numbers in a list.

Exercise - 9 Functions - Continued

a) Write a function nearly equal to test whether two strings are nearly equal. Two strings a and b are nearly equal when a can be generated by a single mutation on b.
b) Write a function dups to find all duplicates in the list.
c) Write a function unique to find all the unique elements of a list.

Exercise - 10 - Functions - Problem Solving

a) Write a function cumulative product to compute cumulative product of a list of numbers.
b) Write a function reverse to reverse a list. Without using the reverse function.
c) Write function to compute gcd, LCM of two numbers. Each function shouldn't exceed one line.

Exercise 11 - Multi-D Lists

a) Write a program that defines a matrix and prints
b) Write a program to perform addition of two square matrices

c) Write a program to perform multiplication of two square matrices

Exercise - 12 - Modules

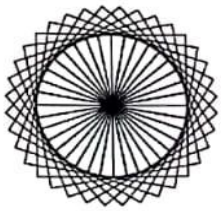
a) Install packages requests, flask and explore them. using (pip)
b) Write a script that imports requests and fetch content from the page. Eg. (Wiki)
c) Write a simple script that serves a simple HTTPResponse and a simple HTML Page

Exercise - 13 OOP

a) Class variables and instance variable and illustration of the self variable
i) Robot
ii) ATM Machine

Exercise - 14 GUI, Graphics

1. Write a GUI for an Expression Calculator using tk
2. Write a program to implement the following figures using turtle



COURSE OUTCOMES:

1	Understand the Numbers, Math functions, Strings, List, Tuples and Dictionaries in Python	K2
2	Demonstrate different Decision Making statements and Functions.	K4
3	Interpret Object oriented programming in Python.	K3
4	Make use and summarize different File handling operations.	K4
5	Identify how to design GUI Applications in Python and evaluate different database operations	K3
6	Design and develop Client Server network applications using Python.	K4

II Year- I Semester	**L**	**T**	**P**	**C**
	2	**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 the Environment: Urban problems related to energy -Water conservation, rain water harvesting - Resettlement and rehabilitation of people; its problems and concerns. Environmental ethics: Issues and possible solutions. Environmental Protection Act -Air (Prevention and Control of Pollution) Act. –Water (Prevention and control of Pollution) Act -Wildlife Protection Act -Forest Conservation Act-Issues involved in enforcement of environmental legislation.
-Public awareness.

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

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

Text Books:

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

Reference:

1. Text Book of Environmental Studies, Deeshita Dave & P. UdayaBhaskar, CengageLearning.
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 InternationalPublishers, 2014.

II Year- II Semester

L	T	P	C
3	0	0	3

MANAGEMENT AND ORGANIZATIONAL BEHAVIOUR

Course Objectives:

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

Unit I

Introduction: Management and organizational concepts of management and organization- Nature and Importance of Management, Functions of Management, System approach to Management - Taylor's Scientific Management Theory, Fayol's Principles of Management, Leadership Styles, Social responsibilities of Management. Designing Organizational Structures: Basic concepts related to Organization - Departmentation and Decentralization, MBO, Process and concepts.

Unit II

Functional Management: Human Resource Management (HRM) Concepts of HRM, Basic functions of HR Manager: Manpower planning, Recruitment, Selection, Training and Development, Wage and Salary Administration Performance Appraisal, Grievance Handling and Welfare Administration, Job Evaluation and Merit Rating. - Marketing Management: Concepts of Marketing, Marketing mix elements and marketing strategies.

Unit III

Strategic Management: Strategic Management and Contemporary Strategic Issues: Mission, Goals, Objectives, Policy, Strategy, Programmes, Elements of Corporate Planning Process, Environmental Scanning, Value Chain Analysis, SWOT Analysis, Steps in Strategy Formulation and implementation, Generic Strategy alternatives. Bench Marking and Balanced Score Card as Contemporary Business Strategies.

Unit IV

Individual Behavior: Perception-Perceptual process- Impression management- Personality development – Socialization – Attitude- Process- Formation- Positive attitude- Change – Learning – Learning organizations- Reinforcement Motivation – Process- Motives – Theories of Motivation: Maslow's Theory of Human Needs, Douglas McGregor's Theory X and Theory Y, Herzberg's Two-Factor Theory of Motivation,

Unit V

Group Dynamics: Types of Groups, Stages of Group Development, Group Behaviour and Group Performance Factors, Organizational conflicts: Reasons for Conflicts, Consequences of Conflicts in Organization, Types of Conflicts, Strategies for Managing Conflicts, Organizational Climate and Culture, Stress, Causes and effects, coping strategies of stress.

Reference Books:

1. Subba Rao P., *Organizational Behaviour,* Himalaya Publishing House. Mumbai.
2. Fred Luthans *Organizational Behaviour*, TMH, New Delhi.
3. Robins, Stephen P., *Fundamentals of Management,* Pearson, India.
4. Kotler Philip & Keller Kevin Lane: Marketing Mangement'12/e, PHI, 2007
5. Koontz & Weihrich: *Essentials of Management*, 6/e, TMH, 2007
6. Kanishka Bedi, *Production and Operations Management*, Oxford University Press, 2007.

II Year- II 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.

UNIT – I: Functions of a complex variable and Complex integration: (10 hrs)
Introduction – Continuity – Differentiability – Analyticity – 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) and problems on above theorems.

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 – Essential – Pole of order m – Residues – Residue theorem (without proof) – Evaluation of real integral of the types $\int_{-\infty}^{\infty} f(x)dx$ and $\int_{c}^{c+2\pi} f(\cos\theta, \sin\theta)d\theta$.

UNIT – III: Probability and Distributions: (10 hrs)
Review of probability and Baye's theorem – Random variables – Discrete and Continuous random variables – Distribution functions – Probability mass function, Probability density function and Cumulative distribution functions – Mathematical Expectation and Variance – Binomial, Poisson, Uniform and Normal distributions.

UNIT – IV: Sampling Theory: (8 hrs)
Introduction – Population and Samples – Sampling distribution of Means and Variance (definition only) – Central limit theorem (without proof) – Representation of the normal theory distributions – 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 – Test of significance for large samples: Single and two means – Single and two proportions – Student's t-distribution: Significance test of a sample mean – Significance test of difference between sample means.

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)

Text Books:

1. B. S. Grewal, Higher Engineering Mathematics, 44th Edition, Khanna Publishers.
2. Miller and Freund's, Probability and Statistics for Engineers, 7/e, Pearson, 2008.

Reference Books:

1. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 9th edition, Mc-Graw Hill, 2013.
2. S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, 11/e, Sultan Chand & Sons Publications, 2012.
3. Jay l. Devore, Probability and Statistics for Engineering and the Sciences, 8th Edition, Cengage.
4. Shron L. Myers, Keying Ye, Ronald E Walpole, Probability and Statistics Engineers and the Scientists, 8th Edition, Pearson 2007.
5. Sheldon, M. Ross, Introduction to probability and statistics Engineers and the Scientists, 4th Edition, Academic Foundation, 2011

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II Year- II 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.

II Year- II Semester

L	T	P	C
3	0	0	3

CHEMICAL ENGINEERING THERMODYNAMICS– I

Learning Objectives:

The students will be able to learn:

- The laws of thermodynamics and their application to chemical engineering systems.
- The volumetric properties, thermodynamic property relations and equations of states for pure substances.
- 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.
- Theoretical principles of power generation from heat.

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 and liquids. Thermodynamic tables and diagrams.

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 Rankine & 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:
The students are able to:

- Apply the laws of thermodynamics and their application to chemical engineering systems.
- Apply the volumetric properties, thermodynamic property relations and equations of states to the pure substances.
- Solve problems using the entropy balance appropriate for a system.
- Evaluate, manipulate and use thermodynamic partial derivatives.
- Correctly use thermodynamic tables and diagrams.
- Apply the phase behavior and properties of pure fluids with applications to the analysis and preliminary design of power plants, refrigeration & liquefaction systems and chemical engineering systems.
- Acquire the theoretical principles of power generation from heat.

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
3	0	0	3

HEAT TRANSFER OPERATIONS

Learning Objectives:

The students will be able to learn:

- The importance of heat transfer in process Industries. Learn different modes of heat transfer and difference between steady and unsteady state heat conduction.
- The importance of LMTD and learn construction and working of different types of heat exchangers.
- Different convective methods and analogy between momentum, heat and mass transfer.
- The phenomena of heat transfer by conduction, convection & radiation.
- The methodology to carry out the detailed process design of shell and tube heat exchangers.

UNIT-I:

Importance of heat transfer in process Industries and Conduction: Nature of heat flow, Modes of heat transfer, Fourier's law, Thermal conductivity and its variation with temperature.

Steady state: heat conduction through plane wall, composite wall, sphere and cylinder, resistance in series.

Unsteady state heat conduction: Equation for one-dimensional conduction with constant surface temperature and varying surface temperature; Semi-infinite solid. Hot and cold Insulation, Optimum thickness of insulation, lagging of steam pipe, critical radius of insulation.

UNIT-II:

Principles of heat flow in fluids: Types of heat exchanger based on flow pattern, equipment for heat exchanger: double pipe heat exchanger, shell and tube exchanger, Plate type heat exchanger, Finned type (extended surface) heat exchanger, counter-current and parallel current flows, energy balances: estimation of rates of heat transfer, calculation of overall heat transfer coefficient and individual heat transfer coefficient, logarithmic mean temperature difference. Heat exchanger effectiveness (NTU method).

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.

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

UNIT-IV:

Natural convection: Natural convection to air from vertical shapes and horizontal planes, effect of natural convection in laminar flow heat transfer.
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 Design: General design of heat exchange equipment, design of shell and tube exchanger – using kern method, heat transfer in agitated vessels, scraped surface heat exchangers, heat transfer in packed beds.
Evaporators: Types of evaporators, performance of tubular evaporator. Capacity and economy, methods of feeding, multiple effect evaporators, vapor recompression.

Outcomes:

The students are able to:

- Apply the fundaments of heat transfer in process Industries.
- Differentiate the modes of heat transfer, steady and unsteady state heat conduction.
- Calculate the LMTD
- Apply the principles of convection to design various heat transfer equipment.
- Analyze the phenomena of heat transfer by conduction, convection & radiation.
- Carry out the detailed process design of shell and tube heat exchangers.

Text Books:

1. Unit Operations of Chemical Engineering, McCabe, W.L., J.C Smith and Peter Harriott, 7th Edition, McGraw-Hill, 2005.
2. Process Heat Transfer, D.Q. Kern, Tata- McGraw-Hill, 1997.
3. Heat Transfer, Holman, J.P., 9th Edition, Tata McGraw-Hill, 2008.

Reference Books:

1. Heat Transfer, Y.V.C. Rao, Universities Press (India) Pvt. Ltd., 2001.
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

MASS TRANSFER OPERATIONS –I 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.

Experiments:

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

Outcomes:

The student will be able to:

- 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.

II Year- II Semester

L	T	P	C
0	0	3	1.5

MATHEMATICAL METHODS FOR CHEMICAL ENGINEERS - 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. Solution of simultaneous equations for steady state material balance on a separation train.
2. Linear regressions after proper transformation to a linear expression for vapor-pressure correlation by Clapeyron Equation.
3. Fitting polynomials & correlations using vapor pressure data.
4. Solution of single non-linear algebraic equation for bubble point calculation of an ideal binary mixture.
5. Least square method of analysis to obtain the relation between friction factor and Reynolds number.
6. Graphical integration for calculation of average velocity for flow of water.
7. Determination of Molar volume and Compressibility from Redlich – Kwong equation of state
8. Calculation of flow rate in a pipeline.
9. Calculation of compressibility factors using van der Waals equation of state.
10. Thermodynamic properties of steam from Redlich – Kwong equation of state.
11. Solution of Stiff Ordinary Differential Equations for a general biological process to obtain substrate and biomass concentration profiles.
12. Expediting the solution of systems of nonlinear algebraic equations to obtain equilibrium constants in a constant-volume gas phase batch reactor.
13. Solving differential algebraic equations for obtaining the number of moles remaining in a batch still for distillation.
14. Method of lines for Partial Differential Equations to obtain temperatures along the slab

Outcome:

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

Textbook:

1. Problem solving in Chemical and Biochemical Engineering with POLYMATH, Excel and MATLAB, Michael B. Cutlip and Mordechai Shacham, 2nd edition, Prentice Hall, 2008.

II Year- II Semester

L	T	P	C
0	0	3	1.5

HEAT TRANSFER OPERATIONS – LABORATORY

Learning Objectives:

Fundamentals of process heat transfer will be demonstrated through a series of laboratory experiments like determination of thermal conductivities of composite wall and metal rod, natural and forced convective heat transfer coefficients (both film and overall coefficients), Stefan-Boltzmann constant, emissivity of a metal plate etc., Students will acquire hands-on experience and 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 students will be able to:

- Apply various 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

II Year- II Semester

L	T	P	C
1	0	2	2

INDUSTRY 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 get exposed to various professional activities in a process industry.
- To judge the importance and relevance of various subjects in curriculum.
- To know the possible career options in a process industry.
- To have an idea of scale of operations.
- To acquaint with different forms of technical communication.

II Year- II Semester

L	T	P	C
0	0	0	0

SUMMER INTERNSHIP

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

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

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

II Year- II Semester

L	T	P	C
4	0	0	4

HONORS/MINOR COURSES

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)/ equivalent department course.
- Enhance knowledge in core subjects.
- Obtain knowledge in inter-disciplinary and job orientated minor courses.
- Acquire the skills for life-long learning.
- Diversify ones understanding of a topic useful to profession.

The departmental courses should be offered in lieu of MOOCS courses in case they are not available in NPTEL/SWAYAM. It is required for the students to do, a minimum of 7 courses to obtain the Honors/Minor degree. To fulfill the criteria of qualifying for Honors/minor degree, additional 20 credits are required.

The list of MOOCS/departmental courses in chemical engineering is given in Appendix-I to do honors and Appendix-II shows the courses for minor degree in chemical engineering. To obtain the minor degree for chemical students the eligible students has to do the courses in any one discipline other than Chemical Engineering.

The **16 credits** for honors or minor degree should be obtained from the fourth semester to the end of eighth semester. A candidate can take a 4-credit course in each semester during the above-mentioned period. It may be noted that, each eligible student has to get **minimum of 8.0 SGPA without any backlogs in each semester to do honors/minor degree.**

The eligible student shall register for the course **(Minimum of 12 weeks)** in the SWAYAM/NPTEL portal, offered through online with the approval of Head of the Department, under the guidance and supervision of a mentor/faculty. The student has to earn and submit a certificate by passing the exam conducted by SWAYAM/NPTEL for each course to obtain the required credits. If the student does not pass the subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered either through SWAYAM/NPTEL or department offered course in the next semester with the recommendation of mentor/faculty, approved by Head of the Department and shall pass in the examination. In case, of departmental courses also the eligible student should pass the examination in each subject conducted by the department to obtain the certificate.

Outcomes:

The students will be able to:

- Overcome the digital divide in acquiring knowledge skills in fast developing technologies and be a part of digital revolution.
- Become a part of National Resource Pool to contribute the subject specific expertise.
- Assess the academic / professional priorities for future development.
- Develop self-learning skills with open-ended problems, case studies for life-long learning.
- Develop additional knowledge skills in core and inter-disciplinary courses.
- Orient themselves with the learning methodologies outlined in the new educational policy of India.

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-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, Duhem's theorem, VLE: Qualitative behavior, the gamma /Phi formulation of VLE, Dew point and bubble point calculations, flash calculations, solute /solvent 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 & latent heat effects and determine the heat effects of industrial reactions.
- Apply the concept of fugacity, residual & excess property relations and estimate partial molar properties.
- Estimate the liquid phase properties from VLE data and apply the models for the excess Gibbs energy for evaluating activity coefficients.
- Calculate the VLE data using Raoult's law, modified Raoult's law, Henry's law, activity coefficient models, and generalized gamma/phi formulation, K-values and equation of states.
- Estimate the reaction equilibrium constant and equilibrium conversion for liquid and 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.

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L	T	P	C
3	0	0	3

INSTRUMENTATION, PROCESS DYNAMICS & CONTROL

Learning objectives:
The students will be able to learn:

- The basic elements of an instrument and its static and dynamic characteristics.
- The various types of industrial thermometers.
- The various types of instruments for measurement of pressure, vacuum, head and density measurement.
- Visualize the behavior and logic of different types of advanced controllers and their strategies.
- The Laplace transforms to get solutions of transfer function equations for different types of systems.
- The basic procedure to derive transfer functions for first order, pseudo second order and second order systems.
- The importance of under damped second order systems in relation to the real life situations.
- The calculations of overall transfer function and thus offset calculation from the control system block diagram.
- 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:
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 and 3 wire - method) -Radiation receiving elements-pyrometers.

UNIT-II:
Pressure, vacuum and head: Liquid column manometers - Measuring elements for gauge pressure and vacuum-indicating elements for pressure gauges - Measurement of absolute pressure - Measuring pressure in corrosive liquids - Static accuracy and response of pressure gauges.
Density and specific gravity measurements- Direct measurement of liquid level - Pressure measurement in open vessels - Level measurements in pressure vessels - Measurement of interface level - Density measurement and level of dry materials.

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

Response of first order systems in series, higher order systems: Second order and transportation lag. Control systems, Controllers and final control elements.

UNIT-IV:
Closed loop transfer functions, Transient response of simple control systems.
Stability: Stability Criterion, Routh Test, Introduction to frequency response, Bode stability criterion, concept on gain and phase margins.

UNIT-V:
Advanced control strategies: Cascade control, Feed forward control, ratio control, dead time compensation, internal model control.
Controller tuning, Control valves.

Outcomes:
The students are able to:

- Apply the concepts of 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, and density.
- Write different types of unsteady and steady state balances
- Describe a process, how it works and what the control objectives are.
- Describe processes with appropriate block diagrams.
- Numerically model a process.
- Identify the stability limits of a system.
- Apply the advance control strategies.
- Tune process controllers.
- Design and operate control valves.

Text Books:

1. Industrial Instrumentation, Donald P. Eckman, CBS, 2004.
2. Process Systems Analysis and Control, D.R. Coughanowr, 3rd Ed. McGraw Hill

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

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 adsorption equipments 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 extraction.

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, psychrometric 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, Batch adsorption, 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.

Outcomes:

The students are able to:

- Analyze liquid-liquid and solid-liquid equilibrium data.
- Design single stage, multi stage liquid extractors and leaching equipment.
- Make calculations using psychrometric charts for humidification, design of humidification and de-humidification equipment.
- Apply the principles of drying and design of various dryers.
- Prepare the adsorption isotherms, 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. Principles of Mass Transfer and Separation Processes, Binay K. Datta, PHI Learning Private Ltd., 2009.
4. 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. 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

INTRODUCTION TO CHEMICAL ENGINEERING
(OPEN ELECTIVE – I)

Learning Objectives:

The student will be able to learn:

- The concepts that will enable the transition from science to chemical engineering.
- The role of Chemical Engineers in everyday life and the importance of Chemical Engineering.
- The various Unit Operations and Unit Processes used in Chemical industries.
- The role of Chemical Engineers in environmental, economical 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.

Introduction to reactions and reactors.

Introduction to Design & control of chemical systems. (Text Book 1, 2 & 3)

UNIT-III:

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)

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), (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. (Text Book 1, 2 & 3).

Outcomes:

The students are able to:

- Apply the concepts that will enable the transition from science to chemical engineering.
- Assess the role of Chemical Engineers in everyday life and the importance of Chemical Engineering.
- Classify various Unit Operations and Unit Processes in Chemical industries.
- Assess 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.

III Year- I Semester

L	T	P	C
3	0	0	3

FUNDAMENTALS OF PETROLEUM REFINING
(OPEN ELECTIVE – I)

Learning Objectives:

The students are able to learn:

- The origin of petroleum and constituents of petroleum.
- 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: paraffins, naphthenes, olefins and aromatics. Non-hydrocarbon constituents.

UNIT-II:

Distillation: Pretreatment of crude-desalter-description of atmospheric and vacuum distillation units.

UNIT-III:

Thermal and Catalytic cracking: Feedstock's-the process and equipment description-catalysts-products-effect of process variables.

Hydrocracking: The process-hardware and the reactions.

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

UNIT-IV:

Catalytic reforming: Feed stocks-different processes and equipment description-products-effect of process variables.

Isomerization: Butane isomerization- C_5/C_6 isomerization.

UNIT-V:

Residue reduction: vis-breaking-coking-hydrotreating.

Hydrogen and Sulphur plants: Hydrogen sources-sulphur technologies.

Asphalt: composition-asphaltic crude oils-asphalt products and applications.

Outcomes:

The students are able to:

- Assess different crude oils and evaluate petroleum fractions according to specifications.
- Apply the chemistry of petroleum in different refining 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.
- Apply the residue reduction processes to obtain more valuable products.
- Assess hydrotreating processes for the reduction of sulphur in crude oil products.
- Assess the requirements of hydrogen and sulfur plants.

Text Book:

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- I Semester

L	T	P	C
3	0	0	3

RENEWABLE ENERGY SOURCES
(OPEN ELECTIVE – I)

Learning objectives:

The students will be 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:

Introduction to Renewable Energy: Comparison of Renewable and Conventional energy sources – Ultimate energy sources - natural energy currents on earth - primary supply to end use - Energy planning - Energy Efficiency and Management.

UNIT – II:

Solar Energy: 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).

Geothermal Energy: Origin and types.

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.

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

UNIT – V:

Biomass based 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.

Outcomes:
The students are 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.
- 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 Hill.

III Year- I Semester

L	T	P	C
3	0	0	3

GENERAL CHEMICAL TECHNOLOGY
(Professional Elective – I)

Learning objectives:

The students will be 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 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 based 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 of cement, compounds in cement, manufacture of Portland cement, Overall factors to be considered in cement industry.

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 – 6,6, polyester fiber, viscose rayon fiber.

Oils, soaps and detergents: Definitions, constitution of oils, extraction and expression of vegetable oils, 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 unit operations and unit processes for inorganic and organic production of chemicals.
- Apply thermodynamic and the chemical process principles for different chemical processes.
- Use the chemical properties of inorganic chemicals and the manufacturing processes to design flow sheets.
- Use the chemical properties of organic chemicals and the manufacturing processes to design flow sheets.
- Utilize waste products for recycling.

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- I Semester

L	T	P	C
3	0	0	3

INDUSTRIAL POLLUTION AND CONTROL
(Professional Elective – I)

Learning objectives:

The students will be able to learn:

- The fundamentals of pollution with a background on historical perspective on pollution.
- The different types of pollutants and wastes from chemical industries, and guidelines set by the environmental protection agencies for maintaining clean environment.
- The Standards for the level of pollutants from the industries.
- The methods of collection and characterization of waste water.
- Classification of major pollutants; their sources and effects (environmental, economic and health) and their analysis.

UNIT-I:

Introduction: Types of pollutants and their sources and impact on environment - Environment legislation, Effluent guidelines and standards.

UNIT-II:

Characterization of effluent streams: Oxygen demands and their determination (BOD, COD, and TOC), Oxygen sag curve, BOD curve mathematical, Controlling of BOD curve, Self-purification of running streams, Sources and characteristics of pollutants in fertilizer, paper and pulp industry, Hydrocarbon industry.

UNIT-III:

Solid waste treatment: Different types of solid wastes- 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.

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

UNIT-IV:

Waste water treatment: Biological treatment of wastewater, Bacterial and bacterial growth curve, Aerobic processes, suspended growth processes, activated aerated lagoons and stabilization ponds, Attached growth processes, Trickling filters, Rotary drum filters, and Anaerobic processes.

Methods of Primary treatments: Screening, Sedimentation, Flotation, Neutralization, and methods of tertiary treatment. Brief studies of Carbon absorption, Ion exchange, Reverse osmosis, Ultra filtration, Chlorination, Ozonation, treatment and disposal.

UNIT-V:

Air pollution control methods and equipment: Source collection methods: raw material changes, process changes, and equipment modification. Cleaning of gaseous equipment's particulate emission control: Collection efficiency, Control equipment like gravitational settling chambers, Cyclone separators, fabric filters, ESP. Scrubbers and absorption equipment.

Outcomes:

The students will be able to:

- Apply knowledge about the different types of pollutants and wastes and impact on the society
- Apply the solid waste treatment methods in the design of equipment.
- Apply the water treatment methods in the design of equipment.
- Apply the air treatment methods in the design of air pollution control equipment.
- Interpret the legislations according to the design and operational requirements.

Text book:

1. Environmental Pollution Control Engineering, C. S. Rao, 2nd edition, New age International Publishers, 2006

Reference books:

1. Pollution control in Process Industries, S. P. Mahajan, Tata McGraw Hill Publishing Company Ltd, New Delhi, 1985.
2. Integrated solid waste management, George Technologies, McGraw Hill Publication, 1993
3. Air pollution, M. N. Rao and H. V. N. Rao, McGraw Hill Publications, 1989.
4. Solid waste engineering, Vesilind, P.A., Worrell, W., Reinhart, D., Cenage learning, New Delhi, 2004
5. Solid and hazardous waste management, P M Cherry, CBS Publishers and Distributors, New Delhi, 2016

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:

Pretreatment and preheating of crude oil: Desalting - heat exchanger networks.

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 and Polymerization Processes: Alkylation feed stocks – Products – Catalysts – Hydrofluoric Acid and sulfuric acid alkylation processes – Comparison of processes – polymerization processes: feed stocks – description – products.

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.
- Design pretreatment and preheating equipment.
- 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
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 will be 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	3	1.5

MASS TRANSFER OPERATIONS – II - LABORATORY

Learning Objectives:

The students are able to:

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

Experiments:

1. Liquid-Liquid equilibria
2. Bi-nodal solubility curve
3. Batch drying
4. Continuous drying
5. Solid-liquid extraction
6. Single stage adsorption
7. Counter current leaching
8. Surface evaporation

Outcomes:

The students are able to:

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

III Year- I Semester

L	T	P	C
1	0	2	2

SOFT COMPUTING TECHNIQUES
(SOFT SKILL COURSE)

Course Objectives: In the course the student will Learn soft computing concepts and techniques and foster their abilities in designing and implementing soft computing-based solutions for real-world problems.

UNIT I:
Fuzzy Set Theory: Introduction to Neuro – Fuzzy and Soft Computing, Fuzzy Sets, Basic Definition and Terminology, Set-theoretic Operations, Member Function Formulation and Parameterization, Fuzzy Rules and Fuzzy Reasoning, Extension Principle and Fuzzy Relations, Fuzzy If-Then Rules, Fuzzy Reasoning, Fuzzy Inference Systems, Mamdani Fuzzy Models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Models, Input Space Partitioning and Fuzzy Modeling.

UNIT II:
Optimization: Derivative based Optimization, Descent Methods, The Method of Steepest Descent, Classical Newton's Method, Step Size Determination, Derivative-free Optimization, Genetic Algorithms, Simulated Annealing, Random Search – Downhill Simplex Search.

UNIT III:
Artificial Intelligence: Introduction, Knowledge Representation, Reasoning, Issues and Acquisition: Prepositional and Predicate Calculus Rule Based Knowledge Representation Symbolic Reasoning Under Uncertainity Basic Knowledge Representation Issues Knowledge acquisition, Heuristic Search: Techniques for Heuristic Search Heuristic Classification State Space Search: Strategies Implementation of Graph Search Search based on Recursion Patent-directed Search Production System and Learning.

UNIT IV:
Neuro Fuzzy Modeling: Adaptive Neuro-Fuzzy Inference Systems, Architecture – Hybrid Learning Algorithm, Learning Methods that Cross-fertilize ANFIS and RBFN – Coactive Neuro Fuzzy Modeling, Framework Neuron Functions for Adaptive Networks – Neuro Fuzzy Spectrum.

UNIT V:
Applications of Computational Intelligence: Printed Character Recognition, Inverse Kinematics Problems, Automobile Fuel Efficiency Prediction, Soft Computing for Color Recipe Prediction.

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

- **CO1** Able to apply fuzzy logic and reasoning to handle uncertainty in engineering problems.
- **CO2** Make use of genetic algorithms to combinatorial optimization problems
- **CO3** Apply artificial intelligence techniques, including search heuristics, knowledge representation, planning and reasoning.
- **CO4** Learn and apply the principles of self-adopting and self-organizing neuro fuzzy inference systems

CO5 Evaluate and compare solutions by various soft computing approaches for a given problem

Text Books:

1. J.S.R.Jang, C.T.Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI, 2004, Pearson Education 2004.
2. N.P.Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press, 2006.

References:

1. Elaine Rich & Kevin Knight, Artificial Intelligence, Second Edition, Tata Mcgraw Hill Publishing Comp., 2006, New Delhi.
2. Timothy J.Ross, "Fuzzy Logic with Engineering Applications", McGraw-Hill, 1997.
3. Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989.
4. S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI,
5. R.Eberhart, P.Simpson and R.Dobbins, "Computational Intelligence - PC Tools", AP Professional, Boston, 1996.
6. Amit Konar, "Artificial Intelligence and Soft Computing Behaviour and Cognitive model of the human brain", CRC Press, 2008

III Year- I Semester

L	T	P	C
2	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/

III Year- I Semester

L	T	P	C
0	0	0	1.5

SUMMER INTERNSHIP EVALUATION

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 field operation, troubleshooting and engineering work.
- Present and / or report the work / project outcomes to various disciplines, departments & interest groups with confidence.
- To give a clear, organized and accurate oral presentation of Summer Training/Internship Report.
- To provide verbally/ through power point presentation of condensed large amounts of technical information into concise, condensed analysis.
- Sharing the practical knowledge obtained during training with fellow students.

Every Student should undergo summer training (summer internship program) in a chemical processing industry/ fertilizer industry/ petroleum refinery/petrochemical complex for 6-8 weeks and submit a report**.**

A summer internship report is a documentation of a student's work—a record of the original work done by the student in the summer internship of 6- 8 week duration at the end of the IV semester.

Summer Internship of the students shall be evaluated for **50 marks (1.5 credits) for weightage of 50% - report and 50% - oral presentation** by a committee constituted by the Head of the Department along with an industry expert or a faculty from other departments.

Outcomes:

The students are able to:

- Work safely in industrial environment.
- Work with various interest groups, disciplines, professionals, managers and technicians etc.
- Polish the engineering skills by applying the practical knowledge in day-to-day operations, trouble-shooting and minor-modifications.

- Build relations between university and industry that helps mutual collaboration and cooperation over long-term.
- Develop/strengthen the basic skills of interviewing, analysis, report writing, communication, decision-making, and problem solving.
- Assess the good practices of petroleum operations.
- Acquire good clarity in the technical topics being presented.
- Develop good communication skills.
- Practice the behaviors of effective speakers.
- Assess strengths in speaking and set goals for future growth.

III Year- I Semester

L	T	P	C
4	0	0	4

HONORS/MINOR COURSES

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)/ equivalent department course.
- Enhance knowledge in core subjects.
- Obtain knowledge in inter-disciplinary and job orientated minor courses.
- Acquire the skills for life-long learning.
- Diversify ones understanding of a topic useful to profession.

The departmental courses should be offered in lieu of MOOCS courses in case they are not available in NPTEL/SWAYAM. It is required for the students to do, a minimum of 7 courses to obtain the Honors

/Minor degree. To fulfill the criteria of qualifying for Honors/minor degree, additional 20 credits are required.

The list of MOOCS/departmental courses in chemical engineering is given in Appendix-I to do honors and Appendix-II shows the courses for minor degree in chemical engineering. To obtain the minor degree for chemical students the eligible students has to do the courses in any one discipline other than Chemical Engineering.

The **16 credits** for honors or minor degree should be obtained from the fourth semester to the end of eighth semester. A candidate can take a 4-credit course in each semester during the above-mentioned period. It may be noted that, each eligible student has to get **minimum of 8.0 SGPA without any backlogs in each semester to do honors/minor degree.**

The eligible student shall register for the course **(Minimum of 12 weeks)** in the SWAYAM/NPTEL portal, offered through online with the approval of Head of the Department, under the guidance and supervision of a mentor/faculty. The student has to earn and submit a certificate by passing the exam conducted by SWAYAM/NPTEL for each course to obtain the required credits. If the student does not pass the subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered either through SWAYAM/NPTEL or department offered course in the next semester with the recommendation of mentor/faculty, approved by Head of the Department and shall pass in the examination. In case, of departmental courses also the eligible student should pass the examination in each subject conducted by the department to obtain the certificate.

Outcomes:

The students will be able to:

- Overcome the digital divide in acquiring knowledge skills in fast developing technologies and be a part of digital revolution.
- Become a part of National Resource Pool to contribute the subject specific expertise.
- Assess the academic / professional priorities for future development.
- Develop self-learning skills with open-ended problems, case studies for life-long learning.
- Develop additional knowledge skills in core and inter-disciplinary courses.
- Orient themselves with the learning methodologies outlined in the new educational policy of India.

III Year- II Semester

L	T	P	C
3	0	0	3

CHEMICAL REACTION ENGINEERING

Learning Objectives:

The students will be able to learn:

- The principles of rate law and stoichiometry.
- 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 – batch reactor, plug flow reactor and mixed flow reactor.
- The size comparison of single reactors, multiple reactor systems, recycle reactor.
- 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 thermal characteristics of various reactions.
- The basic concepts of non-ideal reactors, the RTD and conversion in non-ideal flow.
- The details of heterogeneous reacting systems and the design aspects of heterogeneous catalytic systems.

UNIT – I:

Introduction: kinetics of homogeneous reactions, non – elementary reactions, Arrhenius relation, Collision theory and Transition-state theory, various methods of analyses of batch reactor data obtained for various types of reactions including constant volume and variable volume processes.

UNIT – II:

Ideal reactors and Design for single reaction: Introduction to reactor design, Isothermal batch reactor design, Homogeneous flow reactors - data analysis in flow reactors, space time, space velocity, Design equation for ideal plug flow reactor (PFR), ideal continuous stirred tank reactor (CSTR), CSTRs in series, recycle reactor and combination for PFR & CSTR.

UNIT – III:

Multiple reactions: Product distribution in multiple reactions - parallel reactions and series reactions.

Non-isothermal reactions: Single reactions-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.

UNIT – IV:

Non-ideal flow: E - the age distribution of fluid, the RTD, Residence time distribution curves, C,E and F curves, conversion in non-ideal flow reactors, diagnosing reactors ills (qualitative discussion only).

Interpretation of the response data for the "Dispersion" and "Tanks-in-series" models, calculation of conversion using dispersion and tanks-in-series models. Earliness of mixing, segregation and RTD- self-mixing of a single fluid.

UNIT – V:

Homogeneous and Heterogeneous catalysis: catalysts, steps in a catalytic reaction, rate models, mechanism and rate limiting step. (From chapter 10, H. Scott Fogler).

Gas-Solid catalytic reaction: Introduction, pore diffusion resistance combined with surface kinetics, porous catalyst particles, catalyst deactivation kinetics - the rate and performance equations.

Catalytic reactors: controlling mechanisms- classification and description of catalytic reactors, experimental methods for finding rates;

Outcomes:

The students are able to:

- Apply the reaction rate concepts to interpret the batch reactor data.
- Design different types of reactors for single and multiple reactions.
- Perform the size comparison of single, multiple reactor systems & recycle reactor.
- Analyze the thermal characteristics and design of adiabatic reactors for single and multiple reactions.
- Apply the non-ideality concepts in the reacting system for better understanding the deviations from ideality
- Identify the importance of catalysts.
- Determine the kinetics of solid catalyzed reactions and carry out experiments for determining the rates of solid-catalyzed reactions.
- Assess the rate controlling mechanisms in heterogeneous catalysis and their rate determinations.
- Select suitable reactor(s) for catalytic reactions.

Text Books:

1. Chemical Reaction Engineering, Octave Levenspiel, 3rd Edition Wiley Eastern Ltd., 1998.
2. Elements of Chemical Reaction Engineering, H.S. Fogler, 3rd Edition. PHI, 1992.

Reference Books:

1. Chemical Engineering Kinetics, J. M. Smith, 3rd Edition. McGraw- Hill, 1981.
2. Chemical Reaction and Reactor Engineering, James J. Carberry and Aravind Varma, 1st edition, 1987.
3. Chemical and Catalytic reaction engineering, James J. Carberry, McGraw-Hill, 1976.

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

III Year- I Semester

L	T	P	C
3	0	0	3

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 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 change 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 the momentum flux and velocity distribution for typical geometries.
- Derive the heat flux and temperature distribution for typical geometries.
- Derive the mass flux and concentration distribution for typical geometries.
- Derive the unsteady state and steady state velocity profile, temperature profile and concentration profile.
- 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.

III Year- II Semester

L	T	P	C
3	0	0	3

PLANT DESIGN & ECONOMICS FOR CHEMICAL ENGINEERS

Learning Objectives:
The students will be able to learn:

- The overview of plant design and various terms, activities related to economics.
- The economic analysis to calculate equipment cost and profitability.
- The basic concepts of material handling equipment and design.
- The basic theory of heat transfer in heat exchangers equipment and design of heat exchangers.
- The selection of suitable separation equipment and learn about their design.
- The selection of suitable reactor and its design.

UNIT-I:
Overview of plant design: General overall design –Feasibility survey, Plant location, Plant layout, Plant operation & control. Development of design database, Types of process design, PFD, P&ID, flow sheet synthesis and development.
Introduction to interest and types of interest cost of capital, time value of money, and break even analysis, cash flow patterns.

UNIT-II:
Analysis of cost estimation: Cash flow for industrial operations, Fixed and working capital, cost estimation methods, Estimating Equipment costs by Scaling, cost indexes, the factorial method of cost estimation, Depreciation and depletion method, profitability, payout period, capitalized cost. Optimization application: cyclic operations, economic pipe diameter.

UNIT-III:
Design of material handling equipment: Basic concepts, piping in fluid transports processes, pumping of fluids, Compression and expansion of fluids, design of flow meters and design of belt conveyors.

UNIT-IV:
Design of heat-exchange equipment: Classification of shell and tube heat exchanger, material of construction, cleaning of heat exchangers, heat transfer fluid, agitated vessels, description of shell, tubes, bonnet and channel, pass partition plate, nozzle, baffles, tie rods, baffle spacers, flanges, gaskets and expansion joints. Process design of double pipe exchanger and shell and tube heat exchangers.

UNIT-V:
Separation equipment & reactor design: Selection/Guidelines for suitable separation processes, Types of mass transfer equipment's, packed and tray type towers. Process design of tray and packed towers.

Reactor principles, Development of reactor rate expressions, reactor performance and catalyst equipment, Selection of catalysts, Types of reactors, Selection of reactors, Design of reactor systems, procedure for reactor design.

Outcomes:
The students are able to:

- Apply the basic principles of plant design and various terms related to economics.
- Perform economic analysis to calculate equipment cost, and profitability.
- Design the material handling equipment.
- Design the heat transfer equipment.
- Identify suitable separation process and design the separation equipment.
- Design different types of reactors.

Text Books:

1. Plant Design & Economics for Chemical Engineers, Max Peteres, Klaus D. Timmerhaus, Ronald West, 5th Edition, Tata McGraw-Hill, 2011.
2. Process Engineering Economics, Schwery H.E.,McGraw-Hill, New York, 1955.
3. 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 & Petro Chemical Plants, E.E Ludwig, 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 2ndEdition, 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, ArunDatta, CRC Press, 2008.
7. Product and Process Design Principles – Synthesis, Analysis and Evaluation, Warren D. Seider, Daniel R. Lewin, J. D. Seader, Soemantri Widagdo, Rafiqul Gani and Ka Ming Ng, 4th edition, John Wiley & Sons, 2017.

III Year- II Semester

L	T	P	C
3	0	0	3

PROCESS MODELLING AND SIMULATION
(Professional Elective – II)

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 and partial differential equations: Euler Algorithm and Runge-Kutta (Fourth-Order) methods-Algorithms and solutions for partial differential equations.

UNIT – IV:

Simulation of equipment: 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.
- Develop and solve process models in various unit operations such as fluid flow, heat transfer & mass transfer operations and reaction engineering.
- Apply process equipment simulation models for design.
- Carry out simulation of large process plants using tear streams.
- Apply process simulation software for the design and optimization of chemical process plant.

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.

III Year- II Semester

L	T	P	C
3	0	0	3

BIO CHEMICAL ENGINEERING
(Professional Elective – II)

Learning Objectives:

The students will be able to learn:

- The basic structure and function of important cell types, RNA and DNA, amino acids and proteins
- The enzyme structure, function and kinetics of enzyme catalyzed reactions
- The immobilization of enzymes, industrial applications and understand immobilized enzyme kinetics
- The kinetics of cellular growth, models for cellular growth, and thermal death kinetics of cells and spores
- Various metabolic pathways, biosynthesis, transport across cell membranes, end products of metabolism and stoichiometry of cell growth and product formation
- The design and analysis of various bioreactors and also to have an overview about fermentation technology

UNIT – I:

Introduction to Microbiology: Biophysics and the cell doctrine, the structure of cells, Important cell types, from nucleotides to RNA and DNA, amino acids into proteins.

Kinetics of Enzyme catalyzed reaction: The enzyme substrate complex and enzyme action, Simple enzyme kinetics with one and two substrates, other patterns of substrate concentration dependence, Modulation and regulation of enzyme activity, other influences on enzyme activity.

UNIT – II:

Immobilized Enzyme technology: Enzyme immobilization, Industrial processes, utilization and regeneration of cofactors, Immobilized enzyme kinetics- Effect of external mass transfer resistance, Analysis of intra-particle diffusion and reaction.

Kinetics of cellular growth in batch and continuous culture, Models for cellular growth – Unstructured, structured and cybernetic models, Thermal death kinetics of cells and spores

UNIT–III:

Design and analysis of Biological reactors: Batch reactors, fed-batch reactors, Enzyme catalyzed reactions in CSTR, CSTR reactors with recycle and cell growth, Ideal plug flow reactors, Sterilization reactors, Sterilization of gases, packed bed reactors using immobilized catalysts.

Fermentation technology: Medium formulation, Design and operation of a typical aseptic, aerobic fermentation process.

UNIT–IV:

Transport phenomena in Bioprocess systems: Gas-liquid mass transfer in cellular systems, determination of oxygen transfer rates, overall ka' estimates and power requirements for sparged and agitated vessels, scaling of mass transfer equipment, heat transfer.

UNIT – V:

Downstream Processing: Strategies to recover and purify products; Separation of insoluble products-filtration and centrifugation; cell disruption-mechanical

and non-mechanical methods; Separation of soluble products: liquid-liquid extractions, membrane separation (dialysis, ultra-filtration and reverse osmosis), chromatographic separation-gel permeation chromatography, electrophoresis, final steps in purification – crystallization and drying.

Outcomes:

The students are able to:

- Apply the basic principles of gene expression, translation, transcription, regulation and protein synthesis, RNA and DNA, will become familiar with basic cell structure and biomolecules.
- Develop a clear picture of what enzymes are, what their functions are and analyses the kinetics of enzyme catalyzed reactions.
- Demonstrate a clear understanding of immobilized enzyme technology and the kinetics involved.
- Apply the transport in design of bioprocess systems.
- Design the bioreactors.

Text Books:

1. Biochemical Engineering Fundamentals, J.E.Bailey and D.F.Ollis, 2nd Edition, McGraw Hill, 1986.
2. Introduction to Biochemical Engineering, D.G.Rao, Tata McGraw-Hill, 2008.

Reference books:

1. Bioprocess Engineering, Michael L. Shuler and Fikret Kargi, 2nd Edition, Prentice Hall, 2002.
2. Biochemical Engineering, James M.Lee, Prentice-Hall-1992.
3. Biochemical Engineering, Aiba, Humphrey and Mells, Academic press, 1973.
4. Bioprocess Engineering principles, Pauline M. Doran, Academic Press, 2012.
5. Biochemical Engineering, H.W. Blanch and D.S. Clark, Marcel Dekker, 1997.

III Year- II Semester

L	T	P	C
3	0	0	3

MATERIALS SCIENCE AND ENGINEERING
(Professional Elective – II)

Learning objectives:
The students are able to learn:

- 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.
- The techniques in minimizing equipment breakdown and increasing the on- stream factor.
- The 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 planes: crystalline and non-crystalline 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-Fe_3-C, Pb-Sn, Cu-Ni systems. Phase transformations in Fe-Fe_3-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 and plastic deformations in solid materials: rubber like elasticity, viscoelastic 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, classification of stainless steel materials for fabrications and brief description of heat treatment of steels.

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.

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

Composite materials: types; stress-strain relations in composite materials, applications.

Outcomes:

The students are able to:

- Analyze the structure of materials for fabrication.
- Select the materials appropriately for engineering purposes.
- Evaluate and predict the life of equipment.
- Acquire the abilities to carryout reliability studies.
- Carryout studies on equipment failure analysis and propose the remedial measures.
- Apply the stress-strain relations in composite materials.

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

III Year- II Semester

L	T	P	C
3	0	0	3

BASICS OF WASTE MANAGEMENT
(OPEN ELECTIVE – II)

Learning Objectives:

The student will be able to learn:

- The definition of various solid wastes.
- The characterization of municipal solid wastes and collection.
- Recycling and processing of solid wastes.
- The various aspects of hazardous waste management.
- The classification and management of special wastes like, medical and electronic wastes

UNIT – I:

Introduction: Definition of a solid waste, categories of wastes, Solid waste management - Source reduction – recycling – incineration - land disposal. Brief history of waste management.

UNIT – II:

Municipal solid wastes (MSW): Characterization of solid waste-sampling protocols for MSW – common components in municipal solid waste – chemical and physical properties of MSW,

Municipal solid waste collection: Developing a waste collection system, logistics of the collection program.

UNIT – III:

Recycling Solid wastes: Introduction, recycling terminology, recovery and markets for components of the waste stream, purity of materials, paper, glass, aluminium, ferrous metals, plastics, food waste and yard waste.

Municipal solid waste processing – materials recovery facilities, composting MSW, Incineration of MSW, The sanitary Landfill.

UNIT – IV:

Hazardous waste management: Identification of hazardous waste, generation of hazardous waste and its requirements, hazardous waste transportation, treatment, storage and disposal facility requirements, incineration of hazardous wastes, hazardous waste treatment, land disposal of hazardous waste.

UNIT – V:

Special categories of waste: Universal wastes, management of used oil, medical and infectious wastes, electronics waste.

Outcomes:

The student are able to:

- Classify various solid wastes.
- Characterize the municipal solid wastes and able to devise collection methods.
- Apply the concepts of recycling and processing of solid wastes in the design of equipment.
- Classify hazardous wastes and implement the management techniques.
- Classify special wastes like medical and electronic wastes and implement the management techniques to dispose them.

Text Book:

1. Waste Management Practices Municipal, Hazardous and Industrial, John Pichtel, 2nd edition, CRC press, 2014.

References books:

1. Integrated solid waste management, George Technologies, McGraw Hill Publication, 1993
2. Basic Hazardous Waste Management, William C. Blackman Jr., 3rd edition, CRC Press, 2016.
3. Waste Management and Environmental Health, P. Tabassum, Priya Bajaj, Pawan Kumar 'Bharthi' Discovery Publishing House Pvt Ltd., 2016

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III Year- II Semester

L	T	P	C
3	0	0	3

INTRODUCTION TO PETROCHEMICALS
(OPEN ELECTIVE – II)

Learning Objectives:

The students will able to learn:

- About the petrochemical industry & feed stocks and processing.
- Different pre-treatment processes involved in making the available and suitable feed stocks.
- Various processes and production steps involved in the several petrochemical processes.
- Various products and by-products which can be produced in a variety of petrochemical processes.
- Various processes and production steps involved in producing polymers, elastomers and thermosetting resins, synthetic fibers.

UNIT-I:

Introduction: Introduction to Petrochemical industry - structures of indian petrochemical complexes – segments of indian petrochemical industry - profile of petrochemicals and their end products.

Olefins production: Steam cracking for production of olefins - gas sweetening unit - effect of process variables on steam cracking process.

Processing of Olefinic C_4 and C_5 cut from steam cracking and fluid catalytic cracking: Chemistry of cracking and process variables - overview of FCC feed pre-treatment -description of the FCC process - processing of C_4 stream from steam cracking and FCC oxygenates from refinery C_4 and C_5 stream - upgrading of C_5 cut for recovery of C_5 chemicals.

UNIT-II:

Production of Aromatics: Petroleum feedstock for aromatic hydrocarbons-catalytic reforming process- effect of process variables on catalytic reforming process.

Methane and synthesis gas derivatives: synthesis gas and ammonia manufacture from steam reforming process, manufacture of urea, methanol, formaldehyde, and acetic acid.

UNIT-III:

Ethylene Derivatives: Manufacturing process of ethylene oxide and ethylene glycols - production processes for vinyl chloride, acetaldehyde, ethanol, and ethanol amines - process technologies for ethylene to ethyl benzene & styrene.

Propylene Derivatives: Propylene converted to propylene oxide–propylene glycol – acetone – acrylonitrile – cumene.

UNIT-IV:

Chemicals from C_4: Butadiene–1-Butene – 2-Butene-Isobutylene–n-Butene–Octenes –1,4- Butanediol.

Chemicals from C_5: Chloroprene – Isoprene – Cyclopentadiene and dicyclopentadiene.

Aromatics - BTX Derivatives: Benzene, Toluene, Orthoxylene - Metaxylene-Paraxylene – Phthalic anhydride – Maleic anhydride – Linear alkyl benzene– Phenol - Nitrobenzene and Aniline.

UNIT-V:

Polymers, Elastomers and Polyurethanes: Manufacture of Polyethylene – Polypropylene –Polyvinyl chloride–Polystyrene.

Thermo settling resins, Elastomers and Polyurethanes-II: Phenol-Formaldehyde – Polyurethane; Classification of rubbers (Elastomer)-Manufacturing processes of Acrylonitrile Butadiene Styrene (ABS), Nitrile Rubber, Butyl Rubber, Polytetrafluoroethylene (Teflon) and Polymethylmethacrylate.

Synthetic Fibres: Cyclohexane – Caprolactam – Adipic acid –Adiponitrile– Hexamethylenediamene –Polyester fibre (Polyethylene terephthalate)–Nylon 6-Nylon 6,6.

Outcomes:

The students are able to:

- Apply the basic principles on which a petrochemical industry complex is to be based.
- Apply the knowledge in the production of ethylene, propylene, butylene and butadiene for operation and design of these plants
- Assimilate manufacture of various derivatives/products which can be produced from ethylene, propylene.
- Assimilate manufacture of various derivatives/products which can be produced from C_4 and C_5 Chemicals and various aromatics products.
- Assimilate manufacture of various thermoplastics, elastomers, thermosetting resins, polyurethanes, and synthetic fibres.

Text Book:

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

Reference Books:

1. Chemistry of Petrochemical Processes, Sami Matar and Lewis F.Hatch, 2nd Edition, Gulf Publishing Company, Houston, 2000.
2. Fundamentals of Petroleum Chemical Technology, P Belov, Mir Publishers, 1970.

III Year- II Semester

L	T	P	C
3	0	0	3

FUNDAMENTALS OF GREEN TECHNOLOGIES
(OPEN ELECTIVE – II)

Learning Objectives:

The student will be able to learn:

- The effect of emissions on climate and environment especially carbon emissions
- The mitigative methods for carbon di oxide.
- The green technologies for energy production.
- Green Technologies for personal and citywide applications.
- High-tech measures like carbon dioxide sequestration.
- Various future plans to reduce carbon emissions.

UNIT – I:

Global warming: The new carbon problem, carbon emission factors, carbon absorption in nature, the global emission situation and India. Effects and impacts of climate change.

Planning for future: Control of carbon emissions, general approach in planning for future, developing countrywide and mitigative measures for global reduction of carbon.

UNIT – II:

Opportunities in control of carbon emissions and accumulation: steps for control of carbon emissions and accumulation, Mckinsey's findings for greenhouse gas reduction – globally, a logical approach for carbon reduction, worldwide—more forests, less deforestation.

Green Technologies for energy production: Various technologies available for energy production, Sources of energy production already in use, alternative methods ready for use, green technologies needing some prior R&D work.

UNIT – III:

Green Technologies for personal and citywide application: Carbon emission reduction at personal level, at local authority and citywide level, carbon emissions from imports.

Green Technologies for specific applications: Promotion of 'green' buildings, the leeds rating system guidelines, the 'Griha' rating system guidelines, the energy conservation building code (ECBC), green hotels and hospitals, green technologies for transport, green roads, ports and harbours, green technologies for industries, carbon emissions from industries in general and carbon tax, 'Green' infrastructure for municipal services.

UNIT – IV:

High-tech measures for reducing carbon emissions: Use of solar power with satellite-based systems, use of carbon capture and storage (sequestration), genetic modification of microorganisms, a few miscellaneous measures, a quick SWOT analysis.

UNIT – V:

Recommended Plan of Action: The missions help develop awareness and political will, some demonstration projects of various countries, adaptive

measures essential for indian people to cope with climate change, mitigative measures and poverty alleviation—a suggested scheme for india, low cost and easy measures, the principal thrust area: to improve the indian economy, use of 'missions' to develop needed support programs, advantages of the proposed plan of action.

Outcomes:

The students are able to:

- Assess the effect of carbon emissions on climate and environment.
- Apply the mitigative methods for carbon in industry.
- Devise the green technologies for energy production.
- Devise the green technologies for personal and citywide applications.
- Plan the high-tech measures like carbon dioxide sequestration.
- Help industry for various future plans to reduce carbon emissions.

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
0	0	3	1.5

CHEMICAL REACTION ENGINEERING – LABORATORY

Learning Objectives:

The students will be 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 flowrate on conversion of a reaction 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 effect of flowrate on conversion of a reaction in a tubular reactor.
6. CSTRs in series- comparison of experimental and theoretical values of conversion of a reaction with known kinetics.
7. Determination of mass transfer coefficient for solid-liquid reaction system.
8. Determination of the effect of flowrate on conversion of a reaction in a combined flow reactor.
9. 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

PROCESS EQUIPMENT DESIGN AND 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.

III Year- II 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.

III Year- II Semester

L	T	P	C
1	0	2	2

DATA SCIENCE
(SOFT SKILL COURSE)

Course Objectives:

From the course the student will learn

- Provide you with the knowledge and expertise to become a proficient data scientist.
- Demonstrate an understanding of statistics and machine learning concepts that are vital for data science;
- Produce Python code to statistically analyze a dataset;
- Critically evaluate data visualisations based on their design and use for communicating stories from data

UNIT-I:

Introduction to Core Concepts and Technologies- Introduction, Terminology, data science process, data science toolkit, Types of data, Example applications.

UNIT-II:

Data Collection and Management: Introduction, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, using multiple data sources.

UNIT – III:

Data Analysis: Introduction, Terminology and concepts, Introduction to statistics, Central tendencies and distributions, Variance, Distribution properties and arithmetic, Samples/CLT, Basic machine learning algorithms, Linear regression, SVM, Naive Bayes.

UNIT-IV:

Data Visualization: Introduction, Types of data visualization.

Data for visualization: Data types, Data encodings, Retinal variables, Mapping variables to encodings, Visual encodings.

UNIT-V:

Applications of Data Science: Technologies for visualisation, Bokeh (Python), recent trends in various data collection and analysis techniques, various visualization techniques, application development methods of used in data science.

Course Outcomes:

CO1	Acquire the knowledge and expertise to become a proficient data scientist
CO2	Demonstrate an understanding of statistics and machine learning concepts that are vital for data science
CO3	Explain how data is collected, managed and stored for data science
CO4	Interpret the key concepts in data science, including their real-world applications and the toolkit used by data scientists
CO5	Illustrate data collection and management scripts using MongoDB

Text Books:

1. The Art of Data Science, 1st edition, Roger D. Peng and Elizabeth matsui, Lean Publications, 2015.
2. Algorithms for Data Science, 1st edition, Steele, Brian, Chandler, John, Reddy, Swarna, springers Publications, 2016

Reference Books:

1. Doing Data Science: Straight Talk From The Frontline, 1st edition, Cathy O'Neil and Rachel Schutt, O'Reilly, 2013
2. Mining of Massive Datasets, 2nd edition, Jure Leskovek, Anand Rajaraman and Jeffrey Ullman, v2.1, Cambridge University Press, 2014

III Year- II Semester

L	T	P	C
2	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.

III Year- II Semester

L	T	P	C
4	0	0	4

HONORS/MINOR COURSES

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)/ equivalent department course.
- Enhance knowledge in core subjects.
- Obtain knowledge in inter-disciplinary and job orientated minor courses.
- Acquire the skills for life-long learning.
- Diversify ones understanding of a topic useful to profession.

The departmental courses should be offered in lieu of MOOCS courses in case they are not available in NPTEL/SWAYAM. It is required for the students to do, a minimum of 7 courses to obtain the Honors/Minor degree. To fulfill the criteria of qualifying for Honors/minor degree, additional 20 credits are required.

The list of MOOCS/departmental courses in chemical engineering is given in Appendix-I to do honors and Appendix-II shows the courses for minor degree in chemical engineering. To obtain the minor degree for chemical students the eligible students has to do the courses in any one discipline other than Chemical Engineering.

The **20 credits** for honors or minor degree should be obtained from the fourth semester to the end of eighth semester. A candidate can take a 4-credit course in each semester during the above-mentioned period. It may be noted that, each eligible student has to get **minimum of 8.0 SGPA without any backlogs** in each semester to do honors/minor degree.

The eligible student shall register for the course **(Minimum of 12 weeks)** in the SWAYAM/NPTEL portal, offered through online with the approval of Head of the Department, under the guidance and supervision of a mentor/faculty. The student has to earn and submit a certificate by passing the exam conducted by SWAYAM/NPTEL for each course to obtain the required credits. If the student does not pass the subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered either through SWAYAM/NPTEL or department offered course in the next semester with the recommendation of mentor/faculty, approved by Head of the Department and shall pass in the examination. In case, of departmental courses also the eligible student should pass the examination in each subject conducted by the department to obtain the certificate.

Outcomes:

The students will be able to:

- Overcome the digital divide in acquiring knowledge skills in fast developing technologies and be a part of digital revolution.
- Become a part of National Resource Pool to contribute the subject specific expertise.
- Assess the academic / professional priorities for future development.
- Develop self-learning skills with open-ended problems, case studies for life-long learning.
- Develop additional knowledge skills in core and inter-disciplinary courses.
- Orient themselves with the learning methodologies outlined in the new educational policy of India.

III Year- II Semester

L	T	P	C
0	0	0	0

INDUSTRIAL/RESEARCH SUMMER INTERNSHIP
(MC)

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 industries like fertilizer / organic chemicals/ petroleum refinery/petrochemical complex/pharma /agrochemical/metallurgical etc., for 6-8 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.

IV Year- I Semester

L	T	P	C
3	0	0	3

PROCESS INTENSIFICATION
(PROFESSIONAL ELECTIVE – III)

Learning Objectives:

The student will be able to learn:

- The basic principles and mechanisms adopted in process intensification methodologies.
- The concepts of process intensification in various unit operations and unit processes.
- The case studies in petrochemical, fine chemical & pharmaceutical industries.
- The application of process intensification concepts to bioprocessing and bio-fuel technology.
- The application of process intensification concepts to carbon capture technologies.

UNIT-I:

History of Process Intensification: Rotating boilers – rotating non-pipe – separators – reactors – rotating heat transfer devices.

Overview of Process Intensification: Definition of Process Intensification (PI) – advantages of PI – obstacles to PI.

UNIT-II:

Mechanisms Involved in Process Intensification: Mechanisms involved in heat transfer intensification – mechanisms involved in mass transfer intensification – electrically enhanced process intensification – microfluidics – pressure.

Compact and Micro-heat exchangers & Process Intensification: Plate, printed-circuit, chart-flow, polymer film, foam and mesh heat exchangers – micro-heat exchangers – small channels – nanofluids.

UNIT-III:

Reactor Process Intensification: Spinning disc reactors – oscillatory baffled reactors – micro-reactors – field enhanced reactors – reactive separators – membrane reactors – miscellaneous reactor types.

Separation Process Intensification: Distillation (Dividing wall columns, compact heat exchanger inside the column, cyclic distillation, hi gee) – centrifuges – membranes – drying – precipitation and crystallization – mop fan – electrolysis.

Intensified Mixing: Inline mixers – spinning disc mixer – induction heated mixer.

UNIT-IV:

Process Intensification in Petrochemicals: Catalytic plate reactor applicability in refineries – stripping and gas clean up – intensified methane reforming – reactive distillations for methyl and ethyl acetate – microreactors for methanol production from formaldehyde – Degussa PI route for Hydrogen peroxide production – HEX reactor for olefin hydro formylation – Spinning disc reactors for polymerization – Reactive distillation for Akzo Nobel Chemicals.

UNIT-V:

Process Intensification in Fine chemicals and Pharmaceuticals: Pencillin extraction – Continuous reactor PI by Astra Zeneca – Micro reactor for barium sulphate production – Spinning disc reactor for barium sulphate production – Spinning disc reactor for producing drug intermediates – Continuous flow microwave reactor – Ultrasound and intensification of micro-encapsulation – Scaling up coflore flow reactor in chiral amines production.

Process Intensification in Bioprocessing and Biofuels: Transesterification of vegetable oils – Micro reactor for conversion of bio-ethanol to ethylene – Base chemicals produced from biomass.

Process Intensification for Carbon capture: Intensification of post combustion carbon capture processes – Intensification of other carbon capture processes.

Outcomes:

The students are able to:

- Apply the basic principles and mechanisms adopted in process intensification methodologies.
- Apply the concepts of process intensification in various unit operations and unit processes.
- Apply the concepts of process intensification in petrochemical, fine chemical & pharmaceutical industries.
- Apply the concepts of process intensification in bioprocessing and bio-fuel technology.
- Apply the concepts of process intensification in carbon capture technologies.

Text books:

1. Process Intensification: Engineering for Efficiency, Sustainability and Flexibility, D. Reay, C. Ramshaw and A. Harvey, Butterworth-Heinemann, 1st Edition, Burlington, 2008
2. Re-Engineering the Chemical Processing Plant: Process Intensification, A. Stankiewicz and J.A. Moulijn (Editors), Marcel Dekker, New York, 2004.

IV Year- I Semester

L	T	P	C
3	0	0	3

OPTIMIZATION TECHNIQUES FOR CHEMICAL ENGINEERS (PROFESSIONAL ELECTIVE – III)

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.

UNIT-II:

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-III:

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-IV:

Nonlinear Programming:

Elimination methods: Unrestricted search - exhaustive search - dichotomous search - interval halving method - Fibonacci method -comparison of elimination methods.

Direct search methods: Random search methods - grid search method- univariate method - pattern directions- Powell's method.
Indirect search (descent) methods: Gradient of a function- steepest descent (Cauchy) method- conjugate gradient (Fletcher–Reeves) method- Newton's method.

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.
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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FLUIDIZATION ENGINEERING
(PROFESSIONAL ELECTIVE – III)

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 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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PETROLEUM PRODUCTION ENGINEERING
(PROFESSIONAL ELECTIVE – IV)

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 for 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.
- Classify the properties of reservoir fluids and apply the Darcy's law for development of deliverability equations.
- 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 and apply appropriate 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- I Semester

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COMPUTATIONAL FLUID DYNAMICS
(PROFESSIONAL ELECTIVE – IV)

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- I Semester

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PETROLEUM RESERVOIR ENGINEERING
(PROFESSIONAL ELECTIVE – IV)

Learning Objectives:

The students will be able to learn:

- The basic concepts of reservoir engineering.
- PVT analysis for oil & gas reservoirs.
- The material balance applied to oil & gas reservoirs.
- The concepts of Darcy's law and its applications.
- The derivation of diffusivity equation and its applications.
- The derivation of well inflow equations for stabilized flow conditions.
- The concepts of water flooding.

UNIT-I:

Basic Concepts in Reservoir Engineering: Calculation of hydrocarbon volumes- fluid pressure regimes- oil recovery and recovery factor-volumetric gas reservoir engineering – application of the real gas equation of state - gas material balance and recovery factor- hydrocarbon phase behavior.

UNIT-II:

PVT analysis for oil: Definition of the basic PVT parameters – collection of fluid samples - determination of the basic parameters in the laboratory and conversion for field operating conditions - alternative manner of expressing PVT lab analysis results - complete PVT analysis.

UNIT-III:

Material Balance Applied To Oil Reservoirs: General form -the material balance expressed as a linear equation- reservoir drive mechanism- solution gas drive- gas cap drive- natural water drive- compaction drive under related pore compressibility phenomena.

UNIT-IV:

Darcy's Law and Applications: Darcy's law and fluid potential- sign convention- units and unit conversion- real gas potential – datum pressures- radial steady state flow and well stimulation- two phase flow- effective and relative permeabilities.

Radial Diffusivity Equation: The basic differential equation for radial flow in a porous medium- derivation of the basic radial differential equation – conditions of solution – the linearization of the equation for slightly compressible fluids.

UNIT-V:

Well Inflow Estimation for Stabilized Flow Conditions: Semi steady state solution – steady state solution – example of the application of the stabilized inflow equations – generalized form of inflow equation under semi steady state conditions.

Concepts of immiscible fluid displacement: basic concepts – fractional flow equation – Buckley-Leverett equation – the Welge method – water flooding.

Outcomes:

The students are able to:

- Apply the basic concepts of reservoir engineering.

- Calculate PVT properties for oil & gas.
- Perform the material balance for oil & gas reservoirs.
- Apply the concepts of Darcy's law.
- Adopt the diffusivity equation to solve reservoir engineering problems.
- Apply the well inflow equations for stabilized flow conditions to calculate deliverability of reservoirs.
- Apply concepts of immiscible fluid displacement in the secondary recovery of oil.

Text Books:

1. Fundamentals of Reservoir Engineering, L.P. Dake, Elsevier Science, 1978 (17^{th} Impression 1998).
3. B. C. Craft – M. Hawkins Applied Petroleum Reservoir Engineering, Third Edition, Revised by Ronald E. Terry & J. Brandon Rogers, Prentice Hall, New York, 2014.

Reference Books:

1. Reservoir Engineering Handbook, Tarek Ahmed, 3^{rd}Edition, Gulf Professional Publishing, 2006.
2. Petroleum Engineering: Principles and Practice, J.S Archer & C.G. Wall, Graham &Trotman Inc. 1986.
3. Basic Reservoir Engineering, Rene Cosse, Editions Technip, 1993.
4. Petroleum Reservoir Engineering, James W. Amyx, Daniel M. Bass Jr., Robert L. Whiting, McGraw Hill, 1960.

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 - 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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NANOTECHNOLOGY
(PROFESSIONAL ELECTIVE – V)

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 catalysts, Nano medical applications, textiles, paints, energy, defenses and space applications, structure applications, food and agriculture industry, cosmetics, consumer's goods, automotive industry, water treatment, and environment.

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, van der-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- I Semester

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NATURAL GAS ENGINEERING
(PROFESSIONAL ELECTIVE – V)

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.
- Design equipment 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 methods for 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- I Semester

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PIPELINE ENGINEERING
(OPEN ELECTIVE – III)

Learning Objectives:

The students will be able to learn:

- The elements of pipeline design, route selection & survey and geotechnical guidelines for construction.
- The concepts as well as design of pipeline natural gas transmission.
- The principles and design of gas compression systems.
- The fundamentals of liquid flow and design of pumps.
- The concepts of pipeline protection, instrumentation and pigging.
- The details of mechanical design of pipelines and selection of suitable materials.

UNIT-I:

Elements of pipeline design: Fluid properties – environment - effects of pressure and temperature - supply/demand scenario - route selection - codes and standards - environmental and hydrological considerations – economics - materials/construction – operation - pipeline protection - pipeline integrity monitoring.

Pipeline route selection, survey and geotechnical guidelines: Introduction - preliminary route selection - key factors for route selection - engineering survey - legal survey - construction / as-built survey - geotechnical design.

Pipeline construction: construction – commissioning.

UNIT-II:

Natural gas transmission: General flow equation – steady state - impact of gas molecular weight and compressibility factor on flow capacity - flow regimes – widely used steady-state flow equations – summary of the impact of different gas and pipeline parameters on the gas flow efficiency – pressure drop calculation for pipeline in series and parallel – pipeline gas velocity – erosional velocity – optimum pressure drop for design purposes – pipeline packing – determining gas leakage using pressure drop method – wall thickness/pipe grade – temperature profile – optimization process – gas transmission solved problems.

UNIT-III:

Gas compression: Types of compressors – compressor drivers – compressor station configuration – thermodynamics of isothermal and adiabatic gas compression – temperature change in adiabatic gas compression – thermodynamics of polytrophic gas compression – gas compressors in series – centrifugal compressor horsepower – enthalpy / entropy charts (mollier diagram) – centrifugal compressor performance curve- reciprocation compressors.

Coolers: Gas coolers – air-cooled heat exchangers –heat transfer equations for coolers – fan air mass flow rate – required fan power – gas pressure drop in coolers – iterative procedure for calculations based on unknown T_2.

UNIT-IV:

Liquid flow and pumps: Fully developed laminar flow in a pipe – turbulent flow –multiphase flow - centrifugal pumps – retrofitting for centrifugal pumps (radial-flow) –pump station control – pump station piping design.

Pipeline protection, Instrumentation and Pigging: Pipeline coating – cathodic protection – cathodic protection calculations for land pipelines – internal corrosion – flow meters and their calibration – sensors – pigs.

UNIT-V:

Pipeline mechanical design: Codes and standards – location classification – pipeline design formula – expansion and flexibility – joint design for pipes of unequal wall thickness – valve assemblies – scraper traps – buoyancy control – crossings – depth of cover – aerial markings – warning signs.

Materials selection: Elements of design – materials designation standards.

Outcomes:

The students are able to:

- Apply the elements of pipeline design, route selection & survey and geotechnical guidelines for construction.
- Design pipelines for natural gas transmission.
- Design of natural gas compression systems.
- Design of oil pipelines and pumping systems.
- Use the different methods of pipeline protection, instrumentation and pigging for monitoring pipeline systems.
- Carry out mechanical design of pipelines and selection of suitable materials.

Text Books:

1. Pipeline Design and Construction: A Practical Approach, M. Mohitpour, H. Golshan and M.A. Murray, 2nd Edition, ASME Press, 2007.
2. Pipeline Engineering, Henry Liu, Lewis Publishers (CRC Press), 2003.

Reference Books:

1. Piping Calculation Manual, E. Shashi Menon, McGraw-Hill, 2004.
2. Piping and Pipeline Engineering: Design, Construction, Maintenance Integrity and Repair, George A. Antaki, CRC Press, 2003.
3. Pipeline Planning and Construction Field Manual, E. Shashi Menon, Gulf Professional Publishing, 2011.
4. Pipeline Rules of Thumb Handbook, E. W. McAllister, 7th Edition, 2009.
5. Liquid Pipeline Hydraulics, E. Shashi Menon, Mareel Dekker, Inc., 2004.
6. Gas Pipeline Hydraulics, E. Shashi Menon, Taylor & Francis, 2005.

IV Year- I Semester

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CHEMICAL PROCESS SAFETY
(OPEN ELECTIVE – III)

Learning Objectives:

The students will be able to learn:

- HSE aspects in handling and storage of hazardous chemicals and 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 - significant disasters: case studies.

UNIT-II:

Toxicology: Classification of Toxic substances - Effects of toxicants on biological organisms - Threshold limit values.

Industrial hygiene: Government of India and OSHA regulations - 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.

UNIT-V:

Hazards identification: Process hazards checklists - Hazards surveys - Hazard and operability studies - Safety reviews.

Risk assessment: Review of probability theory - Event trees - Fault trees - QRA and LOPA.

Outcomes:

The students are able to:

- Assess various hazards involved in handling hydrocarbons in Oil & Gas sector.
- Apply procedures to maintain the industrial hygiene.
- Evaluate toxic substances in handling and operation.
- Design various stages of operations without safety risk.
- Design methods to prevent fires and explosions.
- Design and operate liquid & gas relief systems.
- Visualize all possible safety issues at all the phases of industry by applying the techniques like HAZOP, QRA etc.,

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.

IV Year- I Semester

L	T	P	C
3	0	0	3

INTRODUCTION TO SEPARATION PROCESSES
(OPEN ELECTIVE – III)

Learning Objectives:
The students will be able to learn:

- Classification of various mass transfer operations.
- Fick's law and its applications as well as the theory on mass transfer coefficients.
- The basic concepts of humidification and the design of humidification and dehumidification equipment.
- The concepts of gas absorption & stripping and design of various types of equipment.
- The separation of liquids by distillation and its design methods.
- The basic concepts of extraction & leaching and design of various types of equipment.
- The basic concepts and design considerations of drying & membrane separation processes.

UNIT-I:
Introduction: Definition and classification of various mass transfer operations, Fick's law of diffusion – equimolal counter diffusion and Stefen's diffusion – individual and over-all mass transfer coefficients – inter phase mass transfer.

UNIT-II:
Humidification: Fundamental terms – humidification & dehumidification operations – cooling towers.
Absorption and stripping: Basic concepts of gas absorption in liquids – co current and counter current absorption- tray columns: number of trays calculations by graphical and analytical methods, different types of tray columns – packed columns: concepts of HTU, NTU and HETP, calculation of height of the column, different types of packings – principles of stripping in columns.

UNIT-III:
Distillation-I: Ideal and non-ideal liquid mixtures – vapor – liquid equilibria – batch distillation – steam distillation - flash distillation – continuous fractionation – determination of number of equilibrium stages by using graphical methods and analytical methods.
Distillation-II: Distillation equipment – bubble cap, perforated, valve tray columns – packed columns – merits and demerits of tray columns and packed columns – point efficiency – tray efficiency – overall column efficiency.

UNIT-IV:
Extraction: Basic concepts of liquid – liquid equilibria - triangular diagrams and their application – description of equipment - tray extractors: single and multi-stage extraction, co current and counter current methods, analytical calculations for number of stages – packed extractors: application of HTU and NTU methods, packings for extraction.
Leaching: Basic concepts of solid-liquid equilibria – description of equipment – calculation of number of stages.

UNIT-V:

Drying: Basic concepts of drying – rate of batch drying under constant drying conditions – mechanism of batch and continuous drying - different types of dryers and their operation – design considerations.

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, pervaporation, dialysis, membrane extraction, electro-dialysis. Types of synthetic membranes - membrane modules and brief introduction to cryogenic separations - industrial applications.

Outcomes:

The students are able to:

- Classify various mass transfer operations.
- Apply Fick's law and theory on mass transfer coefficients in transfer operations.
- Design and operate humidification & dehumidification equipment.
- Design and operate gas absorption & stripping equipment.
- Design and operate distillation columns.
- Design and operate extraction & leaching equipment.
- Design and operate drying & membrane processes.

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.

IV Year- I Semester

L	T	P	C
3	0	0	3

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

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 of 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. (Text Books 3 & 4)

UNIT – III:
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 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.
3. Dow's Chemical Exposure Index Guide, Dow, 1st Edition, AIChE technical manual, American Institute of Chemical Engineers, 1994.
4. Dow's Fire & Explosion Index Hazard Clasification Guide, Dow, 7th Edition, AIChE technical manual, American Institute of Chemical Engineers, 1994.

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 – IV)

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.
- Apply knowledge of 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

INTRODUCTION TO META-ANALYSIS AND DESIGN OF EXPERIMENTS (OPEN ELECTIVE – IV)

Learning Objectives:

The students will be able to learn:

- A statistical analysis approach to prior available data, perform a meta-analysis and identify data gap in knowledge base and suggest future research directions.
- The concepts of linear and non-linear regression analysis.
- The use of various software packages for statistical design and analysis of experiments.
- Designing and carry out experimental plans based on impact of various process parameters and their interactive features and finally, analyze the data generated from their own experiments.
- The efficient analysis of the data generated from experimentation that can be validated for utilization towards process modeling and simulation.

UNIT-I:

Meta-analysis: Introduction – Definition and approach to perform a quantitative analysis of the all the available data – the streptokinase meta-analysis – statistical significance –application of the analysis results – consistency of effects.

Effect size and precision: Overview, effect sizes based on means – introduction - raw mean difference *D* – standardized mean difference, *d* and *g* and effect sizes based on binary data – introduction – risk ratio – odds ratio – risk difference – choosing an effect size index, converting among effect sizes – introduction - Converting from the log odds ratio to *d*, Converting from *d* to the log odds ratio, Converting from *r* to *d* - Converting from *d* to *r*, factors that affect precision.

UNIT-II:

Fixed-effect and Random-effects Model: introduction, the true effect size, impact of sampling error, performing a fixed – effect meta-analysis and Performing a random-effects meta-analysis.

UNIT-III:

Introduction to probability, Probability laws, Bayes' theorem, Probability distributions, Parameters and statistics.

Normal and t-distributions, Central limit theorem, Random sampling and declaration of independence significance tests.

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 of open source packages for experimental design.

Outcomes:

The students are able to:

- Apply the statistical approach to prior available data, perform a meta-analysis and identify data gap in knowledge base and suggest future research directions.
- Design and carry out experiments based on impact of various process parameters and their interactive features and finally, analyze the data generated from their own experiments.
- 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.
- Minimize the number of experiments and study the impact of large number of parameters.
- Use various software packages for design and analysis of experiments.

Text Books:

1. Introduction to Meta-Analysis, Michael Borenstein, Larry V. Hedges, Julian P.T. Higgins and Hannah R. Rothstein, John Wiley & Sons, 2009.
2. Statistics for Experimenters, G.E.P. Box, William G. Hunter and J.S. Hunter, John Wiley & Sons. 1978.
3. Design and Analysis of Experiments, D.C. Montgomery, 2nd Edition, John Wiley and Sons, 1984.

Reference Book:

1. Design of Experiments in Chemical Engineering: A Practical Guide, Zivorad R. Lazic, Wiley – VCH, 2005.

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

UNIVERSAL HUMAN VALUES 2: UNDERSTANDING HARMONY

(MC)

IV Year - I Semester

L	T	P	C
1	0	2	2

CLOUD COMPUTING
(SOFT SKILL COURSE)

Learning Objectives:

- Ability to understand various service delivery models of a cloud computing architecture.
- Ability to understand the ways in which the cloud can be programmed and deployed.
- Understanding cloud service providers.
- Understand and learn the Characteristics of IaaS and Characteristics of PaaS
- Learn and gain knowledge about the Cloud Service providers.

UNIT-I:

Computing Paradigms: High-Performance Computing, Parallel Computing, Distributed Computing, Cluster Computing, Grid Computing, Cloud Computing, Bio computing, Mobile Computing, Quantum Computing, Optical Computing, Nano computing.

UNIT-2:

Cloud Computing Fundamentals: Motivation for Cloud Computing, The Need for Cloud Computing, Defining Cloud Computing, Definition of Cloud computing, Cloud Computing Is a Service, Cloud Computing Is a Platform, Principles of Cloud computing, Five Essential Characteristics, Four Cloud Deployment Models.

UNIT-3:

Cloud Computing Architecture and Management: Cloud architecture, Layer, Anatomy of the Cloud, Network Connectivity in Cloud Computing, Applications, on the Cloud, Managing the Cloud, Managing the Cloud Infrastructure Managing the Cloud application, Migrating Application to Cloud, Phases of Cloud Migration Approaches for Cloud Migration.

UNIT-4:

Cloud Service Models: Infrastructure as a Service, Characteristics of IaaS. Suitability of IaaS, Pros and Cons of IaaS, Summary of IaaS Providers, Platform as a Service, Characteristics of PaaS, Suitability of PaaS, Pros and Cons of PaaS, Summary of PaaS Providers, Software as a Service, Characteristics of SaaS, Suitability of SaaS, Pros and Cons of SaaS, Summary of SaaS Providers, Other Cloud Service Models.

UNIT-5:

Python for Amazon Web Services, Python for Google Cloud Platform, Python for Windows Azure, Python for MapReduce, Python Packages of Interest, Python Web Application Framework – Django, Designing a RESTful Web API. Cloud Application Development in Python, Design Approaches, Image Processing APP, Document Storage App, MapReduce App, Social Media Analytics App, Cloud Application Benchmarking and Tuning, Cloud Security, Cloud Computing for Education.

Outcomes:

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

CO1 Explain different types of Computing

CO2 Illustrate Four types of Cloud Deployment Models

CO3 Demonstrate different Phases of Cloud Migration Approaches for Cloud Migration

CO4 Analyze and Develop Cloud Service Models

CO5 Design applications for an organization which use cloud environment.

Text Books:

1. Essentials of cloud Computing: K. Chandrasekhran, CRC press, 2014
2. ArshadeepBhaga, Vijay Madisetti, "Cloud Computing AHandson Approach", Universities Press, 2018

Reference Books:

1. Cloud Computing: Principles and Paradigms by RajkumarBuyya, James Broberg and Andrzej M. Goscinski, Wiley, 2011.
2. Distributed and Cloud Computing, Kai Hwang, Geoffery C. Fox, Jack J. Dongarra, Elsevier, 2012.
3. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, Tim Mather, SubraKumaraswamy, ShahedLatif, O'Reilly, SPD,rp2011.

IV Year - I Semester

L	T	P	C
0	0	0	3

INDUSTRIAL/RESEARCH SUMMER INTERNSHIP EVALUATION

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 field operation, troubleshooting and engineering work.
- Present and / or report the work / project outcomes to various disciplines, departments & interest groups with confidence.
- To give a clear, organized and accurate oral presentation of Summer Training/Internship Report.
- To provide verbally/ through power point presentation of condensed large amounts of technical information into concise, condensed analysis.
- Sharing the practical knowledge obtained during training with fellow students.

Every Student should undergo an industrial/research summer training in a chemical processing industry/ fertilizer industry/ petroleum refinery/petrochemical complex for **6-8 weeks** and submit a report**.**

An industrial/research summer internship report is a documentation of a student's work—a record of the original work done by the student in the industrial/research summer internship of 6-8 week duration during VII semester.

Industrial/research summer Internship of the students shall be evaluated for **50 (1.5 credits) marks for weightage of 50% - Report and 50% - oral presentation** by a committee constituted by the Head of the Department along with an industry expert or a faculty from other departments.

Outcomes: Students will extend their abilities to:

- Get themselves good clarity in the technical topics being presented.
- Develop good communication skills.
- Practice the behaviors of effective speakers.
- Assess strengths in speaking and set goals for future growth.

IV Year- I Semester

L	T	P	C
4	0	0	4

HONORS/MINOR COURSES

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)/ equivalent department course.
- Enhance knowledge in core subjects.
- Obtain knowledge in inter-disciplinary and job orientated minor courses.
- Acquire the skills for life-long learning.
- Diversify ones understanding of a topic useful to profession.

The departmental courses should be offered in lieu of MOOCS courses in case they are not available in NPTEL/SWAYAM. It is required for the students to do, a minimum of 7 courses to obtain the Honors/Minor degree. To fulfill the criteria of qualifying for Honors/minor degree, additional 20 credits are required.

The list of MOOCS/departmental courses in chemical engineering is given in Appendix-I to do honors and Appendix-II shows the courses for minor degree in chemical engineering. To obtain the minor degree for chemical students the eligible students has to do the courses in any one discipline other than Chemical Engineering.

The **20 credits** for honors or minor degree should be obtained from the fourth semester to the end of eighth semester. A candidate can take a 4-credit course in each semester during the above-mentioned period. It may be noted that, each eligible student has to get minimum of 8.0 SGPA without any backlogs in each semester to do honors/minor degree.

The eligible student shall register for the course **(Minimum of 12 weeks)** in the SWAYAM/NPTEL portal, offered through online with the approval of Head of the Department, under the guidance and supervision of a mentor/faculty. The student has to earn and submit a certificate by passing the exam conducted by SWAYAM/NPTEL for each course to obtain the required credits. If the student does not pass the subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered either through SWAYAM/NPTEL or department offered course in the next semester with the recommendation of mentor/faculty, approved by Head of the Department and shall pass in the examination. In case, of departmental courses also the eligible student should pass the examination in each subject conducted by the department to obtain the certificate.

Outcomes:

The students will be able to:

- Overcome the digital divide in acquiring knowledge skills in fast developing technologies and be a part of digital revolution.
- Become a part of National Resource Pool to contribute the subject specific expertise.
- Assess the academic / professional priorities for future development.
- Develop self-learning skills with open-ended problems, case studies for life-long learning.
- Develop additional knowledge skills in core and inter-disciplinary courses.
- Orient themselves with the learning methodologies outlined in the new educational policy of India.

IV Year- II Semester

L	T	P	C
0	0	0	12

PROJECT AND SEMINAR
(INDUSTRIAL INTERNSHIP/RESEARCH LABS/IN-HOUSE)

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.
- Do basic design of the process using steady state simulation and generate PFD, heat & material balances and summary of utility consumption.
- Make the 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/Emerging technologies 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/petrochemical process.

c) Any experimental work with physical interpretations.

The project work shall be evaluated for 200 marks (12 credits), 60 marks shall be for Internal Evaluation and 140 marks for the End Semester Examination. The End Semester Examination (Viva-Voce) shall be conducted by the committee. The committee consists of an external examiner, Head of the Department and Supervisor of the Project. The evaluation of project work shall be conducted at the end of the IV year. The Internal Evaluation shall be on the basis of two seminars given by each student on the topic of his project and evaluated by an internal committee.

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.