Rajiv Gandhi University of Knowledge Technologies-AP

NUZVID***RK VALLEY***SRIKAKULAM***ONGOLE

DEPARTMENT OF CHEMICAL ENGINEERING

COURSE STRUCTURE

AND DETAILED SYLLABI OF

B.TECH PROGRAM IN CHEMICAL ENGINEERING

Effective from the batches admitted in **2020-2021** and onwards

CONTENTS

		11.Object Oriented programming through JAVA Lab
	(iii)	**Humanities and Social Sciences including Management courses**
		1. English Language Communication Skills Lab-I
		2.Managerial Economics and Financial Analysis
		3. English Language Communication Skills Lab -II
		4. English Language Communication Skills Lab -III
		5.Indian Community Services
	(iv)	**Mandatory Courses**
		1.Environmental Science
		2.Indian constitution
		3. Aptitude and Reasoning
	(v)	**Professional Core Courses**
		1.Chemical Process Calculations
		2.Fluid Mechanics
		3.Heat Transfer
		4.Mechanical Unit Operations
		5.Fluid Mechanics Lab
		6.Chemical Reaction Engineering – I
		7.Mass Transfer Operations-I
		8.Thermodynamics-II
		9. Heat Transfer Lab
		10.Mechanical Unit Operations Lab
		11.Chemical Process Dynamics and Control

		12.Chemical Technology
		13.Chemical Reaction Engineering-II
		14.Mass Transfer Operations-II
		15.Numerical Methods in Chemical Engineering
		16.Chemical Reaction Engineering Lab
		17.Numerical Methods in Chemical Engineering Lab
		18.Process Equipment Design
		19. Plant Design and Economics
		20.Transport Phenomena
		21.Chemical Process Dynamics and Control Lab
		22.Mass Transfer Operations Lab
	(vi)	**Professional Elective Courses**
		Advanced Mathematical Techniques in Chemical Engineering
		Computational Fluid Dynamics
		Fluidization Engineering
		Food Process Engineering
		Fuel Technology
		Industrial Safety and Hazard Management
		Material Science for Chemical Engineers
		Multiphase Flow
		Novel Separation Processes
		Optimization Methods for Chemical Engineering
		Petrochemical Technology
		Petroleum Refinery Engineering

		Polymer Engineering
		Process Instrumentation and Instrumental Methods of Analysis
		Process Integration
		Process Modeling and Simulation
		Technology of Oils and Fats
		Pharmaceuticals and Fine Chemicals
		Fuel cells and Flow Batteries
		Fertilizer Technology
		Green Technology
		CO2 capture and Utilization
		Sustainable Process Engineering
		Process Intensification
		Solid Waste Management
	(vii)	**Open Elective Courses**
		1.Corrosion Engineering
		2.Environmental Pollution and Control
		3.Introduction to Nano Technology
		4.Renewable Energy
		5.Waste to Energy Conversion
	(viii)	**Summer Internship/Projects**
		1.Summer Internship
		2.Project-I
		3.Project-II

Chapter-1

General, Course structure, Theme and semester-wise credit distribution

A. Definition of Credit:

1 Hour Lecture(L) per week	1 credit
1 Hour Tutorial(T) per week	1 credit
3 Hours Practical(Lab)/week	1.5 credits

B. Total number of credits: 160

C. Minimum number of contact hours/weeks per semester: 15 weeks of teaching

i. For 1 credit course: 15 contact hours per semester

ii. For 2 credit course: 30 contact hours per semester

iii. For 3 credit course: 45 contact hours per semester

iv. For 4 credit course: 60 contact hours per semester

D. Course code and definition

Course code	Definitions
BSC	BASIC SCIENCE COURSE
ESC	ENGINEERING SCIENCE COURSE
HSC	HUMANITIES, SOCIAL SCIENCES AND MANAGEMENT COURSE
PCC	PROFESSIONAL CORE COURSE
PEC	PROFESSIONAL ELECTIVE COURSE
OEC	OPEN ELECTIVE COURSE
MC	MANDATORY COURSE
SI	SUMMER INTERNSHIP
PROJ	PROJECT

E. Structure of Program

S.No	Category	Break up of credits
1	Basic Science Courses	**22.5**
2	Engineering Science Courses	**27**
3	Humanities and Social Sciences including Management courses	**10.5**
4	Professional core courses	**61**
5	Professional Elective courses	**15**
6	Open Elective courses	**9**
7	Project work, seminar and internship in industry or elsewhere	**15**
8	Mandatory courses	**0**
Total		**160**

F. Semester-wise Credits Distribution

COURSE CODE	E1 SEM1	E1 SEM2	E2 SEM1	E2 SEM2	E3 SEM1	E3 SEM2	E4 SEM1	E4 SEM2	SUMMER INTERNSHIP	CREDITS
BSC	11.5	7	4	0	0	0	0	0	**0**	**22.5**
ESC	6.5	7	6	7.5	0	0	0	0	**0**	**27**
HSC	2.5	0	3	0	1.5	1.5	0	2	**0**	**10.5**
MC	0	0	0	0	0	0	0	0	**0**	**0**
PCC	0	7	8.5	13	19	13.5	0	0	**0**	**61**
PEC	0	0	0	0	0	3	6	6	**0**	**15**
OEC	0	0	0	0	0	3	3	3	**0**	**9**
PROJECT/ SUMMER INTERNSHIP	0	0	0	0	0	3	6	6	**0**	**15**
Total Credits	**20.5**	**21**	**21.5**	**20.5**	**20.5**	**24**	**15**	**17**	**0**	**160**

Notations:

E1-S1: First Year Engineering First Semester

E1-S2: First Year Engineering Second Semester

E2-S1: Second Year Engineering First Semester

E2-S2: Second Year Engineering Second Semester

E3-S1: Third Year Engineering First Semester

E3-S2: Third Year Engineering Second Semester

E4-S1: Fourth Year Engineering First Semester

E4-S2: Fourth Year Engineering Second Semester

Final Approved Course structure in BOS meeting (30-12-2020)

Mandatory Induction Program

3 Weeks Duration
• **Physical Activity** • **Creative Arts** • **Universal Human Values** • **Literary** • **Proficiency Modules** • **Lectures by Eminent People** • **Visit to Local Areas** • **Familiarization of Department/Branch Innovations**

I Year – SEMESTER – I
COURSE STRUCTURE

S.NO	Category	Course Code	Subject Name	L-T-P	Credits
1	BSC	20BE1102	Biology for Engineers	3-0-0	3
2	BSC	20CY1101	Physical and Organic Chemistry	3-0-0	3
3	BSC	20MA1101	Differential Equations and Multivariable Calculus	3-1-0	4
4	ESC	20CH1101	Introduction of Chemical Engineering	2-0-0	2
5	ESC	20ME1111	Engineering and Solid Mechanics	3-0-0	3
6	HSC	20EG1181	English Language Communication Skills Lab-I	1-0-3	2.5
7	BSC	20CY1181	Physical and Organic Chemistry Lab	0-0-3	1.5
8	ESC	20ME1185	Workshop	0-0-3	1.5
Contact periods=22/25			Contact hours=33/37.5	**Total credits**	**20.5**

I Year – SEMESTER – II
COURSE STRUCTURE

S.No	Category	Course Code	Subject Name	L-T-P	Credits
1	BSC	20PY1203	Engineering Physics	3-0-0	3
2	BSC	20MA1201	Mathematical Methods	3-1-0	4
3	ESC	20CE1214	Engineering Graphics and Computer Drafting	1-0-3	2.5

4	ESC	20CS1208	Programming and Data Structures	3-0-0	3
5	PCC	20CH1201	Chemical Process Calculations	3-0-0	3
6	PCC	20CH1202	Fluid Mechanics	3-1-0	4
7	ESC	20CS1288	Programming and Data Structures Lab	0-0-3	1.5
Contact periods=24/25 Contact hours= 36/37.5 **Total Credits**					**21**

II Year – SEMESTER – I

COURSE STRUCTURE

S.No	Category	Course Code	Subject Name	L-T-P	Credits
1	BSC	20MA2103	Transform Calculus	3-1-0	4
2	ESC	20ME2112	Mechanical Technology	3-0-0	3
3	ESC	20CH2101	Thermodynamics-I	3-0-0	3
4	PCC	20CH2102	Heat Transfer	3-1-0	4
5	PCC	20CH2103	Mechanical Unit Operations	3-0-0	3
6	HSC	20BM2101	Managerial Economics and Financial Analysis	3-0-0	3
7	PCC	20CH2181	Fluid Mechanics Lab	0-0-3	1.5
Contact periods=24/25 Contact hours= 36/37.5 **Total Credits**					**21.5**

II Year – SEMESTER – II

COURSE STRUCTURE

S.No	Category	Course Code	Subject Name	L-T-P	Credits
1	ESC	20EC2209	Basics of Electrical and Electronics Engineering	3-0-0	3
2	ESC	20CS2207	Object Oriented programming through JAVA	3-0-0	3
3	PCC	20CH2201	Chemical Reaction Engineering-I	3-1-0	4

4	PCC	20CH2202	Mass Transfer Operations-I	3-0-0	3
5	PCC	20CH2203	Thermo Dynamics-II	3-0-0	3
6	ESC	20CS2287	Object Oriented programming through JAVA Lab	0-0-3	1.5
7	PCC	20CH2281	Heat Transfer Lab	0-0-3	1.5
8	PCC	20CH2282	Mechanical Unit Operations Lab	0-0-3	1.5
Contact periods=22/25			Contact hours= 33/37.5	**Total Credits**	**20.5**

III Year – SEMESTER – I

COURSE STRUCTURE

S.No	Category	Course Code	Subject Name	L-T-P	Credits
1	PCC	20CH3101	Chemical Process Dynamics and Control	3-1-0	4
2	PCC	20CH3102	Chemical Technology	3-0-0	3
3	PCC	20CH3103	Chemical Reaction Engineering-II	3-0-0	3
4	PCC	20CH3104	Mass Transfer Operations-II	3-0-0	3
5	PCC	20CH3105	Numerical Methods in Chemical Engineering	3-0-0	3
6	PCC	20CH3181	Chemical Reaction Engineering Lab	0-0-3	1.5
7	PCC	20CH3182	Numerical Methods in Chemical Engineering Lab	0-0-3	1.5
8	HSC	20EG3182	English Language Communication Skills Lab –II	0-0-3	1.5
Contact periods=22/25			Contact hours= 33/37.5	**Total Credits**	**20.5**

III Year – SEMESTER – II

COURSE STRUCTURE

S.No	Category	Course Code	Subject Name	L-T-P	Credits
1	PCC	20CH3201	Process Equipment Design	3-0-1	3.5
2	PCC	20CH3202	Plant Design and Economics	3-0-0	3
3	PCC	20CH3203	Transport Phenomena	3-1-0	4
4	PEC	20CH32XX	Professional Elective Course-1	3-0-0	3
5	OEC	20XX32XX	Open Elective Course-1	3-0-0	3
6	PCC	20CH3281	Chemical Process Dynamics and Control Lab	0-0-3	1.5
7	PCC	20CH3282	Mass Transfer Operations Lab	0-0-3	1.5
8	HSC	20EG3283	English Language Communication Skills Lab -III	0-0-3	1.5
Sub Total Credits					**21**
9	SI	20CH3291	**Summer Internship**		**3**
Contact periods =22/25 (Excluding Internship project) Contact hours =33/37.5 **Total Credits**					**24**

IV Year – SEMESTER – I

COURSE STRUCTURE

S.No	Category	Course Code	Subject Name	L-T-P	Credits
1	PEC	20CH41XX	Professional Elective Course-2	3-0-0	3
2	PEC	20CH41XX	Professional Elective Course-3	3-0-0	3
3	OEC	20XX41XX	Open Elective Course-2	3-0-0	3
4	MC	20HS4104	Aptitude and Reasoning	2-0-0	0
5	MC	20HS4101	Indian Constitution	2-0-0	0
6	PROJ-I	20CH4192	Project	0-0-6	6
(Excluding project) contact periods = 15/25 contact hours = 22.5/37.5 **Total Credits**					**15**

IV Year – SEMESTER – II

COURSE STRUCTURE

S.No	Category	Course Code	Subject Name	L-T-P	Credits
1	PEC	20CH42XX	Professional Elective Course-4	3-0-0	3
2	PEC	20CH42XX	Professional Elective Course-5	3-0-0	3
3	OEC	20XX42XX	Open Elective Course-3	3-0-0	3
4	HSC	20HS4299	Indian Community Services	0-0-4	2
5	PROJ-II	20CH4293	Project	0-0-6	6
6	MC	20BE4201	Environmental Science	2-0-0	0
(Excluding project) Contact periods =15/25 Contact hours =22.5/37.5				**Total Credits**	**17**

LIST OF ELECTIVE COURSES

	Category	Code	Course Name	Credits
1	PEC	20CHXX21	Advanced Mathematical Techniques in Chemical Engineering	3
2	PEC	20CHXX22	CO2 capture and Utilization	3
3	PEC	20CHXX23	Computational Fluid Dynamics	3
4	PEC	20CHXX24	Fertilizer Technology	3
5	PEC	20CHXX25	Fluidization Engineering	3
6	PEC	20CHXX26	Food Process Engineering	3
7	PEC	20CHXX27	Fuel cells and Flow Batteries	3
8	PEC	20CHXX28	Fuel Technology	3
9	PEC	20CHXX29	Green Technology	3
10	PEC	20CHXX30	Industrial Safety and Hazard Management	3
11	PEC	20CHXX31	Material Science for Chemical Engineers	3
12	PEC	20CHXX32	Multiphase Flow	3
13	PEC	20CHXX33	Novel Separation Processes	3
14	PEC	20CHXX34	Optimization Methods for Chemical Engineering	3
15	PEC	20CHXX35	Petrochemical Technology	3
16	PEC	20CHXX36	Petroleum Refinery Engineering	3
17	PEC	20CHXX37	Pharmaceuticals and Fine Chemicals	3
18	PEC	20CHXX38	Polymer Engineering	3
19	PEC	20CHXX39	Process Instrumentation and Instrumental Methods of Analysis	3
20	PEC	20CHXX40	Process Integration	3
21	PEC	20CHXX41	Process Intensification	3
22	PEC	20CHXX42	Process Modeling and Simulation	3
23	PEC	20CHXX43	Solid Waste Management	3
24	PEC	20CHXX44	Sustainable Process Engineering	3
25	PEC	20CHXX45	Technology of Oils and Fats	3

LIST OF OPEN ELECTIVE COURSES

	Category	Code	Course Name	Credits
1	OEC	20CHXX51	Corrosion Engineering	3
2	OEC	20CHXX52	Environmental Pollution and Control	3
3	OEC	20CHXX53	Introduction to Nano Technology	3
4	OEC	20CHXX54	Renewable Energy	3
5	OEC	20CHXX55	Waste to Energy Conversion	3

CHAPTER 2

DETAILED 4-YEAR CURRICULUM CONTENTS

BIOLOGY FOR ENGINEERS

Course code	Course name	Course Category	L-T-P	Credits
20BEXY02	Biology for Engineers	BSC	3-0-0	3

Course Learning Objectives:

1. To convey that Biology is as important a scientific discipline as Mathematics, Physics and Chemistry.
2. The molecular basis of coding and decoding genetic information is universal
3. To convey that all forms of life has the same building blocks and yet the manifestations are as diverse as one can imagine
4. To convey that without catalysis life would not have existed on earth.
5. How to analyses biological processes at the reductionist level. The fundamental principles of energy transactions are the same in physical and biological world.
6. To make understanding of concept of single cell celled organisms.

Course Content:

Unit – I: Introduction and Classification (9 hours)

Fundamental differences between science and engineering by drawing a comparison between eye and camera, Bird flying and aircraft. Need to study biology? Biological observations of 18th Century that lead to major discoveries. Examples from Brownian motion and the origin of thermodynamics by referring to the original observation of Robert Brown and Julius Mayor.

Hierarchy of life forms at phenomenological level. Classification based on (a) cellularity- Unicellular or multicellular (b) ultrastructure- prokaryotes or eucaryotes. (c) energy and Carbon utilization -Autotrophs, heterotrophs, lithotropes (d) Ammonia excretion – aminotelic, uricoteliec, ureotelic (e) Habitat- aquatic or terrestrial (e) Molecular taxonomy- three kingdoms classification (Ernst Haeckel proposed). Model organisms: *E. coli*, *S. cerevisiae*, *D. melanogaster*, *C. elegance*, *A. thaliana*, *M. musculus*.

Unit – II: Genetics and Information Transfer (10 hours)

Mendel's laws, Concept of segregation and independent assortment. Concept of allele. Gene mapping, Gene interaction, Epistasis. Meiosis and Mitosis. Concepts of recessiveness and dominance. Concept of mapping of phenotype to genes. Single gene disorders in humans. Concept of complementation using human genetics.

DNA as a genetic material. Hierarchy of DNA structure- from single stranded to double helix to nucleosomes. Concept of genetic code. Wobble hypothesis, Universality and degeneracy of genetic code. Define gene in terms of complementation and recombination.

Unit – III: Biomolecules **(6 hours)**

Molecules of life. Monomeric units and polymeric structures. sugars, starch and cellulose. Amino acids and proteins. Nucleotides and DNA/RNA. Lipids and glycolipids .

Unit -IV: Macromolecular Analysis **(6 hours)**

Hierarch in protein structure. Primary secondary, tertiary and quaternary structure. Proteins as enzymes, transporters, receptors and structural elements.

Unit -V: Enzyme and Metabolism **(8 hours)**

Monitoring of enzyme catalyzed reactions. Enzyme classification. Mechanism of enzyme action. Discuss at least two examples. Enzyme kinetics and kinetic parameters. RNA catalysis (ribozyme).

Thermodynamics as applied to biological systems. Exothermic and endothermic versus endergonic and exergoinc reactions. Concept of Keq and its relation to standard free energy. Spontaneity. ATP as an energy currency. Glycolysis and Krebs cycle, synthesis of glucose from CO_2 and H_2O (Photosynthesis). Energy yielding and energy consuming reactions. Concept of Energy charge

Unit -VI: Microbiology **(6 hours)**

Concept of single celled organisms. Concept of species and strains. Identification and classification of microorganisms. Microscopy. Ecological aspects of single celled organisms. Sterilization and media compositions. Growth kinetics.

Learning Resources

Text Book:

1. N. A. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, "Biology: A global approach", Pearson Education Ltd, 2014.
2. E. E. Conn, P. K. Stumpf, G. Bruening and R. H. Doi, "Outlines of Biochemistry", John Wiley and Sons, 2009.
3. D. L. Nelson and M. M. Cox, "Principles of Biochemistry", W.H. Freeman and Company, 2012.

Reference Books:

1. L. M. Prescott, J. P. Harley and C. A. Klein, "Microbiology", McGraw Hill Higher Education, 2005.
2. G. S. Stent and R. Calendar, "Molecular Genetics", Freeman and company, 1978.

Web Resources:

1. NPTEL: https://nptel.ac.in/courses/121/106/121106008/

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

CO 1	Describe how biological observations of 18th Century that lead to major discoveries., Convey that classification *per se* is not what biology is all about but highlight the underlying criteria, such as morphological, biochemical and

	ecological
CO 2	Identify DNA as a genetic material in the molecular basis of information transfer, Highlight the concepts of recessiveness and dominance during the passage of genetic material from parent to offspring.
CO 3	Understand structure about DNA, RNA, Protein , carbohydrate and lipid
CO 4	Understand hierarch in protein structure and different roles of proteins.
CO 5	Classify enzymes and distinguish between different mechanisms of enzyme action. Apply thermodynamic principles to biological systems.
CO 6	Identify and classify microorganisms.

Evaluation pattern for Theory Course Only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20CY1101	**Physical and Organic Chemistry**	**BSC**	**3-0-0**	**3**

Course Learning Objectives:

1. To acquire knowledge about distribution law importance, its applications and basic concepts in understanding phase rule.
2. To gain the knowledge on rate of reaction and factors affecting rate of reactions
3. To acquire basic knowledge on electrochemical cells and to gain knowledge on types of water and problems
4. To characterize chemical compound by using analytical techniques
5. To get to know the different types of reactions and its intermediates
6. To understand the types of drugs and it properties

Course Content:

UNIT-I: Distribution Law and Phase Rule (7 Hours)

Distribution Law – Nernst Distribution Law – Distribution Coefficient – Explanation and Limitations of Distribution Law - Modification of Distribution Law – Determination of Equilibrium Constant from Distribution Coefficient – Applications of Distribution Law- Phase Rule – Terms involved in Phase Rule – Types of Liquids – Derivation of Phase Rule – Phase Diagrams of One Component System (Water, CO_2 and Sulphur systems), Two Component System – Eutectic Point (Lead Silver System. Applications of Phase Rule

UNIT-II: Chemical Kinetics (8 Hours)

Introduction to Chemical Kinetics – Theories of Reaction Rates – Collision Theory – Modified Collision Theory –Arrhenius Theory –Brief note on Absolute Reaction Rate Theory (Transition State Theory) – Reaction between Ions – Influence of Solvent (Double Sphere Activated Complex and Single Sphere Activated Complex) – Lindamanns' theory of unimolecular reactions – Influence of Ionic Strength on the Rate of the Reactions – Steady State Approximation in Chain Reactions – Hydrogen and Bromine, Hydrogen and Oxygen (Steady State Treatment) – Explosion Limits.

UNIT III: Electrochemistry & Water Technology (7 Hours)

Electrochemistry: Overview of Fundamentals of Electrochemistry - Concentration Cells – Batteries: Dry Cell - Ni-Cd cells - Ni-Metal hydride cells- Li cells - Zinc – air cells. Fuel cells: - Hydrogen Oxygen fuel cells – Methanol Oxygen fuel cells.

Water Technology: Hard water – Reasons for hardness – units of hardness - Boiler troubles – Priming and Foaming, Scale formation, Boiler corrosion, Caustic embrittlement - Internal treatments - Softening of Hard water : Lime – Soda process, Zeolite process and numerical problems based on these processes and Ion Exchange.

UNIT-IV: Analytical Techniques (8 Hours)

Absorption Spectroscopy: Beer-Lambert's law and its limitations, transmittance, Absorbance, and molar absorptivity; Application of Beers-Lamberts law for simultaneous quantitative analysis of Cr in $K_2Cr_2O_7$, Mn in $KMnO_4$

Separation Techniques: Solvent extraction: Principle and process, Batch extraction, Continuous extraction and counter current extraction, Industrial Applications.

Chromatography: Classification of chromatography methods, Principles and Applications of – Paper Chromatography, Thin Layer Chromatography (TLC), Column Chromatography, Ion-exchange Chromatography, Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Supercritical Fluid Chromatography.

UNIT- V: Organic Chemistry (8 Hours)

Types of reactions-Reaction intermediates – Carbocation, carbanion, free radical, and carbene. Reaction mechanisms - aldol, Perkin, Cannizzaro's reaction, Beckmann rearrangement, Benzoin condensation. Allylic halogenation using N-bromo succinamide (NBS), Heterocylic compounds – Preparation, properties, and applications of pyrrole, furan, thiophene, and pyridine.

UNIT- VI: Pharmaceutical Chemistry (7Hours)

Drug discovery and development process, Sequence of events after drug administration, List of physico-chemical properties related to drug action, Clinical Chemistry and the importance of fundamental chemistry concepts and analytical techniques. Pharmaceuticals – Classification - examples of Antihistamine / Antibacterial / Anti inflammatory/Antifungal drugs - preparation of paracetamol and Aspirin.

Learning resources

Text Books:

1. Peter Atkins, Julia de Paula, *Physical Chemistry*, 9th Edition, Oxford University Press, 2011.
2. Laidler, K. J., *Chemical Kinetics*, 2nd Edition, McGraw-Hill, 1965.
3. Puri, B. R., L. R. Sharma, *Principles of Physical Chemistry*, M. S. Pathama, Vishal Publishing Company, 2008.
4. Jain & Jain, *Engineering Chemistry*, 16th Edition, 2015.
5. Advanced Chemistry – Volumes 1 and 2 by Philip Matthews, Paperback, Cambridge University Press.

Reference Books:

1. L. N. Ferguson, *Text Book of Organic Chemistry*, 2nd Edition, East-West Press, 2009.
2. Shilkha Agarwal, *Engineering Chemistry*, 2nd Edition, 2019
3. Vairam and others, *Engineering Chemistry*, Wiley India Pvt. Ltd., 2014 edition (second)
4. Kapoor, K. L.,*A Textbook of Physical Chemistry*, Macmillan, 2000.
5. *Chemical Separation Methods*, John A. Dean, Van Nostrand Reinhold, 1969.
6. Kour, H., Pragati *An Introduction to Chromatography*, Publishers, 2007.
7. M. N., Himalaya Publications, *Separation Methods*, Sastry, 3rd Edition, 2005.
8. Finar, I. L., Organic Chemistry, Vol 1, Pearsons, 2002.
9. Organic Chemistry Concepts and Applications for Medicinal Chemistry, Joseph E. Rice, Academic Press, 2014, Softcover; ISBN 9780128007396 or eBook; ISBN 9780128008324.
10. David G. Watson. Pharmaceutical Analysis, A Textbook for Pharmacy Students and Pharmaceutical Chemists, 3rd Edition, 2012, Elsevier.

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

CO 1	Determine equilibrium constant from distribution law.
CO 2	Derive rate of reactions based by considering theories of reaction rate, solvent effect, and ionic strength factors.
CO 3	Constructing electrochemical cell and developing different methods for attaining soft water by different treatment procedures.
CO 4	Isolating pure chemical compound and characterizing it based on knowledge on analytical techniques.
CO 5	.To understand the various reaction mechanisms observed in organic compounds
CO 6	To understand the fundamentals of Pharmaceutical and nanomaterials chemistry.

Course Nature		Theory		
Assessment Method				
Assessment Tool	Weekly tests (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course Name	Course Category	L-T-P	Credits
20MA1101	**Differential Equations and Multivariable Calculus**	**BSC**	**3-1-0**	**4**

Course Learning Objectives: The objective of this course is to

1. Discuss the Solutions of first order differential equations
2. Discuss the Solutions of higher order linear differential equations
3. Understand the converge of infinite series with different tests.
4. Learn power series representation of functions and its validity
5. Understand Continuity and differentiability of multi-variable functions and its applications to discuss maximum and minimum
6. Discuss the convergence Improper integrals and apply Leibnitz rule

Course Content:

Unit – I **(10 Contact hours)**

Differential equations of first order and first degree:

Basic concepts, Variable Separable method, homogeneous differential equations, Exact differential equations, Integrating factor, Differentiable equations Reducible to exact, Linear differential equations, Bernoulli differential equations.

Unit - II **(11 Contact hours)**

Linear differential equations of higher order:

Homogenous differentiable equations, Non-homogeneous linear equations of higher order with constant coefficients with RHS term of the type $e^{ax}, sinax, cosax,$ polynomials in $x, e^{ax}\ V(x), xV(x),$ Methods of Undetermined Coefficients, Method of variation of parameters, Euler Cauchy equation.

Unit - III **(12 Contact hours)**

Sequences and Series

Definition of Sequences and convergence, Convergence of series, Comparison test, Ratio test, Root test, Absolute and Conditional convergence, Alternating series, Power series, Taylor's and Maclaurin's series.

Unit - IV **(12 Contact hours)**

Functions of several variables:

Limit, Continuity and Differentiability of functions of several variables, Partial derivatives and their geometrical interpretation, Differentials, Derivatives of Composite and Implicit functions, Chain rule, Jacobians, Derivatives of higher order, Homogeneous functions, Euler's theorem, and Harmonic functions.

Unit - V

Applications of Functions of several Variable: **(8 Contact hours)**

Taylor's expansion of functions of several variables, Maxima and Minima of functions of several variables - Lagrange's method of multipliers.

Unit – VI **(6 Contact hours)**

Beta and Gamma Function:

Beta and Gamma functions - elementary properties, Relation between Beta and gamma functions, Evaluation of Definite integral using Beta and Gamma functions, differentiation under integral sign, and differentiation of integrals with variable limits - Leibnitz rule.

Learning resources

Text book:

1. ERWIN KREYSZIG, '*Advanced Engineering Mathematics'*, Wiley-India, 9th Edition

Reference Books:

1. TOM M. APOSTAL,*' Calculus, Volume II'*, Wiley-India, Second Edition,

2. R. K. JAIN AND S. R. K. IYENGAR,' *Advanced Engineering Mathematics'*, Narosa Publishers, 3rd Edition.

3. B.S.GREWAL, '*Higher Engineering Mathematics'*, Khanna Publishers, 42nd Edition.

Web resources:

1. NPTEL, IIT- Madras, 08-June-2017, Introduction to ordinary differential equations
URL: https://nptel.ac.in/courses/111106100/12
2. NPTEL, IIT- Kanpur, 15-March-2016, Differential Calculus of Several Variables
URL: https://nptel.ac.in/courses/111104092/11
3. NPTEL, IIT- Roorkee, 22-December-2017, Multivariable Calculus
URL:https://nptel.ac.in/courses/111107108/
4. MatheMagician, 24–April-2017, Calculus - sequences and series, URL:
https://www.youtube.com/playlist?list=PLJMXXdEk8kMAeBLj14HX0fhe_LypRc4aW
5.RGUKT Course Content

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

CO 1	Solve first order differential equations.
CO 2	Solve higher order linear differential equations.
CO 3	Check the convergence of infinite series with different methods
CO 4	Discuss the power series representation of a function at various points.
CO 5	Explain limits and continuity, differentiability and partial derivatives of functions of multivariable and solve the extremum problems subjected to constraints.
CO 6	Apply Leibnitz rule and beta gamma functions to evaluate improper integrals.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CH1101	Introduction to Chemical Engineering	ESC	2-0-0	2

Course Learning Objectives:

The course content enables the students to:

1. Know what is meant by chemical engineering
2. Learn the basic principles and applications of various chemical engineering subjects
3. To study the basic unit operations and unit processes in Chemical industry.
4. To study the basic concepts of chemical processes.

Course Content:

Unit-I **(5 Contact hours)**

Introduction, Chemical Engineering in everyday life, Lab scale to plant scale, Versatility of a Chemical/Petrochemical Engineer, Role of Chemical Engineers in Petroleum refinery, Chemical, Petrochemical, Nanotechnology, Energy and environment. Batch Processing, Transition from batch to continuous processing, Case study: Any chemical industry, Role of basic sciences in Chemical Engineering (Introduction)

Introduction to Natural Resources and Their utilization: Renewable and Non – Renewable Raw materials

Unit–II **(5 Contact hours)**

Definition of Chemical Engineering, Basic Concepts in Chemical Engineering: Unit Operations, Basic laws, Useful mathematical methods, Units and Dimensions.

Unit-III **(5 Contact hours)**

Flow of fluids: Nature of Fluid, Viscosity, Flow Field, Flow of Fluid Past a Solid Surface, Conservation Of Mass and Energy, Friction Loses in Laminar Flow through a Circular Tube, Hagen-Poiseuille Equation, Friction Losses in Turbulent Flow, Fanning Equation

Unit – IV **(5 Contact hours)**

Heat Transfer: Fundamental Concepts of Conduction, Convection and Radiation.

Heat Transfer Equipment: Double Pipe, Shell and Tube Heat Exchangers and Evaporators

Unit – V **(5 Contact hours)**

Mass Transfer: Fundamental concepts of Diffusion, VLE, Relative Volatility, Boiling point Diagram, Different Mass Transfer Operations

Unit – VI **(5 Contact hours)**

Reaction Engineering: Introduction, Thermodynamics of Reactions, Determination of the Rate Equation, Effect of Temperature on Reaction Rate, Reactors

Text Book:

1. S. K. Ghosal, S. K. Sanyal& S. Datta, *'Introduction to Chemical Engineering'* Tata-McGraw-Hill,.

2. W.L. McCabe and J.C. Smith and Peter Harriott, *'Unit Operations in Chemical Engineering'*, Mc Graw Hill, 7th Edition

Reference Books:

1. Walter L. Badger, Julius T. Banchero, *'Introduction to Chemical Engineering'* McGraw-Hill Inc.,1955
2. Robert E. Treybal, *'Mass Transfer Operations'* 3rd edition, McGraw Hill, New Delhi.
3. Smith J. M., '*Introduction to Chemical Engineering'* McGraw Hill, New Delhi.

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

CO 1	Identifying the scope of Chemical engineering
CO 2	Build the basic principles and applications of various chemical concepts
CO 3	Analyzing unit operations in Chemical industry
CO 4	Choose unit processes in Chemical industry
CO 5	Estimate the basic chemical calculations.
CO 6	Create an overview on chemical industry.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20ME1111	Engineering and Solid Mechanics	ESC	3-0-0	3

Course Learning Objectives:

1. To introduce the students to the fundamentals of Engineering Mechanics
2. To make the student learn about force systems, axioms and dynamics of rigid bodies
3. To introduce the concepts of solid mechanics to the students
4. To make the students learn concepts of deformable media: like stress and strain tensors, strain rates, constitutive relations
5. To make the students learn the applications of 1 and 2 Dimensional problems relating to above concepts

Unit-I (Contact hours 8)

Introduction:

Introduction to Engineering Mechanics - Force systems, Forces acting at a point, Moment of a force about a point; couple moment; reduction of a force system to a force and a couple. Equilibrium of system of forces: Free body diagram; equations of equilibrium; problems in two dimensions; Analysis of plane trusses.

Unit-II (Contact hours: 8)

Friction: Types of friction, Limiting friction, Laws of Friction, Problems on Static and Dynamic Friction.

Centroid and Centre of Gravity: Centroid of Areas from first principle, Centroid of composite sections; Centre of Gravity and its implications.

Unit-III (Contact hours 6)

Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Product of Inertia, Parallel Axis Theorem, Perpendicular Axis Theorem

Unit – IV (Contact hours: 8)

Particle dynamics- Rectilinear motion; Plane curvilinear motion (rectangular, path, and polar coordinates). Relative motion; Newton's 2nd law (rectangular, path, and polar coordinates).

Unit – V (Contact hours: 8)

Simple Stresses and Strains: Elasticity and Plasticity, Basics of stress and strain, Types of stresses & strains, Generalized Hooks Law, Stress-strain behavior of different materials,

Elastic constants and their relations, applications of normal stresses and strains, strain energy, resilience, toughness

Shear and Bending in beams: Beams-Types of loads, supports, shear force and bending moment diagrams of statistically determinate beams with various loading conditions

Unit-VI **(Contact Hours: 7)**

Theory of simple bending, Bending formula and its assumption, stress distribution in symmetrical sections.

Torsion: Torsion formula and its assumption, Torsion of circular solid and hollow shafts, torsional rigidity, torsion of shafts, power transmitted by shafts.

Learning resources

Text book:

1. Russell C. Hibbeler, '*Mechanics of Materials'*, PEARSON Publishers, 9th Edition.

Reference Books:

1. F. P. Beer, E. R. Johnston and J. T. DeWolf, '*Mechanics of Materials'*, Tata McGraw Hill, India.
2. L. E. Malvern, '*Introduction to the Mechanics of a Continuous Medium'*.

Web resources:

1. **NPTEL: IIT ROORKEE, Jul 31, 2009, *'Lec-1 Solid Mechanics'***

URL: https://www.youtube.com/watch?time_continue=2&v=A1SWKe6ZwVc

2. **NPTEL, Introduction and review – Lectures 1 to 40, *'Strength of Materials'***
URL: https://nptel.ac.in/courses/112107146/

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

CO1	Examine the use of basic concepts of Resolution and composition of forces
CO2	Analyze beams, truss or any engineering component by applying conditions of Equilibrium
CO3	List advantages and disadvantages of various geometric sections used in engineering design
CO4	Compare the different stresses and strains occurring in components of structure
CO5	Calculate the deformations such as axial, normal deflections under different loading conditions

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Course code	Course Name	Course Category	L-T-P	Credits
20EG1181	English Language Communication Skills Lab - I	HSC	1-0-3	2.5

Course objectives:

1. To facilitate computer-aided multi-media instruction enabling individualized and independent language learning
2. To sensitize the students to the nuances of English speech sounds, word accent, intonation and rhythm
3. To provide opportunities for practice in using English in day to day situations
4. To improve the fluency in spoken English and neutralize mother tongue influence
5. To train students to use language appropriately for debate, group discussion and public speaking

Unit-I **(06 Contact Hours)**

Theory: An Ideal Family by Katherine Mansfield

Spoken Skills: Situational Dialogues – Role-play – Expressions in various situations – Self Introduction – Introducing others – Greetings – Apologies – Requests – Giving directions

Unit-II **(06 Contact Hours)**

Theory: Energy -Alternative sources of Energy

Panel Debate on "On-grid & off-grid support to public participation in the production of solar energy in India", Reading the Wikipedia content on "The Green New Deal". Reflective session on the prospects of "The Green New Deal in India"

Writing Skills: Letter Writing (Formal & Informal) and Hands on Session on Letter Writing

Unit-III **(06 Contact Hours)**

Theory: Transport - Problems & solutions

Group Discussion on "The Future of Bullet Trains in India"

PPT on "The Dedicated Freight Corridors & the Future of Indian Economy" – Introduction to Speech

Spoken Skills: Sounds – Vowels, Consonants and Diphthongs – Pronunciation Exercises (Basic Level)

Unit-IV **(06 Contact Hours)**

Theory: Technology - Evaluating technology

PPT on "3R: Reduce, Recycle, Reuse" - Solo Debate on "Can Block Chain Technology Mitigate the Issue of Cyber Crimes and Hacking?"

Presentation Skills: JAM –Description of Pictures, Photographs, Process, Talking about wishes, Information Transfer

Unit-V **(06 Contact Hours)**

Theory: Environment - Ecology versus Development

Listening Skills: Listening Activity on YouTube video on "Greening the Deserts" - Students' seminar on "Waste to Wealth: Examples from around the Globe".

Unit-VI **(06 Contact Hours)**

Theory: Industry - Selling products

Reading Skills: Reading the material on "4Ps: Product, Price, Place, and Promotion" Role play on "How to sell your product and services"

References:

1. Non – Detailed Text Book: Panorama – A Course on Reading published by Oxford University Press, India
2. English for engineers and technologists by Orient Black Swan
3. A Textbook of English Phonetics for Indian Students 2nd Ed T. Balasubramanian. (Macmillan), 2012.
4. Speaking English Effectively, 2nd Edition Krishna Mohan & NP Singh, 2011. (Macmillan).
5. A Hand book for English Laboratories, E.Suresh Kumar, P.Sreehari, Foundation Books,2011
6. English Pronunciation in Use. Intermediate & Advanced, Hancock, M. 2009. CUP
7. Basics of Communication in English, Soundararaj, Francis. 2012.. *New Delhi: Macmillan*
8. English Pronouncing Dictionary, Daniel Jones Current Edition with CD.Cambridge, 17th edition, 2011.

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

CO 1	Understand the issues affecting the economy and environment in India and across the globe
CO 2	Develop the instinct for problem solution
CO 3	Develop the ability to collect materials on various socio-economic-technological issues and prepare PPT for presentation
CO 4	Improving listening skills
CO 5	Inculcate speaking as a behaviour by repeated practice and exposure

Assessment Method:

Course Nature: THEORY + LABORATORY

Internal Assessment (40 Marks)	**External Assessment (**60 Marks)
Record Writing – 10 Marks	Reading Comprehension – 15 Marks
Attendance – 10 Marks	Writing – 30 Marks
Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)	Speaking (Viva-Voce) – 15 Marks

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Course code	Course Name	L	T	P	C
20CY1181	**Physical and Organic Chemistry Lab**	**0**	**0**	**1.5**	**1.5**

Course Learning Objectives:

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

1. To understand the water quality in terms of hardness
2. To know the concentration of unknown acid/base concentration by using titrations methods
3. To study the physical property of chemical substances
4. To study kinetics of reactions
5. To know medicinal compounds preparation

Practical Syllabus

List of Experiments:

1. Determination of temporary and permanent hardness of water using standard EDTA solution.
2. Determination of Iron by a Colorimetric method using thiocynate as reagent.
3. Preparation of Soap from palm oil.
4. pH-metric titrations
    a. strong acid and strong base.

b. strong acid and weak base.

5. Conductometric titrations
   a. strong acid and strong base.
   b. strong acid and weak base.
6. Potentiometric titrations
   a. strong acid and strong base.
   b. $K_2Cr_2O_7$ and Mohr's salt.
7. Determination of density and surface tension of liquids against air
8. Determination of viscosities of pure liquids and solutions
9. Determination of Kinetics of the Reduction of Methylene Blue by Ascorbic Acid.
10. Preparation of Organic Medicinal Compounds:
    Aspirin/ Azodye /Acetanilide /Thiokol Rubber /Paracetamol
11. Extraction of Caffeine from Tea leaves
12. Adsorption of oxalic acid on Charcoal

Reference Books:

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

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

CO 1	Ability to judge water quality of different places in terms of hardness.
CO 2	Estimate unknown concentration of acid/base by using pH-metric, potentiometric and conductometric titration methods.
CO 3	Derive the physical characterization like surface tension and viscosity of chemical substances
CO 4	Determine rate of reactions.
CO 5	Synthesizing medicinal compounds

Course Nature		Practical		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total

Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

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Course code	Course name	Course Category	L-T-P	Credits
20ME1185	**Workshop**	**ESC**	**0-0-3**	**1.5**

Course Learning Objectives:

1. To understand different machining operations on different machines
2. To understand the process of preparing the mold cavity for sand casting
3. To understand the preparation and joining of metal work pieces using welding
4. To understand the preparation and assembly of work pieces using fitting
5. To make different products using sheet metal by Tin smithy operation
6. To understand the joining of wood pieces by Carpentry operation
7. To understand wiring connections in different applications

List of Experiments: (Working Hours: 3hours per experiment)

1.Plain Turning, Step Turning and Taper Turning on Lathe Machine
2.Surface Machining and Drilling operations on Milling Machine
3.Preparation of Mould Cavity using Single Piece Solid Pattern
4.Preparation of Mould Cavity using Split Piece Pattern
5.Preparation of Butt Joint using Shielded Metal Arc Welding
6.Preparation of Lap Joint using Shielded Metal Arc Welding
7.Filling the holes in a given metal work piece using Oxy-Acetylene Gas Welding
8.Preparation of 'V' shape joint using Fitting Operation
9.Preparation of 'L' shape joint using Fitting Operation
10.Preparation of Tray and Cone by Tin smithy Operation
11.Preparation of Dove tail joint by Carpentry Operation
12.Preparation of 'T' joint by Carpentry Operation
13.House wiring for one lamp and two lamps with single switch
14.Staircase wiring connection
15.Go Down wiring connection

Learning resources:

Text books:

1. Balasubramaniam, R., "*Callister's Materials Science and Engineering*", Wiley India Ltd, 2014. 2nd Edition

Reference books:

1. Groover, M. P., "*Fundamentals of modern Manufacturing*", Wiley, 2011.4th Edition.
2. Rao, P. N., "*Manufacturing Technology: Foundry, Forming and Welding*", McGraw Hill, 2013. 4th Edition

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

CO1	Evaluating different machining operations on different machines
CO2	Analyzing the process of preparing the mold cavity for sand casting
CO3	Build the preparation and joining of metal work pieces using welding
CO4	Compose the preparation and assembly of work pieces using fitting
CO5	Make different products using sheet metal by Tin smithy operation
CO6	Select the joining of wood pieces by Carpentry operation
CO7	Criteria in wiring connections in different applications

Course Nature		**Practical**		
Assessment Method				
Assessment Tool	Experiments	Record	Viva-Voce/Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

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Course code	Course name	Course Category	L-T-P	Credits
20PY1203	Engineering physics	BSC	3-0-0	3

Course Learning Objectives:

1. To purse the in-depth knowledge on waves and different types of oscillations, its production and applications.
2. To distinguish vividly the Optical phenomena's exhibited by light waves i.e. interference, diffraction and polarization. And to understand the in depth knowledge of its characteristics of coherent radiations with an example and their applications in real life.
3. To learn all the basic necessary concepts regarding the LASERs production as well basic important types of LASERs. And also enhance the basic knowledge towards optical fibers.
4. To gain knowledge on the foundation principles of crystallography in specific to crystal systems, unit cell and related parameters and to understand the concept of X-ray diffraction to determine the crystal systems.
5. To enhance knowledge on the dielectric, ferroelectric and magnetic materials and its properties, applications. To get basic knowledge on superconducting materials.
6. To gain knowledge on the nano materials and its synthesis process from top down to bottom up approach towards few practical methods.

Unit 1: Oscillations (7 Hours)

Oscillations**:** Simple Harmonic Oscillator (SHO), Damped Oscillations, Forced Oscillations, Amplitude and Velocity Resonance, Quality Factor, Coupled Oscillations &Normal modes, Coupled Pendulums & energy and Oscillation on N coupled modes

UNIT-2: Wave Optics (7 Hours)

Introduction- Coherent sources- Interference in thin parallel film by reflection- Newton's rings- Fraunhofer diffraction due to single slit – Diffraction grating (Qualitative)- Resolving power of grating- Rayleigh criterion for resolving power- Polarization- Double refraction- Half wave plate –Quarter wave plate.

UNIT-3: Laser and Fiber Optics (7 Hours)

LASER: Introduction- Characteristics of lasers- Absorption, Spontaneous and stimulated emission of radiation - Population inversion- Semiconductor laser. Fiber Optics: Introduction- Principle of optical fiber- Acceptance angle- Acceptance cone- Numerical Aperture.

UNIT-III: Crystallography (8 Hours)

Introduction- space lattice- basis- unit cell- lattice parameters- Crystal systems- Bravais lattices- Packing fractions, Directions and Planes in crystals, Miller indices, Interplanar spacing, Bragg's Law of X-Ray diffraction. Structure factor calculations and X-ray diffraction methods to determine crystal structure determination.

UNIT-IV: Magnetic and Dielectric Properties of Material (8 Hours)

Dielectrics: Introduction- Dielectric constant- Electronic, ionic and orientation polarization mechanisms (qualitative) - Internal field- Clausius-Mossotti relation, Piezo, Pyro and Ferroelectric materials and its applications (qualitative)

Concepts of magnetic dipole, magnetic moment, Magnetic quantities -types of magnetic materials: Dia, Para, ferro, antiferro and ferrimagnetic materials (qualitative). Hysteresis: Soft and hard magnetic materials.

Superconductivity: Introduction- Transition temperature, Critical magnetic field, persistent currents, Meissner effect), Type I and Type II superconductors, Applications of superconductors.

.**Unit-VI: Introduction to nanoscience (8 hours)**

History and importance of nanotechnology, difference between bulk and nanoscale materials and their significance, Classification of nanostructures: zero, one, two and three dimensional nanostructures, size dependency in nanostructures, preparation of nano materials: bottom up methods (a) Chemical vapor deposition method (b) chemical methods (Co-precipitation Sol-gel, Hydrothermal, Microwave method, top down method: Ball milling.

Learning resources

TEXT BOOKS

1. 1. Md. N. Khan, S. Panigrahi, '*Principles of Engineering Physics 1 and 2*' Cambridge University press 2016

2. Dr. M.N Avadhanulu, Dr. P.G shirsagar Jan '*A Textbook of Engineering Physics'* S. Chand publications, old edition

3. Gaur and Gupta "*Engineering Physics*, Dhanpathrai Publications, 6th edition.

REFERENCES

1. Hitendra K. Malik and A.K. Singh '*Engineering Physic*s' by , 3 August 2017
2. H.J. Pain '*The Physics of Vibrations and Waves'* Willey Student Edition, 6th edition
3. Sear's and Zemansky *'University Physics'*, Pearson Edition.

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

1. Student will acquire in-depth knowledge on waves and oscillations as well ultrasonic waves, its production and applications.
2. Student will be able to distinguish the phenomena's of interference & diffraction exhibited by light waves theoretically through Young's double slit, Newton's Rings and Plane Diffraction Grating.
3. Student will have skillful in construction and working principles of LASERs and optical Fibers rather closely along with its applications in various fields.
4. Student will have knowledge on the foundation principles of crystallography in specific to crystal systems and basic concept of X-ray diffraction to determine the crystal systems.
5. Student will have capacity to identify, dielectric, ferroelectric, magnetic and superconducting materials by characterizing it properties
6. Student will acquire the capability to prepare nano particles with different synthesis process.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course Name	Course Category	L-T-P	Credits
20MA1201	**Mathematical methods**	**BSC**	**3-1-0**	**4**

Course Learning Objectives: The objective of this course is to

1. Introduce vector spaces and linear transformation.
2. Discuss Eigen values and Eigen vectors of a matrix and various properties.
3. Setup double and triple integrals to find volume and surface area.
4. Discuss directional derivatives and application of Green's, Stokes and Gauss theorems.
5. Discuss numerical methods to find the roots of transcendental equations and Interpolation.
6. Evaluate integrals by using numerical methods and solving IVP.

Course Content:

Unit – I: Linear Algebra: (12 hours)

Vector Spaces, Linear Combinations of Vectors, Linear dependence and Independence, Basis and Dimension, Linear Transformations, Matrix Representations of Linear transformation.

Unit – II: Eigen values and Eigen vectors: (8 hours)

Solving system of Homogeneous and Non-Homogeneous equations by using Gauss elimination method. Characteristic roots and Characteristic Vectors of a matrix - Cayley-Hamilton Theorem (without proof); Finding inverse and power of a matrix by Cayley-Hamilton Theorem.

Unit-III: Multiple integrals: (10 hours)

Double and triple integrals, computations of surface and volumes, Jacobeans of transformations, change of variables in double integrals, Change of Order of double integrals, integrals dependant on parameters - applications.

Unit–IV: Vector calculus: (12 hours)

Scalar and vector fields, level surfaces, directional derivative, Gradient, Curl, Divergence, Laplacian, line, surface integrals and Volume integrals, Green, Gauss and Stokes theorems (without Proof) and problems.

Unit – V: Root finding Methods and Interpolation: (10 hours)

Roots of polynomial and transcendental equations – bisection method, Regula-falsi method and Newton-Raphson method, Finite differences, Newton's forward and backward interpolation formulae.

Unit – VI: Numerical integration and numerical solution of IVP: (8 hours)
Trapezoidal rule, Simpson's $1/3^{rd}$ rule and $3/8^{th}$ rule for numerical integration, Solution of IVP by Euler and Runga-Kutta method.

Learning resources

Text book:
1. ERWIN KREYSZIG**, '***Advanced Engineering Mathematics'*, Wiley-India, 9^{th} Edition.

Reference Books:
1. R. K. Jain and S. R. K. Iyengar**,** '*Advanced Engineering Mathematics',* Narosa Publishing House, New Delhi, 3rd Edition.

2**.** B.S.Grewal, '*A Text Book of Higher Engineering Mathematics'*, Khanna Publishers, 43rd Edition.

3. Gilbert Strang , 'Linear Algebra and its Applications', CENGAGE Learning 4th Edition.

Web resources:
1. https://onlinecourses.nptel.ac.in/noc20_ma54/preview
2. https://onlinecourses.nptel.ac.in/noc21_ma11/preview
3. RGUKT content

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

CO 1	Write Matrix representation for transformations.
CO 2	Find Eigen values and Eigen vector for a Matrix.
CO 3	Setup and evaluating double and triple integrals.
CO 4	Apply Green's Stokes and Gauss Divergence Theorems.
CO 5	Approximate the roots of polynomial and transcendental equations.
CO 6	Approximate the Integral value by numerical methods and solve IVP using

	numerical methods.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CE1214	ENGINEERING GRAPHICS AND COMPUTER DRAFTING	**ESC**	**1-0-3**	**2.5**

Course Learning Objective

1. To know about emergence of Engineering Graphics as a refined communication tool and to be aware of International and national standards of practice for uniform presentation of drawings.
2. To adopt the projection of three dimensional object orthogonally on a set of vertical and horizontal planes and obtain the views of the frontal and the top surfaces.
3. To describe the position of a point and position of the line with respect to all the planes of projection and obtain its views.
4. To learn orthographic projections of various simple plane surfaces in simple and inclined positions.
5. To know about orthographic projections of right and regular solids in simple positions, when their axes are perpendicular to one reference plane and parallel to the other.
6. To learn about types of cutting planes and to obtain views of simple solids.
7. To learn about different methodologies to be used for obtaining the two dimensional layout of the lateral surfaces of uncut solids.

8. To learn about computer aided drafting techniques and to be familiarize with one of the most powerful software 'AutoCAD'.

Course Content:

UNIT-I: Introduction to Engineering Drawing (7-**Contact Hours)**

Introduction to Engineering drawing – Tools and Standards, Geometric Constructions, Scales, Conics and Special Curves - ellipse, parabola, hyperbola, cycloids, Involutes.

UNIT-II- Orthographic projections **(6-Contact Hours)**

Introduction to Orthographic Projections, Projections of Points, Projection of Lines.

UNIT-III- Projection of Solids **(8-Contact Hours)**

Projection of Planes, Projections of Solids cube, prism, pyramid, cylinder, cone and sphere.

UNIT-IV: Section of solids **(9-Contact Hours)**

Sections of Solids - cube, prism, pyramid, cylinder, cone and sphere. Development of Surfaces – Parallel line method and Radial line method.

UNIT-V: Introduction to AutoCAD **(8-Contact Hours)**

Computer Aided Design – Introduction to AutoCAD, Co-ordinate System (UCS) and their Commands, Basic Commands of Drawing and Editing, Dimensioning and Text.

UNIT-VI: Computer Graphics **(8-Contact Hours)**

Drawing practice with AutoCAD – Creating 2D Drawings of Objects from Isometric views, Creating Isometric views form Orthographic views and Introductions to 3D drawings.

Learning Resources:

Textbooks:

1.Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), *'Engineering Drawing'*, Charotar Publishing House

Reference books:

1. Shah, M.B. &Rana B.C. (2008), *'Engineering Drawing and Computer Graphics'*, Pearson Education
2. Agrawal B. & Agrawal C. M. (2012), *'Engineering Graphics'*, TMH Publication

Web resources

1. Prof Anupam Saxena, NPTEL-IIT Kanpur, 'Engineering Drawing'
   URL: https://nptel.ac.in/courses/112104172/

2. Prof Anupam Saxena, NPTEL-IIT Kanpur, 'Computer Aided Engineering Design'. URL: https://nptel.ac.in/syllabus/112104031/

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

CO 1	Student will be aware of International and national standards of practice.
CO 2	Student will be familiar with obtaining the views of the frontal and the top surfaces of an object.
CO 3	Student will be aware of orthographic projections of right and regular solids in simple positions, when their axes are perpendicular to one reference plane and parallel to the other.
CO 4	Student will know about computer aided drafting techniques and will be familiar with one of the most powerful software 'AutoCAD'.

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CS1208	Programming and Data Structures	**ESC**	**3-0-0**	**3**

Course Learning Objectives:

1. To understand the various steps in Program development.
2. To understand the basic concepts in C Programming Language.
3. To learn about arrays and character arrays
4. To learn how to write modular and readable C Programs
5. To understand the basic concepts of Pointers and Dynamic memory allocation.
6. To understand the usage of Structure and Unions and about file operations
7. To Understand the usage of Basic data structures

UNIT 1: INTRODUCTION (8 Contact Hours)

Introduction, History of Programming Languages, Character Set, Variables and Identifiers, Built-In Data Types. Variable Definition, Arithmetic Operators And Expressions, Constants And Literals, Simple Assignment Statement, Basic Input/output Statement, Simple 'C' Program , Conditional Statements And Loops

UNIT 2: ARRAYS (7 Contact Hours)

One Dimensional Arrays: Array Manipulation; Searching, Insertion, Deletion Of An Element From An Array; Finding The Largest/Smallest Element In An Array; Two Dimensional Arrays, Addition/Multiplication Of Two Matrices, Transpose Of A Square Matrix; Character Arrays

UNIT 3: FUNCTIONS (8 Contact Hours)

Function Declaration, Function Definition, Function Call, Call By Value, Call By Reference, Recursion, String Handling Functions.

UNIT 4: STRUCTUES and UNIONS (7 Contact Hours)

Structure Variables, Initialization, Structure Assignment, Nested Structure, Structures and Functions, Structures And Arrays: Arrays Of Structures, Structures Containing Arrays, Unions,

UNIT 5: POINTERS (8 Contact Hours)

Address Operators, Pointer Type Declaration, Pointer Assignment, Pointer Initialization, Pointer Arithmetic, Functions And Pointers, Arrays And Pointers, Pointer Arrays, Dynamic Memory Allocations, Storage Classes

UNIT 6: INTRODUCTION TO DATA STRUCTURES (7 Contact Hours)

Linked List, Double Linked Lists, Stack, Stack Implementation Using Arrays, Stack Implementation Using Linked List.

Learning resources

Text book:

1. Reema Thareja, " Programming in C", Oxford Publications, 2nd Edition

Reference Books:

1. E. BalaguruSwamy, " Programming in ANSI C", Mc Graw Hill, 7th Edition

2. Brian W. Kernighan, Dennis M. Ritchie, " The C Programming Language", Prentice

3. Data structures using C by Reema Thareja, 2nd edition ,Oxford Higher Education

Web resources:

1. Indian Institute of Technology, Kharagpur, "Problem Solving through Programming in C", https://nptel.ac.in/courses/106105171/

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

CO 1	Develop flowcharts, algorithms for given complex problems.
CO 2	Analyze basic programming constructs.
CO 3	Write C programs for real world problems. Implement C programming by using various control structures.
CO 4	Able to write rite modular and readable C Programs
CO 5	Able to use pointers in C programming
CO 6	Appreciate coding standards and best practices for program development.

Assessment Method

Assessment Tool	Experiments	Report/Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	15%	40%
End Semester Examination weightage (%)			60%

Course code	Course name	Course Category	L-T-P	Credits
20CH1201	Chemical Process Calculations	PCC	3-0-0	3

Course Learning Objectives:

1. Learn basic laws about the behavior of gases, liquids and solids and some basic mathematical tools.
2. To comprehend important principles such as Ideal gas Law, Raoult's Law and Humidity charts
3. Learn what material balances without chemical reaction are, how to formulate and apply them, how to solve them.
4. Learn what material balances with chemical reaction are, how to formulate and apply them, how to solve them.
5. Understand the heat properties such as heat capacity, latent heats for a given compound/mixtures
6. To learn the concepts of heat of reaction, exothermic and endothermic reactions, heat of formation, combustion; standard heat of formation, combustion and reaction, adiabatic flame temperatures, and energy balances for models

Course Content:

Unit-1: (8 contact hours)

Basic concepts-Units and Dimensions - Graphical integration – Graphical differentiation – Use of semi-log, log-log and triangular graphs.

Stoichiometry and composition relationships- the gram-mole and pound-mole, limiting reactant, excess reactant, degree of completion, basis of calculation, weight percent, volume percent and mole percent, density and specific gravity- Baume and API gravity scales

Unit-2: (7 contact hours)

Ideal Gas Law, Real Gas relationships, Vapor pressure, Vapor Liquid Equilibrium calculations, Partial saturation.

Humidity – Use of psychometric charts- Percentage saturation, relative saturation or relative humidity, dew point, wet and dry bulb temperatures,

Unit-3: (8 contact hours)

Material Balance without Chemical Reactions: Fundamentals; Batch and flow processes, Steady- flow and unsteady processes, Material balance calculations for single-unit such as absorption, distillation, evaporation, crystallization, leaching, extraction, drying and mixing units under steady state operation. Material balances for Multiple-unit processes.

Unit-4: (7 contact hours)

Material Balance with Chemical Reactions: Concept of limiting and excess reactants,

Extent of Reaction, Material balances involving single reaction, Material balances involving multiple reactions. Material balances for processes involving by-pass, recycle and purging with and without chemical reaction.

Unit-5: (8 contact hours)

Heat capacity of gases and gaseous mixtures, liquids & solids, Sensible heat change in liquid & gases, enthalpy changes during phase transformation. Energy Balances without chemical reactions, Enthalpy changes, thermo-chemistry of mixing process, dissolution of solids.

Energy balances in operations involving phase change – Energy balance Dryers and simple evaporation systems, distillation columns.

Fuels And Combustion: Types of fuels, calorific value of fuels, Proximate and ultimate analysis

Unit -6: (7 contact hours)

Energy Balances with chemical reactions: Heats of reaction, measurement and calculation of heats of reaction - Hess's Law, formation reactions and Heats of Formation, Heats of Combustion Energy balances for combustion reactions - adiabatic reaction temperature, theoretical flame temperature. Problems on combustion of coal, liquid fuels, gaseous fuel, sulfur and sulfur pyrites etc.

Text book:

1. O.A. Hougen, K.M Watson and R.A Ragatz, '*Chemical Process Principles, Part – I*', 5th Edition, CBS Publishers, New Delhi, 2004

Reference Books:

1. David M. Himmelblau, 'Basic Principles and Calculations Chemical Engineers' 5th Ed,. Prentice Hall India Pvt. Ltd.2000.

2. B.I Bhatt & S.M.Vora 'Stoichiometry' – 4th Edition, Tata Mc.Graw Hill ,New Delhi,2006.

Web Links:

1. https://nptel.ac.in/courses/113104010/

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

CO1	Solve the problems on compositions based on stoichiometry.
CO2	compute the problems based on ideal gas and vapor pressure, humidity, heat capacity
CO3	Examine the calculations for single units involving drying, evaporation and crystallization.
CO4	Determine the percentage conversion, yield in a given chemical process involving reaction
CO5	Perform the calculations Energy balance Dryers and simple evaporation systems, distillation columns

CO6	Build the calculations Energy balance adiabatic reaction temperature, theoretical flame temperature

Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CH1202	Fluid Mechanics	PCC	3-1-0	4

Course Learning Objectives:

1.To understand the behavior of fluids and how to deal with fluid at rest.

2. Formulation of basic equations like continuity, momentum etc. to deal with fluid in motion.

3. To understand the flow of fluid in circular and noncircular channels.

4. To study flow of compressible fluids; use of dimensional analysis.

5. To understand the flow of fluid over external surfaces.

6. Understand the importance of course in chemical industries.

Course Content:

Unit–I **(10 contact hours)**

Fluid Flow Phenomena and Fluid Statics: Definition of fluid, shear rate and shear stress, Newtonian and Non-Newtonian fluids, Time dependent flow, viscosity and momentum flux, compressible, incompressible, real and ideal fluids, viscosities of gases and liquids, Laminar and Turbulent flows, Reynolds experiment, Boundary layers, Hydrostatic equilibrium, U-tube manometer, inclined manometer and two fluid manometer and inverted manometer.

Unit – II **(12 contact hours)**

Basic equations of Fluid Flow: path lines, stream lines and stream tube, Mass balance – equation of continuity, one dimensional flow, mass velocity, differential momentum balance- equations of motion, coquette flow, macroscopic momentum balances, momentum of stream and momentum correction factor, layer flow with free surface. Mechanical energy equation-Bernoulli equation- corrections for effects of solid

boundaries, kinetic energy correction factor, corrections for fluid friction, pump work in Bernoulli equation.

Unit – III **(10 contact hours)**

Incompressible flow in pipes & channels and frictional losses: Shear stresses and skin friction, fanning friction factor, flow in noncircular channels, laminar flow of Newtonian and Non-Newtonian fluids, velocity distribution, Hagen Poiseuille equation, Turbulent flow, universal velocity distribution, Roughness, Mody's friction factor chart. Pipes and valves, fittings. Friction losses due to sudden expansion and contraction, Effects of fittings and valves, form frictional losses in the Bernoulli Equation.

Unit - IV **(8 contact hours)**

Dimensional analysis: Buckingham π-theorem and Rayleigh theorem– its applications and limitations.

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

Unit - V **(10 Contact hours)**

Flow past immersed bodies and Fluidization: Motion of particles through fluids – Free settling and hindered settling, Drag and drag coefficient, Flow through packed beds of solids – Kozeny-Carman equation, Burke-Plummer equation and Ergun equation. Fluidization and conditions for fluidization, Minimum fluidization velocity, particulate and bubbling fluidizations, Expansion of fluidized beds, Applications of fluidization.

Unit – VI **(10 Contact hours)**

Transportation and Metering of fluids: Pipes, fittings and valves, pumps: Centrifugal and Positive Displacement Pumps, Characteristics of pumps, suction lift and cavitation, NPSH, Measurement of flowing fluids- Venturi meter, orifice meters, Pitot tube, Rotameters and Notches and Weirs,. Fans, blowers, and compressors.

Learning Resources:

Text book:

1. W.L.McCabe, J.C.Smith& Peter Harriot, '*Unit Operations of Chemical Engineering*', McGraw- Hill, 6th Edition, 2001.

Reference Books:

1. Fox and Mc Donald, '*Introduction to Fluid Mechanics*', John Wiley & Sons Inc, 8th Edition,2011.
2. Christie J. Geankoplis, '*Transport processes and Unit operations*', PHI, 3rd edition,1993.

Web resources:

1. https://nptel.ac.in/courses/103104044/
2. https://cosmolearning.org/courses/fluid-mechanics-chemical-engineering/

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

CO1	Classify fluids and understand their nature; determine pressure distribution in a

	fluid at rest; use manometers.
CO2	Application of basic equations to determine velocity distribution in pipes; use Bernoulli's equation.
CO3	Describe how the fluid loses its energy due to friction from solid boundaries and how to reduce losses.
CO4	Identify how compressible flow is different from incompressible flow; Application of dimensional analysis in developing correlations.
CO5	Applying Fluid flow phenomena over external surfaces and determine pressure drops and velocities in packed beds and fluidized beds
CO6	Explore different pumps, valves, flow meters which are used in chemical industries and choosing a suitable one.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20BE4201	Environmental Science	**MC**	**2-0-0**	**0**

Course Learning Objectives:

1. To provide knowledge about multidisciplinary nature of environment, various sources of natural energy.
2. Understanding of ecosystem structure and function etc.
3. Knowledge of biodiversity and conservation
4. Understanding of problems caused by pollution and its impact
5. Understanding about the various social issues related to environment.
6. Awareness for the environment and human health

Course Content:

UNIT-I: The Multidisciplinary Nature of Environmental Studies and Natural Resources (9 hours)

The Multidisciplinary Nature of Environmental Studies: Definition, scope and importance; Need for public awareness.

Natural Resources: Renewable and Non Renewable Resources

Natural resources and associated problems.
a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people. b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies. d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. e) Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Case studies. f) Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification. Role of an individual in conservation of natural resources. Equitable use of resoureces for sustainable lifestyles.

UNIT-II: Ecosystems (4 hours)

Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers,Energy flow in the ecosystem,Ecological succession, Food chains, food webs and ecological pyramids,Introduction, types, characteristic features, structure and function of the following ecosystem:-a. Forest ecosystem, b. Grassland ecosystem, c. Desert ecosystem, d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).

UNIT-III: Biodiversity and It's Conservation (4 hours)

Introduction – Definition: genetic, species and ecosystem diversity, Biogeographical classification of India,Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, National and local levels, Inida as a mega-diversity nation, Hot-sports of biodiversity, Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India, Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

UNIT-IV: Environmental Pollution (6 hours)

Cause, effects and control measures of:-a. Air pollution, b. Water pollution, c. Soil pollution, d. Marine pollution, e. Noise pollution, f. Thermal pollution, g. Nuclear hazards, Solid waste Management: Causes, effects and control measures of urban and industrial wastes, Role of an individual in prevention of pollution, Pollution case studies, Disaster management: floods, earthquake, cyclone and landslides.

UNIT- V: Social Issues and the Environment (4 hours)

From Unsustainable to Sustainable development Urban problems related to energy, Water conservation, rain water harvesting, watershed management, Resettlement and

rahabilitation of people; its problems and concerns. CaseStudies, Environmental ethics: Issues and possible solutions.• Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. Wasteland reclamation, Consumerism and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation, Public awareness.

UNIT-VI: Human Population and the Environment (3 hours)

Population growth, variation among nations, Population explosion – Family Welfare Programme, Environment and human health, Human Rights, Value Education, HIV/AIDS, Women and Child Welfare, Role of Information Technology in Environment and human health, Case Studies.

Learning resources

Text book:

1. ErachBharucha, '*Textbook of Environmental studies'*, UGC

Reference Books:

1. Clark RS, '*Marine Pollution'*, Clanderson Press, Oxofrd (TB).

2. De AK, '*Environmental Chemistry'*, Wiley Eastern Ltd.

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

CO1	Well understanding about their surrounding natural resources and their conservation
CO 2	Able to understand the ecosystem food chain and habitat.
CO 3	Develop the practices for conservation of biodiversity
CO 4	To well understand the pollution courses, impact and prevention from pollution
CO 5	Able to bring about an awareness of a variety of environmental concerns.
CO 6	It attempts to create a pro-environmental attitude and a behavioral pattern in society that is based on creating sustainable lifestyles.

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage(%)	0	0	100%	100%

**** PASS/FAIL COURSE**

Course code	Course name	Course Category	L-T-P	Credits
20CS1288	Programing and Data Structures Lab	ESC	0-0-3	1.5

Course Learning Objective:

1. Identify situations where computational methods and computers would be useful.
2. Given a computational problem, identify and abstractthe programming task involved.
3. Approach the programming tasks using techniques learned and write pseudo-code.
4. To understand the concepts of Programming language
5. To learn the basics of C declarations, operators and expressions
6. To learn on the manipulation of strings, functions and pointers
7. To apply concepts and techniques for implementation
8. To learn the basic data structures and its usage

UNIT 1: INTRODUCTION (Week1)

1. C Program to calculate the sum of Natural numbers.
2. C Program to find factorial of a number
3. C Program to generate multiplication table of a given number.
4. C Program to display Fibonacci sequence (Up to given number)
5. C Program to Check whether a given number is prime or not
6. C Program to make a simple Calculator using switch case
7. C Program to check whether a number is palindrome or not
8. C Program to display factors of a given number
9. C Program to print Pyramids and Triangles using loops

UNIT II: ARRAYS (Week2&3)

1. C Program to find second largest Element of an Array
2. C Program to add two matrix using multi-dimensional arrays.
3. C Program to multiply two matrix using multi-dimensional arrays.
4. C Program to find transpose of a matrix.
5. C Program to Sort Elements of an Array.

UNIT III: FUNCTIONS (Week4&5)

1. C Program to check whether given number is prime or not using user-defined function.
2. C Program to check whether given number is Armstrong or not using user-defined function.
3. C Program to swap two integer values using call by value and call by reference.
4. C Program to find the sum of Natural numbers using recursion.
5. C Program to find the factorial of a given number using recursion.
6. C Program to calculate length of string without using strlen() function.
7. C Program to sort elements in Lexicographical order (Dictionary order) using in built string functions.

UNIT IV: STRUCTUES AND UNIONS(Week6&7)

1. C Program using structures to read and display the information about a student.
2. C Program to read, display, add and subtract two complex numbers.
3. C Program to read and display the information of a student using nested structure.
4. C Program, using an array of pointers to a structure, to read and display the data of students.
5. C Program to demonstrate arrays of Union variables.

UNIT V: POINTERS (Week8&9)

1. C Program to demonstrate, handling of pointers in C.
2. C Program to access array elements using pointers.
3. C Program to find the sum of n numbers with arrays and pointers.
4. C Program to swap two numbers using pointers and function
5. C Program to find sum of n elements entered by user. To perform this allocate memory dynamically using malloc() function.
6. C Program to find sum of n elements entered by user. To perform this allocate memory dynamically using calloc() function.

UNIT VI: INTRODUCTION TO DATA STRUCTURES (week10&11)

1. Write a program to create a linked list and perform insertions and deletions of all cases. Write functions to sort and finally delete the entire list at once.
2. Write a program to create a doubly linked list and perform insertions and deletions in all cases.
3. Write a program to perform push, pop and peek operations on a stack.
4. Write a program to implement a linked stack.

Course outcomes

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

CO 1	To formulate the algorithms for simple problems
CO 2	To translate the given algorithms to a working and correct program
CO 3	To identify and correct logical errors encountered at run time
CO 4	To write iterative as well as recursive programs
CO 5	To represent Data in arrays, strings, Structures and manipulate them through a program
CO 6	To decompose a problem into functions and synthesize a complete program
CO 7	To be able to create basic data structures

Assessment Method

Assessment Tool	Experiments	Report/Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	15%	40%
End Semester Examination weightage (%)			60%

Course code	Course Name	Course Category	L-T-P	Credits
20MA2103	Transform Calculus	BSC	3-1-0	4

Course Learning Objectives: The objective of this course is to

1. Introduce partial differential equations and solutions of first order PDE.
2. Introduces the concept of transforms and their mathematical properties.
3. Apply Laplace transforms to solve the ordinary and partial differential equations which are not solvable by traditional analytical methods.
4. Write Fourier series expansion of periodic and non-periodic functions.
5. Introduce Fourier transforms and their properties.
6. Apply transformation techniques to solve boundary value problems.

Course Content:

UNIT-I

Laplace Transform: (10 contact hours)

Definition of Laplace Transform, linearity property, conditions for existence of Laplace Transform. First and second shifting properties, Laplace Transform of derivatives and integrals, unit step functions, Dirac delta-function, error function.

UNIT-II

Application of Laplace transforms: (10 contact hours)

Differentiation and integration of transforms, convolution theorem, inversion, periodic functions. Evaluation of integrals by Laplace Transform. Solution of Ordinary differential Equations.

UNIT-III

Fourier Series: (12 contact hours)

Periodic functions, Fourier series representation of a function, Fourier series for Even and Odd functions, half range sine and cosine series, Fourier integral Theorem, Parseval's identity.

UNIT-IV

Fourier Transform: (10 contact hours)

Fourier Transform, Fourier sine and cosine transforms. Linearity, scaling, frequency shifting and time shifting properties. Self reciprocity of Fourier Transform, convolution theorem.

UNIT-V

Boundary Value Problems: (10 contact hours)

Relation between Fourier and Laplace Transforms, Solutions of boundary value problems by Fourier Transforms.

Unit – VI

Partial Differential Equations: (8 contact hours)

Introduction to partial differential equations, Formation of PDE, Lagrange's equation, Pp+Qq=R form, Variable separable method.

Learning resources

Text book:

1. ERWIN KREYSZIG**,** '*Advanced Engineering Mathematics'*, Wiley-India, 9th Edition.

Reference Books:

1. M.K. Jain., '*Numerical solutions of differential equations',* Wiley Eastern, 1984, 2nd Edition.
2. M.K Jain, S.R.K Iyengar, R.K Jain., '*computational methods for PDE*,' Wiley Eastern 1994.
3. S.D. Conte &Carl de Boor., '*Elementary Numerical analysis an algorithmic approach'*, McGraw Hill, Newyork, 1980, 3rdEdition.
4. E. Ward Cheney**,** David R. Kindcaid.,' *Numerical methods and applications'*, Brooks / Cole, 2008.
5. Butcher, J.C, '*Numerical methods for ordinary differential equations'*, Wi- ley, Newyork, 2003.

Web resources:

1. https://onlinecourses.nptel.ac.in/noc19_ma04/preview.
2. RGUKT content.

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

CO 1	Solve the partial differential equations of first and second order.
CO 2	Solve the ordinary differential equations with discontinuous forcing terms.
CO 3	Able to analyze the solutions with various initial and boundary conditions.

CO 4	Able to write series expansions of periodic functions and their physical significance.
CO 5	Solve the various forms of ODEs and PDEs.
CO 6	Solve the various types of differential equations such as Integro- differential equations, System of differential equations.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20ME2112	**Mechanical Technology**	**ESC**	**3-0-0**	**3**

Course Learning Objectives:

1. To impart basic knowledge on basics of thermodynamics and Laws of thermodynamics.
2. To introduce basic knowledge about special casting, molding procedures and different welding techniques used in industry.
3. To impart basic knowledge on power transmission by gear and belt drives.
4. To know the working of thermal power plants, boilers and turbines.
5. To teach the working principle of Internal Combustion Engines.
6. To introduce basic knowledge on Refrigeration & Air Conditioning

Course Content:

Unit - I **(07 Contact hours)**

Basics of Thermodynamics: Introduction and definition of thermodynamics, Dimensions and units, systems, surroundings and universe, Reversibility and Irreversibility, Quasi-static process, Energy, Heat and Work. Introduction to Law of Thermodynamics: Zeroth Law of Thermodynamics, First law of thermodynamics and Second law of thermodynamics.

Unit - II **(09 Contact hours)**

Casting: Introduction, General method in making a Casting, pattern: types, materials and allowances. Moulding materials and equipment, Preparation, properties of moulding sands.

Welding: Principles of gas welding and arc welding, Soldering and Brazing.

Unit - III **(07 Contact hours)**

Power Transmission: Introduction to belt and gears drives, types of gears, Difference between open belts and cross belts, power transmission by belt drives. (theoretical treatment only).

Unit - IV **(07 Contact hours)**

Thermal Power Plant: Thermal power plant layout- Four circuits-Rankine cycle, Boilers: Fire tube Vs Water Tube; BobCock and Wilcox, Cochran Boilers, Steam Turbines, Impulse Vs Reaction Turbines, Compunding of Turbines.

Unit - V **(7 Contact hours)**

IC Engines: Introduction, Main components of IC engines, working of 4-stroke petrol engine and diesel engine, working of 2- stroke petrol engine and diesel engine, difference between petrol and diesel engine, difference between 4- stroke and 2- stroke engines.

Unit – VI **(7 Contact hours)**

Refrigeration & Air Conditioning: Definition – COP, Unit of Refrigeration, Applications of refrigeration system, vapour compression refrigeration system, simple layout of summer air conditioning system.

Learning resources

Text book:

1. Fundamentals of Mechanical Engineering / G.S.Sawheny- PHI.
2. An Integrated Course in Mechanical Engineering / R.K.Rajput /Birala Publications.
3. I.C. Engines / V. GANESAN- TMH.
4. Strength of Materials by R.K. Rajput, S.Chand & Company.
5. Thermal Engineering / R.K. Rajput / Lakshmi Publications.

Reference Books:

1. Thermodynamics and Heat Engines / R. Yadav / Central Book Depot.
2. Strength of Materials by R.K.Bansal, Laxmi Publishers.
3. Engineering Mechanics Statics and dynamics by A.K.Tayal, Umesh Publication, Delhi.

4. Fundamentals of I.C.Engines - P.W. Gill, J.H. Smith & Ziurys- IBH & Oxford pub.

Web resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. RGUKT Course Content

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

CO 1	Awareness on basics of thermodynamics and Laws of thermodynamics.
CO 2	Students will be familiarized with some of the special casting and molding procedures used in industry and different welding techniques with their respective applications.
CO 3	Imparted knowledge about gear and belt drives used in automobile and industrial applications.
CO 4	Understand the basic components of Thermal plant
CO 5	Imparted knowledge about IC Engines, External combustion Engines.
CO 6	Knowledge of Refrigeration and air conditioning systems, which is playing prominent role in the present day industry.

Mechanical Technology		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weight age (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20CH2101	Thermodynamics-I	ESC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Learn the basic concepts and first law of thermodynamics and its applications.
2. Understand the concepts of Volumetric &Thermodynamic Properties Of Pure Fluids
3. Provide the knowledge on Heat effects
4. Provide the knowledge on applications of second law of thermodynamics.
5. Provide the knowledge of Thermodynamic properties of Real fluids
6. Provide the knowledge on applications of thermodynamics in flow processes.

Course Content:

Unit I **(7 Contact hours)**

Introduction: The first Law and other basic concepts Joule's Experiments - Internal Energy - Formulation of the first law of the thermodynamics - the thermodynamic state and state functions – Equilibrium- The phase rule - The Reversible process-Constant Volume and Constant Pressure processes- Enthalpy- Heat Capacity.- Mass and Energy Balances for Open Systems

Unit II **(8 Contact hours)**

Volumetric &Thermodynamic Properties of Pure Fluids: The PVT behavior of pure substances, virial equations, the ideal gas, the applications of the virial equations, Cubic equations of state, generalized correlations for gases-Thermodynamic properties of pure fluids: Property relations for homogeneous phases, residual properties, Applications of the equation of state-Relationship between Peng-Robinson, Redlich-Kwong and Soave-Redlich-Kwong equation of state

Unit III **(7 Contact hours)**

Heat Effects: Sensible Heat effects:– Latent Heats of pure substances - Standard Heat Reaction- Standard Heat of Formation- Standard Heat of Combustion_ Temperature dependence of ΔH^o, Heat Effects of Industrial Reactions

Unit IV **(8 Contact hours)**

The Second Law of Thermodynamics:- Statements of second law- Heat engines Thermodynamic temperature scales- Entropy- Entropy changes of an ideal gas- Mathematical Statement of the Second Law, Entropy Balance for Open Systems, Calculation of Ideal Work, Lost Work- The Third Law of thermodynamics- Entropy from Microscopic Viewpoint

Unit – V **(8 Contact hours)**

Thermodynamic Properties of Real Fluids: Property Relations for Homogeneous Phases- Residual properties- The Two phase systems. Thermodynamic diagrams- Tables of Thermodynamic Properties- Generalized Property Correlations for Gases; Estimation of Auxiliary Physical Properties- properties of pure substances and mixture: - densities, molecular weights, boiling points, vapor pressures, critical pressure, critical volume and critical compressibility factor, acentric factor combining and mixing rules

Unit – VI **(7 Contact hours)**

Applications of Thermodynamics to Flow Processes:- Duct flow of Compressible Fluids, Turbines (Expanders), Compression Processes; Production of Power from Heat:- The Steam Power Plant- Internal Combustion Engines- Otto cycles and Diesel cycle; Jet Engines, Rocket Engines; Refrigeration and liquefaction:- The Carnot Refrigerator- The Vapor-Compression Cycle- The Choice of Refrigerant- Absorption Refrigeration- The Heat Pump- The various processes for liquefaction.

Learning Resources:

Text Books:

1. J.M.Smith, H.C Van Ness and M. M. Abbott, '*Introduction to Chemical Engineering Thermodynamics'*, Sixth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003

Reference Books:

1. Halder G, *'Introduction to Chemical Engineering Thermodynamics'*, 4th edition, Prentice Hall India, 2014.
2. J.Richard Elliott and Carl T. Lira, *'Introductory Chemical Engineering Thermodynamics'*, Second Edition, Prentice Hall, 2012
3. Thomas E Daubert, Chemical Engineering Thermodynamics, McGraw Hill International Editions, 1986
4. K. V. Narayanan, *'Text Book of Chemical Engineering Thermodynamics'*, PHI Learning Limited, 2004,
5. Y. V. C. Rao, '*Chemical Engineering Thermodynamics'*, University Press (India) Private Limited, 2004

Web resources:

1. https://nptel.ac.in/courses/103101004/
2. http://www.msubbu.in/lecture/thermodynamics.html

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

CO 1	Evaluating the concepts of first law of thermodynamics to find heat, work & changes in internal energy and enthalpy during the analysis of any system undergoing reversible &irreversible processes.
CO 2	Design equation of state for gases and liquids to evaluate the changes in PVT behavior of pure fluids.
CO 3	Importance the calculations enthalpy changes
CO 4	Apply the second law of thermodynamics & concept of entropy while analyzing ideal & real systems.
CO 5	Analyzing the PVT behavior of Real Fluids.
CO 6	Able to apply Thermodynamic laws to flow processes.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20CH2102	Heat Transfer	PCC	3-1-0	4

Course Learning Objectives: The objective of this course is to impart in-depth knowledge on

1. Basics concepts related to different modes of heat Transfer.
2. Steady and unsteady state heat conduction in solids with and without internal heat source.
3. Types of convection mode of heat transfer and parameters effecting rate of heat transfer.
4. Heat transfer with phase change in boilers, condensers etc.
5. Concepts related to design of heat transfer equipment.
6. Radiation mode of heat transfer.

Course Content:

Unit–I **(8 Contact hours)**

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

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

Unit – II **(10 Contact hours)**

Heat transfer in fins: Heat transfer from a rectangular fin, fin effectiveness and efficiency.

Unsteady state heat conduction: negligible internal heat resistance and lumped heat analysis, response time of a temperature measuring instrument, unsteady state heat conduction through a semi-infinite slab, three dimensional heat conduction equations in Cartesian, two dimensional heat conduction equations in cylindrical and one dimensional heat conduction equations in spherical coordinates with heat generation term

Unit – III **(12 Contact hours)**

Heat Transfer to Fluids without Phase change: Regimes of heat transfer in fluids, thermal boundary layer.

Forced Convection: Heat transfer by forced convection in laminar flow, heat transfer by forced convection in turbulent flow, the transfer of heat by turbulent eddies and analogy

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

Unit - IV **(10 Contact hours)**

Natural convection: Natural convection to air from vertical shapes and horizontal planes, effect of natural convection in laminar flow heat transfer, free convection in enclosed spaces, mixed free & forced convection.

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

Unit - V **(12 Contact hours)**

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

Evaporators: Evaporators, performance of tubular evaporators, capacity and economy, multiple effect evaporators, vapour recompression.

Introduction to advanced heat transfer equipment: Corrugated tube heat exchanger

Unit – VI **(8 Contact hours)**

Radiation: Introduction, properties and definitions, black body radiation, real surfaces and the gray body, absorption of radiation by opaque solids, radiation between surfaces, radiation shielding, radiation to semitransparent materials, combined heat transfer by conduction, convection and radiation.

Learning Resources:

Text book:

1. W.L.McCabe, J.C.Smith& Peter Harriot, '*Unit Operations of Chemical Engineering*', McGraw- Hill, 6th Edition, 2001.

Reference Books:

1. D. Q. Kern, '*Process heat transfer'*, McGraw-Hill, 2001.
2. Christie J. Geankoplis, '*Transport processes and Unit operations*', 3rd edition, PHI, 1993.
3. Frank P. Incropera, David P. De Witt, '*Fundamentals of Heat and Mass Transfer*", Wiley International,7th edition,2011
4. Binay K Dutta, '*Heat Trasfer- Principles and Applications*', PHI,2000

Web resources:

1. https://nptel.ac.in/courses/103103032
2. https://nptel.ac.in/courses/112101097/

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

CO1	Describe different modes of heat transfer. Explore material properties related to heat transfer.
CO2	Determine temperature distributions in solids and rate of heat transfer using fouriers law of conduction.
CO3	Develop convection mode of heat transfer; Apply Newton's law of cooling; Determine heat transfer coefficients using correlations.
CO4	Importance of heat transfer process with phase change and determine coefficients in different boiling regimes.
CO5	Explore different heat transfer equipment's and describe their applications in chemical industries.
CO6	Analyzing various parameters affecting rate of heat transfer by radiation over different material surfaces.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CH2103	Mechanical Unit Operations	PCC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Learn the basic principles of characterization of particles and bulk solids;
2. Familiarize the construction and operation of crushers, mixers, blenders, settling tanks, industrial sieving equipment and filtration equipment.
3. Explain mechanism and working of mechanical separation, mixing, filtration, transportation of particulates and size reduction equipment.
4. Calculate the power consumption of the equipments for mixing, size reduction operations.

5. Illustrate the Scale-up and Designing procedure for process equipment like mixture, filter press, cyclones and clarifiers
6. To understand the miscellaneous mechanical operations.

Course Content:

Unit I **(8 contact hours)**

Properties and handling of particulate solids

Introduction to Unit operations and their role in Chemical Engineering industries; Characterization of solid particles, differential & cumulative analysis; properties of particulate masses, storage of solids, flow out of bins

Unit II **(7 contact hours)**

Mixing and transportation of particulate solids

Agitation and mixing: Agitation of liquids, axial and radial flow impellers, power consumption in agitated vessels, types of mixers, mixers for cohesive solids, mixers for free flowing solids.

Transportation of solid particulate mass, belt, screw, apron conveyers, bucket elevators, pneumatic conveying.

Unit III **(8 contact hours)**

Size reduction equipment and mechanical separations

Size reduction: Principles of comminution, laws of crushing: Rittinger's law, Kick's law and Bond's law.

Size reduction equipment: crushers, grinders, ultra-fine grinders, cutting machines; Equipment operation: open-circuit and closed-circuit operation.

Mechanical separations: Screening; industrial screening equipments, capacity and effectiveness of screens.

Unit IV **(8 Contact hours)**

Filtration

Classification of filters, cake filters, centrifugal filters, principles of cake filtration, compressible and incompressible filter cakes, constant pressure filtration, principles of centrifugal filtration, continuous filtration, constant rate filtration, washing filter cakes, clarifying filters, liquid clarification, gas cleaning, principles of clarification, cross flow filtration and types of membrane filtration.

Unit V **(7 Contact hours)**

Separations based on motion of particles through fluids

Gravity settling processes: gravity classifiers, sorting classifiers - sink and float methods, differential settling methods; clarifiers and thickeners, flocculation, batch sedimentation, clarifiers and thickeners design; centrifugal settling processes - cyclone separators, cyclone analysis, hydroclones, centrifugal decanters, principles of centrifugal sedimentation.

Unit VI **(7 Contact hours)**

Miscellaneous separations

Coagulation, impingement separators, scrubbers, froth flotation-separation of ores, flotation agents; electrostatic precipitators and magnetic separators.

Learning Resources:

Text Book:

1. W.L. McCabe and J.C. Smith and Peter Harriott, *'Unit Operations in Chemical Engineering'*, McGraw Hill, 5th Edition

Reference Books :

1. C.M. Narayanan & B.C. Bhattacharyya, *'Mechanical Operations for Chemical Engineers '*, Khanna Publishers, 3rd Edition
2. J.H. Perry, *'Chemical engineers hand book'*, McGraw Hill, 7th Edition
3. Kiran D. Patil, *'Mechanical Operations (Fundamental principles and Applications)'*, NiraliPrakashan, Revised 2nd Edition
4. Walter L. Badger, Julius T. Banchero, Introduction to Chemical Engineering, McGraw-Hill Inc.,1955

Web resources:

1. https://nptel.ac.in/courses/103107123/

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

CO 1	Illustrate and apply the basic methods of characterization of particles and bulk solids
CO 2	Demonstrate the construction and operation of crushers, mixers, blenders, settling tanks, industrial sieving equipment and filtration equipment.
CO 3	Choose mechanical separation, mixing, filtration, transportation of particulates and size reduction equipment needed for a particular process industry.
CO 4	Calculate the power consumption of the equipments for mixing, size reduction operations.
CO 5	Utilize the technological methods related to unit operations in process plant

CO 6	Scale-up and Design a mixing tank, filter press, cyclones and clarifiers

Course Nature			**Theory**	
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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MANAGERIAL ECONOMICS AND FINANCIAL ANALYSIS

Course code	Course name	Course Category	L-T-P	Credits
20BM 2101	Managerial Economics and Financial Analysis	HSC	3-0-0	3

Course Learning Objectives:

1. To strengthen students managerial skill.
2. To enhance the conceptual clarity in economic concepts.
3. To develop to forecasting capability.
4. It will help to produce multi-disciplinary thought.
5. It will enhance their conceptual and practical/hand on practice in accounting.
6. It will help to implement and understand the uses of ratios.

Course Contents:

Unit I: (7 hours)

Introduction to managerial economics, consumer behavior, demand, demand analysis, demand forecasting, supply, supply analysis.

Unit II: (7 hours)

Theory of production, production functions, concept of cost, cost analysis, break even analysis.

Unit III: **(7 hours)**

Market structure-monopoly, oligopoly, monopolistic, prefect market; Types of business

organizations-sole proprietorship, partnership, private ltd. Companies and public ltd. Companies, formation of company.

Unit IV: **(8 hours)**

Introduction to capital, capital sources, capital budgeting- NPV, IRR, Payback period, profitability index.

Unit V: **(8 hours)**

Introduction to financial accounting, rules of debit-credit, Double-Entry Book Keeping, Journal, Ledger, Trial Balance- Final Accounts (Trading Account, Profit and Loss Account and Balance Sheet with simple adjustments, Preparation of final account and other related accounting statements.

Unit VI: **(8 hours)**

Financial statements, comparative statement analysis, common- size statement analysis, ,ratio analysis, time series (only theories).

Learning resources

Text book:

1. 1. Aryasri, A. R., *Managerial Economics & Financial Analysis*, McGraw Hill, 2014.

Reference Books:

1. Siddiqui., *Managerial Economics & Financial Analysis*, 2e, New Age International Private Limited, 2017.
2. . Pandey, I.M., "*Financial Management*", 11e, Vikas Publishing House, 2015.
3. . Prasanna Chandra., "*Financial Management: Theory and Practice*", 9e, Mc Graw Hill Education, 2015.

Web resources:

1. Managerial Economics and Financial Analysis, Dr. Trupti , IIT Bombay *http://nptel.ac.in/courses/110101005/*

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

CO 1	A student will be able to understand basic economics as well as management concepts.
CO 2	This subject will provide implication facilities of concepts.
CO 3	Students can be able to do primary data collection and classification.
CO 4	Students can also be able to forecast as well as generate trend series by utilizing the available secondary data.

CO 5	They have basic knowledge about accounting and its terminologies.
CO 6	They will be able to prepare and understand accounting tables.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20HS4101	Indian Constitution	MC	2-0-0	0

Course Learning Objectives:

1. The basic objective of the course is to provide knowledge about institutions
2. It help to understands the processes to governing the society in a systematic way.
3. It helps to establish social Justice, Liberty, Equity and Fraternity.
4. The course will introduce the idea of political system in general
5. It provides idea about working process of constitutional institutions.
6. To create awareness about the functioning of the judicial system in India.

Course Contents:

UNIT-I **(5 Contact hours)**

Introduction-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 **(5 Contact hours)**

Union Government and its Administration-Structure of the Indian Union: Federalism, centre-state relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, Lok sabha, Rajya sabha.

UNIT-III **(5 Contact hours)**

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

UNIT-IV **(3 Contact hours)**

State Government and its Administration- Governor: Role and position, CM and Council of ministers, state secretariat: Organization, structure and functions.

UNIT-V **(7 Contact hours)**

Local Administration-District's Administration head: Role and importance, Municipalities: Introduction, Mayor and role of Elected Representatives, CEO of Municipal Corporation, Panchayati raj: Introduction, PRI: Zilla Panchayat, Elected officials and their roles, CEO Zilla Panchayat: Position and role, Block level: Organizational Hierarchy (different departments), Village level: Role of elected and appointed officials, Importance of grass root democracy.

UNIT-VI **(5 Contact hours)**

Union Judiciary-Establishment and constitution of Supreme court, Appointment of Judges, Establishment of State High court, Establishment of common High court for 2 or more states, WRITS, PIL(Public Interest Litigation).

Learning resources

Text book:

1. Durga Das Basu, *Constitutions of India*, 23rd ed, LexisNexis Publication.

Reference Books:

1. 'Indian Polity' by Laxmikanth
2.'Indian Administration' by Subhash Kashyap
4.'Indian Administration' by Avasti and Avasti
5.'Government and Politics of India' by W.H.Mrrison Jones
6.'Constitution of India' by J.C.Johari

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

CO 1	The students will understand their fundamental rules and duties.
CO 2	The students will learn the political system and the system of elections in India.
CO 3	It is to provide the students the institutions and processes to govern themselves in the manner they prefer.
CO 4	Students can also be able to utilize the laws and facilities provided by constution
CO 5	It will provide over all idea about our legal system.
CO 6	It will enable students more strong in terms of law and practice in day to day life.

For Theory courses only:

Course Nature	**Theory**

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	0	0	100%	100%

**** PASS/FAIL COURSE**

Course code	Course name	Course Category	L-T-P	Credits
20CH	Fluid Mechanics Lab	PCC	0-0-3	1.5

Course Learning Objectives:

The objective of this Lab is to train the student how to operate the experimental setups and generate the required results from them using basics concepts learned in fluid mechanics course.

List of Experiments:

1. To Calculate the friction factor for the given pipe line.
2. To calculate the coefficient of discharge for an orifice meter.
3. To calculate the coefficient of discharge for a venturi meter
4. To verify the Bernoulli's theorem in a continuous fluid flow.ot
5. To calculate the coefficient of discharge for a V–Notch.
6. To calculate the coefficient of discharge for a rectangular –Notch.
7. To calibrate the Rotameter.
8. To calculate the efficiency of multi-stage centrifugal pump and study its characteristics.
9. To study the effect of superficial velocity and bed porosity and pressure drop in packed bed.
10. To study the effect of superficial velocity and bed porosity and pressure drop and determine the minimum fluidization velocity in fluidized bed.
11. Verification of Stokes law

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

CO1	The usage of basic equations derived in fluid mechanics course and checks their validity
CO2	Experiment with the usage of flow meters.
CO3	Design of fluidization and its operation.
CO4	Construction of different experiments in Chemical Industries like flow meters, pumps.

Course Nature	**Practical**

Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

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Course Code	Course Name	Course category	L-T-P	Credits
20EC2209	Basic Electrical and Electronics Engineering	ESC	3-0-0	3

Course Learning Objectives

1. Impart a basic knowledge of electrical quantities such as current, voltage, power, energy and frequency to understand the impact of technology.
2. Provide knowledge for the analysis of basic DC and AC circuits used in electrical and electronic devices.
3. To explain the working principle, construction, applications of DC machines, AC machines.
4. Realize the importance of electronic devices in the present technology.

Course content

Unit-I **(10 Contact hours)**

DC Circuits

Introduction, Basic definitions, Types of elements, Ohm's Law, Kirchhoff's Laws, Series, Parallel circuits, Star-delta and delta-star transformations, equivalent resistance calculation, Mesh and Nodal analysis, superposition theorem, thevenin's theorem and maximum power transfer theorem.

Unit-II **(7Contact Hours)**

AC Circuits

Single-phase: Inductive circuits, capacitive circuits, series RL, RC and RLC circuits, resonance

Three-phase: star connection and delta connection.

Unit-III **(7 Contact Hours)**

DC machines

Generator: Principle of operation of DC Generator, EMF equation, types, applications

Motor: DC motor types, torque equation, applications, three point starter.

UNIT-IV **(7 Contact Hours)**

AC machines

Transformers: Principle of operation of single phase transformers, EMF equation, losses, efficiency and regulation.

Induction machine: Principle of operation of induction motor, slip-torque characteristics, applications.

UNIT-V **(7 Contact Hours)**

Semiconductor Devices

Diode: types of semiconductors, P-N junction diode, V-I Characteristics, zener diode, Diode Applications. **Rectifiers:** Half wave, Full wave and Bridge rectifiers.

UNIT-VI **(7 Contact Hours)**

Transistors

PNP and NPN Junction transistor, Transistor configurations, Transistor as an amplifier

Learning Resources:

Textbooks:

1. Kothari and Nagarath '*Basic Electrical and Electronics Engineering'*, 2nd edition, TMH Publications.

Reference books

1. V.K.Mehta, S.Chand& Co '*Principles of Electrical and Electronics Engineering'*.
2. Kothari and Nagarath, '*Basic Electrical Engineering'*, 2nd Edition, TMH Publications.

Web Resources

1. Prof T S Natarajan, NPTEL-IIT Madras, 'Basic Electronics'
   URL: https://nptel.ac.in/courses/122106025/
2. Prof U Umanand, IISC Bangalore, 'Basic Electrical Technology'.
   URL: http://nptel.ac.in/courses/108108076/
3. Prof S Aniruddhan, IIT Madras, 'Basic Electrical Circuits'.
   URL: https://onlinecourses.nptel.ac.in/noc16_ee03

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

CO 1	Predict the behaviour of any electrical and magnetic circuits.
CO 2	Formulate and solve complex AC, DC circuits
CO 3	Identify the type of electrical machine used for that particular application

CO 4	Realize the requirement of transformers in transmission and distribution of electric power and other applications
CO 5	Utilize the semiconductor devices like diodes and transistors
CO 6	Interlink Knowledge of electrical and electronic circuits to general problems

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course Code	**Course Name**	**Course category**	**L-T-P**	**Credits**
20CS2207	Object Oriented Programing through JAVA	ESC	3-0-0	3

Course Learning Objectives:

1. Gain knowledge about basic Java language syntax and semantics to write Java programs and use concepts such as variables, conditional and iterative execution methods etc.,
2. Understanding the fundamentals of object-oriented programming in Java, including defining classes, objects, invoking methods etc. and exception handling mechanisms.
3. Understand the principles of inheritance, packages and interfaces.
4. Understand the principles of Multithreading and Event handling mechanisms.

Syllabus:

UNIT-I **(8 Contact hours)**

Java Evolution, And Overview of Java Language: Java History –Features of java, how java differ from C and C++, Java and World Wide Web, Web Browser. Java Environment: Java Development kit (JDK), Application Programming Interface (API).
Java Programming Structure, Java Tokens, Constants, Variables, Expressions, Decision Making Statements and Looping, Java Statements, Overview of arrays and strings, Machine Neutral, Java Virtual Machine (JVM), Command Line Arguments

Arrays And Strings: Arrays, One-Dimensional arrays, creating an array, declaration of arrays, initialization of arrays, Two-Dimensional arrays, String arrays, String methods, String Buffer class, Vectors, Wrapper classes.

UNIT-II **(8 Contact hours)**

Classes, Objects and Methods:

Introduction, defining a class, creating objects, accessing class members, constructors, methods overloading, static members.

Inheritance: Defining a sub class, sub class constructor, multilevel variables, Final classes, and Finalize methods, Abstract methods and classes, visibility control.

Managing Errors And Exceptions: Introduction, Types of errors-Compile time and Run time errors, Exceptions, Types of Exceptions, Syntax of Exception handling code, Multiple catch statements, Using finally statement, Throwing our own exceptions.

UNIT-III **(7 Contact hours)**

Interfaces and Multithreaded Programming: Introduction, Defining interfaces, extending interfaces, implementing interfaces. Introduction to threads, Creating Threads, Extending the Thread Class, Implementing the runnable interface, life cycle of a thread, priority of a thread, synchronization, Dead Lock.

UNIT-IV

Applet Programming **(7 Contact hours)**

Introduction, how applet differ from applications, building applet code, applet life cycle, About HTML, designing a web page, passing parameters to applets, Getting input from the User.

UNIT-5 **(8 Contact hours)**

Graphics Programming (8 Contact hours)

Introduction, the abstract window toolkit (AWT), frames, event-driven programming, layout managers, panels, canvasses, drawing geometric figures.

UNIT-6 **(7 Contact hours)**

Creating User Interface:

Introduction, Describe various user interface Components: button, label, text field, text area, choice, list, check box check box group.

Learning Resources

Text books:

1. Herbert Schildt, “The Complete Reference Java”, TMH Publishing Company Ltd, 9th Edition.
2.Cay Horstmann, “Big Java”, John Wiley and Sons, 2nd Edition

Reference Books:

1. Allen B. Downey, “Think Java; How to Think Like a Computer Scientist”, Paper Back, 1stEdition
2. David J. Eck, Hobart and William Smith Colleges, “Introduction to Programming Using Java” Published by Paper Back
3. H.M.Dietel and P.J.Dietel “Java How to Program”, Sixth Edition, Pearson Education/PHI

Web resources:

1. http://www.nptelvideos.com/java/java_video_lectures_tutorials.php
2. https://www.tutorialspoint.com/java/
3. https://www.javatpoint.com/java-tutorial
4. http://mooc.fi/courses/2013/programming-part-1/material.html
5. http://math.hws.edu/javanotes

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

CO 1	Explain OOP Principles and Write Basic Java Programs.
CO 2	Defining Classes and Objects. Identify classes, objects, members of a class and relationships among them needed for a specific problem
CO 3	To be able to write Java Programs to demonstrate method overloading and Demonstrate the concepts of polymorphism and inheritance. Discuss method overriding V/s method overloading.
CO 4	Explain the benefits of JAVA’s Exceptional handling mechanism compared to other Programming Language
CO 5	To be able to write Java Programs to demonstrate Packages and Threading concepts.
CO 6	Discuss and Demonstrate the AWT Concepts and develop the AWT Applications.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
CH2201	Chemical Reaction Engineering – I	PCC	3-1-0	4

Course Learning Objectives:

The objective of this course is to impart in-depth knowledge about

1. Classification of chemical reactions, their speed and kinetics
2. Temperature dependency of rate equation and interpretation of batch reactor data for Constant volume batch reactor
3. Interpretation of batch reactor data for variable volume batch reactor and methods of Analysis of rate data for single and multiple reactions
4. Formulation of performance equations for ideal reactors
5. Reactors for single reactions and multiple reactions; product distribution
6. Temperature and Pressure effects on the progression of a chemical reaction

Course Content:

Unit I: (8 Contact hours)

Introduction: Overview, Classification of chemical reactions, variables affecting the rate of reaction, definition of reaction rate, Speed of chemical reactions, overall plan.

Kinetics of homogeneous reactions:: The rate equation; Concentration dependency; Single and multiple reactions, elementary and non-elementary reactions, Order and molecularity of chemical reactions, rate constant. Representation of elementary and non-elementary reactions.

Unit II: (10 Contact hours)

Temperature dependency: Temperature dependent term of rate equation from Arrhenius law and comparison of collision and transition theories.

Interpretation of Batch reactor data: Constant volume Batch reactor: Integral method of analysis of data-Irreversible first order, second order, third order , n^{th} order and zero order reactions; Half-life method; Fractional life method;

Unit III: (12 Contact hours)

Series reactions, parallel reactions, Catalyzed reactions; First order reversible reactions, reactions of shifting order; Variable volume batch reactor; reaction rate; rate constant; collection and interpretation of kinetic data; parallel and series reactions. Differential

method of analysis; varying volume Batch reactor: Analysis of data using differential and integral methods –Irreversible zero order, first order, second order and nth order reactions; Temperature and reaction rate.

Unit IV: **(10 Contact hours)**

Introduction to reactor design: General Discussion, symbols and relationship between concentration and conversion;

Ideal reactors for single reactions: Ideal batch reactor, steady state mixed flow and plug flow reactors design with and without recycle. Design for single reactions: Size comparison of single reactors, variation of reactant ratio, Graphical comparison;

Unit V: **(12 Contact hours)**

Multiple reactor systems- MFRs and PFRs in series and parallel, best arrangement of set of ideal reactors, Recycle reactor, autocatalytic reactions, reactor combinations.

Design for Parallel reactions: Introduction, Qualitative discussion about product distribution, quantitative treatment of product distribution and of reactor size, the side entry reactor.

Design for single reactions: Size comparison of single reactors, variation of reactant ratio, Graphical comparison.

Potpourri of multiple reactions: Irreversible first order reactions in series- Qualitative discussion about product distribution and quantitative treatment of product distribution-mixed flow reactor.

Unit VI: **(8 Contact hours)**

Combination of first order and zero order reactions in series, two step irreversible series-parallel reaction, The Denbigh reactions.

Temperature and Pressure effects: single reactions- Heats of reactions, equilibrium constants from thermodynamics, general graphical design procedure, optimum temperature progression, Adiabatic and Non-adiabatic operations; multiple reactions-Product distribution and temperature.

Learning Resources:

Text book:

1. Octave levenspiel, 'Chemical Reaction Engineering', Wiley-India, 3rd edition, 2012.

Reference Books:

1. H S Fogler, 'Elements of Chemical Reaction Engineering', PHI, 4th Edition, 2008.

Web resources:

1. https://nptel.ac.in/courses/103108097/

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

CO1	Build a knowledge on different classification of reactions, mechanisms and their kinetics
CO2	Analyzing the procedure of interpretation of batch reactor data for different types of reactions
CO3	Evaluating the performance equations for all ideal reactors
CO4	Find the design parameters such as volume of the chemical reactor for the given duty
CO5	Organize the ideal reactors for best conversions in single reactors and multiple reactions
CO6	Identify the optimum temperature progression for the maximum performance of the reactor

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CH2202	Mass Transfer Operations-I	PCC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. To deduce adequate knowledge in principles of mass transfer and problem-solving techniques.
2. Explore concepts of mass transfer processes such as; absorption, humidification and drying and its applications
3. To recognize the effective usage of mass transfer equipments according to separation process.
4. To able to get an idea of industrial separation equipments.
5. To design the equipments needed for separation processes.
6. To understand the drying operations.

Course Content:

UNIT –I **(8 Contact hours)**

Introduction: Mass transfer operations & their applications. Concepts of molecular diffusion and mass transfer coefficients.

Molecular Diffusion in Fluids: Molecular Diffusion, Fick's first law, Equation of Continuity, binary solutions, Steady State Molecular Diffusion in Fluids at Rest and in Laminar Flow, estimation of diffusivity of gases and liquids. Diffusion in Solids, Fick's Diffusion, Unsteady State Diffusion, types of Solid Diffusion.

UNIT – II **(8 Contact hours)**

Mass Transfer Coefficients and various theories, Correlation's for mass transfer coefficient, Heat and Mass Transfer Analogies

Inter phase Mass Transfer: overall mass transfer coefficients – Two resistance theory – Gas phase & liquid – phase controlled situations

UNIT-III **(7 Contact hours)**

Equipment for Gas Liquid Operations – Stages, Cascades, Description of continuous and stage wise contact equipment Material balances in steady state co-current and counter current stage processes, packing for packed columns, Liquid distribution -Mass transfer coefficients in packed columns, Flooding in packed and plate columns – Ideal -plate – Murphree, point, plate and column efficiency – Comparison of packed and plate

UNIT-IV **(7 Contact hours)**

Absorption and Stripping: Absorption equilibrium, ideal and non-ideal solutions selection of a solvent for absorption, counter current and co-current isothermal absorption and stripping of single component – Operating Lines – Minimum flow rates – Determination of number of transfer units and height of a continuous contact absorbers. Multistage absorption and determination of number plates – absorption factor – Kremser – Brown equation.

UNIT-V **(8 Contact hours)**

Vapor - gas mixtures – Humidity and relative saturation. Dew point adiabatic saturation and wet bulb temperatures – psychometric charts – Enthalpy of gas vapor mixtures – Humidification and dehumidification – Operating lines and design of packed humidifiers, dehumidifiers and cooling towers, Spray chambers.

UNIT-VI **(7 Contact hours)**

Drying: Moisture contents of solids, equilibrium content, bound and unbound moisture, Drying conditions – Rate of batch drying and under constant drying conditions, Mechanism of batch drying, Drying time of batch drying- through circulation drying, Description of batch and continuous dryers.

Text books:

1. R.E. Treybal, *'Mass transfer operations'*, McGraw Hill,1981, 3rd Edition
2. B.K. Dutta, *'Principles of mass transfer and separation processes'*, PHI Learning Private Limited, Eastern Economy Edition

Reference Books:

1. Warren, L., McCabe, Julian C.Smith and Peter Harriot, *'Unit Operations of Chemical Engineering'*, McGraw Hill, 7th Edition
2. Christie John Geankoplis, *'Transport process and separation process principles'*, PHI of India, 4thedition
3. J D Seader and E J Henly, *'Separation Process Principles'*, John Wiley & sons, NY 1998.

Web resources:

1. https://nptel.ac.in/courses/103103034/
2. https://nptel.ac.in/courses/103103035/

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

CO 1	Build a basic knowledge of mass transfer operations and separation processes carried out in chemical industries.
CO 2	Evaluate the applications of different mass transfer processes.
CO 3	Identify technological methods in problem solving of mass transfer operations in industries.
CO 4	Designing of mass transfer equipments used in the chemical industries.
CO 5	Utilize the technological methods in problem solving of mass transfer operations in industries.
CO 6	Recognize the selection criteria for mass transfer process and equipments required by the industries.

Course Nature	**Theory**
Assessment Method	

Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course Code	Course Name	Course category	L-T-P	Credits
20CH2203	Thermodynamics - II	PCC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Understand the concepts of solution thermodynamics
2. Understand ideal solution models to reflect behavior of real mixtures based on the concepts of excess free energy.
3. Understand the models to reflect VLE in ideal and non-ideal solutions
4. Understand phase equilibrium and bubble and dew point.
5. Understand Phase equilibria among phases.
6. Understand Equilibrium constant.

Course Content:

Unit I **(7 Contact hours)**

Properties of Solutions: Partial molar properties, definition, physical significance, determination, Chemical potential definition, effect of temperature and pressure, fugacity in solution, ideal solution, Lewis-Randall rule, Raoult's law, Henry's law, activity and activity coefficients in solutions, effect of temperature and pressure on activity coefficients, Gibbs-Duhem equations, applications

Unit II **(13 Contact hours)**

Property changes on mixing, heat effects of mixing processes, enthalpy composition diagrams, excess properties, relation between excess Gibbs free energy and activity coefficient, Applications of fugacity–fugacity coefficient–Activity–Activity Coefficient
Phase Equilibria: Criterion of phase equilibria, criterion of stability, Duhem's theorem, vapour-liquid equilibrium, phase diagram for binary solutions

Unit III **(10 Contact hours)**

VLE in ideal solutions, non-ideal solutions, positive and negative deviation, azeotropes, VLE at low pressures, Wohl's equation vanlaar equation, Margules equation, Wilson equation, application of activity coefficient equations in equilibrium calculations :basic idea on NRTL,UNIQUAC and UNIFAC methods, Applications of vapor–liquid-Equilibria–minimum boiling Azeotrope–maximum boiling Azeotrope

Unit IV **(10 Contact hours)**

Phase Equilibrium: Vapour-liquid equilibrium at high pressures, vaporization equilibrium Constants: bubble point, dew point and flash calculations in multi component systems, Retrograde condensation, vapour-liquid equilibrium in partially miscible and immiscible systems, phase diagrams

Applications of Bubble Point–Dew Point calculations in separation process–Applications of retrograde condensation

Unit V **10 Contact hours)**

Physical Equilibria Among the Phases: The Gamma/ Phi Formulations of VLE, VLE from Cubic Equations of State, Equilibrium and Stability, Liquid-Liquid Equilibrium (LLE), Vapour- Liquid- Liquid Equilibrium (VLLE), Solid- Liquid Equilibrium (SLE), Solid- Vapour Equilibrium (SVE), Equilibrium Adsorption of Gases on Solids and Osmotic Equilibrium and Osmotic Pressure.; Heat Effects& Chemical Reaction Equilibria: Sensible & latent heat effects of pure substances, Standard heat of reaction, formation, combustion, Temperature dependence of ΔH^0-Reaction stoichiometry, criteria of chemical equilibrium

Unit VI **(10 Contact hours)**

Equilibrium Constant, standard free energy change, standard state, feasibility of reaction, effect of temperature on equilibrium constant, presentation of free energy data, evaluation of K, factors effecting on equilibrium conversion. Effect of pressure and other parameters on conversion, phase-rule for reacting systems, Heat Effect Studies and Equilibrium Constant Calculations in Various Industries.

Learning Resources:

Text Books:

1. J.M.Smith, H.C Van Ness and M. M. Abbott, '*Introduction to Chemical Engineering Thermodynamics'*, Sixth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003

Reference Books:

1. Halder G, *'Introduction to Chemical Engineering Thermodynamics'*, 4th edition, Prentice Hall India, 2014.

2. J.Richard Elliott and Carl T. Lira, *'Introductory Chemical Engineering Thermodynamics'*, Second Edition, Prentice Hall, 2012
3. Thomas E Daubert, Chemical Engineering Thermodynamics, McGraw Hill International Editions, 1986
4. K. V. Narayanan, *'Text Book of Chemical Engineering Thermodynamics'*, PHI Learning Limited, 2004,
5. Y. V. C. Rao, '*Chemical Engineering Thermodynamics'*, University Press (India) Private Limited, 2004

Web resources:

1. https://nptel.ac.in/courses/103101004/
2. http://www.msubbu.in/lecture/thermodynamics.html

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

CO 1	Differentiate solution thermodynamics to gases
CO 2	Inspect the property changes due to mixing and determine the fugacity & activity coefficients of a pure component, mixture & solution
CO 3	Identify the models to evaluate VLE
CO 4	Estimate bubble point, dew-point calculations using Raoult's law & modified Raoult's law.
CO 5	Compute heat effects associated with physical and chemical processes. Apply thermodynamic principles to calculations related to chemical reaction equilibrium
CO 6	Compare equilibrium constants for various pressure and temperature conditions.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course Code	Course Name	Course category	L-T-P	Credits
20CS2287	Object Oriented Programing Through JAVA Lab	ESC	0-0-3	1.5

Course Learning Objective:

1. To build software development skills using java programming for real-world applications.
2. To understand and apply the concepts of classes, packages, interfaces, arraylist, User defined Linked List, File Handling, exception handling and Multi-threading.
3. To develop applications using AWT programming and event handling.

List of Experiments:

Lab No 1: Basic Programs in JAVA
Lab No 2: Programming Assignments on Arrays and Strings
Lab No 3: Programming Assignments on Classes, Objects and Encapsulation
Lab No 4: Implementing the concepts of Inheritance and Array Objects
Lab No 5: Implementing the OOPS Concepts of Abstract, Interfaces and Polymorphism
Lab No. 6: Programming Assignments on File Handling
Lab No. 7: Programming Exercises on Exception Handling
Lab No 8: Working with List Operations
Lab No 9: Implementing the concepts of Multi-Threading
Lab No 10: Programming Exercises on Event Handling

Course Outcomes

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

CO 1	Understanding the control structures and conditional statements in Java
CO 2	Understanding the arrays and String handling in java
CO 3	Understanding the difference between class and object and providing security for objects
CO 4	Understanding the reusability of objects and working with multiple objects
CO 5	Understanding about hiding the data, getting multiple inheritance through interfaces
CO 6	Understanding the data processing from files
CO 7	Understanding about handling run time abnormal program executions
CO 8	Understanding about creating user defined linked list and dynamic objects
CO 9	Understanding the multi-threaded programming and inter thread communication
CO 10	Understanding about GUI creation

Assessment Method

Assessment Tool	Experiments	Report/Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	15%	40%
End Semester Examination weightage (%)			60%

Course code	Course name	Course Category	L-T-P	Credits
20CH2281	Heat Transfer Lab	PCC	0-0-3	1.5

Course Learning Objectives:

The objective of this Lab is to train the student how to operate the experimental setups and generate the required results from them using basics concepts learned in Heat transfer course.

List of Experiments

1. **Thermal Conductivity of Metal Rod**
    i. To Calculate the Thermal Conductivity of metal rod.
    ii. To plot the temperature distribution along the length of rod.
2. **Thermal Conductivity of Liquid**
    i. To determine the thermal conductivity of given liquid.
3. **Emissivity Apparatus**
    i. To determine the emissivity of a given test plate.
4. **Forced Convection Apparatus**
    i. To calculate the heat transfer coefficient for the flow of fluid over a hot surface.
    ii. Comparing heat transferring coefficients for different air flow rates and different temperatures of hot surface.
5. **Natural convection apparatus**
    i. To calculate the average heat transfer coefficient of a cylinder oriented vertically.
6. **Composite wall apparatus**
    i. To calculate total thermal conductivity, thermal resistance of the given composite wall.
    ii. To determine thermal conductivity of one material in composite wall.
    iii. Plot the temperature profile in composite wall at steady state.
7. **Shell and Tube Heat Exchanger**
    i. To calculate the heat duty.
    ii. To calculate mean temperature difference (LMTD)
    iii. To calculate overall heat transfer coefficient.

8. Pool Boiling apparatus

i. To determine the critical heat flux of a given metal wire.

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

CO1	List the application of theoretical concepts discussed in heat transfer course practically and checks their validity.
CO2	Determination of thermal properties of any material.
CO3	Compile heat transfer coefficients in convection mode practically.
CO4	Analyzing the working of heat exchange equipment and their role in chemical industries.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

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Course code	Course name	Course Category	L-T-P	Credits
20CH2282	Mechanical Unit Operations Lab	PCC	0-0-3	1.5

Course Learning Objectives:

This course enables the students to:

1. Understand and apply engineering experimentation techniques and safety procedures common to the chemical industry.
2. Apply principles developed in chemical engineering courses to the analysis of chemical Engineering processes and unit operations.
3. To provide experience on analysis of size and size reduction.
4. To acquaint the students with the separations based on size.
5. Improve skills necessary for group work—interpersonal skills, coordination of the efforts of several persons, leader and subordinate roles, etc.

List of Experiments

1. a)To calculate the efficiency of a ball mill for grinding a material of known work index(Wi)
   b) To study the effect of RPM on the power consumption of ball mill.
   c) To calculate the Critical Speed (nc) of ball mill.
2. To determine the Efficiency of the Jaw crusher for crushing the material of known work index (Wi).
3. To calculate the percentage recovery of Coal in froth flotation cell from coal-sand mixture.
4. a)To calculate specific cake resistance.
   b) To calculate the medium resistance(R).
5. a) To determine the effect of initial concentration and initial suspension height on the sedimentation rates.
   b) To show the effect of flocculating agent.
   c) To show the effect of particle size distribution.
6. a) To demonstrate Gyratory sieve shaker.
   b) To report the screening analysis.

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

CO1	Analyze the characterization of particles and calculate the effectiveness of a given screen.
CO2	Calculate size reduction ratio, work index using ball mill and jaw crusher.
CO3	Estimate the power requirement using crushing laws for various crushers.
CO4	Apply separation techniques like forth floatation, sedimentation to separate a mixture.
CO5	Evaluate performance characteristics of filter press, cyclones, flotation cells and clarifiers.
CO6	Build a bridge between theoretical and practical concept used in industry

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CH3101	Chemical Process Dynamics and Control	PCC	3-1-0	4

Course Learning Objectives:

1. To comprehend important Laplace transform and its properties.
2. To study the dynamics of first order system with different forcing functions.
3. To study the dynamics of second order system with different forcing functions.
4. To analyze different components of a control loop.
5. To study the stability of the control system and tune controller parameters.
6. To study the advance controllers and control valves

Course Content:

Unit-1: **(12 Contact hours)**

Basic Principles: Laplace Transform, Inversion by Partial Fractions and Properties of Transforms Concept of deviation variables. Concept of transfer function. Properties of transfer functions – additively and multiplicity

Introduction to Instrumentation: measuring process variables such as temperature, pressure and flow.

Unit-2: **(10 Contact hours)**

Linear Open-Loop Systems: Dynamic response of First-Order System (thermometer for modeling) with different input/forcing function such as step, ramp, impulse, sinusoidal. Physical Examples of first order system.

Unit-3: **(10 Contact hours)**

Dynamic response of First-Order Systems in Series for interacting and non-interacting system, Dynamics of Second-Order Systems (U tube manometer for modeling) with different input/forcing function such as step, impulse, sinusoidal and Transportation Lag and use of Pade approximation

Unit-4: **(8 Contact hours)**

Linear Closed-Loop Systems: Control System, Controllers (P, PI and PID controllers) and Final Control Elements, Block Diagram of a Chemical-Reactor Control System, Closed-Loop Transfer Functions, Transient response of Simple Control Systems (servo and regulatory problem). Concept of offset.

Unit-5: **(10 Contact hours)**

Stability of dynamic systems: Routh-Hurwitz criteria; Root Locus method.
Frequency Response analysis: Bode plots; Bode Stability Criterion

Selection and Tuning of Controllers: Methods based on FOPDT model and Process Reaction Curve (PRC); Cohen-Coon optimum controller settings; Integral Error Criteria. Ziegler-Nichols

Unit -6: **(10 Contact hours)**

Advanced control strategies: Cascade Control, Feed Forward Control, Ratio Control
Control Valves: Control Valve Construction, Valve Sizing, Valve Characteristics, Valve Positioner.

Learning Resources:

Text book:

1. D.R. Coughanowr, '*Process Systems Analysis and Control*'. McGraw Hill, 3rd ed 1991

Reference Books:

1. G. Stephanopolous, '*Chemical Process Control'*, Prentice Hall, 1984.
2. Peter Harriott, '*Process control*' Tata McGraw-Hill 1964. (10th reprint 2008).

3. William L. Luyben, Michacl L. Luyben, '*Essentials of process control*', McGraw-Hill,1997

Web resources:

1. **https://nptel.ac.in/courses/103105064/**

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

CO1	Applications of Laplace transforms and its properties.
CO2	Determine the dynamic behavior of first order process
CO3	Analyze the dynamic behavior of first order in series and second order process
CO4	Categorize P, PI, and PID Controllers for various purposes.
CO5	Analyze stability of feedback control system and Tune P, PI, PID Controllers
CO6	Importance of control valve sizing.

Assessment Tool	**Weekly tests/Assignments (In semester)**	**Monthly tests (In semester)**	**End Semester Test**	**Total**
Weightage (%)	10%	30%	60%	100%

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CH3102	Chemical Technology	PCC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Understand the schematic representation of important unit operation/ unit processes involved in plant operations. Develop skills in preparing /presenting a neat Engineering drawing for Chemical Process Industries such as Chloro-alkali industries, glass.
2. Develop skills in preparing /presenting a neat Engineering drawing for Chemical Process Industries such as urea, fertilizer.
3. Impart clear description of one latest process along with its Chemistry, Process parameters, Engineering Problems and Optimum Conditions.
4. Demonstrate the importance of updating the latest technological developments in producing products economically and environment friendly.

5. Appreciate the usage of other engineering principles such as Thermodynamics, Heat, mass and momentum transfer in operation and maintain the productivity.
6. Understand the concepts of petroleum industry.

Course Content

UNIT –I **(8 Contact hours)**

Introduction: Chemical industries-facts and figures, Unit operation and unit process concepts, chemical processing and role of chemical engineers.

Chlor-Alkali Industries: Sodium Carbonate, Chlorine-Caustic soda production industries.

Glass: manufacture of special glasses.

UNIT – II **(7 Contact hours)**

Nitrogen Industries: Nitrogen industries: synthetic ammonia, urea, nitric acid (ammonium nitrate), ammonium chloride, ammonium phosphate and complex fertilizers. Phosphorus Industries: Phosphorus, phosphorous pent oxide, phosphoric acid, SSP and TS. Potassium Industries, Sulphur and Sulphuric acid production industries some other chemicals – Aluminum sulphate and alum.

UNIT-III **(8 Contact hours)**

Cement manufacture, special cements, miscellaneous calcium compounds, magnesium compounds.

Oils: Definition, constitution, extraction and expression of vegetable oils, refining and hydrogenation of oils.

UNIT-IV **(7 Contact hours)**

Synthetic fibers: Classification, manufacture of Nylon 66, polyester fiber and viscose rayonfiber.

Soaps and detergents: Definitions, continuous process for the production of fatty acids, glycerin and soap, production of detergents.

UNIT-V **(8 contact hours)**

Pulp and paper industry: methods of pulping, production of sulphate and sulphite pulp, production of paper –wet process

Sugar and Starch Industries: Sucrose, Extraction of sugar cane to produce crystalline white sugar, Extraction of sugar cane to produce sugar, Starch production from maize, Production of dextrin by starch hydrolysis in a fluidized bed.

UNIT-VI **(7 contact hours)**

Petroleum Industry: Origin, occurrence and characteristics of crude oil, crude oil distillation. Petrochemical industries: Manufacturing processes of formaldehyde, acetaldehyde, acetic acid, acetic anhydride, nitrobenzene, ethylene oxide, and ethylene

glycol. Polymerization industries: polyethylene, polypropylene, PVC and polyester synthetic fibers production industries.

Text books:

1. M.Gopal Rao and M.Sittig, Dryden's outlines of Chemical Technology, 3rd Edition, East-West Press, 1997.
2. Austin, Shreve's chemical process industries , 5th ed., M.C.Graw-Hill,1985

Reference Books:

1. Industrial Chemistry by B.K. Sharma,
2. Hand book of industrial chemistry Vol 1& II K.H.Davis& F.S. Berner Edited by S.C. Bhatia, CBS publishers
3. Chemical Technology: G.N. Panday, Vol 1&Vol II

Web resources:

1. https://nptel.ac.in/courses/103107082/
2. https://nptel.ac.in/courses/103103029/

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

CO1	Draw the plant process flow sheet.
CO2	Learn in maintaining all safety norms during their job
CO3	Solve Engineering problems to keep up the productivity
CO4	Propose alternative manufacturing process
CO5	List chemical reactions and their mechanism involved.
CO6	Identify the key in terms of economic viability of the product.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**

20CH3103	Chemical Reaction Engineering- II	PCC	3-0-0	3

Course Learning Objectives:

1. To understand the purpose of Residence time distribution.
2. To learn how to deal with non -ideal reactors.
3. Exploring models available to determine conversions in non- ideal reactors.
4. To study the steps involved in fluid-solid catalytic reactions
5. Understanding the parameters affecting catalytic reactions.
6. To study models available to deal with fluid-solid reactions without catalyst.

Course Content:

Unit–I (8 Contact hours)

Basics of non-ideal flow: The Residence time distribution (RTD), State of aggregation of the flowing stream , Earliness of mixing and their role in determining reactor behavior; E-the age distribution of fluid, the RTD, Measurement of the RTD- The pulse and the Step experiments relation between E and F curves.

Unit – II (8 Contact hours)

Characteristics of the RTD: RTD in real reactors, Diagnostics and troubleshooting.

Conversion in Non-ideal flow reactors: Predicting conversion and exit concentration, reactor modeling using RTD, zero parameter models: segregation model – macro and micro fluids, earliness and late mixing; maximum mixedness model, comparison of zero parameter Vs. maximum mixedness model.

Unit – III (7 Contact hours)

One parameter models: The dispersion model- Axial dispersion, small deviation and large deviations from plug flow; correlations for axial dispersion, Chemical reaction and dispersion-first order and nth order reactions.

Tanks- in-series (T-I-S) model- the RTD for n equal sized tanks in series; Chemical conversion in first order and all other reaction kinetics of micro fluids, chemical conversion of macro fluids. Tanks- in-series Vs. dispersion model.

Unit - IV (8 Contact hours)

Catalysis and catalytic reactors: Introduction to Catalysts, steps in a catalytic reactions- Overview of Internal and External diffusion, Adsorption Isotherms, surface reaction, Desorption, The rate limiting step; Synthesizing a rate law, mechanism and rate limiting step for a solid catalyzed heterogeneous reaction.

Unit - V (7 Contact hours)

Diffusion and reaction: External diffusion effects on heterogeneous reactions : External

resistance to mass transfer, correlation for the mass transfer coefficient, Experimental methods for finding rates, design of packed bed catalytic reactors and Fluidized bed reactors.

Diffusion and reaction in a single cylindrical pore, Thiele modulus and internal effectiveness factor, extension to different particles, Falsified kinetics, heat effects during reaction.

Unit – VI **(7 Contact hours)**

Fluid-solid non-catalyzed reactions: Introduction, selection of a model, progressive conversion model (PCM), shrinking core model (SCM), SCM for spherical particles of unchanging size, SCM for spherical particles of shrinking size, limitations of shrinking core model; Determination of the rate-controlling step.

Learning Resources:

Text book:

1. Octave Levenspiel , '*Chemical Reaction Engineering'*, Wiley – India, 3rd edition (2012)
2. H S Fogler, '*Elements of Chemical Reaction Engineering*', PHI, 4th ed.,2008.

Reference Books:

1. Smith J.M., '*Chemical Engineering kinetics*', McGraw-Hill, 3rd edition 1974.

Web resources:

1. https://nptel.ac.in/courses/103106117/
2. https://nptel.ac.in/courses/103101008/

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

CO1	Predict how real reactor deviates from ideal reactors such as PFR, MFR
CO2	List out parameters affecting the behaviour of non-ideal reactors. Diagnose and troubleshooting them.
CO3	Explore and apply different models available to predict the conversion in non- ideal reactors.
CO4	Analyzing the steps involved in catalytic reactions and the kinetics involved.
CO5	Design the parameters affecting rate of catalytic reactions.
CO6	Explore different mechanisms related to non-catalyzed solid-fluid reactions. Describe enzymatic reactions.

Course Nature	**Theory**

Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20CH3104	Mass Transfer Operations-II	PCC	3-0-0	0

Course Learning Objectives:

The course content enables the students to:

1. To deduce adequate knowledge in principles of mass transfer and problem-solving techniques.
2. Explore concepts of mass transfer processes such as; distillation, liquid- liquid extraction, leaching, adsorption and crystallization and its applications
3. To recognize the effective usage of mass transfer equipments according to separation process.
4. To able to get an idea of industrial separation equipments.
5. To design the equipments needed for separation processes.
6. To design the equipment for crystallization operations.

Course Content:

UNIT – I **(8 Contact hours)**

Distillation-I: Principles of VLE for binary systems–phase diagrams, relative volatility, azeotropes, enthalpy concentration diagrams, flash vaporization, partial condensation, differential distillation, steam distillation, Batch distillation with reflux for binary mixtures. Introduction to Multicomponent distillation, Introduction to cryogenic distillation

UNIT – II **(8 Contact hours)**

Distillation-II : Continuous fractionation of binary mixtures, Ponchon – Savrit method and McCabe – Thiele method of determination of ideal plates for binary mixtures – Optimum reflux ratio – Use of total and partial condensers. Use of open steam. Types of Condensers and Reboilers. Packed bed distillation. Principals of azeotropic and extractive distillation.

UNIT – II **(7 Contact hours)**

Liquid – Liquid Extraction :Solubilities of ternary liquid systems. Triangular and solvent free coordinate systems. Choice of solvent. Extraction with insoluble and partially soluble systems – single stage, multistage cross current and multistage counter current extraction without reflux and with reflux. Continuous contact extraction (packed beds). Equipment's for liquid – liquid extraction operation. Introduction to super critical extraction

UNIT – IV **(7 Contact hours)**

Leaching: Preparation of solid, unsteady state operation, in-place leaching, heap leaching, percolation leaching, Shanks system, agitated vessels, percolation in closed vessels, Percolation vs Agitation. Steady state continuous operation – equipment's - methods of calculation, stage efficiency and practical equilibrium. Single stage leaching, multistage cross current leaching, multistage counter current leaching

UNIT- V **(8 Contact hours)**

Adsorption: Principles of adsorption and their applications – Types of adsorption – Adsorbents – Adsorption equilibrium – Adsorption Isotherms for vapor and dilute solutions. Single stage and multistage adsorption – unsteady state adsorption, adsorption wave and breakthrough curve and fixed bed adsorption.

UNIT-VI **(7 Contact hours)**

Crystallization: Crystal Geometry, Equilibrium and yields, principles of crystallization, Crystallization equipment

Ion-Exchange: Principles of Ion-Exchange, techniques and applications, rate of Ion-Exchange

Introduction to membrane separation processes, Introduction to reactive separation.

Text books:

1. R.E. Treybal, *'Mass transfer operations'*, McGraw Hill,1981, 3rd Edition

2. B.K. Dutta, *'Principles of mass transfer and separation processes'*, PHI Learning Private Limited, Eastern Economy Edition

Reference Books:

1. Warren, L., McCabe, Julian C.Smith and Peter Harriot, *'Unit Operations of Chemical Engineering'*, McGraw Hill, 7th Edition
2. Christie John Geankoplis, *'Transport process and separation process principles'*, PHI of India, 4thedition
3. J D Seader and E J Henly, *'Separation Process Principles'*, John Wiley & sons, NY 1998.

Web resources:

1. https://nptel.ac.in/courses/103104046/

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

CO1	Build a basic knowledge of mass transfer operations and separation processes carried out in chemical industries.
CO2	Importance and applications of different mass transfer processes.
CO3	Identify technological methods in problem solving of mass transfer operations in industries.
CO4	Design of mass transfer equipments used in the chemical industries.
CO5	Utilize the technological methods in problem solving of mass transfer operations in industries and ability to Select appropriate separation technique for intended problem
CO6	Evaluate the selection criteria for mass transfer process and equipments required by the industries.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20CH3105	Numerical Methods in Chemical Engineering	PCC	3-0-0	3

Course Objectives:

The course content enables the students to:

1. Understand errors arise in numerical calculations
2. Understand numerical solution to linear systems and single and multiple integrals
3. Understand single step numerical solution to Initial Value ODE's
4. Understand multi step numerical solution to Initial Value ODE's and system of equations.
5. Understand numerical solution to Boundary Value ODE's.
6. Understand numerical solution to PDE's.

Course Content:

Unit I **(8 Contact hours)**

Errors in numerical calculations: Absolute, relative and percentage errors, a general error formula, errors in a series approximation, **Root finding:** Locating Roots of nonlinear equations formed in chemical engineering applications with one variable: Bisection method, Newton-Raphson method, Secant method, Regula-falsi method, Muller's method; Solution of system of nonlinear equations-Introduction, Iteration method, Newton-Raphson method for systems

Unit II **(7 Contact hours)**

Solution of Linear Systems: Direct methods-LU factorization, Thomas Algorithm, Iterative methods–Jacobi iteration method, Gauss-Seidel iteration method

Numerical Integration: Trapezoidal rule, Simpson's 1/3 Rule, Simpson's 3/8th rule single and multiple integrals.

Unit III **(8 Contact hours)**

Numerical solutions of IVP (ODE's) in Chemical Engineering: Single step methods - Taylor series method, Euler method, Picard's method of successive approximation, Runge Kutta Method.

Unit IV **(7 Contact hours)**

Multi step methods - Predictor-Corrector method, Euler PC method, Milne and Adams Moulton PC method. **System of first order ODE**, higher order IVPs

Unit V **(8 Contact hours)**

Numerical solutions of BVP: Finite difference method, shooting method, Newton's method for system of equations. Non linear BVP, higher order BVP

Unit VI **(7 Contact hours)**

Introduction, **finite difference approximations** to derivatives, Laplace's equation, parabolic equation, hyperbolic equation

Text Books

1. S.K. Gupta, '*Numerical methods in engineering'*, 3rd edition, Tata McGraw Hill, 2013.

Reference Books:

1. Steven C. Chapra, *'Applied Numerical Methods with MATLAB for Engnineers and Scientists*', Third Edition, Tata McGraw Hill
2. B.S. Grewal,' *Higher Engineering Mathematics'*, 40th edition, Khanna publishers, New Delhi, 2007
3. Erwin Kreyszig,' *Advanced Engineering Mathematics'*, Johnwiley& Sons, 8th edition, 2007.

Web resources:

1. https://nptel.ac.in/syllabus/111107062/

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

CO1	Evaluate roots for linear and nonlinear equations
CO2	Able to find solution to linear equations and solution to single and multiple integrals.
CO3	Compute initial value ODE's.
CO4	Solving simultaneous ODE's.
CO5	Predict boundary value ODE's.
CO6	Compute PDE's.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	**Weekly tests/Assignments (In semester)**	**Monthly tests (In semester)**	**End Semester Test**	**Total**

Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20CH3181	Chemical Reaction Engineering Lab	PCC	0-0-3	1.5

Course Learning Objectives:

The objective of this Lab is to train the student how to operate the experimental setups and generate the required results from them using basics concepts learned in chemical reaction engineering-I & II courses.

List of Experiments

1. **RTD In tubular Reactor**
    i. To plot the Residence time distribution Curve for the given Plug Flow Reactor using a pulse tracer.
    ii. To determine the dispersion number in PFR
2. **RTD in CSTR**
    i. To plot the Residence time distribution Curve for the given Continuous stirred tank Reactor using a pulse tracer.
    ii. To determine the dispersion number in CSTR
3. **Isothermal Batch Reactor**
    i. To study the progress of a given chemical reaction and determine its rate constant using kinetic data obtained.
    ii. To study the effect of temperature on reaction rate constant.
4. **Isothermal CSTR**
    i. To study the progress of a given chemical reaction and determine its rate constant.
    ii. To study the effect of temperature on reaction rate constant.
5. **CSTRs in series**
    i. To study the progress of given chemical reaction and determine rate constant using all the tanks in series.
    ii. Plot residence time distribution curves for one tank, two tanks and three tanks using pulse tracer.
    iii. Determination of the influence of flow rate on a three tank system following a step change in input concentration.
    iv. Determination of the response to a step change in input concentration of a system comprising one stirred vessel and a “dead time” module
6. **Batch Reactor**
    i. To find the reaction rate constant in a stirred batch reactor using kinetic data measured using conductivity probe.

ii. To demonstrate the temperature dependence of the reaction and the rate constant.

7. Tubular Reactor

i. To determine the rate constant for a given reaction using tubular reactor.
ii. To investigate the effect of throughput on conversion
iii. To demonstrate the temperature dependence of the reaction and the rate constant.

8. CSTR

i. To determine the rate constant for a given reaction using CSTR.
ii. Determination of the RTD using tracer techniques.

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

CO1	Identify the application of theoretical concepts discussed in chemical reaction engineering course practically and checks their validity.
CO2	Determine chemical kinetics of homogenous reactions.
CO3	Estimate the effect of process conditions on reaction rate, product yield practically.
CO4	Predict the behaviour of a reactor and factors effecting the performance of a reactor using RTD analysis.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course name	Course Category	L-T-P	Credits
20CH3182	Numerical Methods in Chemical Engineering Lab	PCC	0-0-3	1.5

Course Learning Objectives:

The main objective of this lab is to make the student to understand

1. MATLAB software
2. The use of MATLAB for solving various kinds of mathematical problems numerically.
3. To write script files
4. Usage of functions.
5. Draw 2D and 3D plots.

List of Experiments

1. Root finding method for linear equation
2. Root finding method for non linear equation
3. Solution of linear systems
4. Single integral
5. Multiple integral
6. Initial value ODE using single step method
7. Initial value ODE using multi step method
8. Boundary value ODE
9. Boundary value non linear ODE
10. Partial Differential Equations

Course outcomes: At the end of the course, the student will be able to write MATLAB code to solve

CO 1	Root for linear equation
CO 2	Root for non linear equation
CO 3	Solution of linear equations
CO 4	Single integral
CO 5	Multiple integral
CO 6	Initial value ODE using single step method
CO7	Initial value ODE using multi step method
CO8	Boundary value ODE
CO9	Boundary value non linear ODE

CO10	Partial Differential Equations

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course Code	Course Name	Course Category	L – T – P	Credits
20EG3182	**English Language Communication Skills Lab-II**	HSC	0 - 0 – 3	1.5 credits

Course objectives:

1. To improve group discussion skills of the students
2. To help the students to write their CV and Internship application
3. To improve the telephonic etiquettes of the students
4. To help the students to take decision on their career

COURSE CONTENT

UNIT-I: **(06 Contact Hours)**

Group Discussion - How to think and analyze - How to initiate a topic - How to continue a topic - How to support or reject a point-of-view - How to defend your position - Managing distractions and mediating between contenders - How to summarize & conclude

UNIT-II: **(06 Contact Hours)**

Telephonic conversation & Etiquettes - How to introduce oneself - How to introduce the main issue - How to keep the other person engaged - How to convince the other person - How to complain without irritating. - Giving assurance and asking for clarification - How to end a formal telephonic conversation

UNIT-III: **(06 Contact Hours)**

Career Planning & Job-Skill Analysis - ASK: Talking about one's Attitudes, Knowledge, & Skills - SMART goals - Reading & Analysis of Job Advertisements

UNIT-IV: **(06 Contact Hours)**

CV & Resume Writing - Difference between CV & Resume - Writing CV - Writing Resume - Writing Cover Letter

UNIT-V: **(06 Contact Hours)**

Application for Internship - Application for internship in Academic Labs - Application for internship in Industries - Follow up the Application with reminders and requests

UNIT-VI: **(06 Contact Hours)**

Interview Skills - Preparation for the Interview - Frequently asked questions - Dress Codes, Appearance, and Etiquettes. 6.4 Facing the Interview

References:

1. *Business Communication Today*, 12th Edition, Courtland L Bovee & John Thill, Pearson
2. British Council Material on Career Planning & Interviews
3. *Master the Group Discussion & Personal Interview - Complete Discussion on the topics asked by reputed B-schools & IIMs* by Sheetal Desarda, Notion Press
4. *Group Discussion and Interview Skills* by Priyadarshi Patnaik , Cambridge University Press India

5. *The Ultimate Guide to Internships: 100 Steps to Get a Great Internship and Thrive in It* by Eric Woodard
6. Telephone Etiquette by Robert DeGroot

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

CO 1	Get used to a variety of GDs to understand the principles, finer nuances, and intricacies of the art
CO 2	Get exhaustive information on how to prepare for internship and interview
CO 3	Write his/her CV to remain well-prepared for the interviews
CO 4	Take decision on his/her career goals and plans
CO 5	Attain professional speaking skills to enhance his/her employability skills.

Assessment Method:

Course Nature: LABORATORY

Internal Assessment (40 Marks)	**External Assessment (**60 Marks)
Record Writing – 10 Marks	Reading Comprehension – 15 Marks
Attendance – 10 Marks	Writing – 30 Marks
Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)	Speaking (Viva-Voce) – 15 Marks

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CH3201	Process Equipment	PCC	3-0-1	3.5

	Design			

Course Objectives:

The course content enables the students to:

1. understand the development of flow diagrams and design of pipe
2. understand the pressure vessel design
3. understand the design of heads of pressure vessels
4. understand the design of double pipe and shell and tube heat exchangers
5. understand the design of evaporators and reboilers
6. understand the design of continuous distillation column

Unit I **(6 Contact hours)**

Introduction; development of flow diagrams from process description, Introduction to flow sheeting, P and I diagrams, material and energy balances, sizing of equipment, design preliminaries, design codes, MOC selection procedure;

Unit II

(6 Contact hours)

Pipe design: Pump selection, pressure drop in pipe lines, power requirements for pumping liquids, characteristic curves for centrifugal pumps, NPSH, mechanical design of piping system, wall thickness and pipe schedule, pipe support, pipe fittings, pipe size selection.

Unit III **(8 Contact hours)**

Design of Pressure Vessels and Vessel components: General design considerations of pressure vessels, design of thin-walled vessels for internal pressure and external pressure, design principles of tall columns. Types of flanges, design of loose type non-standard flanges, compensation requirements for openings and branches. Impellers stuffing box and design of shaft. Types and selection of equipment supports.

Unit IV **(8 Contact hours)**

Design of heat transfer equipment: Double pipe heat exchangers, Shell and tube exchanger's construction details, TEMA standards and general design considerations. Kern`s methods of Process design of exchangers for sensible heat transfer.

Unit V **(8 Contact hours)**

Design of shell & tube condensers (excluding multi – component condensers). & Design of 1-2 shell and Tube Exchangers in series.

Evaporators: types of chemical evaporators, boiling point elevation, types of feeding in multiple effect evaporators, design of multiple effect evaporators;
Reboiler: types, design of kettle reboiler.

Unit VI **(9 Contact hours)**

Continuous stage wise distillation column (Binary systems), design variables – Mc Cabe thiele Method – Low product concentration – smoker equations – prediction of plate efficiency - column sizing. Distillation with side streams and multiple feeds. Choice of plate verses packed columns. Selection of column pressure. Plate contactors – selection of plate type – plate constructions - sieve plate hydraulics design. Design of sieve plates - Down Comer design.

Text Books:

1. R. K. Sinnot, Coulson and Richardson's *'Chemical Engineering Design'* Vol. 6, 4th Ed., Butterworth–Heinemann, 2005

Reference Books:

1. M. V. Joshi, V. V.Mahajani, *'Process Equipment Design'* 3rd Ed., Macmillan Publishers, 2009
2. B. C. Bhattacharya,*' Introduction to Chemical Equipment Design'*, CBS Publisher, 2003

Web resources:

1. http://www.msubbu.in/lecture/processequipment.html
2. https://nptel.ac.in/downloads/103103027/

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

CO1	Gain Knowledge of basics of process equipment design and important parameters of equipment design and pipe design
CO2	Construct pressure vessels
CO3	Create heads of pressure vessels
CO4	Design double and shell and tube heat exchangers
CO5	Make up evaporators and Reboiler
CO6	Design continuous distillation column

Course Nature	**Theory**
Assessment Method	

Assessment Tool	Internal assessment Only descriptive type as per concerned faculty instructions*	End Semester Test (Only descriptive type) *Open book/Data Sheets	Total
Weightage (%)	40%	60%	100%

*** Timing of exam, Mode of exam (Open book/Closed book)**

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Course code	Course name	Course Category	L-T-P	Credits
20CH3202	Plant Design and Economics	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. To learn fundamentals of engineering investments and economics
2. To demonstrate the importance of economic considerations in the design of process equipment and chemical plant facilities
3. To identify and understand the concepts of fixed capital investment, cash-flow analysis, and cost estimation
4. To know the importance of time value of money, and important engineering depreciation methods
5. To learn the profitability and financial analysis concepts in decision making among alternatives
6. To apply economic optimization methods to evaluate important chemical plant design options

Course Content:

UNIT –I **(7 contact hours)**

Chemical Engineering Plant Design

Introduction: General overall design considerations, General design considerations: health and safety hazards, environmental protection, plant location, plant layout, plant operation and control

UNIT – II **(8 contact hours)**

Process design development: Development of Design Database, Process Creation, Process Design, Process Flow diagrams, Piping and Instrumentation diagrams, equipment design and specifications, Materials and Fabrication Selection

Cost & Asset Accounting and Cost Estimation: Cash flow for industrial operations, factors affecting investment and production cost, capital investments, estimation of capital investments, cost indices: Engineering News–Record-Chemical Engineering Index–Marshall and Swift Cost Index, cost factors in capital investment

UNIT-III **(8 contact hours)**

Methods for estimating capital investments: estimation of total product cost, Gross Profit, Net Profit

Economic Evaluation of Process: Interest and Time Value of Money: types of interest, nominal and effective interest rates, continuous interest, present worth and discount, annuities, taxes and Insurance

UNIT-IV **(7 contact hours)**

Depreciation: types of depreciation, service life, salvage value, present value, methods for determining depreciation: Straight-Line Method, Declining-Balance (or Fixed Percentage) Method, Sum-of-the-Years-Digits Method, Sinking-Fund Method

UNIT-V **(8 contact hours)**

Profitability, alternative investments and replacements: profitability standards, Methods for Calculating Profitability, discounted cash flow, net present worth, capitalized costs, payout period

UNIT-VI **(7 contact hours)**

Alternative investments, replacements, optimum design and design strategy: selecting an procedure with one variable, procedure with two or more variables, comparison of graphical and analytical methods, optimum production rates in plant operation, cyclic operations, economic pipe diameter

Text books:

1. M. S. Peters, K. D. Timmerhaus and R. E. West, *Plant Design and Economics for Chemical Engineering*, 5th Ed., McGraw Hill, 2003

Reference Books:

1. J. R. Couper, *Process Engineering Economics*, Marcel DekkarInc, 2003
2. Harry Silla, *Chemical Process Engineering, Design and Economics*, Marcel DekkarInc, 2003
3. H.E. Schweyer, *Process Engineering Economics*, McGraw-Hili, New York, 1955

Web resources:

1. http://www.ide.iitkgp.ernet.in/Pedagogy3/fullcourse.jsp?COURSE_ID=188
2. https://nptel.ac.in/courses/103103039/40

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

CO1	Identify the general design considerations and steps in the process design development for a successful project
CO2	Estimate fixed capital investment and total production cost
CO3	Use interests and taxes involved and ways and means of getting the capital requirements
CO4	Identify depreciation methods to find present value of equipment
CO5	Compare different profitability techniques and various alternatives for capital investments for important equipment in the project
CO6	Demonstrate the optimization techniques for process variables such as optimum pipe diameter, optimum production rates

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CH3203	Transport Phenomena	PCC	3-1-0	4

Course Learning Objectives:

1. To analyze and characterize fluid flow phenomena of various types of fluids under different conditions.
2. To analyze shell momentum balance in different systems.
3. To develop and solve the equations of change for isothermal systems.
4. To analyze mechanism of Energy Transport.
5. To develop and solve the equations of change for non-isothermal unsteady systems.
6. To analyze mechanism of Mass Transport

Course Content:

Unit I **(12 Contact hours)**

Viscosity and Mechanism of Momentum Transport: Newton's law of viscosity, pressure and temperature dependence of viscosity, Molecular theory of the viscosity of gases at low density, molecular theory of the viscosity of liquids, Velocity Distributions in Laminar Flow using Shell momentum balances and boundary conditions–flow of a falling film–flow through a circular tube–flow through annulus–flow of two adjacent immiscible fluids

Unit II **(10 Contact hours)**

Shell momentum balances and boundary conditions: Laminar flow in a narrow slit - laminar slit flow with a moving wall ("plane Couette flow") - Interrelation of slit and annulus formula, Flow of a film on the outside of a circular tube - Annular flow with inner cylinder moving axially.

Equation of change for Isothermal Systems**:** Equation of continuity and equation of motion, Navier stokes equations.

Unit III **(8 Contact hours)**

Equation of change for Isothermal Systems**:** Navier stokes equations, applications: steady state in a long circular tube-falling film with variable viscosity – operation of coquette viscometer, Shape of surface of a rotating liquid.Velocity Distributions with more than one independent variable- Time dependent flow of Newtonian fluids- flow near a wall suddenly set in motion.

Unit IV **(8 Contact hours)**

Thermal Conductivity and Mechanism of Energy Transport: Fourier's law of heat conduction thermal conductivity and diffusivity- Shell energy balances and boundary conditions–heat conduction with electrical heat source–heat conduction with nuclear heat source–heat conduction with viscous heat source–heat conduction through composite walls–heat conduction in a cooling fin.

Unit V **(10 Contact hours)**

Equations of change for Non-Isothermal Systems: The equations of energy–Special forms of energy equations- steady state forced convection heat transfer in laminar flow in a circular pipe- tangential flow in an annulus with viscous heat generation-steady flow in a Non-isothermal film – Transpiration cooling-

Temperature Distributions with more than One Independent Variable: unsteady state heat conduction in solids - heat of semi infinite slab- heating of finite slab.

Unit VI **(12 Contact hours)**

Diffusivity and the mechanism of mass transport : Fick's law of binary diffusion, Theory of diffusion in gases at low density, Concentration Distribution in solids and in Laminar Flow, Shell mass balances–boundary conditions–diffusion through a stagnant gas film–diffusion with a heterogeneous chemical reaction–diffusion with a homogeneous chemical reaction–diffusion into a falling liquid film (gas absorption)

Learning Resources:

Text book:

1. Bird R.B., Stewart W.E. and Light Foot E.N. '*Transport Phenomena'* – John Wiley International – 2nd Edition, New York, 2002

Reference Books:

1. Christie J. Geankoplis – '*Transport Processes and Unit Operations'* – 3rd Ed., Prentice Hall of India Pvt. Ltd., New Delhi, 1997

Web Resources:

1. **https://nptel.ac.in/courses/103102024/**

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

CO 1	Analyze and characterize fluid flow phenomena of various types of fluids under different conditions.
CO 2	Develop the shell momentum balance.
CO 3	Solve the equations of change for isothermal systems.
CO 4	Analyze mechanism of Energy Transport.
CO 5	Compute the equations of change for non-isothermal systems..
CO 6	Analyze mechanism of Mass Transport

Assessment Method

Course Nature	**Theory**		
Assessment Method			
Assessment Tool	Internal assessment Only descriptive type as per concerned faculty instructions*	End Semester Test (Only descriptive type) *Open book/Data Sheets	Total
Weightage (%)	40%	60%	100%

*** Timing of exam, Mode of exam (Open book/Closed book)**

Course code	Course name	Course Category	L-T-P	Credits
20CH3281	Chemical Process Dynamics and Control Lab	PCC	0-0-3	1.5

Course Learning Objectives:

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

1. To understand the dynamic behavior of the systems
2. To evaluate response of first and higher order characteristics.
3. Study the installed characteristics of the valve.
4. Study if there is a hysteresis in the control valve and sensor.
5. Evaluate the tuning of a PID control via manual and automatic tuning.
6. Evaluate the effect of controller on the control system.

List of Experiments: (any 10 of the following experiments)

1. Differential Pressure Transmitter
   a) To measure pressure/differential pressure from Differential Pressure Transmitter.
   b) To calibrate given Differential Pressure Transmitter.
2. Thermocouple
   a)To calibrate the different Type of Thermocouples.
   b) To plot the Calibration Curve.
3. Interacting-Non interacting systems
   a)To study the dynamic response of liquid level single tank two tank interacting and non-interacting system.
   b)To calculate valve resistance of single tank liquid level system, two tank interacting system, two tank non-interacting system.
   c)To calculate Time constant of single tank liquid level system, two tank interacting system, two tank non-interacting system
   d)To calculate step response of single tank liquid level system, two tank interacting system, two tank non-interacting system to step change in input flow and compare it with the theoretical response
4. Flapper Nozzle System

a) To determine the output characteristics of Flapper Nozzle Trainer System.

5. I/P and P/I converter
   a)To study the working Principle and calibration procedure of I/P converter.
   b) To study the working Principle and calibration procedure of P/I converter.
6. Control Valves
   a)To study the control valve characteristics.
   b)To determine the flow co-efficient C_v of the linear, equal%, open control valves.

c)To study the inherent characteristics of the linear, equal%, quick open control valves.

d)To study the installed characteristics of the linear, equal%, quick open control valves.

e)To study the Hysteresis of the linear, equal%, quick open control valves.

f)To Calculate range ability of the linear, equal%, quick open control valves.

7. Study of response of Temperature controller with proportional integral derivative controller mode
8. Study of response of Level controller with proportional integral controller mode
9. (i) Study of response of pressure controller with proportional integral derivative controller
   ii) Study the tuning of controller(Open loop method) using Zeigler-Nichols method
10. Study of response of Flow controller with proportional controller mode
11. PCI SKID

    To study the single loop feedback control system.

    A) Level Control Loop

    B) Flow Control Loop

    C) Cascade Control Loop

    D) Ratio Control Loop

    E) Level Control Loop with Feed Forward Input

    F) On/Off Level Control Loop

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

CO 1	Estimate the dynamic behavior of the control systems
CO 2	Compute the controllability, speed of response of the control systems.
CO 3	Select proper control valve to meet process needs.
CO 4	Design direct digital control systems handling and operation.
CO 5	Tuning of a PID control via manual and automatic tuning.
CO 6	Choose PID modes that effect controllability, speed of response of the control systems

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%

Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

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Course code	Course name	Course Category	L-T-P	Credits
20CH3282	Mass transfer operations lab	PCC	0-0-3	1.5

Course Learning Objectives:

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

1. To understand the basic principles of diffusion and convective mass transfer
2. To build a bridge between theoretical and practical concept used in industry
3. To study the vapor liquid equilibrium, liquid - liquid equilibrium etc
4. To study the different separation operations and there use off for fluid-fluid operations
5. To understand the characteristics of solid-liquid separations

List of Experiments

1. Simple steam distillation
   Calculate the vaporizing efficiency of the steam distillation column.
2. Solid-liquid Extraction
   a) To calculate the percentage recovery of oil from oil seed.
   b) To show the effect of solvent temperature and solvent rate on the percentage recovery of oil from oil seeds.
3. Liquid-Liquid Extraction
   a) To determine the overall mass transfer coefficient (K_{wa},K_{ta}) for based on continuous phase and dispersed phase.
   b) To determine the overall height of transfer unit (H_{ow},H_{ot}) based on continuous phase and dispersed phase.
   c) To determine the individual height of transfer unit (H_w,H_t) based on continuous phase and dispersed phase.
4. Simple Batch Distillation
   a) To verify Rayleigh equation for batch distillation.
5. Rotary Dryer

To plot the rate of drying curve.

6. Ion Exchange
   a) To deionize water to make it soft.
   b) To determine the exchange rate and saturation point.
7. Packed Bed Distillation Column
   a) To verify Rayleigh equation.
   b) To obtain the T-x data under total reflux condition at steady state and compare it with theoretical value.
   c) To operate the column under total reflux condition and calculate the minimum number of theoretical stages using fenske's equation
   d) To operate the column under any desired reflux condition and calculate the minimum number of theoretical stages using Mc-Cabe Thiele's method.
   e) To calculate the HETP for known packed height.
   f) To estimate batch distillation Curves for a binary system and verify the binary batch distillation equation for known packed height.
   g) To operate the column under total reflux condition and estimate HETP for the packing.
8. Gas Diffusion
   a) To determine the Diffusion Coefficient of a gas by evaporation from a liquid surface.
9. Cooling Tower
   a) Observation of the processes inside a cooling tower with forced flue.
   b) Determination of evaporation velocity.
   c) Mass balance use of psychometric maps
   d) Effect of the cooling load on the "approach" to wet bulb.
   e) Relation between air velocity, wet bulb approach and head loss.
   f) Determination of the cooling capacity.
10. Adsorption
    a) Illustrate the relationship between a breakthrough curve and a concentration profile.
    b) To demonstrate how the contact time affects adsorption.
11. Continuous Distillation Column
    a) To determine the variation with boil-up rate of pressure drop over the distillation column.
    b) To determine the overall column efficiency.
    c) To carry out a distillation at constant reflux ratio, varying top and bottom compositions with time.
    d) To investigate the steady state distillation of a binary mixture under continuous operation.
    e) To investigate the effect of the feed position under continuous operation.

f) To demonstrate a typical application of a PID controller, to observe the response of the process to a change in set point and to a disturbance, and to adjust the controller setting for optimum process control.

g) To demonstrate a typical application of a Programmable logic controller (PLC) with analog inputs and outputs. To observe the response of the process to a change in set point and to a disturbance. To adjust the settings of the PLC for optimum process control of the process.

h) To use PC control and data logging software with the UOP3CC.

12. Gas Absorption

a) To investigate the Absorption process when gas separating gas mixtures in packed column.

b) Determination of pressure losses in the column.

c) Representation of the Absorption process in an operating diagram.

d) To investigate the variables influencing the effectiveness of absorption

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

CO1	Perform experiments in relation to the Mass Transfer fundamentals.
CO2	Find out diffusivity and mass transfer coefficients.
CO3	Evaluate the effectiveness of different separation techniques
CO4	Compare the equilibrium data developed with the theoretical data.
CO5	Ability to design separation system for the effective solution of intended problem
CO6	Recognize the selection criteria for mass transfer process and equipments required by the industries.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	

Weightage (%)	30%	10%	20%	60%

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Course Code	Course Name	Course Category	L – T - P	Credits
20EG3283	**English Language Communication Skills Lab-III**	HSC	0-0-3	1.5

Course objectives:

1. To improve interpersonal skills of the students
2. To help the students to write professional letters and reports
3. To practice the etiquettes to be used at workplace
4. To reward hands on experience on managing meetings
5. To imbibe leadership qualities in the students

COURSE CONTENT

UNIT-I: **(06 Contact Hours)**

Professional Presentation - Collecting & Reading the materials to be presented - Analyzing the main points - Summarizing & concluding - Developing PPT - Delivery of the Presentation

UNIT-II: **(06 Contact Hours)**

Report Writing & Writing Professional Emails & Applications – Routine Reports – Investigative Reports - Professional Emails - Formal Letters and Applications

UNIT-III: **(06 Contact Hours)**

Agenda, Meetings, & Minutes - Setting the agenda for a meeting - Managing a meeting - Keynote address & vote of thanks - Publishing the minutes

UNIT-IV: **(06 Contact Hours)**

People skills and small talks (2 minutes) - Talking to professional executives - Talking to colleagues - Talking to the boss - Talking to your team - Talking to the media delegates

UNIT-V: **(06 Contact Hours)**

Corporate Etiquettes - How to introduce & greet - How to raise a question - How to clarify a doubt - How to say “yes” or “no” - Rapport building - Dining & winning - Counseling somebody - How to influence & motivate

UNIT-VI: **(06 Contact Hours)**

Life Skills - Leadership communication - Interpersonal communication - Stress management - Time Management

References:

1. *Business Communication Today*, 12th Edition, Courtland L Bovee & John Thill, Pearson
2. British Council Material on communication
3. Training in Interpersonal Skills: Tips f: Tips for Managing People at Work **by** Robbins and Hunsaker
4. Soft Skills for Everyone, with CD **Paperback** –by Jeff Butterfield
5. Communication for business by Shirley Taylor, Pearson

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

CO 1	The art of professional presentation
CO 2	Write professional reports and letters
CO 3	Conduct a formal meeting
CO 4	Develop people skills and corporate etiquettes
CO 5	Gain the basic knowledge about leadership communication, stress management and time management

Assessment Method:

Course Nature: LABORATORY

Internal Assessment (40 Marks)	**External Assessment** (60 Marks)
Record Writing	Reading Comprehension – 15 Marks
Attendance	Writing

Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)	Speaking (Viva-Voce) – 15 Marks

Course code	Course name	Course Category	L-T-P	Credits
20HS4104(CHE)	**Aptitude and Reasoning**	MC	2-0-0	0

Course Learning Objectives:

1. To enable the students for their competitive exams
2. To enhance their capability in aptitude and reasoning.
3. To develop their reasoning skill.
4. To prepare them for all type of competitive exams

Course Contents:

Unit I: (4 hours)

Number system: Base System, Exponents, Factorials, LCM & HCF, Properties of Numbers, Remainders, Successive Divisions

Sequence & Series: Arithmetic Progression, Harmonic Progression, Geometric Progression

Unit II: (6 hours)

Arithmetic: Averages, Clocks & Calendars, Simple Interest & Compound Interest, Mixture & Alligations, Percentages, Profit, Loss & Discounts, Ratio & Proportion, Speed, Time & Distance, Time & Work

Algebra: Binomial Theorem, Complex Numbers, Functions, Higher Degree Equations, Inequalities , Linear Equations, Logarithm, Quadratic Equations

Unit III: (6 hours)

Geometry: Mensuration, Lines & Angles, Circles, Polygons, Triangles, Co-ordinate Geometry, Trigonometry

Probability & Statistics: Mean, Median & Mode, Permutation & Combination, Probability Set Theory & Venn Diagram

Unit IV: **(6 hours)**

Logical Reasoning: Logical Sequence, Premise, Assumption & Conclusion, Binary Logic, Blood Relations, Linear & Matrix Arrangement, Seating Arrangement, Coding & Decoding, Statements & Assumptions Puzzles

Analytical Reasoning: Course of Action Fact, Inference & Judgement, Logical Deduction, Statement & Assumption, Strong & Weak Arguments, Syllogism

Unit V: **(4 hours)**

Data Interpretation: Charts (Column, Pie & Bar), Tables Graphs (Line & Area), Venn Diagram, Data Sufficiency. Reading Comprehension

Unit VI: **(4 hours)**

Verbal Ability: Cloze Test Error Spotting, Fill in the blanks, Sentence Correction, Word Usage, Para jumbles, Paragraph Completion, Paragraph Summary

. **Learning resources**

Text book:

1. Sarvesh K Verma, *'Quantitative Aptitude Quantum CAT'*, arihant publications
2. Arun Sharma, Meenakshi Upadhyay, *' Verbal Ability and Reading Comprehension'* , McGraw Hill publications
3. Arun Sharma, *'Data Interpretation'*, McGraw Hill publications
4. Arun Sharma, *'Logical Reasoning'*, McGraw Hill publications

Reference books:

1. Nishit K Sinha, 'Logical Reasoning and Data Interpretation', Pearson publications
2. Arun Sharma, *'Quantitative Aptitude'*, McGraw Hill publications

Web resources:

1. https://unacademy.com/

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

CO 1	Improve aptitude, problem solving skills and reasoning abilities
CO 2	Improve Verbal ability skills, Data interpretation skills
CO 3	Understand the basic techniques required for solving Reading Comprehension
CO 4	Familiarize with the written tests of competitive exams, campus placements and

	PSUs
CO 5	Collectively solve problems in teams and group
CO 6	Adopt and acquire new techniques in solving problem

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage(%)	0	0	100%	100%

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** **PASS/FAIL COURSE**

Professional Elective Courses Syllabus

Course code	Course name	Course Category	L-T-P	Credits
20CHXX21	Advanced Mathematical Techniques in Chemical Engineering	PEC	3-0-0	3

Course Learning Objectives:

The objective of this course is to

1. Introduce model formulation for various chemical processes and associated equations and to have knowledge on vector spaces
2. Have an adequate knowledge on matrices, operators and transformations to solve the associated equations in chemical engineering systems
3. Understand the methods of solution of partial differential modeling equations in chemical engineering systems
4. Have a knowledge on applications of Fourier series, Laplace and Fourier transforms to solve ODE's and PDE's in chemical Engineering
5. Introduce formulation of process models and necessary numerical techniques for solving the model equations arising in chemical engineering systems
6. Learn sensitivity and data analysis, and experimental design essential for modern engineers.

Course Content:

Unit I: (7 Contact hours)

Models in chemical engineering: Linear equations and non- linear equations. Vector and vector spaces, metrics, norms and inner products, linear dependence and dimension, Gram-Schmidt ortho-normalization.

Unit II: (8 Contact hours)

Matrices, operators and transformations: Eigen values and Eigen vectors, Fredholm alternative solvability conditions, Rayleigh's quotient. Application to chemical engineering systems, Geometric basis of the method, self adjoint and non-self adjoint systems.

Unit III: (7 Contact hours)

Partial differential equations and their applications in chemical engineering, classification of second order partial differential equations, linearity and superposition, Strum - Louiville theory, Eigen value problems, Fourier series, Rayleigh's quotient.

Unit IV: (8 Contact hours)

Separation of variables and Fourier transforms: Rectangular, cylindrical and spherical coordinate systems, Fourier series and Fourier transforms unbounded domains, Laplace transforms. Application of Green's function for solution of ODE and PDEs in chemical engineering.

Unit V: (8 Contact hours)

Introduction to numerical methods: Linear algebraic equations, nonlinear algebraic equations. Function evaluation and regression techniques. Numerical methods of solving ordinary differential equations - initial and boundary value problems. Numerical solutions of partial differential equations.

Unit VI: (7 Contact hours)

Linear stability and limit cycles, bifurcation theory, secondary bifurcations and chaos

Learning Resources:

Text book:

1. S. Pushpavanam, *'Mathematical Methods in Chemical Engineering',* Printice-Hall of India, New Delhi, 2001.

Reference Books:

1. R. G. Rice & D. D. Do, Wiley, '*Applied Mathematics and Modeling for Chemical Engineers'*.

2. A. Varma& M. Morbidelli, '*Mathematical Method in Chemical Engineering'*, Oxford University Press.

Web resources:

1. https://nptel.ac.in/courses/103105106

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

CO1	Formulation of various chemical processes
CO2	Apply the concepts of vector spaces, matrices and their transformations to solve equations associated in Chemical Engineering systems
CO3	Identify different advanced methods to tackle the kinds of problems that appear in Chemical Engineering domain.
CO4	The student will enable to develop a deeper understanding and appreciation of the fundamental concepts behind the mathematics associated with a problem in Chemical Engineering
CO5	Solve the model equations arising in Chemical engineering systems using advanced numerical techniques
CO6	Analyze the behavior of complex systems in chemical engineering research

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX23	Computational Fluid Dynamics	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Understand the widely used techniques to obtain the numerical solution of fluid flow equations.
2. Develop governing equations defining the system and solve them.

3. Use finite difference techniques for fluid flow and heat transfer problems.
4. Interpret the solution for heat transfer and fluid flow problems using finite Volume techniques.
5. Distinguish and apply different commercial packages of CFD to analyze Complex fluid flow problems.
6. Enhance their skills related to computer design and evaluation in fluid flow, critical thinking and lifelong learning.

UNIT –I **(7 Contact hours)**

Illustration of the CFD approach; CFD as an engineering analysis tool, Derivation of flow governing equation

UNIT – II **(8 Contact hours)**

Initial and boundary conditions; well posedness. Discretization of the governing equations using finite difference / volume methods.

UNIT-III **(8 Contact hours)**

Concepts of consistency, stability and convergence. Template for the discretization of a generic unsteady transport equation

UNIT-IV **(8 Contact hours)**

Solution of Navier –Stokes equations, MacCormack scheme for a three-dimensional compressible flow, artificial compressibility method and the stream function-vorticity method for the solution of NS equations

UNIT-V **(7 Contact hours)**

Solution of discretized linear algebraic equations: direct methods; classical iterative methods; convergence analysis. Advanced methods for the solution of discretized equations. Structured and unstructured grids.

UNIT-VI **(7 Contact hours)**

Complexity arising from physics and geometry, energy conservation equation, species conservation equation; dealing with chemical reactions Turbulence; Characteristics of turbulent flow; Dealing with fluctuations and the concept of time-averaging.

Text books:

1. C Hirsch, '*Numerical Computation of Internal and External Flows'*, Vol. 1 and 2, John Wiley, 1990.
2. J H Ferziger and M Peric, '*Computational Methods for Fluid Dynamics'*, Springer, 2002

Reference Books:

1. Anderson Jr J. D., '*Computational Fluid Dynamics: The Basics with Applications*', McGraw Hill. 1995.
2. Muralidhar K. and Sundararajan T., '*Computational Fluid Flow and Heat Transfer*', Narosa Publishing House. 2003.

Web resources:

1. https://nptel.ac.in/courses/112105045/
2. https://nptel.ac.in/courses/103106073/

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

CO1	Evaluate the basic principles of mathematics and numerical concepts of fluid dynamics
CO2	Develop governing equations for a given fluid flow system
CO3	Adapt finite difference techniques for fluid flow models
CO4	Apply finite difference method for heat transfer problems
CO5	Solve computational fluid flow problems using finite volume techniques
CO6	Get familiarized to modern CFD software used for the analysis of complex fluid-flow systems

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20CHXX25	Fluidization Engineering	PEC	3-0-0	3

Course Learning Objectives:

1. Understand the fundamentals of fluidization.
2. Acquainted with the fundamentals of fluidization engineering, different regimes, classification of particles.
3. Realize the movement of bubbles mixing in bed.

4. Understand the concept of pneumatic transport of solids via fluidization.
5. Know the mathematical models of Fluidized Bed.
6. Know the effect of Heat and Mass transfer in Fluidized Beds.

Course Content:

Unit I **(6 Contact hours)**

Concept and Applications of Fluidization:The phenomenon of fluidization, liquid like behavior of a fluidized bed, Comparison with other contacting methods, Advantages and disadvantages of fluidized beds

Unit II **(7 Contact hours)**

Industrial applications of fluidized beds, Coal gasification, gasoline from other petroleum fractions, Gasoline from natural and synthesis gases, Heat exchange, Coating of metal objects with plastics, Drying of solids, FCCU, Fluidized combustion of coal, incineration of solid waste, Activation of carbon

Unit III **(8 Contact hours)**

Fluidization and Mapping of Regimes: Minimum fluidization velocity, Pressure drop vs. velocity diagram, effect of temperature and pressure on fluidization, Geldart classification of particles, terminal velocity of particles, turbulent fluidization

Unit IV **(8 Contact hours)**

Pneumatic transport of solids, fast fluidization, solid circulation systems, Mapping of regimes of fluidization, Bubbles in dense bed, Single rising bubbles, Davidson model for gas flow at bubbles, Evaluation of models for gas flow at bubbles

Unit V **(8 Contact hours)**

Bubbling and Turbulent Fluidized Beds: Estimation of bed porosities, Physical models: simple two phase model, K-L model, Turbulent fluidized bed, Fast fluidization pressure drop in turbulent and fast fluidization, Solids Movement, Mixing, Segregation and staging, Vertical movement of solids, Horizontal movement of solids, Staging of fluidized beds

Unit VI **(8 Contact hours)**

Heat and Mass Transfer in Fluidized Beds: Spouted bed, pressure drop-flow diagram, minimum spouting correlation and effect of various parameters on spouting, Variables affecting heat transfer rate, heat transfer at the wall of containing vessel, heat transfer to immersed tubes, models proposed by i) Wicke-Fetting, ii) Mickley and Fair Banks and iii) Levenspiel and Walton, heat transfer in fixed and fluidized beds, definition and evaluation of mass transfer coefficient

Learning Resources:

Text book:

1. K. Kunii, O.Levenspiel, *'Fluidization Engineering',* 5th Edition, Butterworth-Heinemann Publisher, 1991.

Reference Books:

1. D. Geldart, '*Gas Fluidization Technology'*, John Wiley Sons, 1986.
2. L.S.Fan, '*Gas-Liquid-Solid Fluidization Engineering'*, Butterworths, 1989.
3. M.Kwauk, '*Fluidization Idealized and Bubble-less with Applications'*, Science Press, 1992.

Web resources:

1. http://nptel.ac.in/courses/103103132/

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

CO1	Discuss the fluidization behavior.
CO2	Apply the knowledge of fluidization in various industries.
CO3	Estimate pressure drop, bubble size and voidage.
CO4	Explore the mechanism of bubbles.
CO5	Write model equations for fluidized beds.
CO6	List the heat and mass transfer effects in fluidized beds.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CHXX26	Food Process Engineering	PEC/OEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Understand and identify the specific equipments used in food industry

2. Understand tha various unit operation involved in the fod processing industry
3. Understand and identify the specific processing technologies used for vegetables and fruits and the various products derived from these materials.
4. Understand the application of scientific principles in the processing technologies specific to the materials.
5. Having the knowledge of the transportation equipments in food industry
6. Grasp the changes in the composition of foods with respect to the type of processing technology used

UNIT - I **(7 Contact hours)**

Basic Components: Construction and working of pipes, valves, pumps. Material of construction compatible with foods, basic principles in lay out.

UNIT- II **(8 Contact hours)**

Unit Operations In Food Industry: Basic principles of Grinding; prediction of Crushing efficiency; Laws of crushing, pulverization and ultrafine grinding

Unit –III **(7 Contact hours)**

Classification of crushing equipment; Construction and working principle of mostly used equipments, viz., Jaw crushers, gyratory crushers etc.

UNIT -IV **(7 Contact hours)**

Conveyors and Sieves: Classification of conveyors, selection of conveyors; conveying methods like belts, screw etc, Sieving and types of equipments

UNIT -V **(8 Contact hours)**

Drying: Basic principles, different methods of drying including, tunnel, sun, tray, spray drying and low temperature; design of dryer with mass and energy balance, drying time prediction.

UNIT -VI **(8 Contact hours)**

Freezing and Extrusion: Principles of freezing and Chilling, freezing equipment and methods, freezing time and rate calculation; Principle, types and design of extruders.

Learning Resources:

TEXTS BOOKS:

1. Berk, Zeki "*Food Process Engineering and Technology*" Academic Press, 2009.
2. Smith, P.G. "*Introduction to Food Process Engineering*". Springer, 2004.
3. Toledo, Romeo T. "*Fundamentals of Food Process Engineering*". 3rd Edition, Springer, 2007.

REFERENCES:

1. Rao, M.A. et al., "*Engineering Properties of Foods*". 3rd Edition. CRC/Taylor&Fransis, 2005.
2. Gopala Rao, Chandra "*Essentials of Food Process Engineering*". BS Publications, 2006

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

CO1	Identify the working principle of equipments used in food processing industry
CO2	List the various unit operation involved in the food processing industry
CO3	Identify the specific processing technologies used for vegetables and fruits and the various products derived from these materials.
CO4	Discuss the application of scientific principles in the processing technologies specific to the materials.
CO5	Design transportation equipment in food industry
CO6	Grasp the changes in the composition of foods with respect to the type of processing technology used

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20CHXX28	Fuel Technology	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Identify the various solid fuels available, its processing and storage.
2. Learn the Carbonization of coal and by product recovery methods.

3. Familiarize with the liquid fuels and its purifications and recognize various gaseous fuels and its properties.
4. Understand the manufacturing of different gaseous fuels.
5. Have insight on the nuclear fuel and its application.
6. Identify the concepts of combustion technology.

Course Content:

Unit I **(8 Contact hours)**

Solid Fuels : Coal-Origin, Chemical composition, calorific value, Classifications, Characteristics & distribution of Indian coals, Storage and spontaneous combustion of coal, Coal washing and blending, Pertrographic constituents of coal, Carbonization of coal, manufacture and properties of metallurgical coke, recovery of by-products

Unit II **(6 Contact hours)**

Liquid Fuels: Origin and composition of crude oil, crude oil distillation and its products with special reference to gasoline, Kerosene and diesel oil, cracking and reforming, Coal tar distillation Products, Shale oil, Properties of liquid fuels

Unit III **(6 Contact hours)**

Gaseous Fuels: Natural gas, Coal gas, Coke oven and blast furnace gas, Manufacture of Water gas and producer gas, Carburetted water gas, Hydrogen as fuel

Unit IV **(7 Contact hours)**

Synthetic Fuels: Hydrogenation of coal, Fischer–Tropsch synthesis, Introduction to Nuclear fuels and nuclear reactors, moderators and structural materials

Unit V **(8 Contact hours)**

Combustion solid fuels: Combustion of solids fuels, Pulverized coal. Calculation of volumes and weights of air necessary for combustion of fuels, gas analysis

Unit VI **(10 contact hours)**

Combustion Technology: Fundamentals of thermochemistry, Combustion air calculation, Calculation of calorific value of fuels, Adiabatic flame temperature calculation, Mechanism and kinetics of combustion, Flame properties

Learning Resources:

Text Books:

1. S.Sarkar, *' Combustion'*, 3rd Ed., Universities Press, 2009
2. S.P. Sharma, and M. Chander, '*Fuels and Combustion'*, Tata McGraw Hill, 1984
3. Richard A. Dave, '*Modern Petroleum Technology'*, Vol 1, Upstream, 6th ed., John Wiley & Sons. Ltd.

Reference Book :

1. J.S.S. Brame and J. G. King, '*Fuel: Solid, Liquid and Gaseous'*, 5thEd., Edward Arnold Publisher, 1955
2. O. P. Gupta, '*Elements of Fuels, Furnaces and Refractories'*, 3rdEd.,Khanna Publishers, 1996
3. B.K. BhaskarRao, '*Modern Petroleum Refining Processes'*, 4th ed., Oxford & IBH Publishing Co. Pvt. Ltd.

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

CO 1	Explain the various solid fuels available, its processing and storage.
CO 2	Discuss the Carbonization of coal and by product recovery methods.
CO 3	Identify the liquid fuels and its purifications
CO 4	Explain the various gaseous fuels, manufacturing and its properties.
CO 5	Confer about the Nuclear fuel and its application.
CO 6	Apply the concepts of combustion technology

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CHXX30	Industrial Safety and Hazard Management	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Work and develop safety and hazard management system.

2. Learn how to design inherently safer chemical plant.
3. Get knowledge of different hazardous chemicals and what are the hazards and how to work with them, inspection for safety, designing of flares, hazard analysis and risk assessment.
4. Know how to assist engineers and process safety personnel who are involved with chemical processes and operations where flammable gases, vapors, or mists are present.
5. Learn the techniques available for both preventing dust explosions and protecting people and facilities from their effects.
6. Learn the concepts of event trees, fault trees, QRA and LOPA

Course Content:

Unit I **(6 Contact hours)**

Introduction to Safety and Toxicology: Safety programs, Engineering ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, The nature of the Accident Process, Inherent Safety

Unit II **(6 Contact hours)**

Toxicology: how toxicants enter biological organisms, how toxicants are eliminated from biological organisms, effects of toxicants on biological organisms, lethal dosage–Material Safety Data Sheets Industrial Hygiene, Fires and Explosions: Government of India and OSHA regulations, Industrial Hygiene, Identification, Evaluation, Control

Unit III **(8 Contact hours)**

The fire triangle, Distinction between fire and explosions, Definitions, Flammability characteristics of liquids and vapors, MOC and inerting, ignition energy, Auto ignition, Auto oxidation, Adiabatic compression, Explosions

Unit IV **(10 Contact hours)**

Firefighting equipment–Personal protecting equipment–Building fire safety codes

Designs to Prevent Fires and Explosions: Inerting, static electricity, controlling static electricity, explosion proof equipment and instruments, ventilation, sprinkler systems, miscellaneous designs for preventing fires and explosions

Unit V **(8 Contact hours)**

Work permit–Earthling–Color codes for identification of process Hazards Identification and Risk Assessment: Process hazards checklists, hazards surveys, hazards and operability studies, safety reviews, other methods.

Unit VI **(7 Contact hours)**

Review of probability theory, event trees, fault trees, QRA and LOPA
Health and safety foundation–5S Practice–Emergency procedures

Learning resources:

Text Books:

1. D. A. Crowl, J. F. Louvar, '*Chemical Process Safety: Fundamentals with Applications'*, 3rd Ed., Prentice Hall, 2011

Reference Book :

1. H.H.Fawcett and W.S.Wood, '*Safety and Accident Prevention in Chemical Operations'*, John Wiley and sons, 2nd Ed., New York, 1982
2. R. K. Sinnot, '*Coulson and Richardson's Chemical EengineeringseriesVol.6'*, Butterworth–Heinmann Ltd. 1996

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

CO 1	Work and develop safety and hazard management system
CO 2	Learn how to design inherently safer chemical plant.
CO 3	List different hazardous chemicals and what are the hazards and how to work with them, inspection for safety, designing of flares, hazard analysis and risk assessment.
CO 4	Evaluate how to assist engineers and process safety personnel who are involved with chemical processes and operations where flammable gases, vapors, or mists are present
CO 5	Learn the techniques available for both preventing dust explosions and protecting people and facilities from their effects.
CO 6	Compare the concepts of event trees, fault trees, QRA and LOPA

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX31	Material Science for Chemical Engineers	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Know the fundamental science and engineering principles relevant to materials.
2. Understand the relationship between atomic, molecular, crystalline, and microscopic structures,
3. Characterization, properties of materials and
4. Processing and design of materials.
5. Possess knowledge of the significance of research,
6. The value of continued learning and environmental/social issues surrounding materials.

UNIT I **(7 Contact hours)**

Introduction

Historical perspective importance of materials, brief review of modern & atomic concepts in physics and chemistry. Atomic models, periodic table, chemical bonding.

Crystallography and imperfections

Concept of Unit cell, space lattice, bravais lattices, common crystal structures, atomic packing factor and density. Miller indices, X-ray crystallography techniques, imperfections, defects &dislocations in solids.

UNIT II **(8 Contact hours)**

Mechanical properties and testing

Stress strain diagram, ductile and brittle materials, stress Vs. strength, toughness, hardness, fracture, fatigue and creep. Testing, such as strength testing, hardness testing, impact testing, fatigue testing creep testing, non-destructive testing (NDT).

Micro Structural Exam

Microscope principle and methods, preparation of samples and microstructure exam and grain size determination, comparative study of microstructure of various metals and alloys, such as mild steel, CI, brass.

Phase Diagram and Equilibrium Diagram

Unary and binary diagrams, Phase rules, types of equilibrium diagrams: solid solution type, eutectic type and combination type, iron-carbon equilibrium diagram.

UNIT III **(8 Contact hours)**

Ferrous materials

Iron and steel manufacture, furnaces, various types of carbon steels, alloy steels and cast irons, its properties and uses.

Heat Treatment

Various types of heat treatment, such as annealing, normalizing, quenching, tempering and case hardening. Time temperature transformation (TTT) diagrams.

Non-Ferrous metals and alloys

Non-ferrous metals, such as Cu, Al, Zn, Cr, Ni etc. and its applications. Various types of brass, bronze bearing materials their properties and uses. Aluminum alloys, such as duralumin, other advanced materials/alloys.

UNIT IV **(8 Contact hours)**

Magnetic properties

Concept of magnetism- dia, para, ferro magnetic materials, hysteresis, soft and hard magnetic materials, magnetic storages.

Electric Properties

Energy band, concept of conductor, insulator and semiconductor. Intrinsic and extrinsic semi-conductors, p-n junction and transistors, basic devices and their applications. Diffusion of Solid,

Super conductivity and its applications, Messier effect. Type I & II superconductors. High Temperature superconductors.

UNIT V **(7 Contact hours)**

Ceramics

Structure, types, properties and applications of ceramics. Mechanical/electrical behavior and processing of ceramics.

Plastics

Various types of polymers/plastics and their applications. Mechanical behavior and processing of plastics, future of plastics.

UNIT VI **(7 Contact hours)**

Other Materials

Brief description of other materials, such as optical and thermal materials, concrete, composite materials and their uses.

Performance of materials in service

Brief theoretical consideration of fracture, fatigue, and corrosion and its control.

Learning resources:

Textbook (s):

1. V. Raghavan, *Material Science and Engineering*, 4th Ed., Prentice Hall of India Pvt. Ltd., 1998

Reference books:

1. W.D. Callisster, Jr. "Material Science and Engineering An Introduction", 8th ed.,- John Wiley & Sons, Inc.

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

CO1	Analyzing the structure-property of material science
CO2	Identify structural defects and their effects on material properties
CO3	Create the existence of new materials and their properties.
CO4	Choose appropriate material for process equipment.
CO5	Explore the failure analysis and select appropriate materials or relevant corrosion protection schemes for corrosion resistance
CO6	Evaluate the basic aspects of advanced materials and their applications.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20CHXX32	Multiphase flow	PEC	3-0-0	3

Course Learning Objectives:

1. The main objective of this course is to understand fundamental concepts, principles and application of multiphase flow with real life examples.
2. To understand the multi flow and its importance in process industries.
3. To understand the gas-liquid two phase flow and different flow regimes.
4. To understand the theory of Drift flux model in separated flow type.
5. To understand the hydrodynamics and transportation of gas-solid and gas-liquid flows.
6. To understand the measurement techniques for void fraction, pressure drop and flow rate.

Course Content:

Unit –I **(6 Contact hours)**

Introduction to multiphase flow, Types and applications, Common terminologies, Flow patterns and Flow pattern maps and one dimensional steady homogenous flow.

Unit – II **(7 Contact hours)**

Concept of choking and critical flow phenomena, one dimensional steady separated flow model, Phases are considered together but their velocities differ, Phases are considered separately, flow with phase change.

Unit – III **(8 Contact hours)**

Flow in which, inertia effect dominate. Energy equations and the separated flow model for stratified and annular flow.

Unit - IV **(8 Contact hours)**

Drift flux model theory and it's applications for bubbly and slug flow type.

Unit - V **(8 Contact hours)**

Study on Hydrodynamics of solid-liquid and gas-solid flow; Principles of hydraulic and pneumatic transportation.

Unit – VI **(8 Contact hours)**

Introduction to three phase flow; Measurement techniques for multiphase flow; Flow regime identification, pressure drop, void fraction and flow rate measurement.

Learning Resources:

Text book:

1. G.B. Wallis, *'One dimensional Two Phase Flow'*, McGraw Hill Higher Education, 1969.

Reference Books:

1. G.F. Hewitt, *'Measurement of Two Phase Flow Parameters',* Academic Press Inc, 1978.
2. Govier and Aziz, *'Flow of Complex Mixtures in Pipes',* Van Nostrand Reinhold, 1972.
3. Butterworth and Hewitt, *'Two Phase Flow and Heat transfer',* Oxford University Press,1977,
4. Hetsroni, '*Handbook of Multiphase systems',* McGraw-Hill Inc., 1981.

Web resources:

1. https://nptel.ac.in/courses/103105058/37
2. https://nptel.ac.in/courses/103105059/

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

CO1	Design various analytical models to understand the hydrodynamics of different flow regimes.
CO2	Discuss the phenomenon of choking and relevant formulations.
CO3	Apply the concept of separated flow model for different flow regimes.
CO4	Compare the concept of Drift flux model to different flow regimes.
CO5	Important aspects of hydrodynamics of solid-liquid and gas-solid flows.
CO6	Characterize various measurement techniques used for measuring pressure drop, void fraction and identification of flow patterns.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX33	Novel Separation Processes	PEC	3-0-0	3

Course Learning Objectives:

1. To understand the governing mechanisms and driving forces of various advanced separation processes.
2. To perform process and design calculations for advanced separation processes.
3. To understand the different separation techniques for process intensification.
4. To understand the processes of dialysis, electro dialysis and Pervaporation.
5. To understand the use of membrane technology in distillation and contactors.
6. To study the surfactant based separation processes.

Course Content:

Unit –I **(6 Contact hours)**

Fundamentals of Separation Processes: Basic definitions of relevant terms; Membrane based separation processes; Fundamentals and various terms; Classification.

Unit – II **(7 Contact hours)**

Membrane Separation Process: Different types of membranes, module design, concentration polarization and other effects, characterization of membranes, process design.

Unit – III **(8 Contact hours)**

Classification of different membrane separation processes: Pressure driven membrane processes- microfiltration, ultrafiltration, and Nano-filtration and reverse osmosis.

Unit - IV **(8 Contact hours)**

Other Membrane separation processes: Dialysis, Electro dialysis and Pervaporation.

Unit - V **(8 Contact hours)**

Liquid membranes: Emulsion Liquid membrane, supported liquid membrane, new membrane separation processes like membrane distillation, membrane contactor and hybrid processes.

Unit – VI **(8 Contact hours)**

Gas separation: Surfactant based separation processes.

Learning Resources:

Text book:

1.Seader, J.D. and Ernest J. Henley, *'Separation Process Principles'*, New York, Wiley, 1998.

Reference Books:

1. King, C.J, *'Separation Processes',* McGraw-Hill, New York, 2nd edition, 1980.
2. Manson Benedict, *'Nuclear Chemical Engineering',* McGraw-Hill, 2nd edition, 1981.
3. Treybal, R.E, *'Mass Transfer Operations',* McGraw-Hill, New York, 3rd edition, 1980.

Web resources:

1. https://nptel.ac.in/courses/103105060/
2. https://nptel.ac.in/courses/103105061/

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

CO 1	Explore modern separation techniques in various applications.
CO 2	Analyze and design novel membranes for intended applications.
CO 3	Classification of membranes processes.
CO 4	Design pervaporation, chromatography and dialysis based separation processes.

CO 5	Predict the importance of membrane technology in distillation, contactors and hybrid processes.
CO 6	Explore and apply the theoretical concepts in gas separation processes.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX34	Optimization Methods For Chemical Engineering	PEC	3-0-0	3

Course Learning Objectives:

1. Emphasize use economics to derive an objective function aspects
2. Learn how to apply the search methods to the problem
3. Learn how to use principles of engineering to develop single variable optimization with and without constraints
4. Learn how to use principles of engineering to develop multi variable optimization with and without constraints
5. Learn how to apply the concepts of linear programming (graphically).
6. Learn how to apply the concepts of linear programming.

Course Content:

Unit I: **(7 Contact hours)**

The nature and organization of optimization problems: Scope and Hierarchy, General procedure for solving optimization problems, Formulation of the objective function, Basic concepts of optimization - Continuity, Convexity and applications, Necessary and sufficient conditions for an extremum.

Unit II: **(6 Contact hours)**

Optimization of unconstrained functions: Functions of single variable, scanning and bracketing procedures, Newton and Quasi-Newton methods, Evaluation of one-dimensional search methods.

Unit III: **(8 Contact hours)**

Unconstrained multivariable optimization: Methods using function values only, Methods using first derivatives, Newton's method and Quasi-Newton's method

Unit IV: **(8 Contact hours)**

Linear programming: Basic concepts in linear programming; Graphical solution

Unit V: **8 Contact hours)**

Linear programming: Simplex method, duality

Unit VI: **(8 Contact hours)**

Applications of optimization: Heat transfer and energy conservation, separation processes, chemical reactor design and operation

Learning Resources:

Text book:

1. Thomas F. Edgar, David M. Himmelblau, Leon Lasdon. '*Optimization of Chemical Processes'*, 2nd edition, McGraw-Hill Higher Education, 2001.

Reference Books:

1. K. Deb, '*Optimization for Engineering Design: algorithms and examples*', PHI, 2009

Web resources:

1. https://nptel.ac.in/courses/103105139/

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

CO 1	Use economics to derive an objective function
CO 2	Apply the search methods to the problem
CO 3	Evaluate principles of engineering to develop single variable optimization with and without constraints.
CO 4	Discuss principles of engineering to develop multi variable optimization with and without constraints
CO 5	Apply the concepts of linear programming(Graphically)
CO 6	Analyzing the concepts of linear programming

Course Nature	**Theory**

Assessment Method			
Assessment Tool	Internal assessment Only descriptive type as per concerned faculty instructions*	End Semester Test (Only descriptive type) *Open book/Data Sheets	Total
Weightage (%)	40%	60%	100%

*** Timing of exam, Mode of exam(Open book/Closed book)**

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX35	Petrochemical Technology	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Know the overview of modern petrochemical Industries
2. Know the Availability and pretreatment methods of Petrochemical industry-Feedstock
3. Overview on the manufacture of various important chemicals produced from lighter hydrocarbon compounds.
4. Overview on the manufacture of various important chemicals produced from higher hydrocarbon compounds.
5. Overview of manufacture of various chemicals from aromatics
6. Understanding the working principle of various equipments used for the production of chemicals

Course Content:

UNIT I **(8 contact hours)**

Survey of petrochemical industry; Availability of different feed stocks; Production, purification and separation of feed stocks;

UNIT II **(7 contact hours)**

Chemicals from methane; Production and utilization of synthesis gas, oxo reactions.

UNIT III **(7 contact hours)**

Production of chemicals from acetylene; Naphtha cracking;

UNIT IV **(8 contact hours)**

Chemicals from C2, C3, C4 and higher carbon compounds; Polymers - properties, production and utilization.

UNIT V **(8 contact hours)**

Catalytic reforming of naphtha and isolation of aromatics; Chemicals from aromatics; Synthetic fibers, detergents, rubbers and plastics.

UNIT IV **(7 contact hours)**

Petroleum coke; Elements of design of steam reformer, naphtha cracker, and catalytic reformer.

Learning Resources:

Text Book:

1. B.K. BhaskarRao, *A Text on Petrochemicals*, 2nd Edition,Khanna publishers, 1996.
2. J. H. Gary and G. E. Handwerk, *Petroleum Refining, Technology and Economics,* 5th edition, CRC Press, 2007

References:

1. H. A. Wittcoff and B. G. Reuben, *Industrial Organic Chemicals*, Wiley-Interscience,1996
2. G. M. Wells, *Handbook of Petrochemicals and processes*, Aldershot [u.a.] :Ashgate, 1999.
3. G. A.Olah and A. Molnar, *Hydrocarbon Chemistry*, 2nd Edition, Wiley,2003

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

CO1	Assess and development of petrochemical industries and different petrochemical feedstocks
CO2	Determine production of chemicals from methane using different processes
CO3	Estimate the production of chemicals from acetylene using different processes
CO4	Production of chemicals from lighter and higher hydrocarbon compounds.
CO5	Interpret the chemicals from aromatics using various processes
CO6	Discuss the working principles of various equipments such as steam reformer and catalytic reformer

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total

Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX36	Petroleum Refinery Engineering	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. This course will present an overview of modern petroleum refinery
2. To demonstrate the formation of crude oil and it's pretreatment
3. To deduce adequate knowledge of fractionation techniques for petroleum crude to products.
4. Acquire knowledge of the overall refinery operations, refinery products and its test methods.
5. This course provides major insights into secondary cracking process available to produce normal and value added products
6. To understand Hydro-treatment processes in refining.

Course Content:

Unit I **(7 Contact hours)**

Origin of petroleum crude oil. Evaluation of crude oil – evaluation and characterization of crude oil, TBP and other distillation tests.

Unit II **(6 Contact hours)**

Petroleum products, their properties, specification and testing – different properties like flash point, fire point, smoke point, aniline point, carbon residue, kinematic viscosity, pour point, freezing point etc.

Unit III **(8 Contact hours)**

Petroleum refinery distillation – pre-fractionation and atmospheric distillation of crude. Process design for atmospheric distillation. Stabilization of naphtha.

Unit IV **(8 Contact hours)**

Vacuum distillation of RCO. Reforming of naphtha. Other secondary processes like Thermal cracking, Vis-breaking.

Unit V **(8 Contact hours)**

Delayed coking process, FCC Unit. Hydro-cracking, Alkylation, Isomerization Process

Unit VI **(8 Contact hours)**

Hydro-treatment processes in refining: hydro-desulfurization, hydro-finishing Production of lube oil base stock: Furfural/Phenol/NMP extraction, Solvent, dewaxing, propane deasphalting

Text Books:

1. B.K. BaskaraRao, *'Modern Petroleum Refining Processes'*, 4th Edition, Oxford & IBH Publishing.

Reference Books :

3. Ram Prasad, *'Petroleum Refining Technology'*, Khanna Publishers, 2002
4. Nelson W.L., *'Petroleum Refining Engineering'*, McGraw Hill, 4th edition
5. R. N. Watkins, *'Petroleum Refinery Distillation'*, Gulf Publishing company,1979
6. J. H. Gray & G. E. Handwerk, *'Petroleum Refining, Technology & Economics'*, CRC Press, 5th edition

Web resources:

1. https://nptel.ac.in/courses/103102022/

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

CO1	Build a basic knowledge of petroleum refinery processes carried out in chemical industries.
CO2	Know fundamentals of petroleum refining, types of energy resources, fundamentals of crude oil treatment
CO3	Evaluate the properties of various petroleum products and their uses.
CO4	Acquire a knowledge of different refining processes involved in converting crude oil to various products.
CO5	The fundamentals and purposes of re-refining processes and properties of main oil products.
CO6	The importance of petroleum additives in modifying the final refinery products.

Course Nature		**Theory**		
Assessment Method				
Assessment	Weekly	Monthly	End Semester	Total

Tool	tests/Assignments (In semester)	tests (In semester)	Test	
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX38	Polymer Engineering	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Having the broad and fundamental knowledge of the polymers
2. Understand the chemical, physical and mechanical behavior of polymers
3. Emphasis is on the processing techniques, along with the production of polymers
4. Correlate structure-processing properties relationships for polymers
5. Correlate structure-processing properties relationships for blends.
6. Correlate structure-processing properties relationships and composites including nanocomposites.

Unit I

Introduction **(8 Contact hours)**

Defining polymers, classification of polymers and some fundamental concepts, chemical classification of polymers based on polymerization mechanisms, molecular-weight distributions, configurations and crystallinity of polymeric Materials, conformation of polymer molecules, polymeric supports in organic synthesis.

Unit II **(7 Contact hours)**

Effect of chemical structure on polymer properties Introduction, effect of temperature on polymers, additives for plastics, rubbers, cellulose plastics, copolymers and blends, cross-linking reactions, ion-exchange resins.

Unit III **(8 Contact hours)**

Step-growth polymerization

Introduction, esterification of homologous series and the equal reactivity hypothesis, Kinetics of A-R-B Polymerization using equal reactive hypothesis, average molecular

weight in step-growth polymerization of ARB monomers, equilibrium step growth polymerization, and molecular weight distribution in step-growth polymerization.
Reaction engineering of step-growth polymerization: Introduction, analysis of semi-batch reactors, MWD of ARB polymerization in homogeneous continuous flow stirred tank reactors.

Unit IV **(8 Contact hours)**

Chain-growth polymerization

Introduction, radical polymerization, kinetic model of radical polymerization, average molecular weight in radical polymerization, equilibrium of radical polymerization, temperature effects in radical polymerization, ionic polymerization, Anionic polymerization, Ziegler-Natta catalysts in stereo regular polymerization.

Reaction engineering of chain-growth polymerization: Introduction, design of tubular reactors, copolymerization, recycling and degradation of polymers.

Unit V **(7 Contact hours)**

Measurement of molecular weight and its distribution

Introduction, end-group analysis, colligative properties, light scattering, ultracentrifugation, intrinsic viscosity, gel permeation chromatography.

Theory of rubber elasticity

Introduction, elastic force between chain ends, stress-strain behavior, the stress tensor (matrix), measures of finite strain, the stress constitutive equation, vulcanization of rubber and swelling equilibrium.

Unit VI **(7 Contact hours)**

Mechanical properties

Introduction, stress-strain behavior, the glass transition temperature, dynamic mechanical experiments, time-temperature superposition, polymer fracture, crazing and shear yielding, fatigue failure, improving mechanical properties.

Polymer processing

Introduction, extrusion, injection molding and fiber spinning.

Learning Resources:

Textbook (s):

1. Anil Kumar, Rakesh K. Gupta.,"*Fundamentals of Polymer Engineering*", 2nd ed., Marcel Dekker, Inc., 2003.

Reference (s):

1. ZehevTadmor, Costas G. Gogos "*Principles of Polymer Processing* ", 2nd ed., John Wiley & sons, 2006.
2. Santosh K. Gupta, Ajit Kumar, "*Reaction Engineering of Step Growth Polymerization*", Plenum Press, New York, 1987.

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

CO 1	Design the techniques and their characteristics/limitations of synthesis of polymers.
CO 2	Build the structure-processing-property relationship of polymers.
CO 3	Apply the various processing and manufacturing techniques
CO 4	List the basic issues involved in polymer blends
CO 5	Examine the basic issues involved in polymer composites
CO 6	Explore the basic issues involved in nanocomposites.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CH XX39	Process Instrumentation and Instrumental Methods of Analysis	PEC	3-0-0	3

Course Learning Objectives:

1. To provide the basic principles of primary sensing elements, transducers, transmitters, indicators and recorders in process industries.
2. To provide knowledge on types instruments used for measurement of temperature.
3. To provide knowledge on choice of measuring instruments and statistical background of the methods and limitations of measurement techniques for pressure and vacuum.
4. To provide knowledge on choice of measuring instruments and statistical background of the methods and limitations of measurement techniques for head and level.

5. To provide an understanding on instrumental methods for composition analysis.
6. To provide knowledge on principles and types of chromatography used for chemical composition.

Course Content:

Unit –I **(6 Contact hours)**

Qualities of measurement: Elements of instruments, static characteristics, dynamic characteristics, dynamic response of first order instruments.

Recording instruments, indicating and signaling instruments, the control center, instrumentation diagram, process analysis.

Unit – II

Measurement of Temperature: **(7 Contact hours)**

Expansion thermometers: Mercury in glass thermometer, bimetallic, pressure spring, accuracy and response of thermometers. Thermo-electric temperature measurement: thermo electricity, industrial thermocouples, thermocouple lead wires, thermal wells, response of thermocouples, mill voltmeter, null potentiometer.

Resistance thermometers: Thermal coefficient of resistance, industrial resistance, thermometer bulbs, resistance thermometers circuits, wheat stone bridge, calendar Griffiths Bridge, Radiation temperature measurement: laws of radiation, radiation receiving elements, radiation pyrometers, photoelectric pyrometer and optical pyrometers

Unit – III **(8 Contact hours)**

Measurement of Pressure and Vacuum: Liquid column manometers, measuring elements for gauge pressure and vacuum, indicating elements for pressure gauges, measuring of absolute pressure, measuring pressure in corrosive liquids.

Unit - IV **(8 Contact hours)**

Measurement of Head and Level: Head, density and specific gravity, direct measurements of liquid level, pressure measurement in open vessels, level measurements in pressure vessels, measurement of interface level, density measurement.

Flow metering: Head flow meters, area meters, open channel meters, velocity meters, flow of dry materials and viscosity measurement

Unit - V **(8 Contact hours)**

Measurement of Composition:

Instrumental Methods: Beer-Lambert's Law Flame photometry – Principle and instrumentation (Block diagram only) disadvantages. Estimation of Sodium by Flame Photometry. Principle of Flurometry – applications, disadvantages. Introduction of Infra

–Red Spectroscopy- Models of vibrations of atoms in polyatomic molecular – vibration coupling – Instrumentation- Disadvantages- Applications.
Introduction of Atomic absorption Spectrophotometry: Principles- Instrumentation- Block diagram- Disadvantages-Applications –Estimation of Nickel by Atomic Absorption Spectroscopy.

Unit – VI **(8 Contact hours)**

Chromatographic Methods: Ion Exchange Chromatography- Recycling chromatography-Ion Pair Chromatography- Classification of Ion pair liquid Chromatography- Application of Ion Pair liquid chromatography – Retention – Solubility- Thin Layer Chromatography- Paper Chromatography.

Chromatographic Development: High Pressure Liquid Chromatography (HPLC)- Solvent Delivery System- Pumps- Reciprocating pumps- Syringe type pumps-Constant Pressure Pumps- Sample Injection System- Column Packing –Characterization of Detectors- Performance – Advantage of HPLC-Effects of temperature in HPLC-Application of HPLC. Thermo Gravimetric Analysis and Differential Thermal Analysis-Principle- Instrumentation - Applications

Learning Resources:

Text book:

1. Donald P. Eckman, *'Industrial Instrumentation'*, Wiley Eastern Ltd. 1st edition, 2004.

Reference Books:

1. Patrenabis, *'Principles of Industrial Instruments',* Tata McGraw-Hill, 3rd edition, 2010.
2. R.Gurudeep, ChatwalandSham K. Anand, *'Instrumental Methods of Chemical Analysis',* Himalaya Publishing house, 2007.
3. Robert D. Braun, *'Introduction to Chemical Analysis',* McGraw-Hill, 2nd edition, 2012.

Web resources:

1. https://nptel.ac.in/courses/103105064/35

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

CO 1	Acquire the basic measurement principles of the physical quantities of interest and elements of control system.
CO 2	Design expansion and resistance thermometers.
CO 3	Learn various sensors used for measurement of process parameters such as pressure and vacuum.
CO 4	Select various sensors used for measurement of process parameters such as head and level.

CO 5	Familiar with principles and various spectrometric instrumental methods used for measurement of chemical composition.
CO 6	Inspect the principles and various chromatographic methods used for measurement of chemical composition

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CHXX40	Process Integration	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. This course will present an overview principles of pinch technology and techniques
2. To demonstrate the of process integration for better process design
3. To deduce adequate knowledge of economically attractive design with optimal energy requirement
4. To deduce knowledge through a judicious blend of theory and industrial case studies.
5. To understand the network grid representation
6. This course provides finding pinch point, the data extraction and energy targeting.

Course Content:

Unit I **(7 Contact hours)**

Introduction: Introduction to process Intensification and Process Integration (PI). Areas of application and techniques available for PI, onion diagram

Pinch Technology-an overview: Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology

Unit II **(7 Contact hours)**

Key steps of Pinch Technology: Concept of ΔTmin, Data Extraction, Targeting, Designing, Optimization-Super targeting. Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.

Unit III **(10 Contact hours)**

Targeting of Heat Exchanger Network: Energy Targeting, Area Targeting, Number of Units targeting, Shell Targeting and Cost targeting. Designing of HEN:Pinch Design Methods, Heuristic rules, stream splitting, design of maximum energy recovery (MER).Use of multiple utilities and concept of utility pinches, Design for multiple utilities pinches, Concept of threshold problems and design strategy. Network evolution and evaluation identification of loops and paths, loop breaking and path relaxation

Unit IV **(7 Contact hours)**

Design tools to achieve targets, driving force plot, remaining problem analysis, diverse pinch concepts, MCp ratio heuristics. Targeting and designing of HENs with different ΔTmin values, Variation of cost of utility, fixed cost, TAC, number of shells and total area with ΔTmin Capital-Energy tradeoffs.

Unit V **(8 Contact hours)**

Process modifications-Plus/Minus principles, Heat Engines and appropriate placement of heat engines relative to pinch. Heat pumps, appropriate placement of heat pumps relative to pinch. Steam Rankin Cycle design, Gas turbine cycle design, Integration of Steam and Gas turbine with process. Refrigeration systems, Stand alone and integrated evaporators. Heat integrations and proper placement of Reactors for batch Processes as well as continuous processes

Unit VI **(6 Contact hours)**

Retrofit of distillation systems. Case studies

Text Books:

1. Shenoy U. V.; "*Heat Exchanger Network Synthesis",* Gulf Publishing Company**.**

Reference Book

1. Smith R.; "Chemical Process Design", McGraw-Hill
2. Linnhoff B., Townsend D. W., Boland D, Hewitt G.F.,Thomas B. E. A., Guy A. R.andMarsland R. H.; "A User Guide on Process Integration for the Efficient Uses ofEnergy", Inst. Of Chemical Engineers

Web resource:

1. **https://www.youtube.com/watch?v=uY66EVQksk&list=PLbMVogVj5nJS1MaQpZC8Szg7FzBlnSWpT**
2. **http://nptel.ac.in/courses/103107094/**

Course out comes:

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

C0 1	Build a basic knowledge of pinch technology
CO 2	Compose network grid representation
CO 3	Identify pinch point
CO 4	Elaborate data extraction and energy targeting
CO 5	Modify the Process modifications
CO 6	Discuss Retrofit of distillation systems. Case studies

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CHXX42	Process Modeling and Simulation	PEC	3-0-0	3

Course Learning Objectives:

1. To understand types of variables, systems in chemical engineering.
2. To learn basic concepts related to model development
3. To know the importance of numerical methods for chemical engineers
4. To understand the importance and role of thermodynamics in process models.
5. To apply laws of conservation for any chemical engineering process.
6. To learn software's/process simulators

Course Content:

Unit–I **(7 Contact hours)**

Introduction, General concepts: Classification of process variables, Types of mathematical models, use of mathematical models, Scope of coverage, Principles of formation, Fundamental laws, Continuity equation, Energy equation, Equations of motions, Transport equations, Equations of state, Equilibrium, Chemical kinetics.

Unit – II **(8 Contact hours)**

Review of Numerical Methods: Numerical methods to solve single nonlinear algebraic equation, system of linear equations and Ordinary differential equations.

Review of Thermodynamics: Activity Coefficient models: Introduction, The margules model, Vanlaar, Wilson, NRTL, UNIQUAC and UNIFAC models.

Equation of state models: Introduction, RK, SRK, PR and BWR equation of state models.

Unit – III **(8 Contact hours)**

Examples of mathematical models of chemical engineering systems: Introduction, Series of isothermal, constant hold up CSTRs, CSTRs with variable hold-ups, Gas phase pressurized CSTR, Non- isothermal CSTR. Two heated tanks, Single component vaporizer

Unit – IV **(8 contact hours)**

Examples of mathematical models of chemical engineering systems: Reactor with mass transfer, Absorption column, Double pipe Heat exchanger, Batch Reactor modeling and dynamic simulation; CSTR- modeling and dynamic simulation, multiple steady states. Equilibrium flash vaporization, Multi-component flash drum.

Unit - V **(8 Contact hours)**

Distillation Models: Compartmental Distillation model, Ideal Binary Distillation Column, Binary Batch Distillation column- Model and dynamic simulation; Multicomponent Distillation column.

Unit – VI **(6 Contact hours)**

Computer simulation: Simulation examples- Gravity flow tank, Three CSTRs in series, Non-isothermal CSTR, Binary distillation column, Batch reactor, Heat Exchanger.

Usage of Commercial steady state and dynamic simulators- ASPEN PLUS

Learning Resources:

Text book:

1. W.L.Luyben, '*Process modeling simulation and control for chemical engineers*',McGraw-Hill,2nd Edition. 1989
2. A.K.Jana, '*Chemical process modeling and computer simulation*', PHI, 2nd edition, 2011.

Reference Books:

1. S.K. Gupta, '*Numerical Methods For Engineers*', 3rd edition, McGraw Hill., 2013
2. J.M.Smith, H.C Van Ness and M. M. Abbott, '*Introduction to Chemical Engineering Thermodynamics*', 7th Edition, Tata McGraw Hill, 2009.

Web resources:

1. https://nptel.ac.in/courses/103107096/

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

CO 1	Classify types of variables and systems.
CO 2	Explore the steps involved in developing model for any chemical engineering system.
CO 3	Apply laws of conservation principles and transport equations to build a model
CO 4	List the importance and role of numerical methods and thermodynamic concepts.
CO 5	Build process model for frequently used chemical engineering systems like Reactors, distillation columns etc.
CO 6	Involve computers to simulate the developed models using Matlab, C/C++ and commercial process simulators.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX45	**Technology of Oils and Fats**	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Impart knowledge on isolation and purification of fats and oils.
2. Impart knowledge and skills in fat and oil products development
3. Impart skills in quality assurance, assessment and measurement of physical and chemical changes occurring in fat and oil products
4. Impart knowledge of mechanical expressions of fat and oil.To understanding refining of oils
5. Impart knowledge of hydrogenation of oils /fats

Course Content:

Unit I: **(8 Contact hours)**

Position of oils & oil seeds in India &world. Definition, structure, composition, of oils & fats, Distinction between oils &fats. Glycerides: - Definition types – simple, mixed triglycerides, mono & di glycerides, random, - distribution of fatty –acids in glyceride molecule. Fatty acids: - definition types with examples saturated, unsaturated, fatty acids with ketoacids, artificially produced fatty acids. Non glyceride components of oils and fats, constituents present in Crude &Refined oils – Eg: - phosphatides, sterols, pigments, tocopherols, antioxidants vitamin A, D &E.

Unit II: (8 Contact hours)

Classification of oils & fats with examples and detailed glyceride composition with important characteristic of oils .Physiochemical properties of oils & fats: - solubility, specific gravity, refractive index, color, viscosity, smoke flash & fire points, melting points, anisidine value, saponification value etc .Importance of oils & fats in human Diet& nutrition. Chemical reactions of oils & fats in relation to triglycerides, carboxyl groups & fatty acids.

Unit III: (7 Contact hours)

Handling and storage of oilseeds-Mechanical pretreatment principles and process types-preparation of animal matter, preparation of oil seeds- Cleaning, dehulling& separation of hulls, Reduction in size of oilseeds. Heat treatment of oil bearing material principles and process types-Animal origin Dry rendering, wet rendering, digestive rendering

Unit IV: (7 Contact hours)

Plant origin cooking for hydraulic pressing, continuous pressing. Mechanical expression of Expression of oil seed principles and process types Batch process- Open type, closed type. Continuous Pressing, Low pressure pressing. Solvent extraction of oil principles and process types- Solvent used for oil extraction, type ofExtractors-Batch, continuous.

Unit V : (7 Contact hours)

Refining of oils- principles and process types-Alkali refining using caustic soda, batch refining by dry method , Batch refining by wet method continuous caustic refining Liquid, liquid refining, steam refining, micelle refining. Bleaching – principles and process types Adsorbents -batch bleaching, continuous process, recovery of oil from spent clay chemical bleaching. Deodorization batch process, Continuous process. filtration of oils – principles, types and process.

Unit VI: (8 Contact hours)

Hydrogenation of oil/fats – types of oils used for hydrogenation, process of hydrogenation, products based on Hydrogenation -shortenings, margarine, salad dressings ,mayonnaise, Low calorie spreads. Winterizations of oils e.g.:- salad oils

Fortification of oils & fats with nutrients processing of non-edible oils, & animal fats. Fractionation, interestification and esterification of oils

Learning Resources:

Text Books:

1. Daniel S wern, Vol.III Thomas H. Apple White John, *Baily's Industrial Oils And Fats Produts*, Vol-I, II & III 1985 Editons. John Wiley Sonsinterscience publication.

Reference Book

1. B.B. Min, C.C Akoh , *Food lipids* : , 1998- Marcel, Decker
2. D.B. Min, R.E. McDonald, *Food Lipids and Health* : 1996- Marcel Decker

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

CO1	Importance of Isolation and purification of fats and oils.
CO 2	Apply techniques in fat and oil products development
CO 3	Analyze quality assurance
CO 4	Assessment and measurement of physical and chemical changes occurring in fat and oil products
CO 5	Improve refining of oils
CO 6	Explain hydrogenation of oil/fats

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20CHXX37	**PHARMACEUTICALS AND FINE CHEMICALS**	PEC	3-0-0	3

Course Content:

Unit I **(7 Contact hours)**

A brief outline of different grades of chemicals – Reagent grade and Laboratory grade.

Outlines of preparation – Different methods of preparation of Reagent grade and Laboratory grade Chemicals.

Unit II **(7 Contact hours)**

Uses and testing of the pharmaceuticals and fine chemicals – Applications of medicinal value Chemicals and their quality testing procedures.

Unit III **(8 Contact hours)**

Properties, assays and manufacture of Pharmaceuticals and fine chemicals with flow sheets-

Unit IV **(7 Contact hours)**

Physical and Chemical properties, methods of assessing the quality and industrial methods of formulating the drugs and fine chemicals that have no medicinal value but are used as the intermediates.

Unit V **(8 Contact hours)**

Compressed Tablet making and coating – Types of tablets and Methods of compressed tablet making and coating.

Unit VI **(8 Contact hours)**

Preparation of capsules and extraction of crude drugs – Industrial procedures of capsule formulation and methods of recovering the drugs formulated from the reaction mixture.

Sterilization – Need for sterilization, Sterilization methods, batch and continuous sterilization.

Learning Resources:

Text Books:

1. Remington, Pharmaceutical Sciences, Mak. Publishing Co., 16th Edition, 1980.
2. William Lawrence Faith, Donald B. Keyes and Ronald L. Clark, Industrial Chemicals, 4th Edition, John Wiley & Sons, 1975.

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

CO1	Understand the grades of chemicals.
CO2	State properties, uses and testing of pharmaceuticals and fine chemicals
CO3	Draw flow sheets for manufacture of pharmaceuticals and fine chemicals
CO4	Understand tablet making and coating, preparation of capsules and extraction of crude drugs.
CO5	Understand sterilization.

Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20CHXX27	**FUEL CELLS AND FLOW BATTERIES**	PEC	3-0-0	3

Course Content:

Unit I **(6 Contact hours)**

Introduction - Electrochemical Flow Systems - Fuel cells and Flow Batteries.

Unit II **(6 Contact hours)**

Overview of Fuel Cells: Introduction, brief history, classification, working principle, applications, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

Unit III **(8 Contact hours)**

Fuel cell electrochemistry: electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents.

Unit IV **(7 Contact hours)**

PEM Fuel cell process design: Main PEM fuel cell components, materials, properties and processes, Fuel cell operating conditions

Unit V **(8 Contact hours)**

Fuels &Fuel processing: Hydrogen, Hydrocarbon fuels, Direct and in-direct internal reforming, Reformation of hydrocarbons by steam, CO_2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal

Unit VI **(10 Contact hours)**

Flow batteries: Introduction, Redox flow battery technology - brief history, working principle, redox flow battery components and systems, flow battery testing.

Flow Battery Types and Challenges: iron/chromium, Bromine/polysulphide, Vanadium/bromine, Zinc/cerium and All Vanadium flow batteries, current research trends and challenges.

Learning Resources:

Text Books:

1. F. Barbir, PEM Fuel Cells: Theory and Practice, Elsevier/Academic Press, 2 Edition,2013.

2. Huamin Zhang, Xianteng Li, Jiujun Zhang,Redox flow batteries: Fundamentals and Applications, CRC Press, 2017.

3. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, New York, 2006.

4. Kirt A. Page, Christopher L. Soles, James Runt, Polymers for Energy storage and Delivery: Polyelectrolytes for Batteries and Fuel cells, OUP USA, 2012.

5. James Larminie, Andrew Dicks, Fuel Cell Systems Explained, Wiley, 2 Edition, 2003.

6. Hoogers G., Fuel Cell Technology Hand Book, CRC Press, 2003.

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

CO1	Describe working principles of fuel cells and flow batteries
CO2	Analyze the performance of fuel cell systems.
CO3	Identify intricacies in construction and operation of fuel cell stack and fuel cell system
CO4	Discuss construction and operation of flow battery cells and stack

Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX24	**FERTILIZER TECHNOLOGY**	PEC	3-0-0	3

Course Content:

Unit I **(8 Contact hours)**

Introduction: Elements required for plants growth, Classification of fertilizers, Compound,Complex and bulk blended fertilizers. N-P-K values and calculations.

Unit II **(8 Contact hours)**

Nitrogenous Fertilizers: Manufacturing Processes for Ammonia, Manufacture of ammonium sulphate, ammonium chloride, Ammonium phosphate, Ammonium nitrate, nitric acid,Urea etc. Economics and other strategies, Material of construction and corrosion problem.

Unit III **(7 Contact hours)**

Phosphatic fertilizers: Calculation of percentage tricalcium phosphate of lime in phosphatic rock:

Unit IV **(7 Contact hours)**

Manufacture of triple super phosphate and single super phosphate, Nitro phosphate, Sodium phosphate, phosphoric acid and other phosphatic fertilizers.

Unit V **(7 Contact hours)**

Potash Fertilizers: Manufacture of potash fertilizers like potassium sulphate, potassium chloride.

Unit VI **(8 Contact hours)**

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

Learning Resources:

Text Books:

1. Sittig M and GopalaRao M., Dryden's Outlines of Chemical Technology for the 21 Century,WEP East West Press, 3rd Edition, 2010.
2. Austin G T., Shreve's Chemical Process Industries, McGraw Hill Book Company, New Delhi, 5th Edition, 1986.
3. Handbook on Fertilizer Technology, Fertilizer Association of India, JNU, New Delhi, 2 Edition, 1977.

4. Shukla S D and Pandey G N, A Text Book of Chemical Technology, Vol I & II, Vikas Publishing House Pvt. Ltd., New Delhi, 2000.
5. Eugene Perry, Fertilizers: Science and Technology, Callisto Reference Publisher, 2018.
6. A.K. Kolay, Manures and Fertilizers, Atlantic, 2008.

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

CO1	Classify fertilizers
CO2	Explain manufacturing processes for production of fertilizers
CO3	Identify the effect of technologies on the health, safety and environment.
CO4	Explain the mechanism of chemical reactions

Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX29	**GREEN TECHNOLOGY**	PEC	3-0-0	3

Course Content:

Unit I **(7 Contact hours)**

Principles and concepts of Green Chemistry: Introduction, Sustainable Development and Green Chemistry, Rearrangement Reactions, Addition Reactions, Atom Un-economic Reactions, Substitution Reactions, Elimination Reactions, Wittig Reactions, Toxicity.

Waste- Production, Problems and Prevention: Introduction, Some Problems Caused by Waste, sources of Waste from the Chemical Industry, The Cost of Waste, Waste Minimization Techniques.

Unit II **(7 Contact hours)**

Measuring and controlling environmental performance: The Importance of Measurement, Lactic Acid Production, Safer Gasoline, Introduction to Life Cycle Assessment, Green Process Metrics, Environmental Management Systems.

Catalysis and green chemistry: Introduction to Catalysis, Comparison of Catalyst Types, Heterogeneous Catalysts, Basics of Heterogeneous Catalysis and Homogeneous Catalysis.

Unit III **(8 Contact hours)**

Organic solvents, Environmentally benign solutions: Organic Solvents and Volatile Organic Compounds, Solvent-free Systems, Supercritical Fluids, Supercritical Carbon Dioxide, Supercritical Water, Water as a Reaction Solvent, Water-based Coatings, Ionic Liquids, Ionic Liquids as Catalysts, Ionic Liquids as Solvents, Fluorous Biphase Solvents.

Unit IV **(8 Contact hours)**

Renewable Energy as a means of Green energy: Role of Renewable energy sources in promoting Green Technology.

Emerging Greener technologies and Alternative energy solutions: Design for Energy Efficiency, Photochemical Reactions, Advantages of and Challenges Faced by Photochemical, Processes, Examples of Photochemical Reactions, Chemistry Using Microwaves, Microwave Heating, Microwave-assisted Reactions, Sonochemistry, Sonochemistry and Green Chemistry, Electrochemical Synthesis, Examples of Electrochemical Synthesis.

Unit V **(8 Contact hours)**

Designing greener processes: Conventional Reactors, Batch Reactors, Continuous Reactors, Inherently Safer Design, Minimization, Simplification, Substitution, Moderation, Limitation, Process Intensification, Some PI Equipment, Examples of Intensified Processes, In-process Monitoring, Near-infrared Spectroscopy.

Unit VI **(7 Contact hours)**

Inherent safety – safety in design, case studies of major accidents

An integrated approach to a greener chemical industry: Society and Sustainability, Barriers and Drivers, The Role of Legislation, EU White Paper on Chemicals Policy, Green Chemical Supply Strategies.

Learning Resources:

Text Books:

1. Mike Lancaster, Green Chemistry, Royal Society of Chemistry, 2010.
2. Paul T. Anastas, John C. Warner, Green Chemistry: Theory and Practice, Oxford

University Press, 2000.

3. Jay Warmke, Annie Warmke, Green Technology, Educational Technologies Group, 2009.
4. James Clark and Duncan Macquarrie, Handbook of Green Chemistry & Technology, Blackwell Publishing, 2002.
5. S. Suresh and S. Sundaramoorthy, Green Chemical Engineering: An introduction to Catalysis, Kinetics, and Chemical Processes, CRC Press, 2015.

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

CO1	Understand principles and concepts of green chemistry
CO2	Develop manufacturing processes to reduce wastage and energy consumption.
CO3	Design the technologies to reduce the level of emissions from buildings and core infrastructure
CO4	Analyze the effects of pollutants on the environment

Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX22	**CO_2 CAPTURE AND UTILIZATION**	PEC	3-0-0	3

Course Content:

Unit I **(7 Contact hours)**

Introduction: Global status of CO_2 emission trends, Policy and Regulatory interventions in abatement of carbon footprint, carbon capture, storage and utilization (CCS&U)

Unit II **(7 Contact hours)**

CO_2 capture technologies from power plants: Post-combustion capture, Pre-combustion capture, Pre-treatment of flue gas before capture, Oxy-fuel combustion, chemical looping combustion, calcium looping combustion

Unit III **(8 Contact hours)**

CO_2 capture agents and processes: Absorption, Adsorption and Membrane-Based Separation Processes for CO2 Capture, CO_2 capture agents, adsorption, ionic liquids, metal organic frameworks

Unit IV **(7 Contact hours)**

CO_2 storage and sequestration: Geological sequestration methods, Biomimetic carbon sequestration

Unit V **(8 Contact hours)**

CO_2 Utilization: CO_2 derived fuels for energy storage, polymers from CO_2 , CO_2 based solvents,CO2 to oxygenated organics, Conversion into higher carbon fuels, High temperature catalysis

Unit VI **(8 Contact hours)**

Environmental assessment of CO_2 capture and utilization: Need for assessment, Green chemistry and environmental assessment tools, Life cycle assessment (LCA), ISO standardization of LCA,Method of conducting an LCA for CO_2 capture and Utilization.

Learning Resources:

Text Books:

1. Peter Styring, Elsje Alessandra Quadrelli, Katy Armstrong, Carbon dioxide utilization: Closing the Carbon Cycle, Elsevier, 2015.
2. Goel M, Sudhakar M, Shahi RV, Carbon Capture, Storage and, Utilization: A Possible Climate Change Solution for Energy Industry, TERI, Energy and Resources Institute, 2015.
3. Amitava Bandyopadhyay, Carbon Capture and Storage, CO_2 Management Technologies,CRC Press, 2014.
4. Fennell P, Anthony B, Calcium and Chemical Looping Technology for Power Generation and Carbon Dioxide (CO_2) Capture, Woodhead Publishing Series in Energy: No. 82, 2015.
5. Mercedes Maroto-Valer M, Developments in Innovation in Carbon Dioxide Capture and Storage Technology: Carbon Dioxide Storage and Utilization, Vol 2, Woodhead Publishing Series in Energy, 2014

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

CO1	Identify the necessity of CO_2 capture, storage and utilization
CO2	Distinguish the CO_2 capture techniques
CO3	Evaluate CO_2 Storage and sequestration methods
CO4	Assess Environmental impact of CO_2

Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX44	Sustainable Process Engineering	PEC	3-0-0	3

Course Content:

Unit-1 (5 Contact hours)

Concepts: Sustainability concepts, Cleaner Production, Industrial Ecology.

Unit-2: (8 Contact hours)

Strategies: Waste Minimization in Reactors, Waste Minimization in Separation Processes, Identification of Waste in Utility Systems

Unit-3: (8 Contact hours)

Strategies: Energy Conservation, Materials Recycling, Waste Minimization in Operations

Unit-4: (8 Contact hours)

Evaluation: Life Cycle Assessment, Life Cycle Assessment Case Studies

Unit-5: (8 Contact hours)

Evaluation: Safety Evaluation, Assessment of Costs and Economics, Sustainability Assessment

Unit -6: (8 Contact hours)

Implementation: Planning for Sustainable process Industries, Process Design and Project Development, Operations Management

Learning Resources:

Text book:

2. David Brennan, Sustainable Process Engineering, 2012, CRC Press

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

CO1	Apply the fundamental concepts of sustainability, cleaner production and industrial ecology.
CO2	Able to apply the strategies for identifying and minimizing waste in process plants, separation and utility systems through energy conservation and materials recycling
CO3	Perform the assessment for environmental, safety and sustainability criteria
CO4	Develop procedures needed to implement change through planning, design, project development and operations

Assessment Tool	**Weekly tests/Assignments (In semester)**	**Monthly tests (In semester)**	**End Semester Test**	**Total**
Weightage (%)	10%	30%	60%	100%

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CHXX41	**Process Intensification**	PEC	3-0-0	3

Course Content:

Unit I **(6 Contact hours)**

Introduction on Process Intensification: History, Philosophy and Concept, Principle Features , Strategies and domain based techniques.

Mechanism involved in the process intensification: Intensification by fluid flow process, Mechanism of Intensification by mixing, Intensification in Reactive system

Unit II **(7 Contact hours)**

Role of Process intensification in sustainable development, Design Techniques for Process Intensifications

Unit III **(8 Contact hours)**

Stochastic Optimization for Process Intensification, Process intensification by cavitation

Unit IV **(8 Contact hours)**

Process Intensification by monolith reactor: Introduction to monolith reactor, Preparation of monolith catalyst, Application of monolith catalyst, Hydrodynamics, transport of monolith reactor

Process Intensification by interface modification and residence time

Unit V **(8 Contact hours)**

Process intensification in distillation: Introduction and principles, Types of Intensified distillation units, Design of membrane assisted distillation.

Process intensification in extraction: Introduction and principles, Supercritical extraction for process intensification

Unit VI **(8 Contact hours)**

Process intensification by membrane: Introduction to membrane and principles, Membrane engineering in Process Intensification

Micro Process Technology in Process Intensification: Introduction, Process Intensification by micro reactors, Hydrodynamics and transport in micro channel based micro reactor

Learning Resources:

Text Books:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.
2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.

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

CO1	Apply process intensification in industrial processes.

CO2	Implement methodologies for process intensification
CO3	Understand scale up issues in the chemical process.
CO4	Gain the scientific background, techniques and applications of intensification in the process industries.
CO5	Identify and solve process challenges using intensification technologies.

Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX43	Solid Waste Management	PEC	3-0-0	3

Course Content:

Unit-1 (6 Contact hours)

Introducing Municipal Solid Waste Management: overview, Waste Generation Aspects

Unit-2: (7 Contact hours)

Waste Collection, Storage and Transport, Waste Disposal.

Unit3: (8 Contact hours)

Waste Processing Techniques, Source Reduction, Product Recovery and Recycling.

Unit-4: (8 Contact hours)

Recovery of Biological Conversion Products: Compost and Biogas, Incineration and Energy Recovery.

Unit-5: (8 Contact hours)

Hazardous Waste: Management and Treatment

Unit -6: (8 Contact hours)

Integrated Waste Management (IWM)

Learning Resources:

Text book:

1. Tchobanoglous, G., Theisen, H. M., and Eliassen, R. "Solid. Wastes: Engineering Principles and Management Issues". McGraw Hill, New York, 1993.
2. Vesilind, P.A. and Rimer, A.E., “Unit Operations in Resource Recovery Engineering”, Prentice Hall, Inc., 1981
3. Paul T Willams, "Waste Treatment and Disposal", John Wiley and Sons, 2000

Reference Books:

1. Government of India, "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of Urban Development, New Delhi, 2000.
2. Bhide A.D. and Sundaresan, B.B. "Solid Waste Management Collection", Processing and Disposal, 2001
3. Manser A.G.R. and Keeling A.A.," Practical Handbook of Processing and Recycling of Municipal solid Wastes", Lewis Publishers, CRC Press, 1996
4. George Tchobanoglous and Frank Kreith"Handbook of Solid waste Management", McGraw Hill, New York, 2002
5. Ramachandra T.V., 2006. Management of Municipal Solid Waste, Commonwealth Of Learning, Canada and Indian Institute of Science, Bangalore.

6. **Course outcomes:** At the end of the course, the student will be able to

CO1	Understand the nature and characteristics of municipal solid wastes and the regulatory requirements regarding municipal solid waste management
CO2	To plan waste minimization and design storage, collection, transport, processing and disposal of municipal solid waste

Assessment Tool	**Weekly tests/Assignments (In semester)**	**Monthly tests (In semester)**	**End Semester Test**	**Total**
Weightage (%)	10%	30%	60%	100%

Open Elective Courses Syllabus

Course code	Course name	Course Category	L-T-P	Credits
20CHXX51	**Corrosion Engineering**	OEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. This course will present to introduce the principles of corrosion
2. To demonstrate the common corrosion forms
3. To deduce adequate knowledge of corrosion control methods
4. To deduce knowledge ofmaterial selection reduce corrosion cost
5. To understand Electrode Kinetics
6. This course provides Predicting corrosion behavior

Course Content:

Unit I

Introduction: (7 Contact hours)

Definitions of Corrosion-classification of corrosion, Passivity, EMF and Galvanic series, equilibrium potential, Nernst equation for electrode potential, application of Nernst equation to corrosion reactions, expression of corrosion rate, environmental effects, Eh–pH diagrams, Fe-H_2O–O_2 system-applications and limitations, Cost of Corrosion, Metallurgical properties influencing corrosion

Unit II (7 contact hours)

Forms of Corrosion Uniform attack, galvanic, crevice, pitting, Inter granular, selective leaching, erosion and stress corrosion– Mechanisms and their prevention.

Unit III: (8 contact hours)

Corrosion Testing Procedures: Corrosion testing procedures-Introduction, Purpose of Testing, Steps involved in Corrosion testing, NACE test, Huey and Streicher test for stainless steels, Slow stain rate test, Paint test, Seawater test, In vivo corrosion test (Field test),

Unit IV: (7 contact hours)

Protection against corrosion-Design-Wall thickness and Design rules, coatings and inhibitors– Cathodic protection and Anodic protection

Unit V : (8 contact hours)

Electrode Kinetics: Electrode kinetics-Exchange current density, Activation Polarization, Concentration Polarization, Combined Polarization, Mixed potential theory, mixed electrodes, Passivity with modern aspects,

Unit VI: (8 contact hours)

Predicting corrosion behaviour-Effect of oxidizers, Velocity effects, galvanic coupling, Alloy evaluation, Corrosion prevention-Anodic Protection and Noble-Metal Alloying, Corrosion rate measurements-Tafel Extrapolation and Linear Polarization.

Text Books:

1. M. G. Fontana, *Corrosion Engineering*, 3rd Ed., McGraw-Hill Book Company, 1986

Reference Book

1. H. H. Uhlig and R. W. Revie, *Corrosion and Corrosion Control*, Wiley, 1985
2. P.Roberge,'Handbook of Corrosion Engineering', McGraw-Hill, New York, 2000.
3. D. A. Jones, '*Principles and Prevention of Corrosion'*, 2nd Ed., Prentice- Hall,

Course out comes:

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

C0 1	Discuss electrochemical fundamentals
CO 2	Evaluating the corrosion preventing methods
CO 3	Identify the induced corrosion environmental
CO 4	To Analyze and solve corrosion problems
CO 5	To design electrode kinetics
CO 6	Prediction of corrosion behavior

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
20CHXX52	Environmental Pollution and Control	OEC	3-0-0	3

Course Learning Objectives:

1. Emphasize on this course is on the fundamentals of pollution control aspects
2. Learn about different air pollutants sampling and analysis methods

3. Learn air pollution control equipment.
4. Know the primary, secondary and advanced wastewater treatment process.
5. Understand the solid, hazardous waste and their treatment and disposal methods.
6. Learn about EIA

Course Content:

Unit I (10 Contact hours)

Industrial Pollution Emissions and Indian Standards: Types of emissions from chemical industries and effects on environment, Type of pollution and their sources, Effluent guide lines and standards, Characterization of effluent streams, Oxygen demands and their determination (BOD, COD, and TOC), Oxygen sag curve, BOD curve interpretation, Controlling of BOD curve

Unit II (7 Contact hours)

Air Pollution Sampling: Criteria and toxic air pollutants, Air pollution sampling and measurement: Ambient air sampling: collection of gaseous air pollutants, Collection of particulate air pollutants, stack sampling: Sampling system, particulate and gaseous sampling

Unit III (7 Contact hours)

Air pollution control methods and equipments: Particulate emission control: collection efficiency, Control equipments like gravity settling chambers, Cyclone separators, Fabric filters, Electrostatic precipitator, Scrubbers (Spray towers and Venturi scrubbers)

Unit IV (7 Contact hours)

Wastewater treatment Process-Methods of primary treatment; Screening, sedimentation, flotation, neutralization, secondary treatment: Biological treatment of wastewater and bacterial growth curve, suspended growth processes (activated sludge, aerated lagoon and stabilization pond), attached growth processes (trickling filter and rotating biological contactor).Advanced waste water treatment.

Unit V (7 Contact hours)

Solid waste management: Sources and classification, Methods of collection, Disposal methods (Landfill and incineration)

Health and environment effects, sources and disposal methods, Chemical wastes; Health and environment effects, Treatment and disposal.

Unit VI (7 Contact hours)

Environmental Management: Sustainable development, Environmental Impact Assessment (EIA), Environmental Ethics, Legal aspects.

Learning Resources:

Text book:

1. C.S. Rao, '*Environmental Pollution and Control Engineering'*, 2nd Edition, Wiley, India, 2006.

Reference Books:

1. S.P.Mahajan, '*Pollution Control in Processes Industries'*, TMH, 1985.
2. M.NarayanaRao and A.K.Datta, '*Waste water treatment'*, 3rd Edition., Oxford and IBH, 2005.
3. M.N.Rao,H. V.N.Rao, '*Air Pollution'*, Tata McGraw Hill Education Private Limited, India,2010.
4. H.S.Peavy, P.R. Rowe, G. Tchobanoglous, '*Environmental Engineering'*, McGraw Hill, 1985.

Web resources:

1. https://nptel.ac.in/courses/123105001/

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

CO 1	List different types of pollution and apply knowledge for the protection and improvement of the environment
CO 2	Identify suitable sampling, analysis for air pollutants.
CO 3	Design suitable equipment for air pollutants.
CO 4	Select and use suitable wastewater treatment technique
CO 5	Elaborate the most appropriate technique to manage the solid waste.
CO 6	Discuss strategy of EIA

Assessment Method

Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX53	**Introduction to Nano Technology**	OEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. This course will present to understand the synthetic aspects for the design of nano structured materials

2. To demonstrate the using different approaches including both the bottom-up and top-down methods
3. To understanding of self-assembly of different nanostructures and their properties.
4. To understand different dimensions of nano structure.
5. To understanding chemical kinetics of nano technology
6. To understanding formation and applications of nano tubes

Course Content:

Unit I **(7 Contact hours)**

Introduction: Importance of Nano-technology, Emergence of Nano-Technology, Bottom-up and Top-down approaches, challenges in Nanotechnology

Unit II: **(8 Contact hours)**

Zero Dimensional Nano-Structures: Zero Dimensional Nano-structures, Nano particles through homogenous nucleation; Growth of nuclei, synthesis of metallic Nano particles, Nano particles through heterogeneous, nucleation; Fundamentals of heterogeneous nucleation and synthesis of nano particles using micro emulsions and Aerosol

Unit III: **(8 Contact hours)**

One Dimensional Nano-Structures: Nano wires and nano rods, Spontaneous growth: Evaporation and condensation growth, vapor-liquid-solid growth, stress induced recrystallization. Template based synthesis: Electrochemical deposition, Electro-phoretic deposition, Electrospinning

Unit IV: **(7 Contact hours)**

Two Dimensional Nano-Structures: Fundamentals of film growth. Physical vapour Deposition (PVD): Evaporation molecular beam epitaxy (MBE), Sputtering, Comparison of Evaporation and sputtering

Unit V : **(7 Contact hours)**

Chemical Vapour Deposition (CVD): Typical chemical reactions, Reaction kinetics, transportant phenomena, CVD methods, diamond films by CVD

Unit VI: **(8 Contact hours)**

Thin Films and Carbon Fullerence&Nano Tubes Thin films, Atomic layer deposition (ALD), electrochemical deposition (ECD), Sol-Gel films–Special Nano Materials–Carbon fullerenes, formation, properties and applications, Carbon nano tubes: formation and applications

Learning resources:

Text Books:

1. G. Cao, Y. Wang, *Nano structures and Nano materials: Synthesis, properties and applications*, 2nd Ed., World Scientific, 2011

Reference Book

1. A.K.Bandyopadhyay, *Nano Materials*, 1st Ed., New Age Publishers, 2007
2. T.Pradeep, Nano:*The Essentials: Understanding Nanotechnology&Nanoscience*, TMH, 2007

Course out comes:

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

C0 1	Identification Synthetic methodologies
CO 2	List the Various kind of Nanostructures
CO 3	Importance the Physical Properties of Nano materials
CO 4	Explain the fundamental of film growth
CO 5	Compute types of chemical reaction kinetics
CO 6	Formation and application of carbon tubes

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX54	Renewable Energy	OEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Having the knowledge of the renewable energy resources
2. Understanding the scientific examination of the energy field

3. Emphasis on solar energy sources and their technology and application.
4. Emphasis on wind & Bio-Mass energy sources and their technology and application
5. Emphasis on Geothermal &Ocean energy sources and their technology and application
6. Understanding of direct energy conversion systems

Unit I **(7 Contact hours)**

Introduction &Solar Energy: Introduction to renewable energy, necessity of generating electrical power through renewable energy sources, advantages of generating power through renewable energy sources–technical & economical, Provisions in Electricity Act & Renewable Energy Act for renewable energy development, Constitutional provisions for renewable energy development and environment protection, Clean Development Mechanism through renewable energy based power generation

Unit II **(8 Contact hours)**

Solar Energy: Physics of sun, the solar constant, extra-terrestrial and terrestrial solar radiation, instruments for measuring solar radiation and sun shine, Flat Plate and Concentrating Collectors, classification of concentrating collectors, thermal analysis of flat plate collectors, solar applications-solar heating/cooling technique, PV cell model and characteristics, Maximum power point tracking for photovoltaic power systems

Unit III **(8 Contact hours)**

Wind & Bio-Mass Energy: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, Betz criteria, maximum power point tracking for wind- Principles of Bio-Conversion, Anaerobic/aerobic digestion, gas yield, Combustion characteristics of bio-gas, utilization for cooking, I.C.Engine operation

Unit IV **(7 Contact hours)**

Geothermal Energy: Types of Resources (hydrothermal, geopressured, hot dry rock), types of wells, and methods of harnessing the energy (vapor dominated, liquid dominated) Ocean thermal energy conversion, principles of utilization,

Unit V **(7 Contact hours)**

Ocean Energy: Setting of ocean thermal energy conversion plants, closed loop OTEC Cycles- Tidal energy- potential and conversion techniques-single basin, two basin system- Wave energy: potential and conversion techniques

Unit VI **(8 Contact hours)**

Direct Energy Conversion: Need for DEC, faraday's laws, Fuel cells-Principle of working of various types of fuel cells and their working, Magneto-hydrodynamics

(MHD)-Principle of working of MHD Power plant, Hydrogen generation, battery energy storage system

Learning Resources:

Textbook (s)

1. G.D. Rai, '*Non-Conventional Energy Sources'*, 1st Ed., Khanna Publishers, 2000
2. B. H. Khan, '*Non-Conventional Energy resources'*, 2nd Ed. Tata McGraw Hill, 2001

Reference books:

1. Tiwari and Ghosal, '*Renewable energy resources'*, 2nd Ed., Narosa Publishing house, 2001
2. R. Rakesh, D. P. Kothari, K.C Singal, '*Renewable Energy Sources And Emerging Technologies*', 2nd Ed., PHI, 2013

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

CO1	Know the various types of renewable energy resources
CO2	List the new methodologies / technologies for effective utilization of solar energy
CO3	Identify the new methodologies / technologies for effective utilization of solar energy wind & Bio-Mass energy
CO4	Apply the new methodologies / technologies for effective utilization of Geothermal energy
CO5	Compare the new methodologies / technologies for effective utilization of Ocean energy
CO6	Design the direct energy conversion systems

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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Course code	Course name	Course Category	L-T-P	Credits
20CHXX55	Waste to Energy Conversion	OEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Learn the characterization of wastes

2.Learn the concepts of production of energy from different types of wastes through thermal, biological and chemical routes

3. Know the concepts the pyrolysis, gasification and syngas utilization

4. Learn how to improve the efficiency of power plant and energy production from waste.

5. Learn the concepts of anaerobic digestion and fermentation and microbial fuel cells.

6. Keep their knowledge upgraded with the current thoughts and newer technology options along with their advances in the field of the utilization of different types of wastes for energy production.

Course Content:

Unit I **(6 Contact hours)**

Introduction, characterization of wastes

Unit II **(6 Contact hours)**

Energy production form wastes through incineration, energy production through gasification of wastes.

Unit III **(8 Contact hours)**

Energy production through pyrolysis, gasification of wastes and syngas utilization.

Unit IV **(7 Contact hours)**

Densification of solids, efficiency improvement of power plant and energy production from waste plastics, and gas cleanup.

Unit V **(8 Contact hours)**

Energy production from organic wastes through anaerobic digestion and fermentation, and introduction to microbial fuel cells.

Unit VI **(10 Contact hours)**

Energy production from wastes through fermentation and trans esterification Cultivation of algal biomass from wastewater and energy production from algae.

Learning Resources:

Text Books:

3. Rogoff, M.J. and Screve, F., '*Waste-to-Energy: Technologies and Project, Implementation'*, Elsevier Store.
4. Young G.C., '*Municipal Solid Waste to Energy Conversion processes'*, JohnWiley and Sons.

Reference Books:

1. Harker, J.H. and Backhusrt, J.R., '*Fuel and Energy'*, Academic Press Inc.

2. EL-Halwagi, M.M., '*Biogas Technology- Transfer and Diffusion'*, Elsevier applied Science.
3. Hall, D.O. and Overeed, R.P., '*Biomass - Renewable Energy'*, John Willy and Sons.

Web resources:

1. http://nptel.ac.in/courses/103107125/#video

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

CO1	Analyzing the characterization of wastes
CO2	Learn the concepts of production of energy from different types of wastes through thermal, biological and chemical routes
CO3	Evaluate concepts the pyrolysis, gasification and syngas utilization
CO4	Methods to improve the efficiency of power plant and energy production from waste.
CO5	Get the concepts of anaerobic digestion and fermentation and microbial fuel cells.
CO6	Explore knowledge upgraded with the current thoughts and newer technology options along with their advances in the field of the utilization of different types of wastes for energy production.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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