RAJALAKSHMI ENGINEERING COLLEGE
DEPARTMENT OF CHEMICAL ENGINEERING
B. TECH. CHEMICAL ENGINEERING
REGULATIONS 2019
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABUS

VISION

To be a center of excellence in chemical engineering to provide well prepared professionals to the industries and society.

MISSION

- To provide state of art environment to the students for better learning to cater for the chemical industries and pursue higher studies.
- To provide space to the students in research to think, create and innovate things.

PEOs'

1. To produce employable graduates with the knowledge and competency in Chemical Engineering complemented by the appropriate skills and attributes.
2. To produce creative and innovative graduates with design and soft skills to carry out various problem solving tasks.
3. To enable the students to work as teams on multidisciplinary projects with effective communication skills, individual, supportive and leadership qualities with the right attitudes and ethics.
4. To produce graduates who possess interest in research and lifelong learning, as well as continuously striving for the forefront of technology.

Program Outcomes (POs)

Engineering Graduates will be able to

1. Engineering Knowledge:

Apply the knowledge of mathematics, science, and engineering fundamentals, to solve the complex chemical engineering problems

2. Problem analysis:

Identify, formulate, review research literature, and analyze complex chemical engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

3. Design/development of solutions:

Design solutions for complex chemical engineering problems and design system components or process that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal and environmental considerations.

4. Conduct investigations of complex problems:

Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to proceed valid conclusions.

5. Modern tool usage:

Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex chemical engineering activities with an understanding of the limitations.

6. The engineer and society:

Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional chemical engineering practice.

7.Environment and sustainability:

Understand the impact of the professional chemical engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development.

8. Ethics:

Apply ethical principles and commit to professional ethics and responsibilities and norms of the chemical engineering practice.

9. Individual and team work:

Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication:

Communicate effectively on complex chemical engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance:

Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning:

Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological changes in chemical engineering.

PSO

1. Graduates will be able to apply chemical engineering principles to design equipment and a process plant.
2. They will be able to control and analyse chemical, physical and biological processes including the hazards associated with these processes.
3. Will be able to develop mathematical models of real world industrial problems and compute solutions to dynamic processes.

I SEMESTER

S.No	Course Code	Course Name	Periods per week				Credits	Category
			L	T	P	Total		
1	HS19151	Technical English	2	1		3	3	HS
2	MA19153	Applied Calculus	3	1		4	4	BS
3	PH19151	Physics for Chemical Engineering	3			3	3	BS
4	CY19141	Chemistry for Technologists	3		2	5	4	BS
5	GE19101	Engineering Graphics	2	2		4	4	ES
6	GE19121	Engineering Practices – Mech & Civil			2	2	1	ES
7	MC19101	Environmental Science (Non Credit course)	3			3		MC
Total			16	4	4	24	**19**	

II SEMESTER

S.No	Course Code	Course Name	Periods per week				Credits	Category
			L	T	P	Total		
1	MA19251	Differential Equations and Vector Calculus	3	1		4	4	BS
2	PH19243	Material Science	3		2	5	4	BS
3	CY19242	Physical Chemistry	3		2	5	4	BS
4	EE19242	Basic Electrical and Electronics Engineering	3		2	5	4	ES
5	GE19141	Programming using C	2		4	6	4	ES
6	GE19122	Engineering Practices – Electrical & Electronics			2	2	1	ES
7	MC19102	Indian Constitution and Freedom Movement (Non Credit course)	3			3	0	MC
Total			17	1	12	30	**21**	

III SEMESTER

S.No	Course Code	Course Name	Periods per week				Credits	Category
			L	T	P	Total		
1	MA19351	Transforms and Statistics	3	1		4	4	BS
2	CY19301	Organic Chemistry	3			3	3	BS
3	CH19301	Solid Mechanics	2	1		3	3	ES
4	CH19302	Chemical Process Calculations	2	2		4	4	PC
5	CH19341	Fluid Mechanics for Chemical Engineers	3	1	2	6	5	PC
6	GE19301	Life Science for Engineers	3			3	3	ES
7	MC19301	Essence of Indian Traditional Knowledge (Noncredit course)	3			3	0	MC
Total			19	5	2	26	**22**	

IV SEMESTER

S.No	Course Code	Course Name	Periods per week				Credits	Category
			L	T	P	Total		
1	MA19451	Numerical Methods	3	1		4	4	BS
2	CH19401	Chemical Process Industries	3			3	3	PC
3	CH19402	Thermodynamics	2	1		3	3	ES
4	CH19403	Heat Transfer	3	1		4	4	PC
5	CH19441	Particle science and Technology	3		2	5	4	PC
6		Open Elective I	3			3	3	OE
7	GE19421	Soft Skills I	0		2	2	1	EEC
Total			17	3	4	24	22	

V SEMESTER

S.No	Course Code	Course Name	Periods per week				Credits	Category
			L	T	P	Total		
1	CH19501	Process Engineering Economics	3			3	3	HS
2	CH19502	Chemical Engineering Thermodynamics	2	1		3	3	PC
3	CH19503	Mass Transfer I	2	1		3	3	PC
4	CH19504	Chemical Reaction Engineering I	2	1		3	3	PC
5		Elective I	3			3	3	PE
6		Open elective II	3			3	3	OE
7	GE19521	Soft Skills II	0		2	2	1	EEC
8	CH19511	Heat Transfer Lab	0		4	4	2	PC
Total			15	3	6	24	**21**	

VI SEMESTER

S.No	Course Code	Course Name	Periods per week				Credits	Category
			L	T	P	Total		
1	CH19601	Mass Transfer II	3	1		4	4	PC
2	CH19602	Chemical Reaction Engineering II	2	1		3	3	PC
3	CH19603	Process Control	3			3	3	PC
4		Elective II	3			3	3	PE
5	GE19621	Problem Solving Techniques			2	2	1	EEC
6	CH19611	Process Equipment Design			4	4	2	PC
7	CH19612	Mass Transfer Lab			4	4	2	PC
8	CH19613	Innovation and Design Thinking for Chemical Engineers	0	1	2	3	2	EEC
Total			11	3	12	26	**20**	

VII SEMESTER

S.No	Course Code	Course Name	Periods per week				Credits	Category
			L	T	P	Total		
1	CH19701	Transport Phenomena	3	1		4	4	PC
2	CH19702	Comprehensive Chemical Engineering		3		3	3	PC
3	CH19703	Computer Applications in Chemical Engineering	2	1		3	3	PC
4		Elective III	3			3	3	PE
5		Elective IV	3			3	3	PE
6	CH19711	Chemical Reaction Engineering lab			4	4	2	PC
7	CH19712	Process Control Lab			4	4	2	PC
8	CH19713	Computer Applications In Chemical Engineering Lab			4	4	2	PC
Total			11	5	12	28	**22**	

VIII SEMESTER

S.No	Course Code	Course Name	Periods per week				Credits	Category
			L	T	P	Total		
1		Elective V	3			3	3	PE
2	CH19811	Seminar			4	4	2	EEC
3	CH19812	Project			20	20	10	EEC
Total			3		24	27	**15**	

PROFESSIONAL ELECTIVE – I

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	CH19P51	Enzyme Engineering	PE	3	3	0	0	3
2	CH19P52	Waste Water Treatment	PE	3	3	0	0	3
3	CH19P53	Food Technology	PE	3	3	0	0	3
4	CH19P54	Renewable Energy Technology	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE – II

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	CH19P61	Air Pollution and Control	PE	3	3	0	0	3
2	CH19P62	Petroleum Refining and Petrochemicals	PE	3	3	0	0	3
3	CH19P63	Industrial Process Plant Safety	PE	3	3	0	0	3
4	CH19P64	Industrial Nanotechnology	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE – III

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	CH19P71	Environmental Technology	PE	3	3	0	0	3
2	CH19P72	Piping and Instrumentation	PE	3	3	0	0	3
3	CH19P73	Nuclear Technology	PE	3	3	0	0	3
4	CH19P74	Modern Separation Techniques	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE – IV

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	CH19P75	Instrumental Methods of Chemical Analysis	PE	3	3	0	0	3
2	CH19P76	Pinch Technology	PE	3	3	0	0	3
3	CH19P77	Bioprocess Technology	PE	3	3	0	0	3
4	CH19P78	Biochemical Engineering	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE – V

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	CH19P81	Optimization Techniques in Chemical Engineering	PE	3	3	0	0	3
2	CH19P82	Fertilizer Technology	PE	3	3	0	0	3
3	CH19P83	Pilot Plant and Scale-up Studies	PE	3	3	0	0	3
4	CH19P84	Fluidization Technology	PE	3	3	0	0	3

LIST OF OPEN ELECTIVES

S. No	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1	CH19O31	Introduction to Fertilizer Technology	OE	3	3	0	0	3
2	CH19O32	Introduction to Process Technology	OE	3	3	0	0	3

CREDIT DISTRIBUTION

S. No	Catagory	Credits Per Semester								Total Credits
		I	II	III	IV	V	VI	VII	VIII	
1	HS	3	-	-	-	3	-	-	-	6
2	BS	11	12	7	4	-	-	-	-	34
3	ES	5	9	6	3	-	-	-	-	23
4	PC	-	-	9	11	11	14	16	-	61
5	PE	-	-	-	-	3	3	6	3	15
6	OE	-	-	-	3	3	-	-	-	6
7	EEC	-	-	-	1	1	3	-	12	17
Total		19	21	22	22	21	20	22	15	162

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REGULATIONS 2019
SYLLABUS

I SEMESTER

Subject Code	Subject Name	Category	L	T	P	C
HS19151	TECHNICAL ENGLISH Common to all branches of B.E./ B.Tech programmes – I semester	HS	2	1	0	3

Objectives:	
●	To enable learners to acquire basic proficiency in English reading and listening.
●	To write in English precisely and effectively.
●	To speak flawlessly in all kinds of communicative contexts.

UNIT-I	**VOCABULARY BUILDING**	**9**
The concept of word formation - Root words from foreign languages and their use in English - Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives - Synonyms, antonyms, and standard abbreviations. Compound words – abbreviation – single word substitution – **Listening:** Listening comprehension, listening to motivational speeches, podcasts and poetry. **Speaking:** Short talks on incidents - place of visit – admiring personalities, etc.		
UNIT-II	**BASIC WRITING SKILLS**	**9**
Sentence structures - Use of phrases and clauses in sentences - punctuation - coherence - Organizing principles of paragraphs in documents - Techniques for writing precisely. **Reading & Writing** – Free writing – paragraphs - article reading and writing criticism - change of tense forms in short text or story – inferential reading – rewrite or interpret text - prepare questions based on the text. **Speaking:** Everyday situations – conversations and dialogues, speaking for and against.		
UNIT-III	**GRAMMAR AND LANGUAGE DEVELOPMENT**	**9**
Subject-verb agreement- Noun-pronoun agreement - Articles – Prepositions – Redundancies. **Reading & Writing:** Read from innovation and ideas that changed the world, newspaper column writing – **Speaking:** Demonstrative speaking practice using visual aids (charts, graphs, maps, pictures, etc,.).		
UNIT-IV	**WRITING FOR FORMAL PRESENTATION**	**9**
Nature and Style of sensible Writing - Describing – Defining – Classifying - Providing examples or evidence - Writing introduction and conclusion. **Reading & Writing –** Read from Literary pieces – identify different parts text – difference between print and digital writing. Writing: Recommendations - Foreword - Review of book. **Speaking-** Formal Presentations – Debate on social issues/taboos and solutions.		
UNIT-V	**EXTENDED WRITING AND SPEAKING**	**9**
Writing: Précis writing – Essay writing – workplace communication: Resume – Business letters and emails – Proposals. **Speaking:** Panel discussion – reporting an event – mock interview – Master Ceremony.		
	Total Contact Hours : 45	

Course Outcomes: On completion of course students will be able to	
●	Discuss and respond to the listening content.
●	Read and comprehend different texts and appreciate them
●	Understand structures and techniques of precise writing
●	Analyse different genres of communication and get familiarized with new words, phrases, and sentence structures.
●	Write and speak appropriately in varied formal and informal contexts.

Text Books:	
1	1. English for Technologists & Engineers, Orient BlackSwan Publications, Chennai 2012.

Reference Books / Web links:	
1	Technical Communication, Meenakshi Raman & Sangeeta Sharma, Oxford University Press
2	Effective Communication Skills, Kulbushan Kumar, Khanna Publishing House, Delhi
3	Communication Skills, Pushplata, Sanjay Kumar, Oxford University Press
4	Practical English Usage. Michael Swan. OUP. 1995.
5	Remedial English Grammar. F.T. Wood. Macmillan.2007
6	On Writing Well. William Zinsser. Harper Resource Book. 2001
7	Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
8	Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
MA19153	**APPLIED CALCULUS** **Common to I sem. B.Tech. – Biotechnology, Food Technology & Chemical Engineering**		**3**	**1**	**0**	**4**

Objectives:

- To gain knowledge in using matrix algebra techniques.
- To understand the techniques of calculus which are applied in the Engineering problems.

UNIT-I	**MATRICES**	**12**

Symmetric and skew – symmetric matrices , orthogonal matrices – Eigen values and Eigen vectors - Cayley – Hamilton theorem (without proof) and applications - orthogonal transformation and quadratic forms to canonical forms - Nature of quadratic forms.

UNIT-II	**APPLICATION OF DIFFERENTIAL CALCULUS**	**12**

Curvature in Cartesian co-ordinates – Centre and radius of curvature – Circle of curvature – Evolutes – Envelopes - Evolutes as envelope of normals.

UNIT-III	**FUNCTIONS OF SEVERAL VARIABLES**	**12**

Partial differentiation – Homogeneous functions and Euler's theorem – Total derivative – Change of variables – Jacobians – Partial differentiation of implicit functions – Taylor's series for functions of two variables – Maxima and minima of functions of two variables – Lagrange's method of undetermined multipliers.

UNIT-IV	**APPLICATION OF INTEGRATION AND IMPROPER INTEGRALS**	**12**

Evaluation of area, surface area and volume of revolution - Centre of Gravity – Moment of inertia – Improper integrals: Beta and Gamma integrals and their properties .

UNIT-V	**MULTIPLE INTEGRAL**	**12**

Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of solids – Change of variables in double and triple integrals.

	Total Contact Hours	**:**	**60**

Course Outcomes:

On completion of course students will be able to

- Apply the concept of Eigenvalues and eigenvectors, diagonalization of a matrix for solving problems.
- Analyze, sketch and study the properties of different curves.
- Handle functions of several variables and problems of maxima and minima.
- Apply the techniques of integration in engineering problems and to use the concept of improper integrals.
- Apply integration to compute multiple integrals, area, volume, integrals in polar coordinates, in addition to change of order and change of variables.

Text Books:	
1	Grewal B.S., " Higher Engineering Mathematics ", Khanna Publishers, New Delhi, 43rd Edition, 2014.
2	T Veerarajan, Engineering Mathematics –I , Tata Mc Graw Hill Education, 2014
Reference Books / Web links:	
1	Ramana. B.V., " Higher Engineering Mathematics ", Tata Mc.Graw Hill Education Pvt. Ltd, New Delhi, 2016.
2	Erwin Kreyszig ," Advanced Engineering Mathematics ", John Wiley and Sons, 10th Edition, New Delhi, 2016.
3	Bali, N.P. and Manish Goyal, A Text Book of Engineering Mathematics, Lakshmi Publications Pvt. Ltd., New Delhi, 2006.

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
PH19151	**PHYSICS FOR CHEMICAL ENGINEERING** **I sem. B.Tech. Chemical Engineering**	BS	**3**	**0**	**0**	**3**

Objectives:

- To understand the elastic behavior in solid, basics of Laser and Fiber optics communication and their applications.
- To gain the knowledge in thermal properties of materials, Interaction of photons and structure in solids and their applications.

UNIT-I **PROPERTIES OF MATTER** **9**

Elasticity – Stress-strain diagram and its uses - factors affecting elastic modulus and tensile strength – torsional stress and deformations – twisting couple - torsion pendulum: theory and experiment - bending of beams –area moment of inertia - bending moment – cantilever - applications – uniform and non-uniform bending- I-shaped girders - stress due to bending in beams.

UNIT-II **WAVES AND OPTICS** **9**

Oscillatory motion – forced and damped oscillations: differential equation and its solution – plane progressive waves – wave equation. Lasers: population of energy levels, Einstein's A and B coefficients derivation – resonant cavity, optical amplification (qualitative) –CO_2 laser - Semiconductor lasers: homo junction and heterojunction – Fiber optics: principle, numerical aperture and acceptance angle - types of optical fibers (material, refractive index, mode) – losses associated with optical fibers - fiber optic sensors: pressure and displacement.

UNIT-III **THERMAL PHYSICS** **9**

Transfer of heat energy – thermal expansion of solids and liquids – expansion joints - bimetallic strips - thermal conduction, convection and radiation –rectilinear heat flow – thermal conductivity - Forbe's and Lee's disc method: theory and experiment - conduction through compound media (series and parallel) – thermal insulation – applications: heat exchangers, refrigerators, ovens and solar water heaters.

UNIT-IV **QUANTUM PHYSICS** **9**

Black body radiation – Planck's theory (derivation) – Compton effect: theory and experimental verification – wave particle duality – electron diffraction – concept of wave function and its physical significance – Schrödinger's wave equation – time independent and time dependent equations – particle in a one-dimensional rigid box – tunneling (qualitative) – electron microscope - scanning-tunneling microscope.

UNIT-V **CRYSTAL PHYSICS** **9**

Single crystalline, polycrystalline and amorphous materials – single crystals: unit cell, crystal systems, Bravais lattices, directions and planes in a crystal, Miller indices – inter-planar distances -reciprocal lattice - coordination number and packing factor for SC, BCC, FCC, and HCP –Polymorphism and allotropy: diamond and graphite structures - crystal imperfections: point defects, line defects – Burger vectors, stacking faults – role of imperfections in plastic deformation - growth of single crystals: solution and melt growth techniques.

Contact Hours : 45

Course Outcomes:

On completion of the course students will be able to

- Apply the knowledge of basic properties of matter and its applications in Engineering.
- Use the concepts of waves and optical devices and their applications in fiber optics.
- Use the concepts of thermal properties of materials in heat exchangers.
- Use the concepts of quantum theory in electron microscope and material sciences.
- Apply the basic knowledge of crystallography for materials preparation and device fabrication.

Text Books:	
1	Bhattacharya, D.K. &Poonam, T. "Engineering Physics". Oxford University Press, 2015.
2	Gaur, R.K. & Gupta, S.L. "Engineering Physics". DhanpatRai Publishers, 2012.
Reference Books / Web links:	
1	Halliday, D., Resnick, R. & Walker, J. "Principles of Physics". Wiley, 2015.
2	Serway, R.A. & Jewett, J.W. "Physics for Scientists and Engineers". Cengage Learning, 2010.
3	Tipler, P.A. &Mosca, G. "Physics for Scientists and Engineers with Modern Physics'. W.H.Freeman, 2007.
4	Arthur Besier and S. Rai Choudhury,Concepts of Modern Physics (SIE), 7th edition, McGraw-Hill Education, 1994.
5	R. Murugeshan and Kiruthiga Sivaprasath, Modern Physics, S. Chand, 2015.
6	Pandey, B.K. &Chaturvedi, S. "Engineering Physics". Cengage Learning India, 2012.

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CY19141	**CHEMISTRY FOR TECHNOLOGISTS** **Common to I sem. B.Tech. – Chemical Engineering and II sem. B.Tech. – Biotechnology & Food Technology**	BS	**3**	**0**	**2**	**4**

Objectives:

- To acquire molecular level understanding of matter
- To understand the basics of surface chemistry and nanomaterials
- To attain knowledge on natural products and polymers

UNIT-I CHEMICAL BONDING **9**

Types of chemical bonds - electronegativity - bond polarity and dipole moments, partial ionic character of covalent bonds - VB theory - concept of hybridization. Molecular orbital theory - LCAO - bonding in homonuclear and heteronuclear diatomic molecules. Intermolecular forces - types - hydrogen bonding - importance of hydrogen bonding in biomolecules - van der Waals forces – consequences.

UNIT-II SURFACE CHEMISTRYAND CATALYSIS **9**

Adsorption-difference between adsorption and absorption-types-factors influencing adsorption- adsorption from solutions-types of isotherms-Freundlich adsorption isotherm -Langmuir adsorption isotherm -industrial applications of adsorption - applications of surface active agents - detergency-wetting - water repellency- emulsifiers - CMC and defoamers.

Catalysis - general characteristics -types of catalysis -acid -base catalysis - enzyme catalysis -characteristics-Michaelis - Menton equation -effect of temperature on enzyme catalysis - Langmuir- Hinshelwood mechanism for heterogeneous catalysis.

UNIT-III NANO MATERIALS **9**

Basics-distinction between nanoparticles and bulk materials - size-dependent properties - nanoparticles - nanocluster – nanorod - nanotube and nanowire - synthesis of nanoparticles - chemical methods -metal nanocrystals by reduction ,solvothermal synthesis, photochemical synthesis, sonochemical synthesisandchemical vapor deposition -physical methods - ball milling ,electrodeposition - biogenic synthesis - properties and applications.

UNIT-IV HETEROCYCLIC COMPOUNDS AND NATURAL PRODUCTS **9**

Heterocyclic compounds-synthesis and reactions of pyrrole -furan - thiophene- pyridine- quinoline-isoquinoline.

Terpenoids- Isolation - Isoprene rule-structural elucidation of citral and menthol.

UNIT-V POLYMERS **9**

Polymers-definition - polymerization - types - addition and condensation polymerization - free radical polymerization mechanism - effect of structure on the properties of polymers - strength, plastic deformation, elasticity and crystallinity - plastics - preparation - properties and uses of PVC, teflon, polycarbonate, polyurethane, nylon-6,6, PET,KEVLAR-Green polymers-Introduction –poly lactic acid (PLA)

Contact Hours : 45

List of Experiments

1	Estimation of mixture of acids by conductometry
2	Estimation of copper / ferrous ions by spectrophotometry
3	Estimation of acid by pH metry.
4	Estimation of alkalinity by indicator method.
5	Estimation of chloride by argentometric method
6	Determination of total, temporary and permanent hardness by EDTA method.
7	Estimation of DO by winkler's method
8	Estimation of sodium and potassium in water by flame photometry
9	Determination of corrosion rate on mild steel by weight loss method

10	Determination of molecular weight of a polymer by viscometry method.			
11	Verification of adsorption isotherms (acetic acid on charcoal)			
12	Phase change in a solid.			
13	Preparation of simple drug			
14	Determination of rate constant of a reaction			
15	Determination of distribution coefficient			
16	Preparation of Thiokol rubber.			
		Contact Hours	**:**	**30**
		Total Contact Hours	**:**	**75**

Course Outcomes:

On completion of the course students will be able to

- Be conversant with basics of molecule formation and interactions
- measure molecular/bulk properties like absorbance, molecular weight, DO and chloride
- Apply the knowledge of surface chemistry in practical and industrial applications
- Be familiar with structure and properties of natural products
- Be assertive on various types of polymers and their properties including green polymers

Text Books:

1	P. C. Jain and Monika Jain, "Engineering Chemistry", Dhanpat Rai Publishing Company (P) LTD, New Delhi, 2015
2	Bahl B. S., and Arun Bahl, "A Text Book of Organic Chemistry", S. Chand, New Delhi, 2016.

Reference Books / Web links:

1	R.D. Madan, "Modern Inorganic Chemistry", S. Chand, New Delhi, 2012
2	I L Finar "Organic Chemistry" ELBS (1994)
3	Gowarikar V. R., Viswanathan N.V. and Jayadev Sreedhar, ―Polymer Science‖, New Age International (P) Ltd., New Delhi, 2011
4	B.S. Murthy, P. Shankar and others, "Text book of Nano-science and Nanotechnology", University Press, IIM.

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
GE19101	**Engineering Graphics**		**2**	**2**	**0**	**4**

Objectives:

- To understand the importance of the drawing in engineering applications
- To develop graphic skills for communication of concepts, ideas and design of engineering products
- To expose them to existing national standards related to technical drawings.
- To improve their visualization skills so that they can apply these skill in developing new products.
- To improve their technical communication skill in the form of communicative drawings

CONCEPTS AND CONVENTIONS (Not for Examination) **1**

Importance of graphics in engineering applications–Use of drafting instruments– BIS conventions and specifications–Size, layout and folding of drawing sheets– Lettering and dimensioning. Basic Geometrical constructions.

UNIT-I	**PLANECURVES AND FREE HAND SKETCH**	**8**
Curves used in engineering practices: Conics–Construction of ellipse, parabola and hyperbola by eccentricity method–Construction of cycloids, Construction of involutes of square and circle drawing of tangents and normal to the above curves. Visualization concepts and Free Hand sketching: Visualization principles –Representation of Three Dimensional objects – Layout of views- Freehand sketching of multiple views from pictorial views of objects		
UNIT-II	**PROJECTION OFPOINTS, LINES AND PLANESURFACE**	**9**
Orthographic projection- principles-Principal planes- projection of points. First angle projection - Projection of straight lines inclined to both the principal planes – Determination of true lengths and true inclinations by rotating line method- Projection of planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method.		
UNIT-III	**PROJECTIONOFSOLIDS**	**9**
Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is inclined to one of the principal planes by rotating object method.		

UNIT-IV	**PROJECTION OF SECTIONED SOLIDS AND DEVELOPMENTOF SURFACES**	**9**
Sectioning of solids in simple vertical position when the cutting plane is inclined to the one of the principal planes and perpendicular to the other – obtaining true shape of the section. Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids cylinders and cones.		
UNIT-V	**ISOMETRIC AND PERSPECTIVE PROJECTIONS**	**9**
Principles of isometric projecti0on–isometric scale–Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinders and cones. Perspective projection of simple solids-Prisms, pyramids and cylinders by visual ray method.		
	Total Contact Hours : 45	

Course Outcomes: After learning the course, the students should be able

- To construct different plane curves and free hand sketching of multiple views from pictorial objects.
- To comprehend the theory of projection and to draw the basic views related to projection of points, lines and planes
- To draw the projection of solids in different views
- To draw the projection of Sectioned solids and development of surfaces of solids
- To visualize and prepare Isometric and Perspective view of simple solids

Text Book (s):

1	Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House, 50th Edition, 2010.
2	Natrajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2017.

Reference Books(s) / Web links:

1	Varghese P I., "Engineering Graphics", McGraw Hill Education (I) Pvt.Ltd., 2013.
2	Venugopal K. and PrabhuRaja V., "Engineering Graphics", New Age International (P)Limited, 2008.
3	Gopalakrishna K.R., "Engineering Drawing" (Vol. I&II combined), Subhas Stores, Bangalore, 2017.
4	Basant Agarwal and Agarwal C.M., "Engineering Drawing", McGraw Hill Publishing Company Limited, New Delhi, 2018.

Subject Code	**Subject Name (Laboratory Course)**	**Category**	**L**	**T**	**P**	**C**
GE19121	**ENGINEERING PRACTICES LABORATORY – Civil & Mechanical**	**ES**	**0**	**0**	**2**	**1**

Objectives:

To provide exposure to the students with hands on experience on various basic engineering practices in Civil and Mechanical Engineering.

List of Experiments

CIVIL ENGINEERING PRACTICE	
1.	Study of pipeline joints, its location and functions: valves, taps, couplings, unions, reducers, and elbows in household fittings.
2.	Preparation of basic plumbing line sketches for wash basins, water heaters, etc.
3.	Hands-on-exercise: Basic pipe connections – Pipe connections with different joining components.
Carpentry Works:	
4.	Study of joints in roofs, doors, windows and furniture.
5.	Hands-on-exercise: Woodwork, joints by sawing, planning and chiselling.
MECHANICAL ENGINEERING PRACTICE	
6.	Preparation of butt joints, lap joints and T- joints by Shielded metal arc welding.
7	Gas welding practice.
Basic Machining:	
8	Simple Turning and Taper turning
9	Drilling Practice
Sheet Metal Work:	
10	Forming & Bending:
11	Model making – Trays and funnels
12	Different type of joints.
Machine Assembly Practice:	
13	Study of centrifugal pump
14	Study of air conditioner
Total Contact Hours : 30	

Course Outcomes:	
•	Able to perform plumbing activities for residential and industrial buildings considering safety aspects while gaining clear understanding on pipeline location and functions of joints like valves, taps, couplings, unions, reducers, elbows, etc.
•	Able to perform wood working carpentry activities like sawing, planning, cutting, etc. while having clear understanding of the joints in roofs, doors, windows and furniture.
•	Able to produce joints like L joint, T joint, Lap joint, Butt joint, etc. through arc welding process while acquiring in depth knowledge in the principle of operation of welding and other accessories
•	Able to perform operations like Turning, Step turning, Taper turning, etc. in lathe and Drilling operation in drilling machine
•	Able to perform sheet metal operations like Forming, Bending, etc. and fabricating models like Trays, funnels, etc.

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
MC19101	**ENVIROMENTAL SCIENCE AND ENGINEERING** **Common to I sem. B.E. – Aeronautical Engineering, Automobile Engineering, Biomedical Engineering, Civil Engineering, Mechanical Engineering & Mechatronics** **and** **B.Tech. – Biotechnology, Chemical Engineering & Food Technology** **and** **Common to II sem. B.E. – Computer Science and Engineering, Electrical and Communication Engineering & Electrical and Electronics Engineering** **and** **B.Tech. – Information Technology**	MC	**3**	**0**	**0**	**0**

Objectives:	
●	To understand the importance of natural resources, pollution control and waste management.
●	To provide the students about the current social issues and environmental legislations.

UNIT-I	**NATURAL RESOURCES**	**9**

Environment -definition - scope and importance - forest resources -use and overexploitation -water resources -use and over utilization - dams - benefits and problems - water conservation -energy resources - growing energy needs - renewable and non-renewable energy sources - use of alternate energy sources -land resources -land degradation - role of an individual in conservation of natural resources.

UNIT-II	**ENVIRONMENTAL POLLUTION**	**9**

Definition - causes, effects and control measures of air pollution -chemical and photochemical reactions in the atmosphere - formation of smog, PAN, acid rain, and ozone depletion- noise pollution -mitigation procedures - control of particulate and gaseous emission(Control of SO_2, NO_X, CO and HC).

Water pollution - definition-causes-effects of water pollutants–marine pollution-thermal pollution-radioactive pollution-control of water pollution by physical, chemical and biological processes–waste water treatment-primary, secondary and tertiary treatment.

Soil pollution : definition-causes-effects and control of soil pollution.

UNIT-III	**SOLID WASTE MANAGEMENT**	**9**

Solid wastes - sources and classification of solid wastes -solid waste management options - sanitary landfill, recycling, composting, incineration, energy recovery options from wastes

Hazardous waste -definition -sources of hazardous waste-classification (biomedical waste, radioactive waste, chemical waste, household hazardous waste)-characteristics of hazardous waste ignitability (flammable) reactivity, corrosivity, toxicity -effects of hazardous waste -case study- bhopal gas tragedy - disposal of hazardous waste-recycling , neutralization, incineration, pyrolysis, secured landfill - E-waste management -definition-sources-effects -electronic waste recycling technology.

UNIT-IV	**SOCIAL ISSUES AND THE ENVIRONMENT**	**9**

Sustainable development -concept, components and strategies - social impact of growing human population and affluence, food security, hunger, poverty, malnutrition, famine - consumerism and waste products - environment and human health -

role of information technology in environment and human health -disaster management– floods, earthquake, cyclone and landslide.

UNIT-V	**TOOLS FOR ENVIRONMENTAL MANAGEMENT**	**9**

Environmental impact assessment (EIA) structure -strategies for risk assessment–EIS-environmental audit-ISO 14000-precautionary principle and polluter pays principle- constitutional provisions- - pollution control boards and pollution control acts- environmental protection act1986- role of non-government organizations- international conventions and protocols.

Contact Hours	**:**	**45**

Course Outcomes:

On completion of the course students will be able to

- Be conversant to utilize resources in a sustainable manner.
- Find ways to protect the environment and play proactive roles.
- Apply the strategies to handle different wastes
- Develop and improve the standard of better living.
- Be conversant with tools of EIA and environmental legislation.

Text Books:

1	Benny Joseph, "Environmental Science and Engineering", 2nd edition, Tata McGraw-Hill, New Delhi,2008.
2	Gilbert M.Masters, "Introduction to Environmental Engineering and Science", 2nd edition, Pearson Education, 2004.

Reference Books / Web links:

1	Dharmendra S. Sengar, "Environmental law", Prentice hall of India Pvt Ltd, New Delhi,2007.
2	ErachBharucha, "Textbook of Environmental Studies", 3rd edition, Universities Press(I) Pvt Ltd, Hyderabad, 2015.,
3	G. Tyler Miller and Scott E. Spoolman, "Environmental Science", 15th edition, Cengage Learning India PVT, LTD, Delhi, 2014.
4	Rajagopalan, R, "Environmental Studies-From Crisis to Cure", 3rdedition,Oxford University Press,2015.
5	De. A.K., "Environmental Chemistry", New Age International, New Delhi,1996.
6	K. D. Wager, Environmental Management, W. B. Saunders Co., Philadelphia, USA, 1998.

II SEMESTER

Subject Code	Subject Name	Category	L	T	P	C
MA19251	**DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS** **Common to II sem. B.E. – Aeronautical Engineering, Automobile Engineering, Civil Engineering, Mechatronics & Mechanical Engineering and B. Tech. - Biotechnology, Food Technology & Chemical Engineering**	BS	3	1	0	4

Objectives:

- To handle practical problems arising in the field of engineering and technology using differential equations.
- To solve problems using the concept of Vectors calculus, Complex analysis, Laplace transforms.

UNIT-I SECOND AND HIGHER ORDER DIFFERENTIAL EQUATIONS **12**

Second and higher order Linear differential equations with constant coefficients - Method of variation of parameters – Cauchy's and Legendre's linear equations - Simultaneous first order linear equations with constant coefficients.

UNIT-II PARTIAL DIFFERENTIAL EQUATIONS **12**

Formation of partial differential equations - Solutions of standard types of first order partial differential equations - Lagrange's linear equation -- Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.

UNIT-III VECTOR CALCULUS **12**

Gradient, divergence and curl – Directional derivative – Irrotational and solenoidal vector fields – Vector integration – Green's theorem in a plane, Gauss divergence theorem and Stokes' theorem (excluding proofs) – Simple applications involving cubes and rectangular parallelopipeds.

UNIT-IV ANALYTIC FUNCTIONS **12**

Analytic functions – Necessary and sufficient conditions for analyticity in Cartesian and polar coordinates - Properties – Harmonic conjugates – Construction of analytic function - Conformal mapping and Bilinear transformation-Cauchy's integral theorem and Cauchy's integral formula (proof excluded) – Taylor's series and Laurent's series – Singularities – Residues – Residue theorem (without proof), simple problems.

UNIT-V LAPLACE TRANSFORM **12**

Laplace transform – Sufficient condition for existence – Transform of elementary functions – Basic properties – Transforms of derivatives and integrals of functions - Derivatives and integrals of transforms - Transforms of unit step function and impulse functions, periodic functions. Inverse Laplace transform – Problems using Convolution theorem – Initial and final value theorems – Solution of linear ODE of second order with constant coefficients using Laplace transformation techniques.

Total Contact Hours : 60

Course Outcomes:

On completion of course students will be able to

- Apply various techniques in solving ordinary differential equations.
- Develop skills to solve different types of partial differential equations
- Use the concept of Gradient, divergence and curl to evaluate line, surface and volume integrals.
- Use the concept of Analytic functions, conformal mapping and complex integration for solving Engineering problems.
- Use Laplace transform and inverse transform techniques in solving differential equations.

Text Books:

1. Grewal B.S., " Higher Engineering Mathematics ", Khanna Publishers, New Delhi, 43rd Edition, 2014.
2. T Veerarajan, Engineering Mathematics –II , Tata Mc Graw Hill Education, 2018

Reference Books / Web links:

1. Ramana. B.V., " Higher Engineering Mathematics ", Tata McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
2. Erwin Kreyszig ," Advanced Engineering Mathematics ", John Wiley and Sons, 10th Edition, New Delhi, 2016.
3. Bali, N.P. and Manish Goyal, "A Text Book of Engineering Mathematics", Lakshmi Publications Pvt. Ltd., New Delhi, 2006.
4. T Veerarajan, "Transforms and Partial Differential Equations", Third Edition, 2018.

Subject Code	Subject Name	Category	L	T	P	C
PH19243	MATERIAL SCIENCE II sem. B.Tech. - Chemical Engineering	BS	3	0	2	4

Objectives:

- To introduce and study of synthesis and characterization of materials.
- To study the properties of conducting materials, superconductors, insulators, magnetic materials, ceramics and new materials.

UNIT-I PREPARATION AND PROCESSING OF MATERIALS **9**

Phases - Phase rule – binary systems – tie line rule – lever rule – phase diagram – invariantreactions – Fick's laws of diffusion - Nucleation – homogeneous and heterogeneous nucleation – Free energy of formation of a critical nucleus – crystal growth – Czochralski, Bridgman, Solution methods - Thin films – preparation: PVD method - Sol-gel method – heat treatment and hardening processes.

UNIT-II PROPERTIES OF CONDUCTING AND SUPER CONDUCTING MATERIALS **9**

Classical free electron theory of metals –Fermi function - Schrödinger wave equation – Timeindependent and time dependent equations. Physical significance of wave function, particle in a box (in one dimension) – electrons in a metal - Density of energy states – effect of temperature on Fermi energy – carrier concentration in metals - Superconducting Phenomena, Properties of superconductors – Meissner effect and Isotope effect. Type I and Type II superconductors, High Tc superconductors – Magnetic levitation and SQUIDS.

UNIT-III ELECTRONIC MATERIALS **9**

Elemental and compound semiconductors - Origin of band gap in solids (qualitative) - Concept of effective mass of electron and hole – carrier concentration in an intrinsic semiconductor (derivation) – Fermi level – Variation of Fermi level with temperature – electrical conductivity – band gap determination – carrier concentration in n-type and p-type semiconductors (derivation) – variation of Fermi level with temperature and impurity concentration – Compound semiconductors – Hall effect – Determination of Hall coefficient – PN junction (qualitative) -LED and Solar cells.

UNIT-IV INSULATING AND MAGNETIC MATERIALS **9**

Dielectric - Electronic, Ionic, Orientational and spacecharge polarization – Internal field and deduction of Clausius-Mosotti equation – dielectric loss – different types of dielectric breakdown – paraelectric and ferroelectric materials-classification of insulating materials and their applications - Introduction to magnetic materials - Domain theory of ferromagnetism, Hysteresis, Soft and Hard magnetic materials – Anti-ferromagnetic materials – Ferrites, Giant Magneto Resistance materials. Magnetic bubbles.

UNIT-V CERAMIC AND NEW MATERIALS **9**

Ceramics-types, preparation and their applications - Ceramic Fibres - Fibre reinforced Plastics – Fibre reinforced Metal – Metallic glasses – Shape memory alloys – Copper base alloys – Nickel – Titanium alloys – Relaxor- Ferroelectric materials – Electro and magneto rheological fluids - Sensors and Actuators – polymer semiconductos – photoconducting polymers – liquid crystals - Bio-sensors - Scintillation detectors –Bio materials – hydroxyapatite – PMMA – Silicone.

Contact Hours	**:**	**45**

List of Experiments

1	Determination of Young's modulus by non-uniform bending method
2	Determination of thermal conductivity of a bad conductor – Lee's Disc method.
3	Determination of velocity of sound and compressibility of liquid – Ultrasonic interferometer
4	Experiment on moment of inertia measurement- Torsional pendulum by resonance,
5	Determination of magnetic susceptibility of water and ferrous liquid using quincke's Method.
6	Experiments on electromagnetic induction – BH-Curve experiment
7	Determination of Solar Cell parameters
8	Determination of Band gap of Semiconducting material.
9	Determination of Hall coefficient of Semiconductor
10	LC circuit, LCR circuit and Resonance phenomena in LCR circuits;
11	Coupled oscillators - Two compound pendulums;
12	Determination of thickness of a thin wire – Air wedge method

Contact Hours	**:**	**30**
Total Contact Hours	**:**	**75**

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

- Prepare and characterize the structure of various crystals.
- Analyze conducting properties of metals and superconductors.
- Analyze physical properties of semiconductors in electronic devices.
- Analyze the properties of insulating and magnetic materials.
- Analyze the usage of new engineering materials.

Text Books:

1	Raghavan. V. Materials Science and Engineering, Prentice Hall of India, 2002.
2	Palanichamy.. P.K., Materials Science, Scitech., 2003.
Reference Books / Web links:	
1	Kumar.J, MoorthyBabu. S and Vasudevan. S., Engineering Physics, Vijay Nicole Imprints, 2006
2	Calister, W.D., Materials Science and Engineering an Introduction, John Wiley, 2003.
3	Raghavan, V., Physical Metallurgy, Prentice Hall of India, 2002
4	S. O. Pillai, Solid state physics, New Age International, 2015.
5	Charles Kittel, Introduction to Solid State Physics, 8th Edition, Willey India Pvt.Ltd, 2005.

Subject Code	Subject Name	Category	L	T	P	C
CY19242	**PHYSICAL CHEMISTRY** **II Semester B.Tech. – Chemical Engineering**	BS	**3**	**0**	**2**	**4**

Objectives:

- To acquire knowledge in the analysis of reaction kinetics and chemical equilibrium
- To understand the basics of unit processes and analysis of industrial chemicals

UNIT-I	**THE DISTRIBUTION LAW AND COLLIGATIVE PROPERTIES**	**9**

Distribution co-efficient - distribution Law - conditions for the validity of the distribution law - I_2-CCl_4- H_2O system - nature of interaction of the solute with one of the solvents - dissociation - association - applications of distribution law - process of extraction. Colligative properties - vapour pressure lowering - boiling point elevation - freezing point depression-osmotic pressure.

UNIT-II	**UNIT PROCESSES**	**9**

Nitration, Sulphonation, Halogenation, Esterification, Amination, Saponification and Hydrogenation - Role of the above unit processes in industries such as petroleum, drugs, pharmaceuticals and organic synthesis.

UNIT-III	**CHEMICALS AND AUXILIARIES**	**9**

Preparation, properties and uses of bleaching powder, sodium hypochlorite, hydrogen peroxide, chlorine dioxide - estimation of available chlorine in hypochlorite bleach liquor-determination of strength of hydrogen peroxide

UNIT-IV	**CHEMICAL KINETICS**	**9**

Rate of a reaction-order of a reaction -examples and rate equations for zero order, first order, second order and third order reactions -molecularity of a reaction -unimolecular and bimolecular reactions -half life period-kinetics of parallel and opposing reactions -activation energy -arrhenius equation -collision theory of reaction rates - theory of absolute reaction rates- steady state principle.

UNIT-V	**CHEMICAL EQULIBRIUM**	**9**

Definition of standard state, standard free energy change and reaction equilibrium constant, evaluation of reaction equilibrium constant - chemical potential and fugacity - application of phase rule - vapour-liquid equilibrium, phase diagrams for homogeneous systems.

Contact Hours	**:**	**45**

List of Experiments

1	A study of the association of benzoic acid in benzene
2	Determination cryoscopic constant by Rast method
3	Determination molecular weight by Rast method
4	Estimation of available chlorine in bleaching powder.
5	Determination of order of a reaction (iodination of acetone)
6	Estimation of critical solution temperature of Phenol-Water System.
7	Effect of impurity on the CST of phenol-water system
8	Determination of equilibrium constant
9	Study of inversion of canesugar by Polarimetry.
10	Study of simple eutectic formed by naphthalene-biphenyl system.
11	Determination of acid value of oils
12	Determination of iodine value of oils.
13	Estimation of hydrogen peroxide
14	Analytical application of refractive index measurement

Contact Hours	**:**	**30**
Total Contact Hours	**:**	**75**

Course Outcomes: On completion of the course students will be able to	
•	Be conversant with applications of distribution law and colligative properties
•	Apprehend the fundamentals of unit processes which are used in chemical industries
•	Be familiar with the analysis of bleaching agents and oxidants
•	Be assertive on kinetics of various types of reactions
•	Apply the basics of phase equilibria and its determinations
Text Books:	
1	Kund and Jain, "Physical Chemistry", S. Chand and Company, New delhi (2016).
2	Puri.B.R, Sharma. L.R, Pathania. M.S, " Principles of Physical Chemistry", S. Vishal Publishing Co, New Delhi (2016)
Reference Books / Web links:	
1	Gordon M. Barrow, "Physical Chemistry", Sixth Edition, Tata McGraw Hill (1998).
2	Peters Atkins & Julio de Paula, Atkins, "Physical Chemistry", 9th Edition, Oxford university press. (2018).

Subject Code	**Subject Name (Lab oriented Theory Courses)**	**Category**	**L**	**T**	**P**	**C**
EE19242	**BASIC ELECTRICAL AND ELECTRONICS ENGINEERING (COMMON TO AERO, CSE, CHEM, CIVIL, FT AND IT)**	ES	3	0	2	4

Objectives:		
•	To introduce electric circuits and provide knowledge on the analysis of circuits using network theorems.	
•	To impart knowledge on the phenomenon of resonance in RC, RL and RLC series and parallel circuits.	
•	To provide knowledge on the principles of electrical machines and electronic devices.	
•	To learn the concepts of different types of electrical measuring instruments and transducers.	
•	To teach methods of experimentally analyzing electrical circuits, electrical machines, electronic devices and transducers.	
UNIT-I	**DC CIRCUITS**	9
Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff 's current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems.		
UNIT-II	**AC CIRCUITS**	9
Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three phase balanced circuits, voltage and current relations in star and delta connections		
UNIT-III	**ELECTRICAL MACHINES**	9
Construction, Principles of operation and characteristics of; DC machines, Transformers (single and three phase), Synchronous machines , three phase and single phase induction motors.		
UNIT-IV	**ELECTRONIC DEVICES & CIRCUITS**	9
Types of Materials – Silicon & Germanium- N type and P type materials – PN Junction –Forward and Reverse Bias – Semiconductor Diodes –Bipolar Junction Transistor – Characteristics –-Field Effect Transistors – Transistor Biasing – Introduction to operational Amplifier –Inverting Amplifier –Non Inverting Amplifier.		
UNIT-V	**MEASUREMENTS & INSTRUMENTATION**	9
Introduction to transducers - Classification of Transducers: Resistive, Inductive, Capacitive, Thermoelectric, piezoelectric, photoelectric, Hall effect - Classification of instruments - PMMC and MI Ammeters and.Voltmeters – Multimeter - Digital Storage Oscilloscope.		
	Contact Hours : 45	

	List of Experiments
1	Verification of Kirchhoff's Laws.
2	Load test on DC Shunt Motor .
3	Load test on Single phase Transformer.
4	Load test on Single phase Induction motor.
5	Characteristics of P-N junction Diode.
6	Half wave and Full wave Rectifiers.
7	Characteristics of CE based NPN Transistor.
8	Inverting and Non- Inverting Op-Amp circuits.
9	Characteristics of LVDT, RTD and Thermistor.
	Contact Hours : 30
	Total Contact Hours : 75

Course Outcomes:	
On completion of the course, the students will be able to	
•	analyse DC and AC circuits and apply circuit theorems.
•	realize series and parallel resonant circuits.
•	understand the principles of electrical machines.
•	understand the principles of different types of electronic devices, electrical measuring instruments and transducers.
•	experimentally analyze the electric circuits, electrical machines, electronic devices, and transducers.
Text Book (s):	
1	J.B.Gupta, "Fundamentals of Electrical Engineering and Electronics" S.K.Kataria & Sons Publications, 2002.
2	D P Kothari and I.J Nagarath, "Basic Electrical and Electronics Engineering", McGraw Hill Education(India) Private Limited, Third Reprint ,2016
3	Thereja .B.L., "Fundamentals of Electrical Engineering and Electronics", S. Chand & Co. Ltd., 2008
Reference Books(s) / Web links:	
1	Del Toro, "Electrical Engineering Fundamentals", Pearson Education, New Delhi, 2007
2	John Bird, "Electrical Circuit Theory and Technology", Elsevier, First Indian Edition, 2006
3	Allan S Moris, "Measurement and Instrumentation Principles", Elseveir, First Indian Edition, 2006
4	Rajendra Prasad, "Fundamentals of Electrical Engineering", Prentice Hall of India, 2006
5	A.E.Fitzgerald, David E Higginbotham and Arvin Grabel, "Basic Electrical Engineering", McGraw Hill Education(India) Private Limited, 2009

Subject Code	**Subject Name (Lab oriented Theory Course)**	**Category**	**L**	**T**	**P**	**C**
GE19141	**PROGRAMMING USING C**	ES	2	0	4	4

Objectives:	
•	To develop simple algorithms for arithmetic and logical problems.
•	To develop C Programs using basic programming constructs
•	To develop C programs using arrays and strings
•	To develop applications in C using functions, pointers and structures
•	To do input/output and file handling in C

UNIT-I	**GENERAL PROBLEM SOLVING CONCEPTS**	
Computer – components of a computer system-Algorithm and Flowchart for problem solving with Sequential Logic Structure, Decisions and Loops.		
UNIT-II	**C LANGUAGE - TYPES OF OPERATOR AND EXPRESSIONS**	
Introduction- C Structure- syntax and constructs of ANSI C - Variable Names, Data Type and Sizes, Constants, Declarations - Arithmetic Operators, Relational Operators, Logical Operators, Type Conversion, Increment and Decrement Operators, Bitwise Operators, Assignment Operators and Expressions, Precedence and Order of Evaluation, proper variable naming and Hungarian Notation.		
UNIT-III	**I/O AND CONTROL FLOW**	
Standard I/O, Formatted Output – Printf, Variable-length argument lists- Formatted Input – Scanf, Statements and Blocks, If-Else-If, Switch, Loops – while, do, for, break and continue, GoTo Labels.		
UNIT-IV	**FUNCTIONS AND PROGRAM STRUCTURE**	
Basics of functions, parameter passing and returning type, External, Auto, Local, Static, Register Variables, Scope Rules, Block structure, Initialisation, Recursion, C Pre-processor, Standard Library Functions and return types.		
UNIT-V	**POINTERS , ARRAYS AND STRUCTURES**	
Pointers and addresses, Pointers and Function Arguments, Pointers and Arrays, Address Arithmetic, character Pointers and Functions, Pointer Arrays, Pointer to Pointer, Multi-dimensional arrays, Strings, Initialisation of Pointer Arrays, Command line arguments, Pointers to functions, complicated declarations. Basic Structures, Structures and Functions, Array of structures, Pointer of Structures, Self-referential Structures, Table look up, Typedef, Unions, Bit-fields, File Access -Error Handling, Line I/O, Miscellaneous Functions.		
	Contact Hours : 30	

List of Experiments	
1	Algorithm and flowcharts of small problems like GCD.
	Structured code writing with:
2	Small but tricky codes

3	Proper parameter passing			
4	Command line Arguments			
5	Variable parameter			
6	Pointer to functions			
7	User defined header			
8	Make file utility			
9	Multi file program and user defined libraries			
10	Interesting substring matching / searching programs			
11	Parsing related assignments			
		Contact Hours	**:**	**60**
		Total Contact Hours	**:**	**90**

Course Outcomes:

- To formulate simple algorithms for arithmetic and logical problems.
- To implement conditional branching, iteration and recursion.
- To decompose a problem into functions and synthesize a complete program using divide and conquer approach.
- To use arrays, pointers and structures to formulate algorithms and programs.
- To apply programming to solve matrix addition and multiplication problems and searching and sorting problems.

Text Books:

1	Brian W. Kernighan and Dennis M. Ritchie, "The C Programming Language", Pearson Education India; 2nd Edition, 2015.
2	Byron Gottfried, "Programming with C", Second Edition, Schaum Outline Series, 1996.

Reference Books:

1	Herbert Schildt, "C: The Complete Reference", Fourth Edition, McGraw Hill, 2017.
2	Yashavant Kanetkar, "Let Us C", BPB Publications, 15th Edition, 2016.

Web links for virtual lab:

1	https://www.tutorialspoint.com/compile_c_online.php
2	https://www.codechef.com/ide
3	https://www.jdoodle.com/c-online-compiler
4	https://rextester.com/l/c_online_compiler_gcc

Subject Code	**Subject Name (Laboratory Course)**	**Category**	**L**	**T**	**P**	**C**
GE19122	**ENGINEERING PRACTICES - ELECTRICAL AND ELECTRONICS**	ES	0	0	2	1

Objectives:

- To provide hands on experience on various basic engineering practices in Electrical Engineering.
- To impart hands on experience on various basic engineering practices in Electronics Engineering.

List of Experiments

A. ELECTRICAL ENGINEERING PRACTICE

1	Residential house wiring using switches, fuse, indicator, lamp and energy meter.
2	Fluorescent lamp wiring.
3	Stair case wiring.
4	Measurement of electrical quantities – voltage, current, power & power factor in RLC circuit.
5	Measurement of resistance to earth of an electrical equipment.

B. ELECTRONICS ENGINEERING PRACTICE

1	Study of Electronic components and equipment's – Resistor, colour coding, measurement of AC signal parameter (peak-peak, rms period, frequency) using CRO.
2	Study of logic gates AND, OR, EOR and NOT.
3	Generation of Clock Signal.
4	Soldering practice – Components Devices and Circuits – Using general purpose PCB.
5	Measurement of ripple factor of HWR and FWR.

	Total Contact Hours	**:**	**30**

Course Outcomes:	
On completion of the course, the students will be able to	
•	fabricate electrical and electronic circuits
•	formulate the house wiring
•	design the AC-DC converter using diode and passive components
REFERENCE	
1	Bawa H.S., "Workshop Practice", Tata McGraw – Hill Publishing Company Limited, 2007.
2	Jeyachandran K., Natarajan S. & Balasubramanian S., "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
3	Jeyapoovan T., Saravanapandian M. &Pranitha S., "Engineering Practices Lab Manual",Vikas Publishing House Pvt.Ltd, 2006.
4	Rajendra Prasad A. &Sarma P.M.M.S., "Workshop Practice", Sree Sai Publication, 2002.

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
MC19102	**INDIAN CONSTITUTION AND FREEDOM MOVEMENT**	MC	**3**	**0**	**0**	**0**

Objectives:	
•	To inculcate the values enshrined in the Indian constitution
•	To create a sense of responsible and active citizenship
•	To know about Constitutional and Non- Constitutional bodies
•	To understand sacrifices made by the freedom fighters

UNIT-I	**INTRODUCTION**	**9**

Historical Background – Constituent Assembly of India – Philosophical foundations of the Indian Constitution – Preamble – Fundamental Rights – Directive Principles of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies for citizens. Constitution' meaning of the term, Indian Constitution: Sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and Duties, Directive Principles of State Policy.

UNIT-II	**STRUCTURE AND FUNCTION OF CENTRAL GOVERNMENT**	**9**

Union Government – Structures of the Union Government and Functions – President – Vice President – Prime Minister – Cabinet – Parliament – Supreme Court of India – Judicial Review.

UNIT-III	**STRUCTURE AND FUNCTION OF STATE GOVERNMENT AND LOCAL BODY**	**9**

State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts- Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Panchayat Raj: Introduction, Elected officials and their roles, ,Village level: Role of Elected and Appointed officials.

UNIT-IV	**CONSTITUTIONAL FUNCTIONS AND BODIES**	**9**

Indian Federal System – Center – State Relations – President's Rule – Constitutional Functionaries – Assessment of working of the Parliamentary System in India- CAG, Election Commission, UPSC, GST Council and other Constitutional bodies-. NITI Aayog, Lokpal, National Development Council and other Non –Constitutional bodies.

UNIT-V	**INDIAN FREEDOM MOVEMENT**	**9**

British Colonialism in India-Colonial administration till 1857- Revolt of 1857- Early Resistance to British Rule-Rise of Nationalism in India-Indian Freedom Struggle under Mahatma Gandhi-Non- Cooperation Movement-Civil Disobedience Movement- Quit India Movement-British Official response to National movement- Independence of India Act 1947- Freedom and Partition.

	Total Contact Hours	**:**	**45**

Course Outcomes:	
On completion of course students will be able to	
•	Understand the functions of the Indian government
•	Understand and abide the rules of the Indian constitution.
•	Gain knowledge on functions of state Government and Local bodies
•	Gain Knowledge on constitution functions and role of constitutional bodies and non-constitutional bodies
•	Understand the sacrifices made by freedom fighters during freedom movement
Text Books:	
1	Durga Das Basu, "Introduction to the Constitution of India ", Lexis Nexis, New Delhi., 21st ed 2013
2	Bipan Chandra, History of Modern India, Orient Black Swan, 2009

3	Bipan Chandra, India's Struggle for Independence, Penguin Books, 2016
4	Maciver and Page, " Society: An Introduction Analysis ", Mac Milan India Ltd., New Delhi.2nd ed, 2014
5	P K Agarwal and K N Chaturvedi , Prabhat Prakashan, New Delhi, 1st ed , 2017
Reference Books / Web links:	
1	Sharma, Brij Kishore, " Introduction to the Constitution of India:, Prentice Hall of India, New Delhi.
2	U.R.Gahai, "Indian Political System ", New Academic Publishing House, Jalaendhar.

III SEMESTER

Subject Code	Subject Name	Category	L	T	P	C
MA19351	**TRANSFORMS AND STATSTICS** **Common to III sem. B.E. Aeronautical Engineering, Automobile Engineering and B.Tech. Chemical Engineering**	BS	**3**	**1**	**0**	**4**

UNIT-I	**FOURIER SERIES**	**12**
Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series –Half range cosine series – Parseval's identity – Harmonic analysis.		
UNIT-II	**BOUNDARY VALUE PROBLEMS**	**12**
Classification of PDE – Solutions of one dimensional wave equation – One dimensional equation of heat conduction – Steady state solution of two dimensional equation of heat conduction (excluding insulated edges).		
UNIT-III	**Z - TRANSFORMS AND DIFFERENCE EQUATIONS**	**12**
Z- transforms - Elementary properties – Inverse Z - transform (using partial fraction and residues) –Convolution theorem - Formation of difference equations – Solution of difference equations using Z- transform.		
UNIT-IV	**TESTING OF HYPOTHESIS**	**12**
Statistical hypothesis - Large sample test based on Normal distribution for single mean and difference of means -Tests based on t, F and Chi-square test for single sample standard deviation. Chi-square tests for independence of attributes and goodness of fit.		
UNIT-V	**DESIGN OF EXPERIMENTS**	**12**
One way and two way classifications - Completely randomized design – Randomized block design –Latin square design		
	Total Contact Hours :	**60**

Text Books:

1	Grewal B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014.
2	Veerarajan. T., "Transforms and Partial Differential Equations", Tata Mc.Graw Hill Education Pvt. Ltd, New Delhi, Second reprint, 2012.
3	Veerarajan T., 'Probability, Statistics and Random Processes with Queueing Theory and Queueing Networks', Tata Mc Graw Hill, 2016.

Subject Code	Subject Name	Category	L	T	P	C
CY19301	**ORGANIC CHEMISTRY** **For III sem. B.Tech. Chemical Engineering**	BS	**3**	**0**	**0**	**3**

Objectives:

- To impart knowledge on reaction mechanism.
- To acquire knowledge on interconversion of sugars, importance of aminoacids and proteins.
- To obtain knowledge on drugs and green approaches in organic synthesis.

UNIT-I	**ORGANIC REACTION MECHANISM**	**9**
Electrophilic reactions-Friedel crafts reaction, Reimer Tiemann reaction, Beckmann rearrangements; Nucleophilic reactions- aldol condensation, perkin reaction, benzoin condensation; Free radical reaction-halogenation of alkane, addition of HBr on alkene in presence of peroxide; allylic halogenation - using N-Bromo Succinimide (NBS), thermal halogenation of alkene $CH_3 – CH = CH_2$.		
UNIT-II	**CARBOHYDRATES**	**9**
Classification. Monosaccharides- reaction of glucose and fructose, open chain and cyclic structures of glucose and fructose, mutarotation, epimerzation, Killiani- Fisher synthesis, Ruff degradation, conversion of aldoses to ketoses and Ketoses to aldoses. Disaccharides – properties and structure of sucrose. Polysaccharides – properties and structure of starch.		
UNIT-III	**AMINO ACIDS AND PROTEINS**	**9**
Classification, preparation (Strecker, Skraup, Gabriel phthalimide) and properties of Amino acids. Composition and classification of proteins. Structure of proteins – tests for proteins – general properties and relations of proteins – putrefaction of proteins - hydrolysis of proteins.		
UNIT-IV	**DRUGS**	**9**
Drugs- Classification-based on origin and application – drug action-synthesis and mode of action of antibiotics (chloroamphenicol) antimalarial drugs (Chloroquine) - antibacterial drugs (sulphonamide) - antiviral drugs (Amantidine Hydrochloride) – anticancer drugs (Cis-platin).		
UNIT-V	**GREEN CHEMISTRY**	**9**

Introduction- Definition of green Chemistry- need of green chemistry- principles of green chemistry- Green synthesis of adipic acid, furfural, methylmethacrylate, urethane-Paracetamal-Vanillin-Polycarbonate-Disodium iminodiacetate-Microwave assisted reaction in water – Hoffmann elimination – methyl benzoate to benzoic acid – oxidation of toluene and alcohols – microwave assisted reactions in organic solvents. Diels-Alder reactions and decarboxylation reaction.			
	Total Contact Hours	**:**	**45**
Course Outcomes: On completion of course, students will be able to			
●	distinguish type of reaction mechanism		
●	synthesize ascending and descending sugars		
●	identify type of protein.		
●	be capable of synthesizing drugs.		
●	apply the principles of green chemistry in organic synthesis		
Text Books:			
1	K.S. Tiwari, N.K. Vishnoi and S.N. Malhotra "A text book of Organic Chemistry" 4th Edition, Vikas Publishing House Pvt. Ltd. (2017) New Delhi.		
2	M.K. Jain and S.C. Sharma, "Modern Organic Chemistry" revised edition (2017),Vishal Publishing co., Jalandhar		
Reference Books / Web links:			
1	R.T. Morrison and R.N. Boyd "Organic Chemistry" VII Edition, Prentice Hall Inc (2010) USA.		
2	B.S.Bhal and Arun Bhal, "A Text Book of Organic Chemistry", 22nd Ed., S Chand & Co. New Delhi, 2019.		
3	Jonathan Clayden, Nick Greeves, Staurt Warren and Peter Wothers, "Organic Chemistry", Oxford University Press, 2nd Ed., New Delhi, 2013.		

CH19301 SOLID MECHANICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the theory of elasticity including strain/displacement and Hooke's law relationships.
- To solve for stresses and deflections of beams under unsymmetrical loading.
- To obtain stresses and deflections of beams on elastic foundations.
- To solve torsion problems in bars thin walled members.
- To obtain solutions to column buckling and plate problems.

UNIT I STRESS, STRAIN AND DEFORMATION OF SOLIDS 9

Rigid bodies and deformable solids – forces on solids and supports – equilibrium and stability – strength and stiffness – tension, compression and shear stresses – Hooke's law and simple problems – compound bars – thermal stresses – elastic constants and Poisson's ratio – welded joints – design.

UNIT II TRANSVERSE LOADING ON BEAMS 9

Beams – support conditions – types of Beams – transverse loading on beams – shear force and bending moment in beams – analysis of cantilevers, simply – supported beams and over hanging beams – relationships between loading, S.F. and B.M. In beams and their applications – S.F.& B.M. diagrams.

UNIT III DEFLECTIONS OF BEAMS 9

Double integration method – Macaulay's method – Area – moment theorems for computation of slopes and deflections in beams – conjugate beam method.

UNIT IV STRESSES IN BEAMS 9

Theory of simple bending – assumptions and derivation of bending equation (M/I = F/Y = E/R) – analysis of stresses in beams – loads carrying capacity of beams – proportioning beam sections – leaf springs – flitched beams – shear stress distribution in beams – determination of shear stress in flanged beams.

UNIT V TORSION AND COLUMNS 9

Torsion of circular shafts – derivation of torsion equation (T/J = C/R = G0/L) – stress and deformation in circular and hollow shafts – stresses and deformation in circular and hollow shafts – stepped shafts – shafts fixed at both ends – stresses in helical springs – deflection of springs – spring constant- Axially loaded short columns – Euler's theory of long columns.

TOTAL : 45 PERIODS

OUTCOMES:

On completion of this course, the students

- Will be able to determine stress, strain and elasticity with all its prerequisites.
- Will be able to design of beams.
- Will be able to design pipelines and storage tanks.
- Will be able to develop skills on designing reaction columns.
- Will be able to perform the design analysis of support column.

TEXT BOOKS:

1. Junarkar, S.B., Mechanics of Structure Vol. 1, 21st Edition, Character Publishing House, Anand, Indian, (1995)
2. William A.Nash, Theory and Problems of Strength of Materials, Schaum's Outline Series. McGraw Hill International Editions, Third Edition, 1994.

REFERENCE:

1. Elangovan, A., Thinma VisaiIyal (Mechanics of Solids in Tamil), Anna University, Madras, 1995.
2. Bansal, R.K., Strength of Materials, 4th Edition, Lakshmi Publications (P) Ltd, New Delhi, (2009).

COURSE OUTCOME:

CO 1	Will be able to determine stress, strain and elasticity with all its prerequisites.
CO 2	Will be able to design of beams.
CO 3	Will be able to design pipelines and storage tanks.
CO 4	Will be able to develop skills on designing reaction columns.
CO 5	Will be able to perform the design analysis of support column.

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO 1	3	3	2	2	1	1	-	-	1	-	2	1
CO 2	3	3	2	2	1	1	1	-	1	1	1	1
CO 3	3	3	3	3	1	1	-	-	1	-	2	1
CO 4	3	3	2	2	1	1	1	-	1	-	1	1
CO 5	3	3	2	2	1	1	-	-	1	-	2	1

CO/ PSO	**PSO1**	**PSO2**	**PSO3**
CO 1	1	1	1
CO 2	2	2	1
CO 3	2	2	1
CO 4	2	2	1
CO 5	2	2	1

3 –SUBSTANTIAL (HIGH) 2 – MODERATE (MEDIUM) 1 – SLIGHT (LOW)

CH 19302 CHEMICAL PROCESS CALCULATIONS L T P C
2 2 0 4

OBJECTIVES:

- To impart knowledge on units and its conversions
- To teach concept of degree of freedom and its application
- To understand and apply the law conversation of mass and its applications for the calculations with reaction and without reactions
- To understand and apply the law conversation of energy and its applications to the calculations related to energy flow in the processes without and with reactions
- To impart the knowledge of fuels, combustion and analysis.

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UNIT I UNITS , DIMENSIONS AND BASIC CALCULATIONS 12

Units, dimensions and conversion; Methods of expressions, Ideal gases and real gases, vapour pressure, humidity calculations

UNIT II MATERIAL BALANCE WITHOUT REACTIONS 12

Introduction to material balances; DOF Analysis, material balance problems for single units, multiple units; bypass and recycle operations; Unsteady state problems

UNIT III MATERIAL BALANCE WITH REACTIONS 12

Stoichiometry and chemical reaction equations; DOF Analysis, material balance for single and multiple reactions; material balance for processes involving reaction bypass, recycle and purging operations; Unsteady state problems

UNIT IV COMBUSTION CALCULATIONS 10

Fuels, Analysis of fuels, GCV and NCV calculations, combustion processes, analysis of flue gas, Orsat analysis and problems.

UNIT V ENERGY BALANCE CALCULATIONS 14

Thermo Physics; Energy balances, Conservation of Energy processes without reaction, Heat capacity, heat requirement for physical processes.

Thermo Chemistry; Energy balances with chemical reaction, Heat of formation and Heat of reactions calculations, adiabatic calculations. Unsteady state problems.

TOTAL: 60 PERIODS

TEXT BOOKS:

1. Felder, R. M., Rousseau, R. W. and Bullard G. L., "Elementary Principles of Chemical Processes", 4th Edition., John Wiley & Sons, New York, 2016.
2. Bhatt, B.I., and Thakore, S.B., "Stoichiometry ", 5th Edition, McGraw-Hill (2017)
3. K.V. Narayanan and B. Lakshmikutty, "Stoichiometry and Process Calculation", 2nd Edition, PHI Learning Ltd. (2016).

REFERENCES:

1. Hougen O A, Watson K M and Ragatz R A, "Chemical Process Principles Part I: Material and Energy Balance", 2nd Edition, CBS publishers (2004).
2. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering", 8th Edition, Prentice Hall Inc., 2014

COURSE OUTCOME:

At the end of the course the students

CO 1	Can do the conversions of units, analyze and solve the numerical problems
CO 2	Will be able to do the degrees of freedom analysis and solve the material balance problems
CO 3	Can make material balances on unit operations and processes and solve them
CO 4	Will be able to solve combustion related problems
CO 5	Can perform energy balance calculations

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	2	2	2	1	-	-	1	-	-	1
CO 2	3	3	3	3	2	1	-	-	1	-	1	1
CO 3	3	3	3	3	2	1	1	-	1	-	1	1
CO 4	3	3	3	3	2	1	1	-	1	-	1	1
CO 5	3	3	3	3	2	1	1	-	1	-	1	1

CO/ PSO	PSO1	PSO2	PSO3
CO 1	3	2	2
CO 2	3	2	2
CO 3	3	2	2
CO 4	3	2	2
CO 5	3	2	2

3 –SUBSTANTIAL (HIGH) 2 – MODERATE (MEDIUM) 1 – SLIGHT (LOW)

CH19341 FLUID MECHANICS FOR CHEMICAL ENGINEERS L T P C

3 1 2 5

OBJECTIVE:

- To impart the knowledge on fluid properties
- To explain the concepts of fluid static characteristics and its applications
- To explain the concepts of fluid at motion and its applications
- To explain the principles of dimensional analysis and its application
- To explain the principle of various instruments used to measure fluid properties

UNIT I BASICS OF FULID MECHANICS 9

Methods of analysis and description - fluid as a continuum – Velocity and stress field - Newtonian and non-Newtonian fluids – Classification of fluid motion – Reynold's transport theorem.

UNIT II FLUID STATICS, KINEMATICS AND DYNAMICS 12

Fluid statics – basic equation - equilibrium of fluid element – pressure variation in a static fluid - application to manometry – Differential analysis of fluid motion – continuity equation of motion, Bernoulli equation and Navier- Stokes equation.

UNIT III DIMENSIONAL ANALYSIS 12

The principle of dimensional homogeneity – dimensional analysis, Rayleigh method and the Pi-theorem - non-dimensional action of the basic equations -similitude - relationship between dimensional analysis and similitude - use of dimensional analysis for scale up studies

UNIT IV FLOW THROUGH PIPES 15

Reynolds number regimes, internal flow - flow through pipes – pressure drop under laminar and turbulent flow conditions – major and minor losses; Line sizing; External flows - boundary layer concepts, boundary layer thickness under laminar and turbulent flow conditions- Flow over a sphere – friction and pressure drag - flow through fixed and fluidized beds.

UNIT V FLOW MEASUREMENT, VALVES AND PUMPS 12

Flow measurement - Constant and variable head meters; Velocity measurement techniques; Types, characteristics and sizing of valves; Classification, performance characteristics and sizing of pumps, compressors and fans

TOTAL : 60 PERIODS

COURSE OUTCOME:

At the end of the course the students

CO 1	Can identify and obtain the values of fluid properties and understand the principles of continuity and energy equation for fluid flow.
CO 2	Will be able to apply the principles of dimensional homogeneity
CO 3	Can understand various fluid flow phenomenon at various conditions and understand theories of flow measurement equipments, pumps and valves.
CO 4	Ability to estimate frictional losses in fluid flow and predict the coefficient of discharge for flow through pipes.
CO 5	Ability to experiment with flow measurement devices like venturi-meter and orifice meter

MAPPING OF PO'S with Course Outcome:

CO	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	3	2	2	2	-	1	-	2	1	1	3
II	3	3	3	3	3	-	2	-	2	1	1	2
III	3	3	3	1	2	-	1	-	2	1	1	3
IV	3	3	3	2	3	-	1	-	3	3	2	2
V	3	3	3	2	3	-	2	-	3	3	2	3

PSO'S MAPPING with Course Outcome:

CO	PSO		
	I	II	III
I	3	2	1
II	3	2	1
III	3	3	3
IV	3	2	2
V	3	1	1

GE19301 LIFE SCIENCE FOR ENGINEERS L T P C
3 0 0 3

Course objective:
Broad objective of this course is to give an introduction of life science to engineering students. The course helps students to familiarize with human physiology, life style diseases and their management and basic diagnostic aspects.

UNIT I OVERVIEW OF CELLS AND TISSUES 9
Introduction to Bacteria, virus, fungi and animal cells. Organisation of cells into tissues and organs. Functions of vital organs.

UNIT II HEALTH AND NUTRITION 9
Balanced diet, Importance of RDA, BMR, and diet related diseases. Role of antioxidants PUFA, DHA, Essential amino acids, Essential fatty acids in diet. Water and its significance for human health. Physical and Mental health – Significance of exercise and yoga.

UNIT III UNHEALTHY PRACTICES AND THEIR IMPACT ON HEALTH 9
Drug induced toxicity, Unhealthy practices - Drug abuse/Narcotics/Smoking/Alcohol/Self-medication/Undue usage of electronic gadgets.

UNIT IV COMMON DISEASES AND LIFESTYLE DISORDERS 9
Prevention and management of food, water and airborne illness (Common cold, dehydration, food poisoning etc). Lifestyle disorders – obesity, diabetes, stroke, heart attack, ulcer, renal calculi, cancer, AIDS, hepatitis- prevention and management.

UNIT V DIAGNOSTIC TESTS AND THEIR RELEVENCE 9
Normal range of biochemical parameters, significance of organ function tests, organ donation.

Course outcomes:
The students at the end of this course, should be able to

- Classify the living organisms and relate the functions of vital organs
- Demonstrate the importance of balanced diet and plan methods for healthy living
- Analyse the hazards of unhealthy practices and take preventive measures
- Categorise the various life style disorders and recommend ways to manage the common diseases
- Evaluate and interpret biochemical parameters and their significance

Text books:

1.Diseases of human body , Carol D Tamparo, Marcia A Lewis , Marcia A, Lewis ,EdD, RN, CMA-AC, F.A Davis Company, 2011.
2.Textbook of Medical Biochemistry ,Chatterjea ; Rana Shinde.

Reference Books

1.Biology for Engineers, Arthur.T.,Johnson, CRC Press, Taylor and Francis, 2011.
2.Cell Biology and Genetics, Cecie Starr, Ralph Taggart, Christine Evers and Lisa Starr, Cengage Learning, 2008.

Web link: https://nptel.ac.in/courses/122103039/

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
GE19301.1	3	1	2	2	2	3	1	1	1	2	1	3
GE19301.2	3	1	2	2	2	3	1	1	1	2	1	3
GE19301.3	3	1	2	2	2	3	1	3	1	2	1	3
GE19301.4	3	1	2	2	2	3	1	1	1	2	1	3
GE19301.5	3	1	2	2	3	3	1	1	1	2	1	3
Average	3	1	2	2	2.2	3	1	1.4	1	2	1	3

IV SEMESTER

Subject Code	Subject Name	Category	L	T	P	C
MA19451	**NUMERICAL METHODS** **Common to IV sem. B.E. Aeronautical Engineering, Civil Engineering and B.Tech. Chemical Engineering**	BS	**3**	**1**	**0**	**4**

Objectives:

- To provide the necessary basic concepts of a few numerical methods.
- To provide procedures for solving numerically different kinds of problems occurring in the field of Engineering and Technology.

UNIT-I	**SOLUTION OF EQUATIONS**	**12**

Solution of algebraic and transcendental equations - Fixed point iteration method – Newton Raphson method- Solution of linear system of equations - Gauss elimination method – Gauss Jordan method – Iterative methods of Gauss Jacobi and Gauss Seidel.

UNIT-II	**INTERPOLATION**	**12**

Interpolation with equal intervals - Newton's forward and backward difference formulae - Interpolation with unequal intervals – Newton's divided difference interpolation - Lagrange's interpolation – Cubic Splines

UNIT-III	**NUMERICAL DIFFERENTIATION AND INTEGRATION**	**12**

Approximation of derivatives using interpolation polynomials - Numerical integration using Trapezoidal, Simpson's 1/3 rule and Simpson's 3/8 rule – Romberg's method - Two point and three point Gaussian quadrature formulae – Evaluation of double integrals by Trapezoidal rule.

UNIT-IV	**INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS**	**12**

Single Step methods: Taylor's series method - Euler's method - Modified Euler's method – Fourth order Runge - Kutta method for solving first order equations - Multi step methods: Milne's and Adams- Bash forth predictor corrector methods for solving first order equations.

UNIT-V	**BOUNDARY VALUE PROBLEMS IN ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS**	**12**

Finite difference method for solving second order differential equations - Finite difference techniques for the solution of two dimensional Laplace and Poisson equations on rectangular domain – One dimensional heat flow equation by implicit and explicit methods – One Dimensional Wave Equation by Explicit method.

Total Contact Hours	**:**	**60**

Course Outcomes:

On completion of course, students will be able to

- solve algebraic equations that arise during the study of Engineering problems.
- use various interpolation techniques for solving problems in Engineering.
- use numerical methods to solve problems involving numerical differentiation and integration.
- solve initial value problems numerically that arise in Science and Engineering.
- solve boundary value problems that encounter in different fields of Engineering study.

Text Books:

1. Kandasamy P., Thilagavathy K., and Gunavathy,S., 'Numerical Methods', Chand and Co., 2008.
2. Grewal B.S., and Grewal. J.S.,"Numerical methods in Engineering and Science",Khanna Publishers, 10th Edition, New Delhi, 2012.
3. Sastry S.S, "Introductory Methods of Numerical Analysis", Prentice- Hall of India PVT. LTD., 5th edition, New Delhi, 2012.

Reference Books / Web links:

1. Veerarajan T., Ramachandran T., 'Numerical Methods with Programs in C and C++' Tata McGraw Hill., 2007.
2. Jain M.K., Iyengar, S.R., and Jain, R.K., 'Numerical Methods for Scientific and Engineering Computation', New Age Publishers. 6th edition, 2007.
3. Chapra S.C., and Canale. R.P, "Numerical Methods for Engineers", 7th Edition, Mc.Graw Hill, New Delhi, 2016.
4. Brian Bradie "A friendly introduction to Numerical analysis", Pearson Education, Asia, New Delhi, 2007.
5. Sankara Rao K., "Numerical methods for Scientists and Engineers", Prentice Hall of IndiaPrivate, 4th Edition, New Delhi, 2018.

CH17401 CHEMICAL PROCESS INDUSTRIES L T P C
3 0 0 3

OBJECTIVE:

- To gain the knowledge in the manufacture of various chemicals present in day to day products.
- To understand the various unit processes and unit operations and the sequence involved in different chemical industries.
- To outline the components present in chemical process industries and design the chemical process plant.
- To give an exposure on aspects of safety for various chemical industries.

UNIT I INTRODUCTION AND CHLORO- ALKALI INDUSTRIES 9

The role of a chemical engineers in process industries, Introduction to common devices used in manufacturing processes, block diagrams, flowcharts and standard symbols used for devices, industrial safety and pollution, outline of plant and equipment design.

Manufacture of Soda ash and sodium bi carbonate, chlorine and caustic soda; bleaching powder and related bleaching agents, Sodium chloride, By-products of common salt industry.

UNIT II ACID INDUSTRIES 9

Mining and manufacture of sulphur, recovery of sulphur from polluting gases, sulphur trioxide and sulphuric acid, hydrochloric acid, synthetic ammonia, sitric acid, phosphoric acid

UNIT III SILICATE, PAPER AND SUGAR INDUSTRIES 9

Types and manufacture of Portland cement, manufacture of glasses and special glasses, ceramics and refractories, manufacture of pulp – different processes of pulping – manufacture of paper – manufacture of boards- raw and refined sugar, by products of sugar industries, Starch and starch derivatives.

UNIT III OIL AND FIBRE INDUSTRIES 9

Hydrogenation of oils, fatty acids: soaps, synthetic detergents- manufacture of Nylon 6. 6. Polyesters fibres – manufacturer of – cellulosic fibres – viscose rayon production manufacture of films - cellulose acetate, PVC, polyesters - polyethylene

UNIT V FERTILIZER INDUSTRIES 9

Growth elements, functions, ammonium sulphate, ammonium nitrate, ammonium phosphate, potassium chloride, potassium sulphate, single, triple super phosphate introduction to pesticides, herbicides and bio-fertilizers.

TOTAL : 45 PERIODS

COURSE OUTCOME:

At the end of the course the students

CO 1	Ability to understand the manufacturing of various inorganic and organic chemicals
CO 2	Ability to understand the process flow diagram and various process parameters
CO 3	Ability to identify engineering problems during production
CO 4	Will be able outline the components present in various process industries
CO 5	Will have an idea of manufacturing fertilizers

MAPPING OF PO'S with Course Outcome:

CO	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	3	2	1	1	2	2	1	1	1	1	2
II	3	2	3	2	2	2	3	1	2	2	1	2
III	2	3	1	1	1	2	2	1	2	1	2	1
IV	3	1	2	1	1	2	2	1	2	2	1	2
V	3	3	2	1	1	2	2	1	1	1	1	2

PSO'S MAPPING with Course Outcome:

CO	PSO		
	I	II	III
I	1	2	2
II	2	2	2
III	1	2	2
IV	2	2	2
V	2	2	2

TEXT BOOKS:

1. Austin, G.T., Shreve's Chemical Process Industries, Fifth Edition, McGraw-Hill International Book Co, Singapore, 1984
2. Dryden, C.E., Outlines of Chemicals Technology, Edited and Revised by Gopala Rao, M. and M. Sittig, Second Edition, Affiliated East-West press,1993.

REFERENCES:

1. Shukla and G.N. Pandey "Text book on Chemical Technology", Vikas Publishing company 1997
2. Kirk and Othmer ,"Encyclopedia of Chemical Technology", III Edition.
3. Srikumar Koyikkal,"Chemical Process Technology and Simulation", PHI Learning Ltd (2013).

CH19402 THERMODYNAMICS L T P C
3 0 0 3

OBJECTIVE

- To train the students for the familiarization of heat and work transfer calculation by applying the basic principles.
- To develop knowledge on selecting an equation of state for representing PVT behavior of fluids
- To impart knowledge on first law and second law of thermodynamics in chemical processes mainly refrigeration processes
- To train the students for the familiarization of single stage and multistage compression process

UNIT I BASIC CONCEPTS 6

Scope of thermodynamics; Definition of system, control volume, state and path function, equilibrium, reversibility, energy, work and heat. zeroth law; temperature scales

UNIT II PVT RELATIONSCHIPS 7

PVT behavior of fluids; Mathematical representation of PVT behaviour; generalized compressibility factor correlation; generalized equations of state

UNIT III LAWS OF THERMODYNAMICS 12

Joule's experiment, internal energy, first law, energy balance for closed systems, mass and energy balance for open systems Statements of the second law of thermodynamics, heat engine and refrigerator, Carnot cycle and Carnot theorems, thermodynamic temperature scale, entropy and its calculation, second law of thermodynamics for a control volume, Third law of thermodynamics, entropy from a microscopic point of view, Refrigeration, vapor compression and vapor absorption cycle.

UNIT IV THERMODYNAMIC REALTIONSHIPS 12

Thermodynamic potentials – internal energy, enthalpy, Helmholtz free energy, Gibbs free energy; thermodynamic property relations – Maxwell relations – partial derivatives and Jacobian method; residual properties; thermodynamic property tables and diagrams

UNIT V APPLICATIONS 8

Duct flow of compressible fluids, Compression and expansion processes, steam power plant, internal combustion engines, jet and rocket engines.

TOTAL : 45 PERIODS

OUTCOMES:

Upon completion of this course, the students would be able to

- Identify the difference between heat and work, isentropic and isenthalpic processes
- Use equation of state, correlation to predict the PVT data
- Analyze the process with respect to first and second law of thermodynamics and understand entropy of the system
- Understand interrelationship of properties and their calculations
- Understand the purpose of inter cooling in multistage compressors

TEXT BOOKS:

1. Smith, J.M., Van Ness, H.C and Abbot M.M "Introduction to Chemical Engineering Thermodynamics ", McGraw Hill Publishers, VII Edition, 2010.
2. Rao, Y.V.C., "Chemical Engineering Thermodynamics" Universities Press, 2009.
3. Narayanan, K.V. A Textbook of Chemical Engineering Thermodynamics, Prentice Hall India, II Edition, 2013.

REFERENCES:

1. Kyle, B.G., "Chemical and Process Thermodynamics III Edition", Prentice Hall of India Pvt. Ltd., 1999.
2. Pradeep Ahuja," Chemical Engineering Thermodynamics", PHI Learning Ltd, (2009).
3. Gopinath Halder," Introduction to Chemical Engineering Thermodynamics", PHI Learning Ltd (2009).

COURSE OUTCOME:

CO 1	Identify the difference between heat and work, isentropic and isenthalpic processes
CO 2	Use equation of state, correlation to predict the PVT data.
CO 3	Analyze the process with respect to first and second law of thermodynamics and understand entropy of the system
CO 4	Understand interrelationship of properties and their calculations
CO 5	Understand the purpose of inter cooling in multistage compressors

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	2	2	1	1	1	-	1	-	2	1
CO 2	3	3	2	2	1	1	-	-	1	-	1	1
CO 3	3	3	3	3	1	1	1	-	1	-	2	1
CO 4	3	3	2	2	1	1	-	-	1	-	1	1
CO 5	3	3	2	2	1	1	1	-	1	-	2	1

CO/ PSO	PSO1	PSO2	PSO3
CO 1	3	1	1
CO 2	3	2	1
CO 3	2	3	1
CO 4	2	3	1
CO 5	2	2	2

3 –SUBSTANTIAL (HIGH) 2 – MODERATE (MEDIUM) 1 – SLIGHT (LOW)

CH19403 HEAT TRANSFER L T P C
3 1 0 4

OBJECTIVE:

- To learn various heat transfer methods involved in chemical processes.
- To study the mechanism of heat transfer in unit operations such as evaporation, drying etc.
- To be exposed to calculations involved in heat transfer principles
- To apply heat transfer concepts in real industry scenario
- To design heat transfer equipments such as Shell & Tube Heat exchanger, boiler etc

UNIT I CONDUCTION HEAT TRANSFER 12

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

UNIT II CONVECTION HEAT TRANSFER 12

Concepts of heat transfer by convection - Natural and forced convection, analogies between transfer of momentum and heat - Reynold's analogy, Prandtl and Coulburn analogy. Dimensional analysis in heat transfer, heat transfer coefficient for flow through a pipe, flow past flat plate, flow through packed beds.

UNIT III HEAT TRANSFER WITH PHASE CHANGE 12

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

UNIT IV RADIATION AND UNSTEADY STATE HEAT CONDUCTION 12

Radiation heat transfer - Black body radiation, Emissivity, Stefan - Boltzman law, Plank's law, radiation between surfaces – unsteady state heat conduction-flat plate, cylinder and spheres.

UNIT V APPLICATIONS 12

Heat exchangers-types of heat exchangers; plate heat exchangers; use of correction factor charts; heat exchangers effectiveness; number of transfer unit - Chart for different configurations - Fouling factors. Evaporation-Theory of evaporation - single effect and multiple effect evaporation – Design calculation for single and multiple effect evaporation

TOTAL: 60 PERIODS

OUTCOME:

1. Ability to understand the basic principles of heat transfer
2. Ability to understand and solve conduction problems
3. Ability to analyse and solve problems on convection and radiation.
4. Ability to apply analogies and correlations to solve industrial problems.
5. Ability to design and analyze the performance of heat exchangers & evaporators

TEXT BOOKS:

1. Kern, D.Q., "Process Heat Transfer", McGraw-Hill, 2001.
2. Holman, J. P., 'Heat Transfer', X Edition., McGraw Hill, 2009.
3. Ozisik, M. N., "Heat Transfer: A Basic Approach", McGraw-Hill, 1984

REFERENCES:

1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", XII Edition., McGraw-Hill, 2017.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol.I, VI Edition, Asian Books Pvt. Ltd., India, 2006.
3. Binay. K Dutta, "Heat Transfer: Principles and Applications", PHI Learning private limited.

CO-PO MAPPING

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CH19403.1	3	-	-	-	-	-	-	-	-	-	-	-
CH19403.2	2	3	2	2	-	1	-	-	-	-	-	-
CH19403.3	2	3	2	-	-	-	-	-	-	-	-	-

CH19403.4	-	3	3	3	-	-	-	-	-	-	-	-
CH19403.5	1	3	3	3	-	2	2	2	-	2	2	2

CO-PSO MAPPING

PSO / CO	PSO1	PSO2	PSO3
CH19403.1	2	1	3
CH19403.2	3	1	3
CH19403.3	3	2	3
CH19403.4	3	1	1
CH19403.5	3	1	1

3-strong 2- moderate 1-weak

CH19441 PARTICLE SCIENCE AND TECHNOLOGY L T P C
3 1 0 4

OBJECTIVE:

- To learn the characterization of solids and size reduction techniques
- To gain the knowledge on various separation processes such as solid-solid separation, Fluid-solid separation and Mechanical-physical separation.
- To select the appropriate separation technique or equipment based on nature of the solution or size of the particles.
- To expose to calculation and machinery involved in various solid handling operations
- To introduce nano-technological aspects

UNIT I SIZE ANALYSIS AND SIZE REDUCTION 9

General characteristics of solids, different techniques of size analysis, shape factor, surface area determination, estimation of particle size. Screening methods and equipment, screen efficiency, ideal and actual screens.

Laws of size reduction, energy relationships in size reduction, methods of size reduction, classification of equipment, crushers, grinders, power requirement, work index; size enlargement - principle of granulation, briquetting, pelletisation, and flocculation.

UNIT II MECHANICAL SEPARATIONS 9

Gravity settling, sedimentation, thickening, elutriation, double cone classifier, rake classifier, bowl classifier. Centrifugal separation - continuous centrifuges, super centrifuges, design of basket centrifuges; industrial dust removing equipment, cyclones and hydro cyclones, electrostatic and magnetic separators, heavy media separations, floatation, jigging

UNIT III FILTRATION 9

Theory of filtration, Batch and continuous filters, Flow through filter cake and filter media, compressible and incompressible filter cakes, filtration equipments - selection, operation and design of filters and optimum cycle of operation, filter aids.

UNIT IV MIXING, AGITATION, STORAGE AND TRANSPORTATION 9

Mixing and agitation - Mixing of liquids (with or without solids), mixing of powders, selection of suitable mixers, power requirement for mixing. Storage and Conveying of solids - Bunkers, silos, bins and hoppers, transportation of solids in bulk, conveyer selection, different types of conveyers and their performance characteristics.

UNIT V SYNTHESIS AND CHARACTERISATION OF NANOPARTICLES 9

Synthesis of Nanoparticles – Chemical and physical processing methods, Characteristics of Nanoparticles – FTIR, XRD, SEM, TEM - Applications -

TOTAL : 45 PERIODS

Course Outcomes:

I. Ability to characterize particles and perform experiments determine its size.

II. Will be able to calculate and experiment the power required by various solid handling equipments

III. Will be able to select the appropriate separation technique or equipment based on nature of the solution or size of the particles and perform experiments to determine its efficiency.

IV. Ability to identify various filtration equipments in process industries and will be able to calculate time taken for filtration process and carry out experiments to determine filtration characteristics

V. Will be aware of various techniques involved in the synthesis of nano-materials

MAPPING OF PO'S with Course Outcome:

CO	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	2	2	2	2	1	1	-	2	1	-	3
II	3	3	3	3	3	1	2	-	2	1	-	2
III	3	3	3	1	2	1	1	-	2	1	-	3
IV	3	3	3	2	3	1	1	-	2	3	-	2
V	3	2	3	2	3	1	2	-	-	3	-	3

PSO'S MAPPING with Course Outcome:

CO	PSO		
	I	II	III
I	3	2	1
II	2	2	1
III	1	2	3
IV	2	2	2
V	-	2	-

TEXT BOOKS:

1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", VII Edition., McGraw-Hill, 2017.

2. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", Tata McGraw Hill, 2001.
3. Foust, A. S., Wenzel, L.A., Clump, C.W., Naus, L., and Anderson, L.B., "Principles of Unit Operations", 2nd Edn., John Wiley & Sons, 2008.

REFERENCE:

1. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I, VI Edition., Asian Books Pvt. Ltd., India, 1999.

V SEMESTER

CH19501 PROCESS ENGINEERING ECONOMICS L T P C
3 0 0 3

OBJECTIVE:

- To learn the basic concepts of economic analysis for process, involving equipment cost, and profitability.
- To teach principles of cost estimation, feasibility analysis, management, organization and quality control
- To provide a conceptual and methodological framework for evaluating the cost, revenue, profitability and risk of chemical engineering processes and products.

UNIT I PRINCIPLES OF MANAGEMENT AND ORGANISATION 12

Planning, organization, staffing, coordination, directing, controlling, communicating, organization as a process and a structure; types of organizations. Method study; work measurement techniques; basic procedure; motion study; motion economy; principles of time study; elements of production control; forecasting; planning; routing; scheduling; dispatching; costs and costs control, inventory and inventory control.

UNIT II INVESTMENT COSTS AND COST ESTIMATION 8

Time Value of money; capital costs and depreciation, estimation of capital cost, manufacturing costs and working capital, capital budgeting and project feasibility.

UNIT III PROFITABILITY, INVESTMENT ALTERNATIVE AND REPLACEMENT 9

Estimation of project profitability, sensitivity analysis; investment alternatives; replacement policy; forecasting sales; inflation and its impact.

UNIT IV ANNUAL REPORTS AND ANALYSIS OF PERFORMANCE 8

Principles of accounting; balance sheet; income statement; financial ratios; analysis of performance and growth.

UNIT V ECONOMIC BALANCE 8

Economic decisions in Chemical Plant - Economics of size - Essentials of economic balance – Economic balance approach, economic balance for insulation, evaporation, heat transfer.

TOTAL : 45 PERIODS

OUTCOME:

- Ability to estimate the capital investment, cost of production, depreciation and cash flows of chemical engineering processes
- Will be able to make decisions about the profitability of chemical engineering processes by applying discounted profitability analysis including net present value, internal rate of return and discounted payback period
- Ability to analyze the economic risk of a chemical engineering process by means of sensitivity, scenario, and decision tree analysis as well as calculation of expected net present value
- Will be able to explain how optimization of a chemical engineering processes based on profitability yields simple rules of thumb for the design of chemical engineering processes
- will be able to size and estimate the capital costs of heat exchangers and evaporators

TEXT BOOKS:

1. Peters, M. S. and Timmerhaus, C. D. RE West , "Plant Design and Economics for Chemical Engineers", III Edn, McGraw Hill, 2003.

2. Holand, F.A., Watson, F.A. and Wilkinson, J.K., "Introduction to process Economics", 2nd Edition, John Wiley, 1983.
3. Banga T.R., and Sharma S.C., Industrial Organization and Engineering economics, Khanna Publishers, New Delhi.

REFERENCES:

1. Allen, L.A., "Management and Organization", McGraw Hill.
2. Perry, R. H. and Green, D., "Chemical Engineer's Handbook ", 7th Edition, McGraw Hill.
3. Narang, G.B.S. and Kumar, V., "Production and Costing", Khanna Publishers, New Delhi.

CO PO MAPPING

CO	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	2	2	2	2	1	1	1	1	1	1	3
2	2	3	3	3	3	2	2	1	1	1	1	2
3	2	3	3	1	2	1	1	1	1	1	1	1
4	2	3	3	2	3	2	1	2	2	3	1	2
5	2	2	3	2	3	2	2	1	2	3	2	1

CO PSO MAPPING

CO	PSO		
	1	**2**	**3**
1	2	2	2
2	1	1	1
3	2	2	1
4	2	2	3
5	2	2	2

CH19502 CHEMICAL ENGINEERING THERMODYNAMICS

L T P C
2 1 0 3

OBJECTIVE:

- To understand the theory and applications of thermodynamic properties of solutions
- To understand the methods used to describe and predict phase equilibria
- To understand and estimate the reaction rate constant at various conditions
- To understand the behavior of fluids under PVT conditions and also apply them for practical purpose

.

UNIT I PROPERTIES OF SOLUTIONS 9

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

UNIT II PHASE EQUILIBRIA 9

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

UNIT III CORRELATION AND PREDICTION OF PHASE EQUILIBRIA 9

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

UNIT IV CHEMICAL REACTION EQUILIBRIA 9

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

UNIT V REFRIGERATION 9

Principles of refrigeration, methods of producing refrigeration, liquefaction process, co-efficient of performance, evaluation of the performance of vapour compression and gas refrigeration cycles.

TOTAL : 45 PERIODS

OUTCOME:

- Will be able to calculate thermodynamic properties of solutions and mixtures
- will be able to apply solution thermodynamics fundamentals to solve VLE, LLE, SLE, and GLE problems including bubble point, dew point and flash calculations.
- Will be able to correlate and predict phase equilibria in Chemical engineering systems
- will understand the fundamental principles of chemical reaction equilibria including extent of reaction, equilibrium constant and its temperature-dependence, equilibrium conversion.
- will be able to perform energy conversion calculations for Rankine, power and compression refrigeration cycles.

TEXT BOOKS:

1. Smith, J.M., Van Ness, H.C and Abbot M.M "Introduction to Chemical Engineering Thermodynamics ", McGraw Hill Publishers, VI Edition, 2003
2. Rao, Y.V.C., "Chemical Engineering Thermodynamics" Universities Press, 2005
3. Narayanan, K.V. A Textbook of Chemical Engineering Thermodynamics, Prentice Hall India, 2004.

REFERENCES:

1. Kyle, B.G., "Chemical and Process Thermodynamics III Edition", Prentice Hall of India Pvt. Ltd., 1999.
2. Pradeep Ahuja," Chemical Engineering Thermodynamics", PHI Learning Ltd, (2009).
3. Gopinath Halder," Introduction to Chemical Engineering Thermodynamics", PHI Learning Ltd (2009).

CO PO MAPPING

CO	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	3	2	2	1	-	2	-	1	2	-	1
2	3	3	2	2	1	-	2	-	1	2	-	1
3	3	3	2	2	1	-	2	-	1	2	-	1
4	3	3	2	2	1	-	2	-	1	2	-	1
5	3	3	2	2	1	-	2	-	1	2	-	1

CO PSO MAPPING

CO	PSO		
	1	**2**	**3**
1	2	2	2
2	1	1	1
3	2	2	1
4	2	2	3
5	2	2	2

CH19503 MASS TRANSFER I L T P C
2 1 0 3

OBJECTIVE:

- To impart the knowledge on diffusion under various conditions
- Ability to determine mass transfer rates under laminar and turbulent conditions.
- Ability to apply mass transfer theories in various mass transfer operations such as humidification, drying and crystallization
- Ability to design cooling towers, crystallizers and dryers

UNIT I DIFFUSION 9

Introduction to mass transfer operations; Molecular diffusion in gases, liquids and solids; diffusivity measurement and prediction; multi-component diffusion.

UNIT II MASS TRANSFER CO-EFFICIENTS 10

Eddy diffusion, concept of mass transfer coefficients, theories of mass transfer, different transport analogies, application of correlations for mass transfer coefficients, inter phase mass transfer, relationship between individual and overall mass transfer coefficients. NTU and NTP concepts, Stage-wise and differential contractors.

UNIT III HUMIDIFICATION 9

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

UNIT IV DRYING 9

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

UNIT V CRYSTALLIZATION 8

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

TOTAL : 45 PERIODS

OUTCOME:

At the end of the course the students

- Will be to understand the concepts of diffusional mass transfer
- Will be able to use the correlations in calculating the mass transfer coefficients
- Will be able to apply the mass transfer concepts in the design of humidification columns
- Ability to understand the mechanism of crystallization and absorption
- Ability to design the driers and crystallizers

TEXT BOOKS:

1. Treybal, R.E., "Mass Transfer Operations", 3rd Edn, McGraw-Hill, 1981.
2. J.D. Seader and E.J. Henley, "Separation Process Principles", 2nd Ed., John Wiley, 2006.
3. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7th Edn., McGraw-Hill, 2005.

REFERENCES:

1. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I and II 4th Edition,Asian Books Pvt. Ltd., India, 1998.
2. Geankoplis, C.J., "Transport Processes and Unit Operations", 4th Edition, Prentice Hall Inc., New Jersey, 2003.
3. Binay K. Dutta,"Principles of Mass Transfer and Seperation Processes", PHI Learning Ltd, 2013.

CO PO MAPPING

CO	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	3	2	2	1	2	2	-	-	1	1	2
2	3	3	2	2	1	2	3	-	-	1	1	2
3	3	2	2	2	1	2	3	-	-	1	2	2
4	3	2	2	2	1	2	3	-	-	1	2	2
5	3	2	2	2	1	2	3	-	-	1	2	2

CO PSO MAPPING

CO	PSO		
	1	**2**	**3**
1	3	2	2
2	3	2	2
3	3	3	2
4	3	3	2
5	3	3	2

CH19504 CHEMICAL REACTION ENGINEERING – I L T P C 2 1 0 3

OBJECTIVE:

- To impart the knowledge on chemical kinetics and analysis techniques
- To apply the knowledge of thermodynamics and kinetics to solve ideal reactor design problems
- To design chemical reactors used in process industries at various complicated levels
- To impart the knowledge on Residence time distribution and design of real reactors

UNIT I RATE EQUATION AND ANALYSIS OF KINETIC DATA 9

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

UNIT II DESIGN OF IDEAL REACTORS 9

Design of continuous reactors - stirred tank and tubular flow reactor, recycle reactors, combination of reactors, size comparison of reactors.

UNIT III DESIGN OF REACTORS FOR MULTIPLE REACTIONS 9

Design of reactors for multiple reactions - consecutive, parallel and mixed reactions - factors affecting choice, optimum yield and conversion, selectivity, reactivity and yield.

UNIT IV TEMPERATURE EFFECTS 9

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

UNIT V RESIDENCE TIME DISTRIBUTION 9

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

TOTAL : 45 PERIODS

OUTCOME:

- Will be able to develop rate equation
- Will be able to analyze data
- Will be able to design of ideal reactors for single and complex reactions
- Will be able to design of non-isothermal reactors
- Ability to design the non-ideal reactors through RTD studies

TEXT BOOKS:

1. Levenspiel O, "Chemical Reaction Engineering", Wiley Eastern Ltd., II Edition, 2000.
2. Fogler.H.S., "Elements of Chemical Reaction Engineering", Prentice Hall of India Ltd., III Edition, 2000
3. Smith, J.M, "Chemical Engineering Kinetics", McGraw Hill, III Edition, 1981.

REFERENCE:

1. Froment. G.F. & K.B.Bischoff, "Chemical Reactor Analysis and Design", John Wiley and Sons,1979.

CO PO MAPPING

CO	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	3	3	2	2	-	3	-	-	1	1	2
2	3	2	2	2	1	-	3	-	-	1	1	2
3	3	3	2	2	1	-	3	-	-	1	1	2
4	3	2	2	2	1	-	3	-	-	1	1	2
5	3	3	2	2	1	-	3	-	-	1	1	2

CO PSO MAPPING

CO	PSO		
	1	**2**	**3**
1	3	2	3
2	3	2	2
3	2	3	2
4	3	3	2
5	3	3	2

CH19511 HEAT TRANSFER LAB **L T P C**
0 0 4 2

OBJECTIVE:
To enable the students to develop a sound working knowledge on different types of heat transfer equipments.

LIST OF EXPERIMENTS
1. Performance studies on Cooling Tower
2. Batch drying kinetics using Tray Dryer
3. Heat transfer in Open Pan Evaporator
4. Boiling Heat Transfer
5. Heat Transfer through Packed Bed
6. Heat Transfer in a Double Pipe Heat Exchanger
7. Heat Transfer in a Bare and Finned Tube Heat Exchanger
8. Heat Transfer in a Condenser
9. Heat Transfer in Helical Coils
10. Heat Transfer in Agitated Vessels

TOTAL : 60 PERIODS

OUTCOME:
Student would be able to calculate heat transfer by conduction, different types of convection using classical models for these phenomena.

LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS
1. Cooling Tower
2. Tray Dryer
3. Open Pan Evaporator
4. Boiler
5. Packed Bed
6. Double Pipe Heat Exchanger
7. Bare and Finned Tube Heat Exchanger
8. Condenser
9. Helical Coil
10. Agitated Vessel

CO PO MAPPING

CO	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	2	2	2	2	1	1	1	1	-	-	3
2	2	3	3	3	3	2	2	1	-	1	1	2
3	2	3	3	1	2	1	1	1	1	-	-	1
4	2	3	3	2	3	2	1	2	2	3	1	2
5	2	2	3	2	3	2	2	1	2	3	2	1

CO PSO MAPPING

CO	PSO		
	1	**2**	**3**
1	3	2	2
2	3	2	2
3	2	3	2
4	3	2	1
5	3	3	2

VI SEMESTER

CH19601 MASS TRANSFER II L T P C
3 1 0 4

OBJECTIVE:

- To teach the students different separation techniques
- To explain the design of a distillation column and absorption column
- To explain calculations involved in liquid -liquid extraction and solid-liquid extraction
- To explain calculations involved in adsorption and ion exchange

UNIT I ABSORPTION 12

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

UNIT II DISTILLATION 12

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

UNIT III LIQUID-LIQUID EXTRACTION 12

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

UNIT IV LEACHING 12

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

UNIT V ADSORPTION AND ION EXCHANGE & MEMBRANE SEPARATION PROCESS 12

Adsorption - Types of adsorption, nature of adsorbents, adsorption equilibria, effect of pressure and temperature on adsorption isotherms, Adsorption operations - stage wise operations, steady state moving bed and unsteady state fixed bed adsorbers, break through curves. Principle of Ion exchange, techniques and applications. Solid and liquid membranes; concept of osmosis; reverse osmosis; electro dialysis; ultra-filtration.

TOTAL : 60 PERIODS

OUTCOME:

- Will be able to design an absorber based on mass transfer principles
- Will be able to perform design calculations of distillation column
- Will be able to understand the principles of separation by liquid-Liquid extraction
- Ability to design leaching equipments
- Will be aware of principles of other separation processes.

TEXT BOOKS:

1. Treybal, R.E., "Mass Transfer Operations", 3rd Edn, McGraw-Hill, 2017.
2. Wankat, P., "Equilibrium Stage Separations", Prentice Hall, 1993.

3. J.D. Seader and E.J. Henley, "Separation Process Principles", 2nd Ed., John Wiley, 2006.
4. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7th Edn., McGraw-Hill, 2005.

REFERENCES:

1. King, C. J., "Separation Processes ", 2nd Edition, Tata McGraw-Hill 1980.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I and II 4th Edition, Asian Books Pvt. Ltd., India, 1998.
3. Geankoplis, C.J., "Transport Processes and Unit Operations", 4th Edition, Prentice Hall Inc., New Jersey, 2003.

CO PO MAPPING

CO	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	2	3	2	1	2	2	-	-	1	2	2
2	3	3	3	2	1	3	3	-	-	1	2	2
3	3	3	2	2	1	2	2	-	-	1	1	2
4	2	2	2	2	1	2	2	-	-	1	1	2
5	3	2	2	2	1	2	2	-	-	1	1	2

CO PSO MAPPING

CO	PSO		
	1	**2**	**3**
1	3	3	2
2	3	3	2
3	3	2	2
4	3	2	1
5	3	2	1

CH19602 CHEMICAL REACTION ENGINEERING II L T P C
2 1 0 3

OBJECTIVE:

- To understand the design of catalyst
- To apply the knowledge of material and energy balances, mass transfer and chemical reaction engineering–I for solving problems involving heterogeneous reaction systems
- To understand and apply the principles of non-ideal flow in the design of reactors
- To enable the students to learn the gas-solid catalytic and non-catalytic reactors and gas-liquid reactors and design them

.

UNIT I CATALYSTS 5

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

UNIT II HETEROGENEOUS REACTORS 10

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

UNIT III GAS-SOLID CATALYTIC REACTORS 12

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

UNIT IV GAS-SOLID NON-CATALYTIC REACTORS 9

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

UNIT V GAS-LIQUID REACTORS 9

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

TOTAL : 45 PERIODS

OUTCOME:

- Ability to synthesis catalyst and determine its characteristics.
- Develop rate laws for heterogeneous reactions
- Design of reactors for gas-solid catalytic reactions
- Design of reactors for gas-solid non-catalytic.
- Design of towers for gas–liquid operations with and without chemical reaction

TEXT BOOKS:

1. Levenspiel, O., "Chemical Reaction Engineering ", III Edition, John Wiley,1999.
2. Fogler. H. S. "Elements of Chemical Reaction Engineering ", III Edition., Prentice Hall of India, 1999.

REFERENCES:

1. Smith J.M., "Chemical Engineering Kinetics ", III Edition, McGraw-Hill, NewYork, 1981.
2. Froment G.F & K.B. Bischoff, "Chemical Reaction Analysis and Design",John Wiley and Sons, 1979.

CO PO MAPPING

CO	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
1	2	2	2	2	1	-	3	2	-	1	1	2
2	3	2	2	2	1	-	3	-	-	1	1	2
3	3	3	2	2	1	-	3	-	-	1	1	1
4	2	2	2	2	1	-	3	-	-	1	1	2
5	3	3	2	2	1	-	3	-	-	1	1	2

CO PSO MAPPING

CO	PSO		
	1	2	3
1	2	2	2
2	3	2	3
3	3	3	2
4	3	3	1
5	3	3	2

CH19603 PROCESS CONTROL **L T P C**
3 0 0 3

OBJECTIVE:

- To impart the knowledge on various measuring techniques to the students
- To teach and train the students to derive the transfer function first and second order open systems
- To impart the knowledge on closed loop system and various controllers
- To teach the students about frequency response systems and determination of stability
- To give the basic knowledge about advanced control systems to the students

UNIT I INSTRUMENTATION 9

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

UNIT II OPEN LOOP SYSTEMS 9

Laplace transformation and its application in process control. First order systems and their transient response for standard input functions, first order systems in series, linearization and its application in process control, second order systems and their dynamics; transportation lag.

UNIT III CLOSED LOOP SYSTEMS 9

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

UNIT IV FREQUENCY RESPONSE 9

Introduction to frequency response of closed-loop systems, control system design by frequency response techniques, Bode diagram, stability criterion, tuning of controllers Z-N tuning rules, C-C tuning rules.

UNIT V ADVANCED CONTROL SYSTEMS 9

Introduction to advanced control systems, cascade control, feed forward control, Smith predictor, control of distillation towers and heat exchangers, introduction to computer control of chemical processes.

TOTAL : 45 PERIODS

OUTCOME:

At the end of the course the students will be able

1. To measure various properties of the objects
2. To derive transfer function and solve various physical systems
3. To select a suitable controller for the process and design
4. To analyse the stability of a system
5. To understand the advanced control systems.

TEXT BOOKS:

1. Stephanopoulos, G., "Chemical Process Control", Pearson India Education Services Pvt. Ltd., 2015.
2. Coughnowr, D., "Process Systems Analysis and Control ", 3rd Edn., McGraw Hill, New York, 2008.
3. Raghunathan Rengaswamy, Babji Srinivasan and Nirav Bhatt, "Process Control Fundamentals, Analysis, Design, Assessment and Diagnosis", CRC Press, 2020.

REFERENCES:

1. Marlin, T. E., "Process Control ", 2nd Edn, McGraw Hill, New York, 2000.
2. Smith, C. A. and Corripio, A. B., "Principles and Practice of Automatic Process control", 2nd Edn., John Wiley, New York, 1997.

CO PO MAPPING

CO	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	3	3	3	3	1	1	-	2	1	1	3
2	3	3	3	3	3	2	2	-	2	1	1	3
3	3	3	3	3	2	1	1	-	2	1	1	3
4	3	3	3	3	3	1	1	-	2	3	1	3
5	3	3	3	3	3	1	2	-	2	3	2	3

CO PSO MAPPING

CO	PSO		
	1	**2**	**3**
1	3	3	3
2	3	3	3
3	3	3	3
4	3	3	3
5	2	2	2

CH19611 PROCESS EQUIPMENT DESIGN

L T P C
0 0 4 2

(All Tables/Chemical Engineers' Handbook/Data Books/Graph Sheets are permitted during the Examination.)

OBJECTIVE:

To impart practical knowledge on the shape and drawing of the process equipments.

UNIT I **12**

Fundamental principles, equations, general design and drawing considerations of cooling towers, evaporators and driers.

UNIT II

Heat exchangers, condensers and reboilers. **12**

UNIT III **12**

Distillation columns- sieve tray, and bubble cap tray columns and packed column.

UNIT IV

Equipments for absorption and adsorption of gases. **12**

UNIT V **12**

Equipments for liquid-liquid extraction and solid-liquid extraction

TOTAL: 60 PERIODS

OUTCOME:

- Will be able to apply the key concepts learnt in plant design
- Will be able to design equipment's used in process plants
- To make decisions on operating conditions
- Will be aware of safety measures while operating any equipment

- Opportunity to know the practical use of equipment's in process industries

TEXT BOOKS:

1. M.V.Joshi and V.V. Mahajan, "Process Equipment Design", MacMillan India Ltd.
2. S.D.Dawande, "Process Design of Equipments", Central Techno Publications, Nagpur, 2000.

REFERENCES:

1. Indian Standard Specifications IS-803, 1962; IS-4072, 1967; IS-2825, 1969.Indian Standards Institution, New Delhi.
2. R.H. Perry, "Chemical Engineers' Handbook", McGraw-Hill.
3. W.L.McCabe, J.C.Smith and Harriet, "Unit Operation of Chemical Engineering", McGraw-Hill.
4. Robert Treybal, "Mass Transfer Operations", McGraw-Hill.
5. J.M. Coulson and J.Richardson, "Chemical Engineering", vol. 6, Asian Books Printers Ltd.

CO PO MAPPING

CO	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	3	3	2	3	-	3	-	-	1	1	2
2	3	2	2	2	3	-	3	-	-	1	1	2
3	3	3	2	2	3	-	3	-	-	1	1	2
4	3	2	2	2	3	-	3	-	-	1	1	2
5	3	3	2	2	3	-	3	-	-	1	1	2

CO PSO MAPPING

CO	PSO		
	1	**2**	**3**
1	3	2	3
2	3	2	3
3	3	2	3
4	3	2	3
5	3	2	3

CH19612 MASS TRANSFER LABORATORY

L T P C
0 0 4 2

OBJECTIVE:

To train the students to develop sound working knowledge on different types of mass transfer equipment.

LIST OF EXPERIMENTS

1. Separation of binary mixture using Simple distillation
2. Separation of binary mixture using Steam distillation
3. Separation of binary mixture using Packed column distillation
4. Liquid-liquid extraction
5. Drying characteristics of Vacuum Dryer
6. Drying characteristics of Tray dryer
7. Drying characteristics of Rotary dryer
8. Water purification using ion exchange columns

9. Estimation of mass/heat transfer coefficient for cooling tower
10. Demonstration of Gas – Liquid absorption

TOTAL : 60 PERIODS

OUTCOME:
Students would be able to determine important data for the design and operation of the process equipment like distillation, extraction, diffusivity and drying principles which are having wide applications in various industries

CO PO MAPPING

CO	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
1	3	3	3	2	1	2	2	3	3	3	2	2
2	3	2	2	2	1	2	2	2	2	2	1	2
3	3	2	1	2	2	1	3	1	2	1	2	2
4	3	2	2	2	3	2	2	1	2	1	1	2
5	3	1	1	2	2	1	2	1	1	1	1	2

CO PSO MAPPING

CO	PSO		
	1	2	3
1	3	2	3
2	3	2	3
3	3	1	2
4	3	1	2
5	3	2	3

CH19613 INNOVATION AND DESIGN THINKING FOR CHEMICAL ENGINEERS

L T P C

0 1 2 2

UNIT I **9**

Introduction – Creative Thinking - Generating New Design Ideas - Lateral Thinking – Analogies observed in Chemical Engineering Concepts - Development of process - Integration – Innovative Thinking – Importance and Scope in Chemical Process Industries.

UNIT II **9**

Hierarchy and approaches of Chemical process Design, Role of process economics, optimization of Heat transfer equipment's – Role of design in effective heat recovery – Waste heat utilization – Heat exchanger train configurations – set up – Innovative concepts.

UNIT III **9**

Innovative design concepts involved in Separation for Heterogeneous mixtures, Settling and Sedimentation, Inertial and Centrifugal separation, Filtration, Scrubbing, Flotation and Drying.

UNIT IV **9**

Innovative design concepts involved in Separation for Homogeneous fluid mixtures, Distillation, Absorption, stripping and Liquid-Liquid extraction, Adsorption, Membranes, Crystallization, Evaporation, Sequencing.

UNIT V **9**

Reaction, separation and Recycle systems for continuous processes and for batch processes, Energy capital and total cost targets, network Design. Steam systems and Cogeneration, Cooling water networking design.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Anil Kumar, Chemical Process Synthesis and Engineering Design, McGraw Hill, 1982.
2. Robin Smith, Chemical Process Design and Integration, Second Edition, Willey India Pvt Ltd, New Delhi, 2009.
3. Herbert M.Schoen, New Chemical Engineering Separation Techniques, Interscience publishers, 1962.
4. Brownell, L.E, & Young, E.H.: Process Equipment Design, Wiley Eastern, New Delhi, (1977).

REFERENCE BOOKS

1. Smith, B.D.: Design of Equilibrium Stage Processes, McGraw Hill, New York, (1963).
2. Kern, D.Q.: Procss Heat Transfer, McGraw Hill (ISE), (1950).
3. Coulson J.M., Richardson J.F., Sinnott R.K., Chemical Engineering, Vol. VI, Maxwell-Macmillan, New York, 1989.
4. Perry, R.H., and Green, D.W,: Perry's Chemical Engineers Handbook, Eighth Edition, McGraw Hill (ISE), 2008.

CO PO MAPPING

CO	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	3	3	3	2	1	1	1	1	1	1	3
2	3	2	3	2	3	2	2	1	1	1	1	2
3	3	2	2	2	2	1	1	1	1	1	1	1
4	3	3	2	1	3	2	1	2	2	3	1	2
5	3	2	2	2	3	2	2	1	2	3	2	1

CO PSO MAPPING

CO	PSO		
	1	**2**	**3**
1	3	2	2
2	2	2	2
3	3	1	2
4	3	2	2
5	3	3	2

VII SEMESTER

CH19701	**TRANSPORT PHENOMENA**	**L T P C**
		4 0 0 4

OBJECTIVE:

- To understand different types of fluids, their flow characteristics and different mathematical models applied to actual situations.
- To provide the fundamentals to solve real life problems involving transports of momentum, energy and mass in biological, mechanical and chemical systems using a unified approach.
- To explain the mechanism of fluids in motion under different conditions.

UNIT I FUNDAMENTALS AND ANALOGY OF TRANSPORT PHENOMENA 12

Importance of transport phenomena; analogous nature of transfer process; basic concepts, conservation laws; continuous concept, field, reference frames, substantial derivative and boundary conditions; methods of analysis; differential, integral and experimental methods. Importance of analogy; development and applications of analogies between momentum and mass transfer; Reynolds, Prandtl, Von Karman and Colburn analogies.

UNIT II TRANSPORT PHENOMENA BY MOLECULAR MOTION 12

Vectors/Tensors, Newton's law of viscosity, Newtonian & Non-Newtonian fluids, rheological models, Temperature, pressure and composition dependence of viscosity, Kinetic theory of viscosity, Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity, Kinetic theory of thermal conductivity, Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity, Kinetic theory of diffusivity.

UNIT III ONE DIMENSIONAL MOMENTUM TRANSPORT 12

Shell Momentum balances, boundary conditions, velocity profiles, average velocity, momentum flux at the surfaces of Newtonian and non-Newtonian for flow of a falling film, flow through circular tube, slits, flow through an Annulus, Adjacent flow of two Immiscible fluids. Equations of Change (Isothermal), equation of continuity, equation of motion, equation of energy (isothermal) their applications in fluid flow problems.

UNIT IV ONE DIMENSIONAL HEAT TRANSPORT 12

Shell energy balances, boundary conditions, temperature profiles, average temperature, energy fluxes at surfaces for different types of heat sources such as electrical, nuclear viscous and chemical, Equations of change (non-isothermal), equation of motion for forced and free convection, equation of energy (non-isothermal).

UNIT V ONE DIMENSIONAL MASS TRANSPORT 12

Shell mass balances, boundary conditions, concentration profiles, average concentration, mass flux at surfaces for Diffusion through stagnant gas film, Diffusion with homogeneous and heterogeneous

chemical reaction, Diffusion in to a falling liquid film, Diffusion and chemical reaction in porous catalyst and the effectiveness factor, equation of continuity for binary mixtures, equation of change to set up diffusion problems for simultaneous heat and mass transfer.

TOTAL: 60 PERIODS

OUTCOME:

- Impart knowledge on the fundamental connections between the conservation laws in heat, mass, and momentum and apply different analogies of transport phenomena.
- Will gain knowledge of vector and tensor fluxes in terms of molecular motion and ability to model and analyze fluid flow.
- Develop the ability to analyze heat, mass and momentum transfer processes.
- Apply the shell balance approach to derive differential heat balance equations for laminar flow system.
- Apply the shell balance approach to derive differential mass balance equations for laminar flow system and solve heat and mass transfer problems.

TEXT BOOKS:

1. R.B. Bird, W.E. Stewart and E.W. Lightfoot, "Transport Phenomena", John Wiley, II Edition 2006.
2. Robert, S Brodkey, Harry C. Hershey, "Transport Phenomena A Unified Approach", Brod key Publishing 2003.

REFERENCES:

1. L.S.Sissom, and D.R.Pitts, "Elements of Transport Phenomena", McGraw-Hill, New York, 1972.
2. R.W.Fahien, "Elementary Transport Phenomena", McGraw-Hill, New York,1983.
3. J.R. Welty, R.W. Wilson, and C.W.Wicks, Rorer G.E, Wilson R.W."Fundamentals of Momentum Heat and Mass Transfer", V Edn. John Wiley, New York, 2007.

CH19702 COMPREHENSIVE CHEMICAL ENGINEERING LT P C
0 3 0 3

OBJECTIVE:

- To learn the fundamental concepts of thermodynamics and material and energy balance calculations of any process systems.
- To impart the knowledge on chemical kinetics, Residence time distribution and design of the real reactors
- To impart the knowledge on closed loop system and various controllers and also apply heat transfer concepts in real industry scenario
- To explain the principle of various instruments used to measure fluid properties and also to select the appropriate separation technique or equipment based on nature of the solution or size of the particles.
- To teach the students different separation techniques in mass transfer

UNIT 1 Thermodynamics and Process Calculations 10

Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium. Steady and unsteady state mass and energy balances including multiphase, multi-component, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis.

UNIT II Chemical Reaction Engineering 10

Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, kinetics of enzyme reactions (Michaelis-Menten and Monod models), non-ideal reactors; residence time distribution, single parameter model; non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis; rate and performance equations for catalyst deactivation.

UNIT III Instrumentation and Process Control and Heat Transfer 10

Measurement of process variables; sensors and transducers; P&ID equipment symbols; process modelling and linearization, transfer functions and dynamic responses of various systems, systems with inverse response, process reaction curve, controller modes (P, PI, and PID); control valves; transducer dynamics; analysis of closed loop systems including stability, frequency response, controller tuning, cascade and feed forward control. Equation of energy, steady and unsteady heat conduction, convection and radiation, thermal boundary layer and heat transfer coefficients, boiling, condensation and evaporation; types of heat exchangers and evaporators and their process calculations; design of double pipe, shell and tube heat exchangers, and single and multiple effect evaporators.

UNIT IV Fluid Mechanics and Mechanical Operations 07

Fluid statics, surface tension, Newtonian and non-Newtonian fluids, transport properties, shell- balances including differential form of Bernoulli equation and energy balance, equation of continuity, equation of motion, equation of mechanical energy, Macroscopic friction factors, dimensional analysis and similitude, flow through pipeline systems, velocity profiles, flow meters, pumps and compressors, elementary boundary layer theory, flow past immersed bodies including packed and fluidized beds, Turbulent flow: fluctuating velocity, universal velocity profile and pressure drop. Particle size and shape, particle size distribution, size reduction and classification of solid particles; free and hindered settling; centrifuge and cyclones; thickening and classification, filtration, agitation and mixing; conveying of solids.

UNIT V Mass Transfer 08

Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stage-wise and continuous contacting and stage efficiencies; HTU & NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption, membrane separations (micro-filtration, ultra-filtration, nano-filtration and reverse osmosis).

TOTAL: 45 PERIODS

TEXT BOOKS:

1. GATE way to Chemical Engineering by M. Subbu (5 Volumes), Rishi Publications, 2018.
2. Objective Type Questions and Answers in Chemical Engineering by O.P. Gupta, Khanna Publishers, 2016 edition.
3. Objective Type Questions and Answers in Chemical Engineering by Ram Prasad, Khanna Publishers, 2017 edition.

COURSE OUTCOME:

At the end of the course the students

CO1	Will be able to do the degrees of freedom analysis and solve the material and balance problems and analyze the process with respect to first and second law of thermodynamics and understand entropy of the system and able to predict and correlate the Phase and Chemical reaction equilibria
CO2	Will be able to design of ideal reactors for single and complex reactions and also design of non-isothermal reactors
CO3	Will be able to select a suitable controller for the process and design and analyze the stability of a system and also ability to understand the basic principles of heat transfer and develop correlations to solve industrial problems.

CO4	Will be able to understand various fluid flow phenomenon at various conditions and understand theories of flow measurement equipments, pumps and valves.
CO5	Will be able to understand the principles of different separation techniques in mass transfer

CO-PO Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	-	2	-	1	2	-	1
CO2	3	3	2	2	1	-	3	-	-	1	1	2
CO3	3	3	3	3	2	1	1	-	2	1	1	3
CO4	3	3	3	1	2	-	1	-	2	1	1	3
CO5	3	3	2	2	1	2	2	-	-	1	1	2

CO-PSO Mapping:

COs	PSO1	PSO2	PSO3
CO1	2	2	1
CO2	2	3	2
CO3	3	3	3
CO4	3	3	3
CO5	3	2	2

3 –SUBSTANTIAL (HIGH) 2 – MODERATE (MEDIUM) 1 – SLIGHT (LOW)

CH19703 COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING L T P C 3 0 0 3

OBJECTIVES

To obtain skill in creating database retrieval of data and also to solve Mathematical models thro' linear and non-linear programming.

UNIT I INTRODUCTION 9

Basic, Review on Programming languages, Python, Review on operating system commands.

UNIT II SPREAD SHEETS 9

Application in Density, molecular weight, mole and percentage compositions, Empirical and Molecular formula calculations, Heat of mixing, Gas laws, Vapour pressure, Chemical Kinetics calculations.

UNIT III SPREAD SHEETS (DATA ANALYSIS) 9

Application in data processing, Statistical analysis of data, Regression. Analysis of variance, Interpolation, Graphical representations of various Chemical Engineering problem both in laboratory exercise and core subjects such as Mechanical operation, Reaction Engineering, Distillation etc.,

UNIT IV DATABASE 9

Design and developments of simple databases on Chemical and Physical properties of substances. Retrieval and Database in report, query and other formats, Interfacing with other software. Preparation of Material and energy Balances preparation of plant layout.

UNIT V MATHEMATICAL PROGRAMMING 9

Linear Programming, Transportation, Dynamic Programming in Chemical Engineering, Formulation and solution through PC based programes.

TOTAL : 45 PERIODS

OUTCOMES

- Students will be equipped with the software applications and the numerical solutions of Chemical engineering problems.

TEXT BOOKS

1. Hanna, O.T. Scandell, O.C. Computational Methods in Chemical Engineering, Prentice Hall, 1995.
2. Michael B. Cutlip, Problem solving in chemical and biochemical with polymath, Matlab, excel,

REFERENCES

1. Jerry, O., Breneman, G.L. Spreadsheet Chemistry, Prentice Hall, Englewood Cliffs, 1991.
2. Myers, A.L. Seider W.D. Introduction to Chemical engineering and Computer Calculations.

COURSE OUTCOMES

CO I	Will be able to code in Python for solving chemical engineering application
CO II	Will be able to compute density, vapour pressure problems using EXCEL/ Polymath
CO III	Will be able to solve and compute chemical engineering regression problems using EXCEL/ Polymath
CO IV	Will be able to design and development simple databases on Chemical and Physical properties of substances.
CO V	Will be able to solve numerical problems on Linear, Dynamic programming, Transportation.

MAPPING OF PO'S with Course Outcome:

CO	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	3	3	3	3				2	1	1	1
II	3	3	3	3	3				2	1	1	1
III	3	3	3	3	3				2	1	1	1
IV	3	3	3	3	3				2	1	1	1
V	3	3	3	3	3				2	1	1	1

PSO'S MAPPING with Course Outcome:

CO	PSO		
	I	II	III
I	2		3
II	2		3
III	2		3
IV	2		3
V	2		3

CH19711 CHEMICAL REACTION ENGINEERING LABORATORY L T P C
0 0 4 2

OBJECTIVE:

To impart knowledge on design of reactors.

LIST OF EXPERIMENTS

1. Kinetic studies in a Batch reactor
2. Kinetic studies in a Plug flow reactor
3. Kinetic studies in a CSTR
4. Kinetic studies in a Packed bed reactor
5. Kinetic studies in a PFR followed by a CSTR
6. RTD studies in a PFR
7. RTD studies in a Packed bed reactor
8. RTD studies in a CSTR
9. Studies on micellar catalysis
10. Study of temperature dependence of rate constant using CSTR.
11. Kinetic studies in Sono chemical reactor
12. Batch reactive distillation
13. Kinetics of photochemical reaction
14. Demonstration of heterogeneous catalytic reaction
15. Demonstration of gas-liquid reaction

TOTAL : 60 PERIODS

OUTCOME:

Students would get a sound working knowledge on different types of reactors.

LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS

1. Batch Reactor
2. Plug flow reactor
3. CSTR
4. Sono-chemical reactor
5. Photochemical reactor
6. Packed bed reactor

*Minimum 10 experiments shall be offered.

CH 19712PROCESS CONTROL LABORATORY

L	T	P	C
0	0	4	2

OBJECTIVE:

To determine experimentally the methods of controlling the processes including Measurements using process simulation techniques.

LIST OF EXPERIMENTS

1. Response of first order system
2. Response of second order system
3. Response of Non-Interacting level System
4. Response of Interacting level System
5. Open loop study on a thermal system
6. Closed loop study on a level system
7. Closed loop study on a flow system
8. Closed loop study on a thermal system
9. Tuning of a level system
10. Tuning of a pressure system
11. Tuning of a thermal system
12. Flow co-efficient of control valves
13. Characteristics of different types of control valves
14. Closed loop study on a pressure system
15. Tuning of pressure system
16. Closed loop response of cascade control system

*Minimum 10 experiments shall be Offered.

TOTAL: 60 PERIODS

OUTCOME:
Students would have knowledge on the development and use of right type of control dynamics for process control under different operative conditions.

LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS
1. U tube manometer with controller
2. Interacting Tank
3. Non Interacting Tank
4. Open loop control system
5. Closed loop control system
6. ON/OFF controller
7. Control valve characteristics
8. Pressure Tuner
9. Temperature Tuner
10. Proportional Controller
11. Flow Transmitter
12. Level Transmitter
13. Cascade control system

CH19713	**COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING LABORATORY**	**L T P C** **0 0 4 2**

OBJECTIVES
To give the students an understanding the fundamentals concepts in mathematics, problems solving and computer programming.

SOFTWARE REQUIRED
MS Office (EXCEL) 10 user license
MATLAB, Five user license
ASPEN PLUS/HYSYS 10 user license

SUGGESTED EXERCISES
1. Equations of state using Newton's method
2. Regression for parameter estimation using a set of data points
3. Equilibrium flash distillation (Multi component Ideal)
4. Batch Reactor
5. CSTR in Series Stage wise contacting equipment
6. Solving a simple flow sheet by simultaneous approach
7. Simulation of batch Distillation (binary ideal).
8. Gravity Flow Tank
9. Heat Exchanger
10. Plug Flow Reactor
11. Absorber

Specific examples in ASPEN/HYSYs/MATLAB/EXCEL
1. Solving equation of state, regression of parameters using EXCEL/MATLAB
2. Calculation of Reynolds number, friction factor and pressure drop using EXCEL/MATLAB
3. Calculation of heat transfer coefficient in a Heat Exchanger using EXCEL/MATLAB
4.Calculation of minimum Reflux ratio for a system in a fractionator using EXCEL/ MATLAB
5. Calculation of HTU and NTU in a Absorber using EXCEL/MATLAB

6. Calculation of Antoine's coefficient using EXCEL/MATLAB
7. Estimation of settling velocity of solids in liquids using Stoke's law using EXCEL/MATLAB
8. Calculation of minimum number of stages in a distillation column using EXCEL/MATLAB
9. Solving mass and energy balance problems using EXCEL/MATLAB
10. Calculation of Power in reciprocating compressor using EXCEL/MATLAB
11. Steady state simulation of Heat Exchanger using ASPEN PLUS/ HYSYS
12. Steady state simulation of a CSTR using ASPEN PLUS/ HYSYS
13. Steady state simulation of Flash vessel using ASPEN PLUS/ HYSYS
14. Steady state simulation of Distillation Column using ASPEN PLUS/ HYSYS
15. Steady state simulation of an Absorption column using ASPEN PLUS/ HYSYS
16. Dynamic simulation of Heat Exchanger using ASPEN PLUS/ HYSYS
17. Dynamic simulation of a CSTR using ASPEN PLUS/HYSYS
18. Dynamic simulation of Flash vessel using ASPEN PLUS/ HYSYS
19. Dynamic simulation of Distillation Column using ASPEN PLUS/ HYSYS
20. Dynamic simulation of an Absorption column using ASPEN PLUS/ HYSYS

TOTAL: 60 PERIODS

OUTCOMES

- Students will be equipped with the software applications to solve Chemical engineering problems
- Students will be equipped with problem solving skills to solve Chemical engineering problems.

TEXT BOOKS

1. Bequette. B.W, "Process Dynamics": Modelling, Analysis and Simulation," Prentice Hall (1998)
2. Himmelblau. D.M. and Bischoff. K.B, "Process Analysis and Simulation", Wiley, 1988.
3. Strang.G. ,"Introduction to Linear Algebra", Cambridge Press, 4th edition,2009.
4. Chapra.S.C. and Canale.R.P. "Numerical Methods for Engineers", McGraw Hill, 2001

MAPPING OF PO'S with Course Outcome:

CO	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	3	3	3	3				2	1	1	1
II	3	3	3	3	3				2	1	1	1

PSO'S MAPPING with Course Outcome:

CO	PSO		
	I	II	III
I	2		3
II	2		3

VIII SEMESTER

PROFESSIONAL ELECTIVE V

PROFESSIONAL ELECTIVES

PROFESSIONAL ELECTIVE I

CH19P51 ENZYME ENGINEERING L T P C
3 0 0 3

OBJECTIVE:

To develop skills of the students in the area of Enzyme Engineering with mphasis on reactor operation and design.

UNIT I **9**
Types of Microorganism: Structure and function of microbial cells. Fundamentals of microbial growth, batch and continuous culture. Isolation and purification of enzymes from cells. Cell and Enzyme Immobilization.

UNIT II **9**
Fermentation – Types of mechanisms, Continuous fermentation – aeration and agitation, kinetics of fermentation – Processes

UNIT III **9**
Introduction of Bioreactor design: Continuously stirred aerated tank bioreactors. Mixing power correlation. Determination of volumetric mass transfer rate of oxygen from air bubbles and effect of mechanical mixing and aeration on oxygen transfer rate, heat transfer and power.

UNIT IV Enzyme and Enzyme Kinetics **9**
Introduction to Biochemistry, Function and applications. Nature and function of enzyme. Coenzyme / Cofactor. Classification of enzymes. Assay methods and units. Examples of applications of enzymes in industry, analytical technique medicine and Pharmaceuticals.

UNIT V **9**
Industrial Bioreactors Utilizing Isolated enzymes and biosensors development and applications. Designs of reactor, Batch and continue type; analysis for immobilized enzyme reactors. Sterile and non sterile operations; reactors in series with and without recycle.

TOTAL : 45 PERIODS

OUTCOME:
At the end of the course, the students would have learnt about classification of enzymes, immobilization, extraction and purification of enzymes and biosensors.

TEXT BOOKS:

1. Technological Applications of Bio-catalysts, BIOTOL series, Butter worth, 1995.
2. Cornish. A -Bowden, Analysis of Enzyme Kinetic Data, Oxford University Press, 1996.

REFERENCES:
1. Wiseman. A and Blakeborough N and Dunnill P, Enzymic and nonenzymic catalysis, Ex. Vol.5 Ellis and Harwood, U.K. (1981).
2. Wiseman A (Ed.), Topics in enzyme and fermentation Bio-technology, Ellis and Harwood, U.K. Vol-5.

CH19P52 WASTEWATER TREATMENT L T P C
3 0 0 3

OBJECTIVE:
To focus on the wastewater transport system and the theory and design technique for the wastewater treatment process.

UNIT I WASTE WATER TREATMENT AN OVERVIEW 9
Terminology – Regulatios – Health and Environment Concerns in waste water management – Constituents in waste water inorganic – Organic and metallic constituents.

UNIT II PROCESS ANALYSIS AND SELECTION 9
Components of waste water flows – Analysis of Data – Reactors used in waste water treatment – Mass Balance Analysis – Modeling of ideal and non ideal flow in Reactors – Process Selection.

UNIT III CHEMICAL UNIT PROCESSES 9
Role of unit processes in waste water treatment chemical coagulation – Chemical precipitation for improved plant performance chemical oxidation –Neutralization – Chemical Storage.

UNIT IV BIOLOGICAL TREATMENT 9
Overview of biological Treatment – Microbial metabolism – Bacterial growth and energatus – Aerobic biological oxidation – Anaerobic fermentation and oxidation – Trickling filters – Rotating biological contractors – Combined aerobic processes – Activated sludge film packing.

UNIT V ADVANCED WASTE WATER TREATMENT 9
Technologies used in advanced treatment – Classification of technologies Removal of Colloids and suspended particles – Depth Filtration – Surface Filtration – Membrane Filtration Absorption – Ion Exchange – Advanced oxidation process.

TOTAL : 45 PERIODS

OUTCOME:
Upon completion of this course, the students would have knowledge on physical/chemical/biological characteristics of and the evaluation technique for sewage.

TEXT BOOKS:
1. Waste water Engineering Treatment and Reuse: Mc Graw Hill, G. Tchobanoglous, FI Biston, 2002.
2. Industrial Waste Water Management Treatment and Disposal by Waste Water Mc Graw Hill III Edition 2008.

CH19P53 FOOD TECHNOLOGY L T P C
3 0 0 3

OBJECTIVE:
To enable the students to learn to design processing equipments for Food Industries.

UNIT I AN OVERVIEW 5
General aspects of food industry; world food needs and Indian situation.

UNIT II FOOD CONSTITUENTS, QUALITY AND DERIVATIVE FACTORS 10
Constituents of food; quality and nutritive aspects; food additives; standards; deteriorative factors and their control.

UNIT III GENERAL ENGINEERING ASPECTS AND PROCESSING

METHODS **9**

Preliminary processing methods; conversion and preservation operations.

UNIT IV FOOD PRESERVATION METHODS **12**

Preservation by heat and cold; dehydration; concentration; drying irradiation; microwave heating; sterilization and pasteurization; fermentation and pickling; packing methods.

UNIT V PRODUCTION AND UTILISATION OF FOOD PRODUCTS **9**

Cereal grains; pulses; vegetables; fruits; spices; fats and oils; bakery; confectionery and chocolate products; soft and alcoholic beverages; dairy products; meat; poultry and fish products.

TOTAL : 45 PERIODS

OUTCOME:

Upon completion of this course, the students would get the exposure on use of different chemical additives in foods during food processing and preservation

TEXT BOOKS:

1. Heid J.L. Joslyn M.A., Fundamentals of Food Processing Operation, The AVI publishing Co., West port 1967.
2. Potter N.N., Food Science, The AVI publishing Co., Westport, 1963.

REFERENCES:

1. Heldman D.R., Food Process Engineering, The AVI publishing co., 1975.
2. Charm S.E., The Fundamentals of Foods Engineering, The AVI Publishing Co., Westport, 1963.

CH19P54 ENERGY TECHNOLOGY **L T P C**
3 0 0 3

OBJECTIVE:

To enable the students to understand the interaction between different parts of the energy system

UNIT I ENERGY **8**

Introduction to energy – Global energy scene – Indian energy scene - Units of energy, conversion factors, general classification of energy, energy crisis, energy alternatives.

UNIT II CONVENTIONAL ENERGY **8**

Conventional energy resources, Thermal, hydro and nuclear reactors, thermal, hydro and nuclear power plants, efficiency, merits and demerits of the above power plants, combustion processes, fluidized bed combustion.

UNIT III NON-CONVENTIONAL ENERGY **10**

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

UNIT IV BIOMASS ENERGY **10**

Biomass origin - Resources – Biomass estimation. Thermochemical conversion – Biological conversion, Chemical conversion – Hydrolysis & hydrogenation, solvolysis, biocrude, biodiesel power generation

gasifier, biogas, integrated gasification.

UNIT V ENERGY CONSERVATION 9

Energy conservation - Act; Energy management importance, duties and Responsibilities; Energy audit – Types methodology, reports, instruments. Benchmalcing and energy performance, material and energy balance, thermal energy management.

TOTAL : 45 PERIODS

OUTCOME:

On completion of this course, the students would have the ability to apply the fundamentals of energy conversion and applications.

TEXT BOOKS:

1. Rao, S. and Parulekar, B.B., Energy Technology, Khanna Publishers, 2005.
2. Rai, G.D., Non-conventional Energy Sources, Khanna Publishers, New Delhi, 1984.
3. Nagpal, G.R., Power Plant Engineering, Khanna Publishers, 2008.
4. Energy Management, Paul W.O'Callaghan McGraw – Hill, 1993

REFERENCES:

1. Nejat Vezirog, Alternate Energy Sources, IT, McGraw Hill, New York.
2. El. Wakil, Power Plant Technology, Tata McGraw Hill, New York, 2002.
3. Sukhatme. S.P., Solar Enery - Thermal Collection and Storage, Tata McGraw hill, New Delhi, 1981. Handbook of Energy Audit by 7th edition Albert Thumann, P.E., C.E.M & William J Younger C.E.M, Faiment Press 2008

PROFESSIONAL ELECTIVE II

CH19P61 AIR POLLUTION AND CONTROL L T P C

3 0 0 3

OBJECTIVE:

To enable the students to learn about Air Pollution, effects of air pollution, Global effects, Sampling of pollutants, Meteorology and air pollution, Atmospheric stability, Plume rise and dispersion and Prediction of air quality.

UNIT I INTRODUCTION 9

Air Pollution Regulatory Framework Histroy – Air Pollution Regulatory Framework - Regulatory System – Laws and Regulations – Clean air Act – Provisions for Recent Developments.

UNIT II AIR POLLUTION GASES 9

Measurement fundamentals – chemicals and physical properties – Phase Equilibrium - consecution laws – Incinerators – Design and Performance – Operation and Maintainance - Absorbers – Design operation and improving performances Absorbers.

UNIT III PARTICULATE AIR POLLUTION 9

Particle Collection mechanisms– Fluid particle - Dynamics – Particle size Distribution – Efficency – Gravity Setling chambers Cyclones- Electrostatic precepators Bannouses

UNIT IV HYBRID SYSTEM 9

Heat electrostatic precepitation – Genizing Heat Scrubbers – Dry Scrubbers – Electrostatically Augmented Fabric Fillration

UNIT V AIR POLLUTION CONTROL EQUIPMENT 9

Introduction – Installation – Cost Model.

TOTAL : 45 PERIODS

OUTCOME:
Upon completion of this course, the students would have the knowledge of ambient air pollution, its sources, its effects, and mechanisms for air pollution prevention.

TEXT BOOKS:
1. Air Pollution Control Equipment Louis Theodore, Burley Intuscence 2008.
2. Air Pollution Control CD Cooper and FC.Alley Wairland Press III Edition 2002.
3. Air Pollution Control Engg, Noel de nevey – Mcgrew Hill.

CH19P62 PETROLEUM TECHNOLOGY L T P C
3 0 0 3

OBJECTIVE:
To make the students understand petroleum engineering principles, their application to petroleum and natural gas manufacturing problems.

UNIT I INTRODUCTION 9
Refinery products – Refinery Feeds – Crude distillation – Coking and thermal process.

UNIT II CATALYTIC CRACKING 9
Catalytic Cracking - Catalytical hydro cracking – Hydroprocessing and Reused processing hydro treating.

UNIT III CATALYTICAL 9
Reforming and isomerization alkylation and polymerization – Product blending – Supporting processes.

UNIT IV LUBRICIATING 9
Lubriciating oil blending stocks petrochemical feedstocks.

UNIT V COST EVALUATION 9
Cost Evaluation – Economic evaluation of petroleum reused and refineries.

TOTAL : 45 PERIODS

OUTCOME:
On completing this course, the students will be able to understand the concepts of catalytic cracking lubricating used by the oil and gas production technician today.

TEXT BOOKS:
1. Petroleum Refining : Technology and economics CRC Press V Edition 2007 J.CH Garry , Hardward G.E and M.J.Kaiser.
2. Modern Petroleum Technology Upstream Vol I A.G. Lucas Hurley Edition 2002

CH19P63 INDUSTRIAL PROCESS PLANT SAFETY L T P C
3 0 0 3

OBJECTIVE:
To enable the students to become a skilled person in hazopard hazarel analysis and finding out the root cause of an accident. Gain knowledge in devising safety policy and procedures to be adopted to implement total safety in a plant

UNIT I INTRODUCTION TO SAFETY PROGRAMMES 9

Safety in industries; need for development; importance safety consciousness in Indian chemical industry; social environmental setup; tolerance limit of the society; psychological attitude towards safety programmes. Elements of safety programme; effective realization; economic and social benefits; effective communication training at various levels of production and operation.

UNIT II INDUSTRIAL SAFETY 9

Chemical process industries; potential hazards; chemical and physical job safety analysis; high pressure; high temperature operation; dangerous and toxic chemicals; highly radioactive materials; safe handling and operation of materials and machineries; planning and layout.

UNIT III SAFETY PERFORMANCE 9

Appraisal; effective steps to implement safety procedures; periodic inspection and study of plant layout and constant maintenance; periodic advice and checking to follow safety procedures; proper selection and replacement of handling equipments; personal protective equipments.

UNIT IV ACCIDENTS 9

Industrial accidents – accident costs – identification of accident spots; remedial measures; identification and analysis of causes of injury to men and machines – accident prevention – accident proneness – vocational guidance, fault free analysis. Fire prevention and fire protection.

UNIT V HEALTH HAZARDS AND LEGAL ASPECTS 9

Health hazards – occupational – industrial health hazards – health standards, and rules – safe working environments – parliamentary legislations – factories act – labour welfare act – ESI Act – Workmen Compensation Act .Role of Government, safety organizations, management and trade unions in promoting industrial safety.

TOTAL : 45 PERIODS

OUTCOME:

Upon completion of this course, the students would have learnt the basic concepts relating to chemical hazards, risk, and ethics. They also develop knowledge of quantitatively analyze release and dispersion rates of liquids and vapors.

TEXT BOOKS:

1. Ridley Safety at Work, VII Edition, Butterworth Heinman 2007.
2. William Handley, Industrial Safety Hand Book McGraw-Hill Book Company 2nd Edition, 1977.
3. Fawatt, H.H. and Wood, W.S.Safety and Accident Prevention in Chemical Operation, Interscience, 1965

REFERENCES:

1. Heinrich, H.W. Dan Peterson, P.E. and Nester Rood. Industrial Accident Prevention, McGraw-Hill Book Co., 1980
2. Blake, R.P., Industrial Safety, Prentice Hall Inc., New Jersy – 3rd Edn. 1963.

CH19P64 INDUSTRIAL NANOTECHNOLOGY

L T P C
3 0 0 3

OBJECTIVE:

To enable the students to learn about basis of nanomaterial science, preparation method, types and application

UNIT I INTRODUCTION 8

Nanoscale Science and Technology- Implications for Physics, Chemistry, Biology and Engineering-

Classifications of nanostructured materials- nano particles- quantum dots, nanowires-
ultra-thinfilms-multilayered materials. Length Scales involved and effect on properties: Mechanical, Electronic, Optical, Magnetic and Thermal properties. Introduction to properties and motivation for study (qualitative only).

UNIT II GENERAL METHODS OF PREPARATION 9

Bottom-up Synthesis-Top-down Approach: Co-Precipitation, Ultrasonication, Mechanical Milling, Colloidal routes, Self-assembly, Vapour phase deposition, MOCVD, Sputtering, Evaporation, Molecular Beam Epitaxy, Atomic Layer Epitaxy, MOMBE.

UNIT III NANOMATERIALS 12

Nanoforms of Carbon - Buckminster fullerene- graphene and carbon nanotube, Single wall carbon Nanotubes (SWCNT) and Multi wall carbon nanotubes (MWCNT)- methods of synthesis(arc-growth, laser ablation, CVD routes, Plasma CVD), structure-property Relationships applications- Nanometal oxides-ZnO, TiO2,MgO, ZrO2, NiO, nanoalumina, CaO, AgTiO2, Ferrites, Nanoclays- unctionalization and applications-Quantum wires, Quantum dots-preparation, properties and applications

UNIT IV CHARACTERIZATION TECHNIQUES 9

X-ray diffraction technique, Scanning Electron Microscopy - environmental techniques, Transmission Electron Microscopy including high-resolution imaging, Surface Analysis techniques- AFM, SPM, STM, SNOM, ESCA, SIMS-Nanoindentation

UNIT V APPLICATIONS 7

NanoInfoTech: Information storage- nanocomputer, molecular switch, super chip, nanocrystal, Nanobiotechlogy: nanoprobes in medical diagnostics and biotechnology, Nano medicines, Targetted drug delivery, Bioimaging - Micro Electro Mechanical Systems (MEMS), Nano Electro Mechanical Systems (NEMS)- Nanosensors, nano crystalline silver for bacterial inhibition, Nanoparticles for sunbarrier products - In Photostat, printing, solar cell, battery

TOTAL : 45 PERIODS

OUTCOMES:

Upon completing this course, the students Will familiarize about the science of nanomaterials Will demonstrate the preparation of nanomaterials Will develop knowledge in characteristic nanomaterial

TEXT BOOKS:

1. A.S. Edelstein and R.C. Cammearata, eds., "Nanomaterials: Synthesis, Properties and Applications", Institute of Physics Publishing, Bristol and Philadelphia, 1996.
2. N John Dinardo, "Nanoscale charecterisation of surfaces & Interfaces", 2nd edition, Weinheim Cambridge, Wiley-VCH, 2000

REFERENCES:

1. G Timp (Editor), "Nanotechnology", AIP press/Springer, 1999.
2. Akhlesh Lakhtakia (Editor),"The Hand Book of Nano Technology, Nanometer Structure, Theory, Modeling and Simulations". Prentice-Hall of India (P) Ltd, New Delhi, 2007.

PROFESSIONAL ELECTIVE III

CH19P71 ENVIRONMENTAL TECHNOLOGY L T P C

3 0 0 3

OBJECTIVE:

To provide technical expertise in Environmental Engineering which will enable them to have a career and professional accomplishment in the public or private sector

UNIT I ENVIRONMENT AWARENESS 9

Environment – friendly chemical Process; Hazard and risk analysis; Environmental Audit.

UNIT II CHEMICAL ENGINEERING PROCESSES 9

Unit Operations – application of - Abatement of water pollution; Current strategies to control air pollution; Disposal of solid wastes

UNIT III RECYCLING METHODOLOGY 9

Economic recovery and recycling of waste; Transport fuel- Bio-diesel for a cleaner environment.

UNIT IV CLEAN TECHNOLOGY 9

Towards Eco- friendly products of chemical industry; Pesticides –Their transfer and Transformation in the environment, Biological and electrochemical technology for effluent treatments

UNIT V POLLUTION PREVENTION 9

Mass exchange network synthesis for pollution control and minimization Implications of environmental constraints for process design, policies for regulation of environmental impacts, Concept of common effluent treatment; Environmental legislations, Role of Government and Industries

TOTAL : 45 PERIODS

OUTCOME:

Upon completion of this course, the students would understand the importance of environmental audit, concepts behind the methodologies to control pollution, the importance of recycling and concepts behind pollution prevention.

TEXTBOOKS:

1. Rao, C.S Environmental Pollution control Engineering, Wiley- Eastern Ltd. 1991.
2. Peavy H.S. Rowe D.R., and George Technologious, Environmental Engineering, Mc Graw Hill Book Company, Ny, 1985.
3. Rao M.N and H.V.N. Rao. "Air pollution" ,Tata McGraw Hill Publishing Co. Ltd.1989.
4. Theodore L and Buomlore A.J Air pollution control equipments. Prentice Hall Inc, NY. 1982.

CH19P72 PIPING AND INSTRUMENTATION

L T P C
3 0 0 3

UNIT I 15

Fluid Flow: Types of pipes–metallic and Non-metallic pipe. Piping and pipeline codes. Fluid properties. Pressure drop due to friction, minor losses-values, fittings, enlargement, reduction, entrance and exit loss.

Single phase incompressible flow of Newtonian and Non-Newtonian liquids-veloctiy, flow equation. Complex piping system -pipe in series and parallel. Pipe network. Single phase compressible flow-flow analysis for ideal and non-ideal gas. Work, energy and power required for compression of gas.

UNIT II 15

Piping Design: Economic diameter, equivalent length estimation. Fitting number and types. Gravity flow, Sizing economics. Steam line –optimum diameter, temperature (low and high) considerations, and vacuum considerations. Pressure design calculation for plant piping, slurry piping and plastic piping-Pipeline design – waste water system, compressed air system, oil piping system, slurry system and Non-Newtonian fluid system

UNIT III 15

Pipeline Operation and Maintenance: Friction reduction, cleaning, coating, war, freezing prevention of by bleeding, leak detection, leak detection using SCADA. Pipeline failure- outside force damage, internal pressure, subsidence strains, Rupture. Pipeline economics and cost. Piping insulations and repair techniques

TOTAL :45 PERIODS

TEXT BOOKS

1. John J.Mcketta, "Piping Design Handbook", Marcel Dekker Publication, 1992.
2. Henry Liu, "Pipeline Engineering", Lewis Publishers, 2003.

REFERENCE BOOK

1. George A. Antaki, "Piping and Pipeline Engineering: Design, Construction, Maintenance, Integrity and Repair", Marcel Dekker Publication,2003.

CH19P73 NUCLEAR ENGINEERING L T P C
3 0 0 3

COURSE OBJECTIVES:

- To gain some fundamental knowledge about nuclear physics, nuclear reactor, nuclear fuels, reactors and safe disposal of nuclear wastes.
- Knowledge about nuclear physics, nuclear reactor, nuclear fuels, reactors and safe disposal of nuclear wastes.

UNIT I Nuclear physics

Nuclear model of an atom-Equivalence of mass and energy-binding- radio activity-half life neutron interactions-cross sections.

UNIT II Nuclear reactor

Nuclear reactors: types of fast breeding reactors. Design and construction of fast breeding reactors-heat transfer techniques in nuclear reactors- reactor shielding. Fusion reactors.

UNIT III Nuclear reactions and reaction materials

Mechanism of nuclear fission and fusion- radio activity- chain reactions-critical mass and composition-nuclear fuel cycles and its characteristics-uranium production and purification. Zirconium, thorium, beryllium.

UNIT IV Properties of irradiated fuel - separation of reactor products

Uses of stable isotopes and methods of isotope separation principles of isotope separation - Separation of isotopes of light elements - separation of isotopes of heavy elements.

UNIT V Safety and disposal

Nuclear plant safety-safety systems-changes and consequences of accident-criteriafor safetynuclear waste-types of waste and its disposal-radiation hazards and their preventionweapons proliferation.

TEXT BOOKS:

1. Thomas J.Cannoly, "Fundamentals of Nuclear Engineering" 1978, John Wiley.
2. Collier J.G., and Hewitt G.F, "Introduction to Nuclear power", 1987, Hemisphere publishing, New York.

REFERENCES:

1. Wakil M.M.El., "Power Plant Technology" 1984, Mc Graw-Hill International.

COURSE OUTCOMES:

1. Ability to understand nuclear reaction process
2. Able to gain knowledge on nuclear fuels.
3. Gaining knowledge in nuclear fuel reprocessing technology
4. Understanding of nuclear power plants
5. Acquiring knowledge in safety and disposal of nuclear fuels

CH19P74 MODERN SEPARATION TECHNIQUES L T P C 3 0 0 3

OBJECTIVE:

To enable the students to learn the principle and technical concept of advanced separation processes.

UNIT I BASICS OF SEPARATION PROCESS 9

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

UNIT II MEMBRANE SEPARATIONS 9

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

UNIT III SEPARATION BY ADSORPTION 9

Types and choice of Adsorbents, Adsorption Techniques, Dehumidification Techniques, Affinity Chromatography and Immuno Chromatography, Recent Trends in Adsorption.

UNIT IV INORGANIC SEPARATIONS 9

Controlling factors, Applications, Types of Equipment employed for Electrophoresis, Dielectrophoresis, Ion Exchange Chromatography and Eletrodialysis, EDR, Bipolar Membranes.

UNIT V OTHER TECHNIQUES 9

Separation involving Lyophilisation, Pervaporation and Permeation Techniques for solids, liquids and gases, zone melting, Adductive Crystallization, other Separation Processes, Supercritical fluid Extraction, Oil spill Management, Industrial Effluent Treatment by Modern Techniques.

TOTAL : 45 PERIODS

OUTCOME:

The students would fully understand key concepts of separation processes including equilibrium stages, reflux, countercurrent contacting, limiting cases, efficiency and mass transport effects.

REFERENCES:

1. King, C. J., "Separation Processes", Tata McGraw Hill, 1982.
2. Roussel, R. W., "Handbook of Separation Process Technology", John Wiley, New York, 1987.
3. Nakagawal, O. V., "Membrane Science and Technology"' Marcel Dekkar, 1992.

PROFESSIONAL ELECTIVE IV

CH19P75 INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS **L T P C**
3 0 0 3

OBJECTIVE:
To make the students understand the working principles of different types of instruments and their applications.

UNIT I INTRODUCTION OF SPECTROMETRY 9
Properties of electromagnetic radiation- wave properties – components of optical instruments – Sources of radiation – wavelength selectors – sample containers – radiation transducers – Signal process and read outs – signal to noise ratio - sources of noise – Enhancement of signal to noise - types of optical instruments – Principle of Fourier Transform optical Measurements.

UNIT II MOLECULAR SPECTROSCOPY 9
Molecular absorption spectrometry – Measurement of Transmittance and Absorbance – Beer's law – Instrumentation - Applications -Theory of fluorescence and Phosphorescence –Instrumenation – Applications – Theory of Infrared absorption spectrometry – IR instrumentation - Applications – Theory of Raman spectroscopy – Instrumentation – applications.

UNIT III MAGNETIC RESONANCE SPECTROSCOPY AND MASS SPECTROMETRY 9
Theory of NMR – environmental effects on NMR spectra – chemical shift- NMR-spectrometers – applicatons of 1H and 13C NMR- Molecular mass spectra – ion sources – Mass spectrometer. Applications of molecular mass - Electron paramagnetic resonance- g values – instrumentation.

UNIT IV SEPARATION METHODS 9
General description of chromatography – Band broadening and optimization of column performance- Liquid chromatography – Partition chromatography - Adsorption chromatography – Ion exchange chromatography -size exclusion chromatography- Affinity chromatography-principles of GC and applications – HPLC- Capillary electrophoresis – Applications.

UNIT V ELECTRO ANALYSIS AND SURFACE MICROSCOPY 9
Electrochemical cells- Electrode potential cell potentials – potentiometry-reference electrode – ion selective and molecular selective electrodes – Instrument for potentiometric studies – Voltametry – Cyclic and pulse voltametry- Applications of voltametry . Study of surfaces – Scanning probe microscopes – AFM and STM.

TOTAL : 45 PERIODS

OUTCOME:
Upon completion of this course, the students would have knowledge about the Qualitative and quantitative instrument analysis of different materials.

TEXT BOOK:
1. Instrumental Methods of Analysis. D.A. Skoog, F. James Holler, Stanky, R.Crouch . Cengage Learning – 2007.

REFERENCE:
1. Instrumental Methods of Analysis, Willard.H.H, Merritt.I.I, Dean J.A, Settle. F.A, 6th Edition, CBS Publishers-1986

CH19P76 PINCH TECHNOLOGY L T P C
3 0 0 3

UNIT-I Introduction to Pinch Technology 08

Definition of pinch technology. Basis of Pinch Technology. Objectives of Pinch Analysis. Process Integration by Pinch Analysis. Development of Pinch Technology. Areas of applications of Pinch Technology. The concept of process synthesis. The role of thermodynamics in process design.

UNIT-II Heat recovery 12

Basic concepts of heat exchange, the temperature-enthalpy diagram, Composite curves, A targeting procedure. The grand composite curve and shifted composite curves. The pinch and its significance.
Heat exchanger network design: Network grid representation, design for maximum energy recovery. Choosing dTmin, Super targeting.
Methodology of Pinch Analysis: The range of pinch analysis techniques, and application of pinch study.

UNIT-III Data Extraction 10

Data extraction: Heat and mass balance, stream data extraction, calculating heat loads and heat capacities, choosing streams, mixing, heat losses. Organics distillation plant-a case study.
Energy targeting: dTmin contributions for individual streams, Threshold problems. Organics distillation plant - a case study.

UNIT-IV 08

Process change and evolution: Basic objective, The plus-minus principle, appropriate placement applied to unit operations, reactor systems, distillation columns.

UNIT-V 07

Case studies: Crude preheat train, Aromatics plant.

Text Books

1. A user guide on process integration for the efficient use of energy, B. Linnhoff, David W. Townsend, D. Boland and G.F. Hewitt
2. Pinch Anlysis and Process Integration, second edition: A user guide on process integration for the efficient use of energy, Ian C. Kemp, IChemE

Reference Books

1. Chemical Process: Design& Integration, Robin Smith, John Wiley and Sons.

CH19P77 BIOPROCESS TECHNOLOGY L T P C
3 0 0 3

Course Objectives:

To understand the growth kinetics, sterilization techniques, various reactors and separation methods of the products.

UNIT I MICROBIAL GROWTH KINETICS 9

Media Preparation, Media design and optimization. Microbial growth patterns and kinetics in batch culture, Microbial growth parameters, Environmental conditions affect growth kinetics, Kinetics of thermal death of microorganisms, Heat Generation by microbial growth, Quantitative analysis of microbial growth by direct and indirect methods.

UNIT II STERILIZATION 9

Sterilization: concept and methods. Type of Sterilizations, Batch heat sterilization of liquids, Estimation of sterilizer efficiency, Continuous heat sterilization of liquids, Sterilization of air: Methods and Mechanism, Design of depth filter and estimation of its efficiency. Stoichiometric calculations, Theoretical prediction of yield coefficients, Stoichiometry of growth and product formation, Maximum possible yield, Theoretical oxygen demand, Stoichiometry of single-cell protein synthesis.

UNIT III BIOCHEMICAL REACTORS 9

Ideal Reactor Operation: Batch, Fed Batch & Continuous operation of mixed bioreactors, Microbial pellet formation, Kinetics and dynamics of pallet formation. Chemostat with immobilized cells, Chemostate with cell recycle, substrate utilization and product formation in bioreactor, Scale up of Bioreactors.

UNIT IV MASS TRANSFER 9

Role of diffusion in Bioprocessing, Convective mass transfer, Gas-liquid mass transfer, Oxygen uptake in cell cultures, Factor affecting cellular oxygen demand, Oxygen transfer in bioreactors, Measurement of volumetric oxygen transfer coefficient, Oxygen transfer in large bioreactor.

UNIT V CONTROL OF BIOREACTORS 9

Bioreactor control mechanism, Physical, Chemical and Biological environment of bioreactor, Manual control system, Role of physical, chemical & biological sensors, Advanced control strategies viz. PID controllers, Fuzzy logic-based controllers and artificial neural network based Controllers. Basic concepts of computer modeling and optimization in bioprocess applications.

TOTAL : 45 PERIODS

Course Outcomes:

At the end of the course, the students will be

1. Able to develop a microbial growth kinetics
2. Able to perform various sterilization techniques
3. Able to design biochemical reactors
4. Able to understand oxygen transfer techniques
5. Able to control the bioreactors.

TEXT BOOKS

1. Shular and Kargi, Bioprocess Engineering: Basic Concepts,3rd edition, Pearson, 2017.
2. Skalak R and Shu Chien, Hand Book of Bioengineering, 4th edition, McGraw-Hill Edition, 1987.
3. P. M. Doran, Bioprocess Engineering Principles, 2nd edition, Academic Press, 2012

REFERENCE BOOKS

1. A Moser and Springer-Verlag, “Bioprocess Technology – Kinetics & Reactors” ,1st edition, Springer,1988
2. B. Atkinson and F. Mavituna, “Biochemical Engineering and Biotechnology Handbook” 2nd edition, Stockton Press,2015
3. A.H.Scragg, Bioreactors in Biotechnology: A Practical approach, 1st edition. Ellis Horwood Ltd,1992.

CH19P78 BIOCHEMICAL ENGINEERING L T P C
3 0 0 3

OBJECTIVE
This course mainly discusses the role of enzymes and microbes in biotechnology sectors.

UNIT I INTRODUCTION 6
Industrial biochemical processes with typical examples, comparing chemical and biochemical processes, development and scope of biochemical engineering as a discipline. Industrially important microbial strains; their classification; structure; cellular genetics.

UNIT II KINETICS OF ENZYME ACTION 9
Kinetics of enzyme catalyzed reaction: the enzyme substrate complex and enzyme action, modulation and regulation of enzyme activity, types of inhibition. Immobilized enzyme technology: enzyme immobilization, Immobilized enzyme kinetics: effect of external mass transfer resistance.

UNIT III KINETICS OF MICROBIAL GROWTH 9
Kinetics of cellular growth in batch and continuous culture, models for cellular growth unstructured,structured and cybernetic models , medium formulation. Thermal death kinetics of cells and spores, stoichiometry of cell growth and product formation , Design and analysis of biological reactors.

UNIT IV TRANSPORT PHENOMENA 9
Transport phenomena in bioprocess systems: Gas-liquid mass transfer in cellular systems, determination of oxygen transfer rates, power requirements for sparged and agitated vessels, scaling of mass transfer equipment, heat transfer.

UNIT V DOWN STREAM PROCESSING 12
Down stream 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.

TOTAL : 45 PERIODS

OUTCOME:
Upon completion of this course, the students would develop the ability to design novel bioprocesses for their research in various areas. They will have the ability to find solutions to the problems which occur when materials and processes interact with the environment.

TEXT BOOKS:
1. Biochemical engineering fundamentals by J.E.Bailey and D.F.Ollis, 2nd ed, 1986, McGraw Hill.
2. Bioprocess Engineering by Michael L. Shuler and Fikret Kargi, 2nd edition, Pearson education.

REFERENCES:
1. Biochemical engineering by James M.Lee – Prentice-Hall-1992.
2. Bioprocess engineering principles, Pauline M. Doran, Academic Press.
3. Biochemical Engineering, H.W. Blanch and D.S. Clark, Marcel Dekker, 1997.

PROFESSIONAL ELECTIVE V

CH19P81 OPTIMIZATION OF CHEMICAL PROCESSES L T P C
3 0 0 3

OBJECTIVE:

i. Introduce the fundamental concepts of Optimization Techniques;
ii. To make the learners aware of the importance of optimizations in real scenarios;
iii. To provide the concepts of various classical and modern methods of for constrained and unconstrained problems in both single and multivariable.
iv. To apply the methods of optimization in real life situation.

UNIT I OPTIMIZATION 15

Introduction; formulation of objective functions; fitting models to data; classification of functions; necessary and sufficient conditions for optimum; unimodal, multimodal functions; analytical methods lagrange multiplier methods.

UNIT II NUMERICAL METHODS 15

Unimodel functions; newton's quasi newton, secant methods; region elimination methods, polynomial approximation; quadratic and cubic interpolation techniques for optimum. Multimodal functions; direct methods; random, grid. Hooke's nelder and mead methods; Powell's technique; indirect methods; gradient and conjugate gradient methods; secant methods.

UNIT III LINEAR AND NON-LINEAR PROGRAMMING APPLICATIONS 15

Review on basic concepts of LP formulations; Simplex methods; Integer, quadratic, geometric and dynamic programming. Heat transfer and energy conservation; separation processes; fluid flow systems; reactor design and operation; large scale systems.

TOTAL : 45 PERIODS

OUTCOME:

After successful completion of this course the students will be able to

i. Recognize the importance of optimization of industrial process management
ii. Apply basic concepts of mathematics to formulate an optimization problem.
iii. Analyse and appreciate variety of performance measures for various optimization problems formulate optimization problems.
iv. Understand and apply the concept of optimality criteria for various type of optimization problems.
v. Solve various constrained and unconstrained problems in single variable as well as Multivariable.

TEXT BOOKS:

1. Edgar, T.F., Himmelblau, D.M., "Optimisation of Chemical Processes", McGraw-Hill II Edition 2001.
2. Reklaitis, G.V., Ravindran, A., Ragsdell, K.M. "Engineering Optimisation", John Wiley, II Edition 2006

REFERENCES:

1. Biles, W.E., Swain, J.J.; "Optimisation and Industrial Experimentation", Inter Science, New York, 1980.
2. Seinfeld, J.H.; Lapidus, L; "Process Modelling, Estimation and Identification", Prentice Hall, Englewood Cliffs, New Jersey, 1974.
3. Beveridge, C.S.; Schechter, R.S.; "Optimisation: Theory and Practice", McGraw-Hill Book Co., New York, 1970.

CH19P82 FERTILIZER TECHNOLOGY L T P C

3 0 0 3

OBJECTIVE:

To enable the students to learn the fertilizer manufacturing including new or modified fertilizer products and new techniques.

UNIT I NITROGENOUS FERTILISERS 9

Methods of production of nitrogenous fertilizer-ammonium sulphate, nitrate, urea and calcium ammonium nitrate; ammonium chloride and their methods of production, characteristics and specifications, storage and handling.

UNIT II PHOSPHATIC FERTILISERS 9

Raw materials; phosphate rock, sulphur; pyrites etc., processes for the production of sulphuric and phosphoric acids; phosphates fertilizers - ground rock phosphate; bone meal-single superphosphate, triple superphosphate, triple superphosphate, thermal phosphates and their methods of production, characteristics and specifications.

UNIT III POTASSIC FERTILISERS 9

Methods of production of potassium chloride, potassium schoenite, their characteristics and specifications.

UNIT IV COMPLEX AND NPK FERTILISERS 9

Methods of production of ammonium phosphate, sulphate diammonium phosphate, nitrophosphates, urea, ammonium phosphate, mono-ammonium phosphate and various grades of NPK fertilizers produced in the country.

UNIT V MISCELLANEOUS FERTILISERS 9

Mixed fertilizers and granulated mixtures; biofertilisers, nutrients, secondary nutrients and micro nutrients; fluid fertilizers, controlled release fertilizers, controlled release fertilizers.

TOTAL : 45 PERIODS

OUTCOME:

At the end of this course, the students would know about the manufacturing techniques of fertilizers and design the equipment in fertilizer industry

TEXT BOOKS:

1. “Handbook of fertilizer technology”, Association of India, New Delhi, 1977. 82 2. Menno, M.G.; “Fertilizer Industry - An Introductory Survey”, Higginbothams Pvt. Ltd., 1973.

REFERENCES:

1.Sauchelli, V.; “The Chemistry and Technology of Fertilizers”, ACS MONOGRAPH No. 148, Reinhold Publishing Cor. New York, 1980.

2. Fertiliser Manual, “United Nations Industrial Development Organisation”, United Nations, New York, 1967.

3.Slack, A.V.; Chemistry and Technology of Fertilisers, Interscience, New York, 1966.

CH19P83 PILOT PLANT AND SCALEUP STUDIES L T P C

3 0 0 3

Course Objectives:
To understand different scale up methods in chemical engineering and applying the knowledge to scale up the reactors for industrial scale operations.

UNIT 1 **DIMENSIONAL ANALYSIS** 15
Dimensional Analysis: (Review of Rayleigh's, Buckingham-nmethod's), Differential equation for static systems, flow systems, thermal systems, mass transfer processes, chemical processes-homogeneous and heterogeneous.

Module 2 **REGIMES** 15
Regime Concept: Static regime. Dynamic regime. Mixed regime concepts. Criteria to decide the regimes. Equations for scale criteria of static, dynamic processes, Extrapolation. Boundary effects.

Module 3 **MASS TRANSFER OPERATIONS** 15
Stagewise mass transfer processes. Continuous mass transfer processes. Scale up of momentum and heat transfer systems. Environmental challenges of scale up.

TOTAL : 45 PERIODS

Course Outcomes:
At the end of the course, the students
1. Able to develop a prototype (Large scale plant) based on pilot plant studies.
2. Able to correlate the performance of geometrically similar paddle, propeller and turbine mixers.
3. Able to design equipment by successive approximation method (Extrapolation).
4. Able to scale up of equipment like heat exchangers, evaporator, and packed towers, agitated vessel and chemical reactors.
5. Able to Analyze the problems involved in chemical engineering equipment.

Text Books:
1. Scale up of Chemical Processes, Attilio Bisio, Robert L. Kabel, John Wiley & Sons, 1985
2. Pilot Plants Models and scale up method in Chemical Engineering, John stone and Thring, McGraw Hill, 1957.

Reference Books:
1. Pilot Plants and Scale up Studies, Ibrahim and Kuloor.

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CH19P84 FLUIDIZATION ENGINEERING **L T P C**
3 0 0 3

OBJECTIVE:
To enable the students to learn the design aspects of fluidized beds.

UNIT BASICS OF FLUIDIZATION 9
Packed bed – Velocity – Pressure drop relations – Correlations of Ergun, Kozney-karman – On set of fluidization – Properties of fluidized beds – Development of fluidization from fixed bed.

UNIT II FLUIDIZED BED TYPES 9

Minimum fluidization conditions – Expanded bed – Elutriation – Moving solids and dilute phase – spouted bed.

UNIT III DESIGN ASPECTS 9

Channeling – Bed expansion in liquid – Solid and gas – Solid fluidizations. Design aspects of fluidized bed systems.

UNIT IV HEAT AND MASS TRANSFER IN FLUIDIZED BEDS 9

Heat and mass transfer in fluidized bed systems – Industrial applications and case studies of fluidized bed systems.

UNIT V OTHER TYPES OF FLUIDIZATION 9

Single stage and multistage fluidization – Collection of fines – Use of cyclones.

TOTAL : 45 PERIODS

OUTCOME:

Upon completion of this course, the students will have the knowledge on fluidization phenomenon, behavior of fluidized beds and industrial applications.

TEXT BOOKS:

1. Levenspiel, "Fluidization Engineering", 2nd Edition, Butterworth – Heinmann, 1991.
2. Robert H. Perry and Don W. Green, "Perry's Chemical Engineer's Hand Book", 7th Edition, Mc Graw Hill – International, 1997.

REFERENCES:

1. Rowe and Davidson, "Fluidization", Academic Press,1971.
2. Leva, M., "Fluidization", McGraw Hill Book Co, 1959.
3. Wen-Ching Yang., "Handbook of Fluidization and Fluid-Particle Systems", Marcel Dekker Inc, 2003.