Course Structure and Syllabus for 4-year, 8-semester B.Tech. Course in Chemical Technology

With specialization

A. **Ceramic Engineering**
B. **Oil Technology**
C. **Petrochemicals & Petroleum Refinery Engineering**
D. **Pharmaceutical & Fine Chemical Technology**

DEPARTMENT OF CHEMICAL TECHNOLOGY
UNIVERSITY OF CALCUTTA

CURRICULUM

B. Tech. in Chemical Technology (Ceramic Engineering/Oil Technology/Petrochemicals & Petroleum Refinery Engineering/Pharmaceutical & Fine Chemical Technology)

(With effect from Academic year 2024-2025)

Course Structure

1st Semester

Serial No.	Name	Code	Credit	Weekly Load			Total Load
				L	T	P	
1	Communication English, Management and Social Sciences	HU101	03	2	1	0	03
2	Physics-I	PH102	03	2	1	0	03
3	Chemistry-I	CH103	03	2	1	0	03
4	Engineering Mathematics-I	MA104	03	2	1	0	03
5	Basic Electrical Engineering	EE105	03	2	1	0	03
6	Language Lab	HU106	1.5	0	0	3	03
7	Physics Lab -I	PH107	1.5	0	0	3	03
8	Chemistry Lab -I	CH108	1.5	0	0	3	03
9	Basic Electrical Engineering Lab	EE109	1.5	0	0	3	03
	TOTAL		**21**	10	5	11	27

2nd Semester

Serial No.	Name	Code	Credit	Weekly Load			Total Load
				L	T	P	
1	Physics-II/ Chemistry-II[#]	PH201/CH201	03	2	1	0	03
2	Engineering Mathematics-II	MA202	03	2	1	0	03
3	Engineering Mechanics	ME203	03	2	1	0	03
4	Basic computer Science and Engineering	CS 204	03	2	1	0	03
5	Basic Electronics	BE205	03	2	1	0	03
6	Physics Lab –II/ Chemistry Lab–II[#]	PH206/CH206	01	0	0	2	02
7	Workshop Practice	ME 207	1.5	0	0	3	03
8	Engineering Drawing	ME 208	1.5	0	0	3	03
9	Computer Programming Lab	CS 209	1.5	0	0	3	03
10	Basic Electronics Lab	BE210 ET 205	1.5	0	0	3	03
	TOTAL		**22**	10	5	14	29

[#] For students of Stream CE,CT,PST, JFT will be assigned CH 201& CH 206 and for students of Stream ECE,CSE,IE,EE, IT,OOE will be assigned PH 201&PH 206 in 2nd Semester only.

3rd Semester

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
Theory									
20.	PCC-CT301	Chemical Technology–I							
	Module I	Process Calculation	1	1	-	2	15	35	50
	Module II	Energy Technology	1	1	-	2	15	35	50
21.	OEC-CT302	Chemical Technology–II							
		Elective I: A. Organic Technology B. Inorganic Technology	1	1	-	2	15	35	50
		Elective II: A. Biotechnology B. Fundamentals of Iron & Steel making	1	1	-	2	15	35	50
22.	PCC-CT303	Chemical Engineering I Fluid Mechanics	3	1	-	4	30	70	100
23.	HM-CT304	Humanities & Social Science							
	Module I	Human Values & Professional	2	0	-	2	15	35	50
	Module II	Ethics Indian Constitution	2	0	-	2	15	35	50
Practical									
24.	OEC-CT305	Elective III: A. Organic Technology Lab B. Inorganic Technology Lab	-	-	3	1.5	15	35	50
25.	PCC-CT306	Energy Technology Lab	-	-	3	1.5	15	35	50
26.	PCC-CT307	Physical Chemistry Lab	-	-	3	1.5	15	35	50
27.	OEC-CT 308	Elective IV: A. Biotechnology Lab B. Physical Characterization Lab		-	3	1.5	15	35	50
		Total	11	5	12	22	180	420	600

4th Semester

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
Theory									
28.	PCC-CT401	Engineering Thermodynamics	3	1	-	4	30	70	100
29.	PCC-CT402	Chemical Engineering – II Process Heat Transfer	3	1	-	4	30	70	100
30.	PCC-CT403	Chemical Technology – III	1	1	-	2	15	35	50

		Module I: Process Instrumentation Module II: Process Dynamics & Control	1	1	-	2	15	35	50
31.	PEC-CT404	Special Paper–I*	3	1	-	4	30	70	100
Practical									
32.	PCC-CT405	Chemical Engineering Lab I	-	-	3	1.5	15	35	50
33.	PCC-CT406	Instrumental Method of Analysis Lab	-	-	3	1.5	15	35	50
34.	PEC-CT407	Special Lab.–I#	-	-	3	1.5	15	35	50
35.	PEC-CT408	Special Lab.–II^	-	-	3	1.5	15	35	50
		Total	11	5	12	22	180	420	600

*Special Paper–I: Ceramic Engineering I/ Oil Technology I/ Petrochemicals & Petroleum Refinery Engineering I/ Pharmaceutical and Fine Chemical Technology I

#Special Lab–I: Ceramic Engineering Lab. I/ Oil Technology Lab. I/ Petrochemicals & Petroleum Refinery Engineering Lab. I/ Pharmaceutical and Fine Chemical Technology Lab. I

^Special Lab–II: Ceramic Engineering Lab. II/ Oil Technology Lab. II/ Petrochemicals & Petroleum Refinery Engineering Lab. II/ Pharmaceutical and Fine Chemical Technology Lab. II

5th Semester

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
Theory									
36.	PCC-CT501	Material Science & Technology	3	1	-	4	30	70	100
37.	PCC-CT502	Chemical Engineering–III Mass Transfer Operation	3	1	-	4	30	70	100
38.	OEC-CT503	Elective V: A. Reaction Engineering B. Material Characterization Techniques	3	1	-	4	30	70	100
39.	PEC-CT504	Special Paper–II#	3	1	-	4	30	70	100
Practical									
40.	PCC-CT505	Chemical Engineering–Lab. II	-	-	3	1.5	15	35	50
41.	PCC-CT506	Environment Technology Lab.	-	-	3	1.5	15	35	50
42.	PEC-CT507	Special Lab.–III^	-	-	3	1.5	15	35	50
43.	PEC-CT508	Special Lab.–IV$	-	-	3	1.5	15	35	50
		Total	12	4	12	22	180	420	600

#Special Paper–II: Ceramic Engineering II/ Oil Technology II/ Petrochemicals & Petroleum Refinery Engineering II/ Pharmaceutical and Fine Chemical Technology II

^Special Lab.–III: Ceramic Engineering Lab. III/ Oil Technology Lab. III/ Petrochemicals & Petroleum Refinery Engineering Lab. III/ Pharmaceutical and Fine Chemical Technology Lab. III

[$]Special Lab.–IV: Ceramic Engineering Lab. IV/ Oil Technology Lab. IV/ Petrochemicals & Petroleum Refinery Engineering Lab. IV/ Pharmaceutical and Fine Chemical Technology Lab. IV

6th Semester

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
Theory									
44.	PCC-CT601	Chemical Technology IV							
	Module I	Numerical Analysis	1	1	-	2	15	35	50
	Module II	Modeling & Simulation	1	1	-	2	15	35	50
45.	PCC-CT602	Chemical Engineering–IV							
	Module I	Separation Process	1	1	-	2	15	35	50
	Module II	Mechanical Operation	1	1	-	2	15	35	50
46.	OEC-CT603	Elective–VI A. Safety &Hazard Analysis B. Project Engineering	3	1	-	4	30	70	100
47.	PEC-CT604	Special Paper–III[#]	3	1	-	4	30	70	100
Practical									
48.	PCC-CT605	Design & Simulation Lab	-	-	3	1.5	15	35	50
49.	PCC-CT606	Process Equipment Design	-	-	3	1.5	15	35	50
50.	PEC-CT607	Special Lab.–V^	-	-	3	1.5	15	35	50
51.	PEC-CT608	Special Lab.–VI[$]	-	-	3	1.5	15	35	50
		Total	10	06	12	22	180	420	600

[#]Special Paper–III: Ceramic Engineering III/ Oil Technology III/ Petrochemicals & Petroleum Refinery Engineering III/ Pharmaceutical and Fine Chemical Technology III

^Special Lab.–V: Ceramic Engineering Lab. V/ Oil Technology Lab. V/ Petrochemicals & Petroleum Refinery Engineering Lab. V/ Pharmaceutical and Fine Chemical Technology Lab. V

[$]Special Lab.–VI: Ceramic Engineering Lab. VI/ Oil Technology Lab. VI/ Petrochemicals & Petroleum Refinery Engineering Lab. VI/ Pharmaceutical and Fine Chemical Technology Lab. VI

7th Semester

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
Theory									
52.	HM-CT701	Social Science & Management							
	Module I	Industrial Economics	1	1	-	2	15	35	50
	Module II	Business Management	1	1	-	2	15	35	50
53.	OEC-CT702	Elective–VII	3	1	-	4	30	70	100

		A) Nanotechnology B) Optimization method in Chemical Technology C) Sol-Gel Technology							
54.	PEC-CT703	Special Paper–IV[#]	3	1	-	4	30	70	100
Practical									
55.	PROJ-CT704	Project: Foundation	-	-	8	4	15	35	50
56.	PCC-CT705	Plant Design & Feasibility Studies	-	-	8	4	15	35	50
57.	PCC-CT706	Seminar	-	-	-	2	15	35	50
58.	INDTRG-CT707	In Plant Training / Institutional Training	-	-	-	-	15	35	50
		Total	08	4	16	22	150	350	500

[#]Special Paper–IV: Ceramic Engineering IV/ Oil Technology IV/ Petrochemicals & Petroleum Refinery Engineering IV/ Pharmaceutical and Fine Chemical Technology IV

8th Semester

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
Theory									
59.	PEC-CT801	Special Paper–V[#]	3	1		4	30	70	100
Practical									
61.	PEC-CT802	Grand Viva	-	-	-	2	15	35	50
62.	PROJ-CT803	Project Assessment–II	-	-	8	4	15	35	50
		Total	3	1	8	10	60	140	200

[#]Special Paper–V: Ceramic Engineering V/ Oil Technology V/ Petrochemicals & Petroleum Refinery Engineering V/ Pharmaceutical and Fine Chemical Technology V

Total Credit Point: 21+22+22+22+22+22+22+10 = 163

IA: Internal Assessment; UE: University Examination; TM: Total Marks

For Honours courses in 5th, 6th, 7th & 8th Sem 5 credits each = total 20 credits

For 5th, 6th & 8th Sem MOOC courses has to be taken and for 7th Sem Special course to be taken.

UNIVERSITY OF CALCUTTA
DEPARTMENT OF CHEMICAL TECHNOLOGY
Syllabi for Courses for 8-semester B. Tech. in Chemical Technology, University of Calcutta

SEMESTER- I
THEORETICAL PAPERS

COMMUNICATION ENGLISH, MANAGEMENT AND SOCIAL SCIENCES
Sub Code: HU101 **L-T-P: 3-0-0**

Total Lectures 40 hours + Contact Hours **Credit: 3**

1.1 . COMMUNICATIVE ENGLISH (GRAMMAR): [18L]

Course Objective: The objective of the course is to enhance the understanding of the students on the principles, techniques and application of grammar and to acquire appropriate proficiency and skills in reading, writing, speaking and comprehension.

Module 1: [3L]

Sentences: Clauses, Phrases, Types of Sentences, Sentence Structures and Transformation, Correction of Errors in Sentences.

Module 2: [1L]

Misplaced Modifiers and Modals.

Module 3: [4L]

Vocabulary Building and Usage: Word Formations (by adding suffixes and prefixes), Root words from foreign languages and their use in English; Synonyms; Antonyms; One Word Substitution/Single Word for a group of Words, Standard abbreviations; Redundant Words/ Redundancies/Redundantism; Clichés.

Module 4: [3L]

Remedial Grammar: Noun Pronoun Agreement, Articles, Prepositions, Agreement of Subject and Verb; Fill in the blanks using correct Words.

Module 5: [1L]

Précis Writing.

Module 6: [1L]

Essay, Paragraph Writing.

Module7: [1L]

Comprehension Passage.

Module 8: [3L]

Rapid reading- ‘Bill Moss, Tentmaker’ by Robert Gannon.

Module 9: [1L]

Taking notes: Dictation.

1.2 COMMUNICATIVE ENGLISH (TECHNICAL COMMUNICATION) [6L]

Course Objective: The objective of the course is to enhance the understanding of the students on the principles of effective technical communication and their application in official or professional communication.

Module 1: [2L]

The Theory of Communication –Definition & Scope; Barriers of Communication; Effective Communication (Verbal / Nonverbal).

Module 2: [1L]

Job Application Letter; C.V./Bio-data/Resume.

Module 3: [3L]

Organizational Communication: Memorandum; Notice; Official Notes; Minutes; Report (Technical Report): Progress Report, Event Report; Project Proposal; Brochures; Newsletters; Technical Articles; Manuals; Business Letter Circular, Agenda, Invitation, Seminars, Press Release, Newspaper Insertion.

1.3 MANAGEMENT AND SOCIAL SCIENCES [16L]

Course Objective: To understand the principles of management and their application to the functioning of an organization.

Module 1: [2L]

The Development of Management: Scientific Management - Organic Organization,

Networked organization, Postmodern Organization, Debureaucratization, Transformation of Management.

Module 2: [1L]

Labour Management: Fordism, Post-Fordism and the Flexible Firm.

Module 3: [1L]

Principles of management and their application to the functioning of an organization Contents: Definition of management, science or art.

Module 4: [1L]

Manager vs entrepreneur; Types of managers- managerial roles and skills.

Module 5: [1L]

Evolution of management- scientific, human relations, system and contingency approaches.

Module 6: [1L]

Types of Business Organizations, sole proprietorship, partnership, company, public and private enterprises.

Module 7: [1L]

Organization culture and environment.

Module 8: [1L]

Current trends and issues in management.

Module 9: [1L]

Nature and purpose of Planning, types of Planning, objectives, setting objectives, policies.

Module 10: [1L]

Strategic Management, Planning Tools and Techniques, Decision making steps & processes.

Module 11: [1L]

Nature and purpose of Organizing, formal and informal organization, organization structure, types, line and staff authority, departmentalization, delegation of authority, centralization and decentralization, job design, human resource management, HR planning.

Module 12: [1L]

Recruitment selection, Training & Development, Performance Management, Career planning and Management.

Module 13: [1L]

Directing, individual and group behavior, motivation, motivation theories, motivational techniques, job satisfaction, job enrichment.

Module 14: [1L]

Leadership, types & theories of leadership, effective communication.

Module15: [1L]

Controlling, system and process of controlling, budgetary and non-budgetary control techniques, use of computers and IT in management control, productivity problems and management, control and performance, direct and preventive control, reporting.

Course Outcomes:

CO 1. The students will understand proper use of English grammar.

CO 2. The students will acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.

CO 3. The students will acquire proficiency in formal official communication skills.

CO 4. Upon completion of this course, the students will get a clear understanding of management functions in an organization.

Reference Books:

1. Effective English Communication, by V. Syamala.
2. Best Science Writing: Reading and Insights edited by Robert Gannon prescribed text (Hyderabad: University Press (India) Limited, 1991).
3. Effective Technical Communication, M. Ashraf Rizvi, Tata Mc Graw-Hill.2005

4. Pronunciation Practice Activities – Martin Hewings – Cambridge University Press
5. A Textbook of English Phonetics for Indian Students – T. Balasubhramanian- Macmillan Publications
1. Concise Oxford Dictionary
2. Practical English Usage. Michael Swan. OUP. 1995.
3. Remedial English Grammar. F.T. Wood. Macmillan.2007
4. English For All edited by Nilanjana Gupta
5. Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
6. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press
7. . David F. Beer and David McMurrey, Guide to writing as an Engineer, John Willey. New York, 2004
8. Raman Sharma, Technical Communications, Oxford Publication, London, 2004.
9. Dale Jungk, Applied Writing for Technicians, McGraw Hill, New York, 2004. (ISBN: 07828357-4)
10. Sharma, R. and Mohan, K. Business Correspondence and Report Writing, TMH New Delhi 2002.
11. Robins S.P. and Coulter M., Management, Prentice Hall India, 10th ed., 2009.
12. Stoner JAF, Freeman RE and Gilbert DR, Management, 6th ed., Pearson Education, 2004.
13. P.C. Tripathy& P.N. Reddy, Principles of Management, Tata McGraw Hill, 1999.

PHYSICS - I

Sub Code: PH-102 **L-T-P: 3-0-0**

Total Lectures 40 hours + Contact Hours **Credit: 3**

Course objectives:

The objective of the course is to enhance the understanding of the Students' on some basic philosophies and corresponding application based reasoning of Physics. To help the students in acquiring the necessary skills to solve the application based problems useful for almost all branches of physics and engineering, on the basic of theoretical understanding.

1.1. Optics: [14L]

Module 1: [2L]

Introduction to interference and examples -Young's double slit experiment, Newton's rings (qualitative).

Module 2: [4L]

Diffraction: Introduction to diffraction, Fraunhofer and Fresnel diffraction, Fraunhoffer diffraction due to single slit and plane diffraction grating, characteristics of diffraction grating and its applications. The Rayleigh criterion for limit of resolution and resolving power of Diffraction gratings.

Module 3: [3L]

Polarization– Polarisation by reflection, Brewster's law, polarisation by double refraction, polaroids, Malus Law, linearly, circularly and elliptically polarized light (qualitative), half wave and quarter wave plates, Optical activity

Module 4: [2L]

Fibre Optics: Introduction, total internal reflection, numerical aperture and various fibre parameters, step and graded index fibres, application of optical fibres.

Module 5: [3L]

Lasers: Principles and working of Laser: population inversion, pumping, various modes, types of Laser (qualitative), application of Laser

1.2. Thermodynamics: [6L]

Module 1: [2L]

Degrees of freedom and Equipartition of energy, Energy and Work,First Law of Thermodynamics.

Module 2: [4L]

Second Law of Thermodynamics, Heat engines, Carnot's theorem, Entropy and equilibrium, Change in Entropy, Enthalpy, Free Energy, Chemical Potential, Gibb's function, Maxwell's relations(qualitative).

1.3. Quantum Mechanics- I: [12L]

Module 1: [5L]

Black body radiation, Planck's radiation law and its uniqueness, Compton Effect and its significance-wavelength shift and recoil of electron

Module 2: [4L]

Wave nature of Particles, De-Broglie hypothesis, Matter wave, Born interpretation of wave function, Uncertainty principle, Operators-Eigen value and Eigen function, operators and expectation values of some dynamical variables like momentum, total energy, angular momentum etc.

Module 3: [3L]

Schrödinger wave equation in three dimension and one dimension and its' significance, Time-dependent and time independent form, Application of Schrodinger wave equation in case of particle in one dimensional box (qualitative).

1.4. Dielectric and Magnetic Properties of Materials: [8L]

Module 1: [2L]

Divergence and Curl of electrostatic field, Gauss's law and its application, Laplace's and Poisson's equations for electrostatic potential

Module 2: [3L]

Dipole moments, electric field and potential due to dipole, Bound charges and Dielectric polarization, polar and non-polar dielectrics, Electric displacement vector, dielectric susceptibility, permittivity and dielectric constant, Boundary conditions, simple electrostatics problems in presence of dielectrics

Module 3: [3L]

Magnetisation, magnetic field ***B*** and ***H***, permeability and susceptibility, classification of magnetic materials, discussion of magnetic field in presence of magnetic materials(qualitative).,

Course Outcomes:

CO1: To provide knowledge and to develop an understanding of principles and processes of wave optics and optical communication.
CO2: To understand and apply fundamental concepts of Thermodynamics.
CO3: To provide knowledge and to understand the basic of quantum physics to develop concept of Modern Physics required for all branches of the engineering.
CO4: To apply fundamental laws of electricity and magnetism in engineering. To enable students to learn and to apply the basic concepts of Dielectric and Magnetic material in identifying and solving material physics problems.

Reference books:

1. Introduction to Optics by Hecht E. Addison-Wesley.

2. OPTICS by Ajoy Ghatak, 2nd edition, Tata McGraw Hill

3. Fundamentals of Optics by F. A. Jenkins and H.E. White, McGraw-Hill

4. Geometrical and Physical Optics by B K. Mathur

5. Principles of Optics by M. Born and E. Wolf, Cambridge University Press

6. Introduction to Electrodynamics by David Griffiths, Prentice Hall

7. Principles of Physics by David Halliday, Robert Resnick Jearl Walker , 10ed,Wiley.

8. Electricity, Magnetism, and Light by Wayne M. Saslow, Academic Press.

9. Electromagnetism by Grant and Phillips, John Wiley.

10.Thermodynamics in Materials Science by Robert DeHoff, CRC Press.

11. A treatise on Heat By M. N. Saha and B. N. Srivastava. The Indian Press.

12. Heat and Thermodynamics by Zemansky and Dittman, McGraw-Hill.

13. Fundamentals of Statistical and Thermal Physic by Reif, Sarat Book Distributors.

14. Introduction to Quantum Mechanics by David J. Griffiths, Prentice Hall.

15. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles by Eisberg & Resnick, Wiley.

16. Introduction to Electrodynamics by David Griffiths, Prentice Hall.

17. Electricity, Magnetism, and Light by Wayne M. Saslow, Academic Press.

18. Electromagnetism by Grant and Phillips, John Wiley.

19. Web Platform: NPTEL, SWAYAM, Archive.org etc

CHEMISTRY –I

Sub Code: CH-103 **L-T-P: 3-0-0**

Total Lectures 40 hours + Contact Hours **Credit: 3**

Course Objective: The objective is to Impart in depth understanding of fundamental concepts in chemistry that have been introduced at the 10+2 levels in school and to develop analytical skill among students necessary to design and solve the new problems. The course will familiarize students with different analytical techniques used in present day chemistry and explore the relevance in engineering applications.

Module 1: Atomic and molecular structure [12L]

Introduction to quantum theory: Schrodinger equation. Origin of quantization. Particle in a box and its applications with respect to conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations.

Bonding in molecules: Valence bond theory, Molecular orbital theory. Bonding and plots of molecular orbitals for diatomic and polyatomic molecules. Pi-molecular orbitals of butadiene and benzene and aromaticity.

Crystal field theory: Bonding in octahedral complexes, tetrahedral, tetragonally distorted octahedral and square planar complexes. Magnetic properties of all types of complexes. Color of complexes.

Band structure of solids and the role of doping on band structures.

Module 2: Intermolecular forces and real gases [4L]

Ionic, dipolar and van der Waals interactions. Deviation of real gas from ideal behavior. Equations of state of real gases and critical phenomena.

Module 3: Spectroscopic techniques and applications [6L]

Principles of spectroscopy and selection rules. Electronic spectroscopy. Vibrational spectroscopy. Nuclear magnetic resonance spectroscopy. Applications.

Module 4: Electrochemistry [8L]

Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Electrochemical series and its application. Nernst equation and applications of emf measurements. Potentiometric titrations: Acid base, oxidation reduction, precipitation titrations. Corrosion.

Module 5: Stereochemistry [4L]

Representations of three dimensional structures. Structural isomers and stereoisomers. Symmetry. Chirality and optical activity. Enantiomers, diastereomers, racemates. Configuration. Geometrical and conformational isomerism. Conformations of cyclic and acyclic systems.

Module 6: Organic reactions [6L]

Electronic influencing effects, Reactive intermediates. Aromaticity. Introduction to reactions involving rearrangement, substitution, addition, elimination, oxidation-reduction, cyclization and ring opening. Synthesis of a commonly used drug molecule.

Course Outcome:

The students will be able to

CO1. Understand and apply the concepts of basic quantum chemistry and chemical bonding to explain the molecular structure and physical/electronic properties of molecules.

CO2. Apply fundamental principles of electronic, vibrational, rotational and nuclear magnetic resonance spectroscopy towards identifying the structure of organic molecule.

CO3. Understand and apply fundamental concepts of electrochemistry.

CO4. Apply basic principles of organic chemistry for analyzing reaction mechanism and to develop methodology for synthesis.

Reference Books:

1.Chemistry: Principles and Applications by M. J. Sienko and R. A. Plane

2.Concise Inorganic Chemistry by J.D. Lee

3.General & Inorganic Chemistry, Vol I and Vol II by R.P. Sarkar

4.Physical Chemistry by P. W. Atkins and J. de Paula

5.Fundamentals of Molecular Spectroscopy by C. N. Banwell

6.Organic Spectroscopy by W. Kemp.

7.Organic Chemistry by I. L. Finar

8.Organic Chemistry by J. Clayden and N. Greeves

9.Organic Chemistry by R. T. Morrison and R. N. Boyd

10. Organic Chemistry by T. W. G. Solomons and C. B. Fryhle

11. A Guidebook to Mechanism in Organic Chemistry by P. Sykes

12. Engineering Chemistry (NPTEL Web book) by B. L. Tembe, Kamaluddin and M. S. Krishnan

13. Engineering Chemistry by Prasanth Rath

ENGINEERING MATHEMATICS-I

Sub Code: MA-104 **L-T-P: 3-0-0**

Total Lectures 40 hours + Contact Hours **Credit: 3**

Course Objective:

The objective of this course is to familiarize the prospective engineers with techniques in calculus, multivariate analysis and vector algebra. At the end of this course students will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines.

Module 1: Differential Calculus: [11 L]

Differential Calculus: Successive differentiation, Leibnitz Rule. Rolle's Theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; indeterminate forms and L'Hospital's rule; Maxima and minima.

Multivariable Calculus: Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers.

Module 2: Sequences and series: [12 L]

Convergence of sequence and series, tests for convergence; Power series, Taylor's series, series for exponential, trigonometric and logarithm functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

Module 3: Vector Algebra: [7L]

Vector calculus: Brief review of vector algebra, scalar and vector triple products, Directional derivatives, gradient, divergence, curl, vector integration, statements and applications of Gauss's theorem, Green's theorem, Stokes' theorem, examples

Module 4: Integral Calculus (Integration): [10L]

Int. Calculus: Properties of definite integrals, Quadrature, Rectification, Double integral, Triple integrals, change of order of integration, change of variables, determination of length, area, volume. Applications of definite integrals to evaluate surface areas and volumes of revolutions

Course Outcome:

The students will learn:

CO1: Explain limit, continuity, differentiability and apply differentiation to solve maxima and minima problems.

CO2: Recognize the limits in inderminate forms by a repeated use of L'Hospital rule.

CO3: Know about Fourier series initial conditions and its applications to different engineering models.

CO4: Understand scalar and vector functions and evaluate Gradient, Divergence and Curl of a point function depending upon its nature.

CO5: Know the applications of double and triple integration in finding the area and volume.

Reference Books

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 43nd Edition, 2015.
2. P.N. Wartikar & J.N .Wartikar, Applied Mathematics (Volume I and II) Pune Vidyarthi Griha Prakashan, 7th Edition 1994.
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons Inc., 10th Edition, 2011
4. Peter V. O' Neil, Advanced Engineering Mathematics, Thomson Brooks/Cole, 7th Edition, 2011.
5. Glyn James, Advanced Modern Engineering Mathematics, Pearson Education, 4th Edition, 2010.
6. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
7. S.S. Sastry, Introductory methods of numerical analysis, PHI, 4th Edition, 2005.
8. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.

BASIC ELECTRICAL ENGINEERING

Sub Code: EE-105 **L-T-P: 3-0-0**

Total Lectures 40 hours + Contact Hours **Credit: 3**

Course Objective: The objective of the course is to enhance the understanding of the Students' on the basics of AC & DC circuits along with basics of three phase circuits and to help the students to understand the basics of basic electrical machines, also helps the students understand the necessity of power system components.

Module -1 [L-3]

D.C. Circuits: Network theorems – Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem. Star-Delta & Delta-Star transformation.

Module -2 [L 3]

Magnetic Circuit: MMF, Flux, Reluctance. B-H Loop. Hysteresis and Eddy current loss. Magnetic circuit analysis with air gap.

Module -3 [L3]

A.C. Fundamentals: Sinusoidal quantities, phase & phase difference, average & RMS values, form factor & peak factor, concept of Sinusoids, impedance & admittance, power & power factor,

Module -4 [L 3]

A.C. Circuits: Series and parallel R-L-C Circuits, Form Factor, Peak. Factor. Phasor concept of Sinusoids. Impedance and Admittance. Power, Power Factor, V A, V AR.

Module -5 [L 3]

Balanced 3-phase: 3-phase AC balanced circuits. Phase-sequence, Star and Delta connections. Connection of wattmeter in 1-ph circuit for power measurement & Connection of two wattmeters in 3-ph circuit for power measurement.

Module -6 [L 2]

Power Factor Improvement: Causes & effect of low power factor, advantages of power factor improvement, methods of power factor improvement.

Module -7 [L 7]

DC Machines: Construction, working, different types, EMF equation, characteristic (Generator & Motor), starting and speed control.

Module -8 [L 7]

1-PhaseTransformer: Construction. EMF equation. Phasor diagram. Equivalent circuits. Open circuit and Short circuit test. Losses and Efficiency

Module -9 [L 7]

3-Phase Induction Machine: Types of induction machines. Rotating magnetic field, slip, torque equation, torque speed curve. DOL starting and reduced voltage starting.

Module -10 [L 1]

Power System Structure: Single line diagram of a power system structure.

Course Outcome:

CO1. Understand and apply the basic laws and different network theorems of electrical engineering.

CO2. Understand the basics of AC circuit and derive expression for impedance, admittance, current, power in series and parallel RLC circuit under AC supply with phasor diagram.

CO3. Understand the basics of three phase system and learn how to connect wattmeters for power measurement.

CO4. Differentiate between electrical and magnetic circuit and analyze magnetic circuit with air gap.

CO5. Understand the basics of basic electrical machines.

Reference Books:

1. Basic Electrical Engineering By I..Nagrath ,Tata McGraw-Hill Publishing Co. Ltd

2. Basic Electrical Engineering By T.K. Nagsarkar & M.S. Sukhija, Oxford University Press

3. Electrical & Electronics Technology By Hughes, Dorling Kindersley India, New Delhi

4. Electrical Technology By H. Cotton, CBS Publisher, New Delhi

5. A course in Electrical Engineering Vol-I & II By C.L.Dawes Publisher: McGraw-Hill Book Co. Inc

PRACTICAL PAPERS

LANGUAGE LAB

Sub Code: HU-106 **L-T-P: 0-0-3**

Total : 36 hours **Credit: 1.5**

Course Objective:

The objective of the practical classes is to make the students familiar with the applied aspects of the English language, pronunciation, behavioural strategies and realistic dimensions of interpersonal interaction in the context of organizational communication. The practical exercises include the following topics:

Exercises:

- Group Discussion –Principle & Practice [Courtesy- Teaching Cohesion and Coherence strategies for handling criticism and adverse remarks. Teaching strategies of Turn- taking,

timing, effective and creative intervention, formal and informal language, kinesics (use of body language), politeness and courtesies and all components of soft skills].

- Mock/Job Interview.
- Role Play/Conversation.
- Formal Presentation [power point presentation/extempore/ public speaking skills, Elementary Phonetics (theory): Pronunciation/ Stress/Intonation/ Rhythm/ Voice modulation/ Pitch and Accent of connected speech].
- Listening Comprehension: Audio File Analysis/Video File Analysis.

Course Outcomes:

CO 1: The students will acquire skills on appropriate pronunciation.

CO 2: The students will learn to prepare presentation.

CO 3: The students will be able to participate in group discussion

CO 4: The students will also acquire better verbal ability in Spoken English.

Reference:

The manual required for all the exercises will be given to the students.

PHYSICS LAB –I

Sub Code: PH-107 **L-T-P: 0-0-3**

Total :36 hours **Credit: 1.5**

Course objectives:

The objective of the practical classes is to make the students familiar with the technological features of theory as well as to provide hand-on experience of corroboration between model theory and it's practical aspect.

Experiments:

Experiments are based on modern optics-Lasers, general properties of matter, mechanics with advanced measurement techniques and Virtual lab

Course Outcomes:

The students will be able to

CO1: To impart practical knowledge about some theoretical phenomena they have studied in the engineering physics course.

CO2: To teach how to make careful experimental observations and how to think about and draw conclusions from such data.

CO3: To learn about the constraints in implementation of basic theory in application level and to learn about the optimum mode of operation in realization.

CO4: To apply the analytical techniques and graphical analysis to the experimental data

Reference:

The manual corresponds to all experiments will be provided to the students.

CHEMISTRY LAB –I

Sub Code: CH-108 **L-T-P: 0-0-3**

Total :36 hours **Credit: 1.5**

Course Objective:

The students will get hands-on experience on the different practical aspects of chemistry that they learned in the theory paper. Students will learn different features of chemical compounds, synthesizing of simple molecules, water analysis etc.

Choice of 8 − 10 experiments from the following:

1. Titrations: Acid –base, conductometric, pH-metric, complexometric titrations.
2. Estimation of hardness of water.
3. Determination of chloride content of water.
4. Colligative properties using freezing point depression.
5. Determination of the rate constant of a reaction.
6. Determination of cell constant and conductance of solutions.
7. Potentiometry-determination of redox potentials and emfs.
8. Determination of the partition coefficient of a substance between two immiscible liquids.
9. Determination of surface tension and viscosity.
10. Thin layer chromatography.
11. Saponification/acid value of an oil.
12. Synthesis of drug molecule/polymer.
13. Lattice structures and packing of spheres.
14. Models of potential energy surfaces.
15. Chemical oscillations-Iodine clock reaction.
16. Adsorption of acetic acid by charcoal.

Course Outcome:

The students will be able to

CO1. Apply the basic principles of chemistry to measure molecular/system properties such as surface tension, viscosity, pH, conductance of solutions, redox potentials, chloride content of water, etc.

CO2. Able to analyze the significant parameters of water related to industrial applications.

CO3. Synthesize simple molecules.

CO4. To design new experiments applying the fundamentals of chemistry.

ELECTRICAL ENGINEERING LAB–I

Sub Code: EE-109 **L-T-P: 0-0-3**

Total: 36 hours **Credit: 1.5**

Course Objective:

The objective of this practical course is to familiarize the students to the various instruments & devices & its hand on use, to run the rotating electrical machines & to familiarize with the construction & use of single phase transformer.

Experiments on the following topic:

- Familiarization experiments (Variac, Potential divider, MCV. MIV, MCA,MIA &Wattmeter)
- Characteristics of Tungsten and Carbon filament lamps
- Experiments on DC circuits and DC machines
- Study of AC series R-L-C series circuit
- Experiments on Single phase Transformer
- Calibration of voltmeter, ammeter and energy meter
- Experiments on magnetic circuit principles

Course Outcome:

Students will be able to

CO1. Verify Thevenin's, Norton's, Superposition and maximum power transform theorem using DC circuit.

CO2. Understand the difference in characteristic of Tungsten and Carbon filament lamp and measure current, power and resistance of lamps.

CO3. Understand the need of calibration of instruments.

CO4. Analyze of an AC series circuit and learn how to draw phasor diagram for the circuit.

CO5. Determine parallel and series parameters and measure losses by performing Open Circuit test and Short Circuit test of single phase transformer.

SEMESTER- II

THEORETICAL PAPERS

PHYSICS- II

Sub Code: PH-201 **L-T-P: 3-0-0**

Total Lectures 40 hours + Contact Hours **Credit: 3**

Course objectives:

The objective of the course is to enhance the understanding of the Students' on some basic philosophies and corresponding application based reasoning of Physics. To help the students in acquiring the necessary skills to solve the application based problems useful for almost all branches of physics and engineering, on the basic of theoretical understanding.

1.1. Electromagnetic Theory: [6L]

Module 1: [3L]

Biot-Savart law, The divergence and Curl of $\boldsymbol{B}$, Ampere's law, Inductance- self and mutual, magnetic vector potential, Faraday's law of electromagnetic induction, Differential form of Faraday's law and its' consequence.

Module 2: [3L]

Maxwell's equations, Maxwell's equation in vacuum and in matter, energy in an electromagnetic field, Poynting's theorem (qualitative), Electromagnetic wave equation in Vacuum and in matter (brief).

1.2. Introduction to Statistical Mechanics: [3L]

Statistical approach to system of particles, Phase space, Macrostate, Microstate, Density of states, Brief discussion on Maxwell Boltzmann, Fermi-Dirac and Bose-Einstein statistics and their differences.

1.3. Quantum Mechanics - II: [12L]

Module 1: [5L]

Application of Schrödinger equation in – (i) Barrier potential with qualitative discussion on examples like tunneling, alpha decay etc, (ii) The square well potential, (iii) Infinite square well potential and (iv) Simple Harmonic oscillator ,

Module 2: [4L]

Application of Schrödinger equation in three dimension- (i) Particle in three dimensional box and concept of degeneracy, (ii) One-electron Atom problem – Equations, Solutions, Eigenvalues, Quantum number and Eigen functions.

Module 3: [3L]

Application of quantum mechanics to solid - Free electron Theory of metals, Fermi Level, Density of states, qualitative discussion on Bloch's Theorem, Kronig- Penny model and origin of band gaps.

1.4. Mechanics: [10L]

Module 1: [2L]

Meaning of gradient-Potential energy function, equipotential surfaces, Conservative vector fields - gravitational and electrostatic examples.

Module 2: [2L]

Central forces; Conservation of Angular Momentum; Features of central force motion. Energy equation and energy diagrams (qualitative);

Module 3: [2L]

Non-inertial frames of reference; Rotating coordinate system, Velocity and Acceleration in a Rotating Coordinate System

Module 4: [2L]

Angular momentum of a system of particles, Torque, Moment of inertia , Parallel and Perpendicular axes theorem and consequences

Module 5: [2L]

Motion of a rigid body in a plane, Angular momentum about a point of a rigid body in planar motion; Euler's laws of motion, rigid body motion in three-dimension (brief)

1.5. Waves & Oscillation: [9L]

Module 1: [2L]

Simple harmonic motion, Composition of simple harmonic motion, Mechanical and electrical simple harmonic oscillators, complex number notation and phasor representation of simple harmonic motion. **Module 2: [2L]**

Damped harmonic oscillator – heavy, critical and light damping, energy decay in a damped harmonic oscillator (brief).

Module 3: [2L]

Forced vibration and resonance, steady state motion of forced damped harmonic oscillator, power absorbed by oscillator, steady state, application in mechanical and electrical oscillation (brief), ,

Module 4: [3L]

Wave equation in one dimension and travelling wave solution, Standing waves, Wave velocity and group velocity, Acoustics wave and velocity of sound, ultrasonic(qualitative)

Course Outcomes:

CO1: To familiarize the students with the fundamentals of electromagnetism, fields and electromagnetic waves required for clear concept in modern modes communication.

CO2: To develop analytical and problems solving skill on applying principles of statistical physics to various classical and quantum mechanical system.

CO3: The student will have a solid foundation in the tools and methods of quantum mechanics to deal with some problems in quantum mechanics on the basis of quantum mechanics I.

CO4: Development of the idea about the basic concepts of mechanics required for all branches of the engineering.

CO5: To gain the knowledge on the basic concepts of oscillations exhibited by various systems in nature as well as within atoms and molecules in material.

Reference books:

1. Introduction to Electrodynamics by David Griffiths, Prentice Hall

2. Principles of Physics, 10thed, David Halliday, Robert Resnick Jearl Walker , Wiley

3. Electricity, Magnetism, and Light by Wayne M. Saslow, Academic Press.

4. Electromagnetism by Grant and Phillips, John Wiley.

5.Thermodynamics in Materials Science by Robert DeHoff, CRC Press

7. Fundamentals of Statistical and Thermal Physics, Reif, Sarat Book Distributors

8. Introduction to Quantum Mechanics by David J. Griffiths.(Prentice Hall)

9. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles by Eisberg & Resnick, Wiley

10. Classical Mechanics by Goldstein, Poole and Safko Pearson Education.

11. Concepts of Modern Physics, Arthur Beiser, Sixth Edition, McGraw-Hill.

12. An Introduction to Mechanics by Klepner and Kolenkow, McGraw Hill.

13. Engineering Mechanics - Dynamics, 7th ed. - JL Meriam

14.Theory of Vibrations with Applications — WT Thomson

15. The Physics of Waves and Oscillations by N.K. Bajaj, Tata McGraw-Hill.

16. Oscillations and waves in physics by Ian G. Main.

17. Web Platform: NPTEL, SWAYAM, Archive.org etc

CHEMISTRY - II

Sub Code: CH-201 **L-T-P: 3-0-0**

Total Lectures 40 hours + Contact Hours **Credit: 3**

Course objective:

The objective is to develop understanding of the concepts and applications of chemical kinetics and different analytical techniques. Course will impart knowledge of physical/chemical behavior and applications of various engineering materials and explore water chemistry, green chemistry and non-conventional energy sources.

Module 1: Analytical techniques [8L]

Applications of spectroscopic techniques. Surface characterization techniques. Diffraction and scattering. Chromatographic methods of separation and analysis. Mass spectrometry. Thermal analysis.

Module 2: Kinetics of Chemical Reactions [10L]

Reversible, consecutive and parallel reactions. Steady state approximation. Chain and oscillatory reactions. Kinetics of photochemical &photophysical processes. Catalysis.

Module 3: Metals and Alloys: [3L]

Phase rule and applications to one, two and multi-component systems. Iron-carbon phase diagram. Types of alloys, carbon steel, alloy steel, alloys of Cu, Al, Pb.

Module 4: Polymers [3L]

Mechanism of polymerization and synthesis of polymers. Molecular weight, shape and conformation of polymers. Crystallinity, melting point and glass transition. Copolymerization. Viscoelasticity. Elastomers-structure, applications and curing. Conducting polymers and applications.

Module 5: Surfactants and lubricants [3L]

Critical micelle concentration and its determination. Hydrophobic and hydrophilic interactions. Micelles and reverse micelles. Detergents. Fricohesity of lubricants and chemical properties, types and mechanism of lubrication. Additives of lubricants and freezing points of lubricants.

Module 6: Nanomaterials [3L]

Properties of nanomaterials, size dependent properties, general methods of synthesis, bottom-up and top-down approach, characterization of nanomaterials, electron microscopy, self-assembly, nanoscale materials, Applications of nanomaterials.

Module 7: Environmental and green chemistry [6L]

Water chemistry: Sources of water. Hardness of water and softening methods. Alkalinity of water. Boiler feed water. Treatment of water for domestic and industrial use.

Air, water and noise pollution. Optimum level of pollution. Significance and determination of COD and BOD. Solid waste treatment of collection of NKP. Greenhouse effect and global warming. e-Waste. Radioactive pollution. Applications of green chemistry and green technology. Concept of atomic and molecular economy and its use in green chemistry.

Module 8: Energy science [4L]

Analysis of coal. Petroleum refining, liquid fuels, anti-knock agents. Cracking of oils. Limitations of fossil fuels. Alternative and non-conventional sources of energy - solar, wind, geo, hydro-power and biomass. Advantages and disadvantages. Nuclear energy, reactors and nuclear waste disposal. Safety measures for nuclear reactors. Battery technology. Rechargeable batteries. Fuel cells. Photovoltaics.

Course Outcome:

The students will be able to

CO1: Appreciate the usefulness of new analytical techniques for elucidating the structure of chemical systems.

CO2: Apply the basic principle of chemical kinetics in order to analyze and develop chemical reactors and reaction systems.

CO3: Use the knowledge on compounds of interest like polymers, surfactants, nanomaterials towards their engineering applications.

CO4: Able to apply the principles of green chemistry in designing alternative reaction methodologies to minimize hazards and environmental degradation.

Reference Books

1.Fundamentals of Analytical Chemistry by S. Crouch, D. West, F. Holler, D. A. Skoog

2.Organic Spectroscopy by W. Kemp.

3.Physical Chemistry by P. W. Atkins and J. de Paula

4.Chemical Kinetics, by K. Laidler

5.Introduction to Nanoscience by S. M. Lindsay

6.Nanoscience and Nanotechnology: Fundamentals to Frontiers by M. S. R. Rao, S. Singh

7.A Textbook of Engineering Chemistry by Shashi Chawla

8.Engineering Chemistry by S. S. Dara

9.Engineering Chemistry by P. C Jain and M. Jain

10. A Textbook of Environmental Chemistry by O. D. Tyagi and M. Mehra

11. Engineering Chemistry (WIND) by Wiley editorial

ENGINEERING MATHEMATICS-II

Sub Code: MA-202 **L-T-P: 3-0-0**

Total Lectures 40 hours + Contact Hours **Credit: 3**

Course Objective:

The objective of this course is to know the use of mathematical techniques in Linear algebra that are needed by engineers for practical applications, familiarize with differential equation with its application in Laplace transform, introduction to the concepts of improper integrals, Gamma, Beta function which are needed in engineering applications, and finally to acquaint with numerical methods in evaluating polynomial equations, differential equation and integration.

Module 1: Linear Algebra: Matrices, Vectors, Determinants, Linear Systems: [12 L]

Inverse and rank of a matrix, Determinants, Cramer's Rule, Solutions of Linear Systems: Existence, Uniqueness , rank-nullity theorem, Symmetric, skew symmetric, and orthogonal matrices, Vector Space, Linear dependence of vectors, basis, Eigenvalues and eigen vectors , Cayley-Hamilton Theorem and Orthogonal transformation.

Module 2: Convergence of improper integrals: [3 L]

Convergence of improper integrals, tests of convergence, Beta and Gamma functions elementary properties.

Module 3: Differential Equation: [10 L]

First order equations, Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations, solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Second order linear differential equations with variable coefficients; Method of variation of parameters; Wronskian

Module 4: Integral transform: [7 L]

Laplace Transform, Properties of Laplace Transform, Laplace transform of periodic functions, inverse Laplace transform, convolution theorem, Evaluation of integrals by Laplace transform, solving ODEs by Laplace Transform method, Fourier transforms.

Module 5: Numerical Methods: [8 L]

Finite differences, Newton's forward and backward interpolation formulae, Trapezoidal rule and Simpson's 1/3rd rule of integration, Solution of polynomial and transcendental equations, Bisection method, Newton Raphson method and Regular Falsi method, Numerical solutions of first order differential equations by Euler's method and 4th order Runge- Kutta method.

Course Outcomes

The students will be able to

CO1: Use appropriate Methods to solve first order and higher order differential equations and apply it to find solutions of engineering problems.

CO2: Develop the concepts of Laplace transformation & inverse Laplace Transform with its property to solve Ordinary Differential Equation which is helpful in all engineering research work.

CO3: Solve qualitative problems based on vector analysis and matrix analysis such as linear independence and dependence of vectors, rank etc.

CO4: Calculate the roots of algebraic and transcendental equations. Explain relation between the finite difference operators.

CO5: Familiarize with special functions such that they can evaluate some proper and improper integrals using beta and gamma functions

Text/Reference Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
3. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
4. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
5. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
6. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
7. V. Krishnamurthy, V.P. Mainra and J.L. Arora, An introduction to Linear Algebra, Affiliated East–West press, Reprint 2005.
8. S.S. Sastry, Introductory methods of numerical analysis, PHI, 4th Edition, 2005.
9. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984
10. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.

ENGINEERING MECHANICS

Sub Code: ME-203 **L-T-P: 3-0-0**
Total Lectures 40 hours + Contact Hours **Credit: 3**

Course Objectives

Modern day engineering mechanics idealizes the practical problems. Engineering Mechanics deals with the Mechanics of rigid bodies. -Statics and Dynamics- without taking the effect of their deformation structures separately. Therefore to meet the present -day needs, the focus of teaching engineering mechanics turned to the knowledge of proper conceptualization and modeling, assuming that rest of the things will be carried out using standard techniques.

Module 1: [2L]

Statics: Basic concepts, Scalars and vectors, parallelogram law, Lami's theorem,

Module 2: [2L]

Application of Vectors in Mechanics, Force Systems in two Dimensions;

Module 3: [4L]

Moments and Couples; Resultants and Components in concurrent coplanar, forces, parallel forces in a plane, Free Body Diagram Concept

Module 4: [4L]

Fundamentals of Friction, Limiting angle of Friction, Applications to wedges.

Module 5: [6L]

Centroid, Moment of Inertia.

Module 6: [5L]

Plane Trusses; Frames and Machines.

Module 7: [2L]

Dynamics: Introduction to vector calculus, Definition of vectors in Dynamics.

Module 8: [5L]

Two dimensional Kinematics in Rectangular Co-ordinates, Rectilinear Motion, Curvilinear motion of particle and description of different coordinate systems, Kinetics.

Module 9: [4L]

Newton's Law and D' Alembert's principle, and application to rectilinear and curvilinear motion, constrained motion,

Module 10:[4L]

Energy and Momentum methods. Linear Impulse; Angular Impulse and Momentum – Central Force Motion.

Module 11:[2L]

Concept of Stress and Strain, Stress-Strain Diagram of Ductile and Brittle Material ,Normal stress , shear stress etc., Relevant numerical.

Course Outcomes:

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

CO1. Understand different force systems and determine the resultant of different forces or force-couple systems.

CO2. Draw the free body diagram for the analysis of particles and rigid body in equilibrium.

CO3. Acquire knowledge about coulomb friction and solve problems related to friction.

CO4. Compute the location of the centroid and the moment of inertia of the composite area about centroidal or any arbitrary axis.

CO5. Understand the concept of motion of particles and rigid bodies in one and two dimensions.

Reference Books :

1. Engineering Mechanics by S Timoshenko , D H Young and J V Rao , Tata McGraw Hill
2. Engineering Mechanics (Statics & Dynamics, Volume I&II) by J.L. Meriam and L.G. Kraige, Wiley India pvt Limited.
3. A Text book of Engineering Mechanics by A. R. Basu, Dhanpat Rai& Co.
4. Engineering Mechanics by Basudeb Bhattacharyya ,Oxford University Press.
5. Engineering Mechanics by S S Bhavikatti, New Age International (P) Limited.
6. Engineering Mechanics by A. K. Tayal, Umesh Publications.
7. Engineering Mechanics by K L Kumar, Tata McGraw Hill
8. Engineering Mechanics by P.K Nag , Sukumar Pati &T.K. Jana , McGraw Hill Education (India) Private Limited.
9. Engineering Mechanics by B B Ghosh, S Chakrabarti& S Ghosh, Vikas Publishing House pvt Ltd.
10. Strength of Material by S S. Ratan, McGraw Hill Education (India) Private Limited.
11. NPTEL on line courses relevant to your topic; Source: onlinecourses.nptel.ac.in

BASIC COMPUTER SCIENCE AND ENGINEERING

Sub Code: CS-204 **L-T-P: 3-0-0**

Total Lectures 40 hours + Contact Hours **Credit: 3**

Course objectives:

The objective of this course is to give the introduction of computing systems to the students. The students will also learn the basics of programming languages. In order to solve good programming problems data structure is also taught.

Module- 1. Introduction to Computer:[8 L]

Basic Building blocks, Algorithms, Flowcharts, Pseudo codes, System and Application Software-concepts & terminologies, Concepts of Machine Language, Assembly Language and High level languages, Fundamentals of World Wide Web and Internet

Module- 2.Introduction to Programming:**[14 L]**

Variables, Assignments; Expressions; Input/Output; Conditionals and Branching; Iteration; Functions; Recursion; Arrays; Pointers; Structures;

Module- 3.Introduction to Data Structure:(18 L)

Array, Stack, Queue, Linked List Searching: Linear Search, Binary Search, Sorting: Bubble, Insertion, Selection

Course Outcome:

CO1. Develop an understanding of basic building blocks of a computing system.

CO2. Learn the theoretical background of C programming language.

CO3. Develop an ability to write C programs.

CO4. Develop an understanding about basic data structure and its applications.

CO5. Develop an ability to write simple computer algorithm and analyzing their complexity.

Reference Books:

1. Computer Fundamentals by P.K.Sinha

2. Data Structures by Seymour Lipschutz

3. Fundamentals of Data Structures in C by E.Horowitz, SartajSahni

4. Data Structures Using Cby ReemaThareja

5. The C programming Language by Brian W. Kernighan and Dennis M. Ritchie

6. Programming with C by Byron Gottfried

7. Programming in ANSI C by E. Balagurusamy

8. Understanding Pointers in C by KanetkarYashavant P.

BASIC ELECTRONICS

Sub Code: BE-205 **L-T-P: 3-0-0**

Total Lectures 40 hours + Contact Hours **Credit: 3**

Course Objective:

The objective of this course is to acquaint to the students initially the basic concepts of semiconductors and semiconductor devices which are widely used in electronics engineering. Further the electronic circuits used in electronics engineering, comprising of analog electronic and digital electronic circuits will also be introduced in this course. Lastly, the important application areas of electronics engineering, namely communication engineering and sensor and actuators will also be introduced.

Module 1: Concepts of Semiconductors [6L]

Basic ideas of electronics, charged particles, review of atomic energy levels, elementary concepts of energy bands in crystals, conduction band and valence band, distinction between metal, semiconductor and insulator, Fermi-Dirac Distribution and definition of Fermi level, intrinsic and extrinsic semiconductors, concepts of majority and minority carries in semiconductors, current flow in semiconductors.

Module 2: Semiconductor Devices[12L]

P-N Junction and Diode, Concept of space charge, effects of forward and reverse bias, current-voltage characteristics of P-N junction diode, concept of breakdown, Zener diode principle and applications, equivalent circuit of diodes, concepts of rectifiers, principle of LED. Bipolar junction transistor, mechanism of transistor action, current components in a bipolar transistor, modes of transistor operation, I-V characteristics of a bipolar transistor, transistor biasing, introduction to field effect transistor, principle of junction field effect transistor, concept of metal semiconductor field effect transistor, p-channel and n-channel, current flow in field effect transistors and I-V characteristic curves.

Module 3: Analog Electronics using Operational Amplifier [7L]

Concept of Analog Signal and Analog Electronics, Basic concept of positive and negative feedback, Basic information of operational amplifier, ideal characteristics, 741- OPAMP, Basic OPAMP applications using ideal model: inverting amplifier, non-inverting amplifier, summing amplifier, difference amplifier, differentiation and integration using operational amplifier, comparator circuit using operational amplifier

Module 4: Digital Electronics using Gates[13L]

Concept of Digital Signal, Binary Numbers, Signed-binary numbers, Decimal-to-Binary & Binary-to Decimal Conversion, Binary Addition, Subtraction, Multiplication and Division, Hexadecimal Number Systems, Logic Gates like OR, AND, NAND, NOR and NOT, Boolean

Algebra, De Morgan's Theorems, Laws of Boolean Algebra, Logic Circuit Implementation of Boolean Expressions, Arithmetic circuits, Combinational circuits: Multiplexers, De-Multiplexers, Encoders Decoder, Comparator, Sequential circuits:counters, registers, ADC and DAC,Basic ideas of flip flops.

Module 5: Electronics Applications [2L]

Introduction to communication systems. Principle of modulation including amplitude and frequency modulation. Transmitter and receiver system.

Course Outcome:

The students will be able

CO1: To introduce the basic concepts of semiconductor devices

CO2 : To give knowledge working of different semiconductor devices

CO3: To understand the concept of Analog electronics using an Operational amplifier

CO4: To study Digital electronics including binary to hexadecimal number systems,

logic gates, and implementation of logic circuits.

CO5: To expose students to Electronic applications encompassing sensors, actuators,

and different modulation techniques in communication systems.

Reference Books:

1. Electronics: Fundamentals and Applications, D.Chattopadhyay and P.C. Rakshit
2. Electronic Devices and Circuits, J.Millman and C.C. Halkias.
3. Linear Integrated Circuits, D.Roychoudhuryand S.Jain
4. Electronic Devices and Circuit Theory , Robert Boylestad and Louis Nashelsky
5. Digital Logic and Computer Design , M.Moriss Mano
6. Digital Electronics S. Salivahanan

PRACTICAL PAPERS

SUB: PHYSICS LAB-II

Sub Code: PH-206 **L-T-P: 0-0-2**

Total : 24 hours + Help Room **Credit: 1**

Course objectives:

The objective of the practical classes is to make the students familiar with the technological features of theory as well as to provide hand-on experience of corroboration between model theory and it's practical aspect.

Experiments are based on electricity and magnetism, optics and quantum mechanics with advanced measurement techniques.

Course Outcome:

CO1: To make the students familiar with the technological aspects of theory as well as to provide hand-on experience on corroboration between model theory and it's practical application.

CO2: To develop concept of practical applications of engineering materials and use the principle in the right way to implement the modern technology.

CO3: To understand the need for precise measurement practices for data recording.

CO4: Develop basic communication skills through working in groups in performing the experiments and by interpreting the results.

Reference:

The laboratory manual corresponds to all experiments will be provided to the students.

CHEMISTRY LAB - II

Sub Code: CH- 206 **L-T-P: 0-0-2**

Total : 24 hours + Help Room **Credit:1**

Course objectives:

The students will learn about chemical kinetics, organic functional group. They will come to know about different analytical methods and instruments.

Experiments:

1. Study of kinetics of chemical reactions.
2. Redox titrations: Dichromatometry, Permanganometry, Iodometry and Iodimetry.

3. Experiments based on Chromatography (paper, thin layer, column chromatography)
4. Detection of different functional groups in known and unknown organic samples.

Course Outcome:

The students will be able to

CO1. Identify reaction rate parameters.

CO2. Systematically identify simple organic compounds.

CO3. Use different analytical instruments.

WORKSHOP PRACTICE

Sub Code: ME - 207 **L-T-P: 0-0-3**

Total :36 hours + Help Room **Credit: 1.5**

Course Objectives:

Work shop Practice presents clear and concise explanation of the basic principles of manufacturing processes and equips students with overall knowledge of engineering materials, tools and equipment commonly used in the engineering field. The curriculum describes the general principles of different workshop processes such as primary and secondary shaping processes, metal joining methods. The workshop processes covered also include the hand-working processes such as bench work, fitting, welding, sheet metal work, and carpentry. It also explains the importance of safety measures to be followed in workshop processes and details the procedure of writing the records of the practices.

Fitting Shop:

Introduction to different hand tools, equipment and measuring devices, sawing, filing & drilling process. Practice Jobs on Mild Steel Plate, Production of nuts and bolts.

Carpentry Shop:

Specification of wood and wood products, Introduction to Tools and equipment, different wood joints. Practice jobs on Dove Tail Notch or Dovetail Bridle Joint or Cross Joint

Forging Shop:

Demonstration of forging a Octagonal Chisel.

Welding Shop

Metal joining process, Arc welding practice.

Sheet metal work

Sheet metal work through, production of funnel.

Course Outcomes:

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

1. Understand the appropriate tools, materials, instruments required for specific operations in

the workshop.

2. Understand report of procedures followed for a given task in fitting, foundry, sheet metals, welding, drilling, casting and moulding.

3. Design and model different prototypes in the carpentry trade such as cross lap joint, T-joint, Dovetail joint.

4. Design and model various basic prototypes in the trade of fitting such as straight fit, V fit.

5. Demonstrate and produce various basic prototypes in the trade of welding such as Lap joint, Lap tee joint, Edge joint, Butt joint and Corner joint.

6. Perform various operations like facing, parting, taper turning, end turning in order to develop various cylindrical prototypes in lathe.

Reference Books:

1. Work shop Technology (Volume- I and Volume-II , By Hazra ,Choudhary),Media Promoters & Publishers Pvt Ltd.
2. Mechanical Workshop Practice, PHI Learning Pvt. Ltd.
3. Work shop Manual / P.Kannaiah/ K.L.Narayana/ Scitech Publishers.

ENGINEERING DRAWING

Sub Code: ME - 208 **L-T-P: 0-0-3**

Total :36 hours + Help Room **Credit: 1.5**

Course Objectives

Primary objective of the course of Engineering Drawing is to understand the language of engineers which is very much essential for engineering career. Students of all engineering disciplines to develop a spatial bent of mind to observe, visualize and understand the structure of objects from different perspectives.

Module:1

Engineering Lettering, Numbering

Module:2

Types of Lines and Dimensioning methods.

Module:3

Construction of Plane Scales, Diagonal Scales &Venier Scales.

Module:4

Engineering Curves – Parabola, Ellipse, Involutes

Module:5

Orthographic Projection of Points, Lines, Surfaces, Solids and Section of solids.

Module:6

Introduction of Isometric projection.

Module:7

Introduction to CAD tools – basics; Introduction of Development and Intersection of surfaces.

Course Outcomes:

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

C01. Get acquainted with the instruments used for the different purposes to construct a drawing.

C02. Improve their imagination skills by gaining knowledge about points, lines, and planes.

C03. Construct different scales used in engineering purposes.

C04. Construct different types of curves such as parabola, hyperbola, ellipes etc.

C05. Become proficient in drawing the projections of points, lines and surfaces and solids.

C06. Gain knowledge about orthographic and isometric projections.

Reference Books

1. Engineering Drawing By N.D. Bhatt Pvt. Ltd.,
2. Engineering Drawing By N S Parthasarathy and Vela Murali, Oxford University press
3. A Text Book of Engineering Drawing - by R.K.Dhawan.

COMPUTER PROGRAMMING LAB

Sub Code: CS - 209 **L-T-P: 0-0-3**

Total :36 hours + Help Room **Credit: 1.5**

Course Objective:

The objective of this practical course is to conceptualize the basic features of programming language. The students will learn how to write the different programs for simple to advanced problems using C language.

Experiments on the following topic:

The assignments will be given based on the topics covered in Module-II and Module-III of CS 204. They will write the programs using C.

Course Outcome:

The students will be able to

CO1. Analyze and solve a given computational problem.

CO2. Develop the ability to write programs in C language.

CO3. Identify various datatypes and data structures and use them appropriately.

CO4. Understand the concept of pointers and apply it in various programs.

CO5. Learn how to implement modular programming concept using functions.

Reference Books:

1. The C programming Language by Brian W. Kernighan and Dennis M. Ritchie

2. Programming with C by Byron Gottfried

3. Programming in ANSI C by E. Balagurusamy

4. Understanding Pointers in C by KanetkarYashavant P.

BASIC ELECTRONICS LAB

Sub Code: BE - 210 **L-T-P: 0-0-3**

Total : 36 hours + Help Room **Credit: 1.5**

Course Objective:

The objective of this course is to train the students on the working of semiconductor diodes and transistor circuits, analog electronic circuits using operational amplifiers, digital logic circuits using Gates through hands-on-experiments.

Each experiment should be carried over bread boards and/or kits. Experimental observations should be properly tabulated and/or represented graphically. The derived results from experimental data should be compared with theoretical models and errors should be properly reported. Conclusion should be scientifically drawn. Each experiment should be preceded with a theoretical discussion of the concerned topic and identification of the associated circuit components and/or measuring instruments.

Experiment 1: Identification of Circuit Components

Study of resistors, capacitors and inductors. Determination of values and comparison of the same with measurement by multi meters/ LCR meters.

Experiment 2: Semiconductor Diodes

2(a): Identification of Ordinary P-N diode and Zener Diode.

2(b): Study the Forward Bias V-I Characteristics of P-N Junction Diode and determination of impedance.

2(c): Forward and Reverse Characteristics of Zener Diode, Load Voltage and Line Voltage Regulation.

Experiment 3: Bipolar Transistors

3(a): Identification of NPN and PNP Bipolar Transistors.

3(b): Study input & output characteristics of transistor in CE & CB modes and determination of hybrid parameters.

Experiment 4: MOSFET

4(a): Identification of MOSFET

4(b): Study V (DS) vs. I (D) characteristics and Study V (GS) vs. I (D) characteristics and hence to calculate the MOFET parameters.

Experiment 5: Analog Electronics using Operational Amplifiers

5(a): Identification of 741C OPAMP, pin diagram and power supply requirements. Concept of positive and negative supply.

5(b): Study of inverting and non-inverting amplifier configurations.

5(c): To use integrating and differentiating circuits with 741C OPAMP and study with C.R.O. Measurement of phase and frequency with C.R.O.

Experiment 6: Digital Electronics using Logic Gates

6(a): Identification of various digital logic gates.

6(b): Study of NOT, OR, AND, NAND, NOR & XOR gates and verification of truth tables.

Course Outcome:'

CO1. identification of Circuit Components

CO2. Study of Forward and Reverse bias of PN junction and Zener Diodes

CO3. Analysing the input and output characteristics of NPN and PNP Bipolar junction transistor

CO4. Study the VI characteristics of MOSFET

CO5. Develop the inverting and non-inverting configurations of OP-AMP IC 741

CO6. Determine the different ICs for different Logic gates and verification of different truth tables.

Semester III
(Theory)

Paper Code: PCC-CT301

Chemical Technology –I

Module I: Process Calculation **50 marks /2 Credits**

Units and Dimensions: Basic and derived Units, Different ways of expressing units of quantities and physical constants. Dimensional analysis and representation of results.
Stoichiometric principles: Properties of gases, liquids and solids, Critical properties.
Properties of mixtures and solutions and phase equilibria, vaporisation, drying, condensation. Wet and dry bulb thermometry. Concept of relative humidity, molal humidity, dewpoint, partial saturation.
Material Balance: Recycle, purging, bypass in batch, stagewise and continuous operations in systems with and without chemical reactions.
Energy balance: Thermophysics – concept of and calculations involving energy. Heat, work and enthalpy of reversible processes and combustion of fuels.
Thermochemistry – heat of formation, combustion, solution, dilution and the effects of pressure on them.
Calculation of theoretical and actual flame temperature during combustion of fuels.
Energy balance of systems with and without chemical reactions, unsteady state material and energy balances.
Combined material and energy balances for nuclear, electrochemical, photochemical and biochemical and less conventional separation processes.
Typical industrial applications.

Recommended Books :

1. Basic Principles And Calculations In Chemical Engineering, - D. M. Himmelblau, PHI Learning Pvt. Ltd.
2. Stoichiometry and Process Calculations - Narayanan K.V., Lakshmikutty B, PHI
3. Introduction to Process Calculations Stoichiometry - KA. Gavhane, Nirali Prakashan
4. Elementary principles of chemical processes - R. M. Felder and R. W.Rousseau 3rd Ed., Wiley, 1999.
5. Handbook of Chemical Engineering Calculations- N. Chopey, 3rd Ed., Mc-Graw Hill, 2004
6. Chemical Process Principles, Part 1: Material and Energy Balances- A. Olaf, K.M. Watson and R. A. R. Hougen John Wiley & Sons, 1968

Module II: Energy Technology **50 marks /2 Credits**

Energy crisis in India. Conventional energy sources: solid fuels, fossil fuel: coal it's origin and classification. Testing and processing of coal: preparation, washing, storage, and carbonization.
Liquid fuel: liquid fuel from crude oil. Synthetic and other liquid fuels. Storage and handling of liquid fuels.
Gaseous fuels: Natural gas. Manufacture of other commercial gaseous fuels. Analysis of fuel gases.
Non conventional, renewable energy sources: Introduction to solar energy, nuclear energy, wind energy, geothermal energy, tidal energy, biogas energy.
Furnaces: General classification and description of different types of furnaces with special reference to furnaces used in ceramic, glass, petroleum, oils and pharmaceutical industries. Heat saving applications.
Burners. Refractories and insulating materials.
Combustion stoichiometry and heat balance calculations.

Recommended Books:

1. Fuels & Combustion, 3rd edition, Dr. Samir Sarkar, Universities Press
2. Elements of Fuels, Furnaces & Refractories – Prof. O.P.Gupta, Khanna Publishers

Paper Code: OEC-CT302

Chemical Technology –II

Elective I: Organic Technology/ Inorganic Technology **50 marks /2 Credits**

A. *Organic Technology*

Spectroscopic analysis of organic compounds involving UV, NMR and MS.
Heterocyclic chemistry of compounds of industrial importance.
Dyes and pigments – chemistry and applications
Feedstock sources for the organic chemical industries and uses of principal organic chemicals in industries based on these chemicals.
Principal organic chemical industries manufacturing Polymers, Adhesives, Paints and Varnishes, Printing Inks, Dyes, Products by Fermentation, Synthetic fibres, Sugars, Paper and Explosives – Production statistics, raw materials, processes employed, safety and pollution aspects.
Studies of the principles of unit processes viz., Nitration, Sulphonation, Halogenation, Hydrogenation and the application of these processes for the manufacture of principal organic chemicals.
Stereospecific synthesis, stereochemical analysis and structure elucidation.
Concepts of combinatorial chemistry.

Recommended Books:

1. Advanced organic chemistry (organic synthesis, heterocyclic compounds and biomolecules) publisher: Books and Allied Organic Chemistry (A modern approach), Vol-lll, McGraw hill.
2. Unit Processes in Organic Synthesis, P.H. Groggins, McGraw hill, 2001.

B. *Inorganic Technology*

Water treatment and conditioning, Scale and sludge formation, Desalination of water, Membrane process, Piezodialysis., Reverse Osmosis.
Chemistry and applications of rare earth elements and their oxides.
Selected chemical industries – Fertilizers, caustic soda, chlorine, soda ash.
Electrochemical Industries and important products.
Electrothermal Industries - Artificial abrasives, Calcium Carbide, Graphite.
Nuclear Fuels, Nuclear Reactor.
Important industrial gases – H_2, CO_2, O_2 and He.
Production of important mineral acids – H_3PO_4, H_2SO_4, HCl and HNO_3.
Non-ferrous metallurgy: Different steps of extraction of Copper, Zinc, Aluminum. Principles and applications.

Recommended Books
1. Dryden's outlines of Chemical Technology for the 21st century
   M. Gopala Rao & Marshall Sittig
2. Manual of Chemical Technology - Inorganic Products
   D. Venkateswarlu

Elective II: Biotechnology/Fundamentals of Iron & Steel making **50 marks /2 Credits**

A: Biotechnology

Introduction to Biotechnology:

Classification of enzymes, sources and characteristics; Bioprocesses, whole cell and cell free systems. Kinetics of enzyme reactions, rapid reaction kinetics, kinetics in water rich and water deficient medium.
Bioreactors, types of bioreactors, bioreactor design and control parameters; Fermentation process technology; Biomaterial separation processes.
Industrial biotechnology for food, antibiotics, organic acids, enzymes, alcohols, perfumery chemicals and biodegradable polymers.
Biotechnology products and processes as applied in i) fats and oil technology, ii) pharmaceutical & fine chemical technology, iii) petrochemicals & petroleum refinery technology, iv) Ceramic technology, v) biomaterials and composites, vi) metallurgy and mineral dressing.
Environmental biotechnology concepts and application: Industrial waste management, air quality and control, bio-waste management.
Energy Biotechnology: Biogas, biodiesel, alternative energy sources like methane, hydrogen, biotransformations bioenergy economics.

Recommended Books:

1. Text book of Biotechnology by R.C. Dubey. S. Chand. Edition- 5th.
2. Biotechnology for beginners by Reinhard Renneberg, Academic Press, Edition- 2nd.

B: Fundamentals of Iron & Steel making

Iron making

World production of iron & steel, occurrence and distribution of iron ore, coal & limestone in India, Concept of integrated steel plant, different types of ironmaking processes, Agglomeration techniques, raw materials for iron making & their properties.

Production of Cast Iron, pig Iron and Sponge iron. Overview of Blast furnace, different zones of blast furnace, Blast furnace operation and Chemistry of Blast Furnace Reactions.

Concept of alternative iron-making processes, Idea about direct reduction process – DRI, HBI, Principles & technology of different coal based & gas based direct reduction processes like Rotary kiln, Rotary hearth, Midrex, HyL etc., Concept of other smelting reduction processes like Corex, Romelt, HiSmelt, Finex etc., Advances in iron making.

Steel making

Introduction to basic principles of steelmaking; Physicochemical principles of steelmaking & its refining reactions. Classification of steel.

Primary steelmaking (Basic oxygen steelmaking, BOF, Electric arc furnace, EAF) Bessemer converter, L-D converter etc. Secondary steelmaking (Ladle metallurgy operation including deoxidation, desulphurization, inert gas ringing and vacuum reactors, AOD, VOD). Ingot casting and continuous casting, production of alloy steels, stainless steel.

Recommended Books:

1. S. Biswas, D. Sarkar, Introduction to Refractories for Iron- and Steelmaking, 2020
2. Fundamentals of Steelmaking, E.T. Turkdogan
3. A. Ghosh and A. Chatterjee, Ironmaking and Steelmaking Theory and Practice, Prentice-Hall of India Private Limited, 2008
4. A. Ghose and H. S. Ray, Principles of Extractive Metallurgy, Wiley Eastern, 1991

Paper Code: PCC-CT303

Chemical Engineering I **100 marks /4 Credits**

(Fluid Mechanics)

Module I

Introduction to fluids, Forces on fluids, Normal & shear stresses
Fluid Statics: Pressure distribution, Manometry, Forces on submerged bodies, Buoyancy
Euler's equation of motion, Bernoulli's equation and applications, Fanning equation, Friction factor vs. Reynold's plot, Concept of equivalent length; Boundary layer theory, Laminar and turbulent flow Pressure drop and energy considerations in flow of fluids, Flow through packed bed, Settling of solids, Free settling, Hindered settling, Concept of fluidization

Module II

Flow measurement (Venturimeter, Orificemeter, Rotameter, Pitot Tube, Weir)
Fluid transportation equipment and accessories, Process pumps: reciprocating, rotary and centrifugal pumps, NPSH, Cavitation, Construction and application of valves, Blowers and compressors.

Recommended Books:

1. R. W. Fox and A. T. McDonald, Introduction to fluid mechanics, 5th Ed., John Wiley & Sons, 1998.
2. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, 6th Ed., McGraw - Hill, International Edition, 2001.
3. B. R. Bird, E. W. Stewart, and N. E. Lightfoot, Transport Phenomena, John Wiley & Sons, 2nd Ed., 2003.
4. J. M. Coulson and J.F. Richardson, Chemical Engineering, Vol-1: Fluid flow, Heat Transfer and Mass Transfer, Pergamon Press, 4th Ed., 1990.

Paper Code: HM-CT304

Paper: Humanities & Social Science

***Module I*:** Human Values & Professional Ethics **50 marks /2 Credits**

Unit I

Human society and the Value System

Types of Values: Social Values: Justice, Rule of Law, Democracy, Indian Constitution, Secularism; Aesthetic Values, Organizational Values, Spiritual Values and their role in our everyday life; Value Crisis in Contemporary Society: at: Individual Level, Societal Level, Cultural Level; Value Crisis management: Strategies and Case Studies.

Unit II

Principles and theories of ethics, Ethics of care, justice and fairness, rights and duties.

Types of Ethics, Work ethics and quality of life at work. Professional Ethics: Ethics in Engineering Profession; Code of Professional Ethics Sample Code of ethics like ASME, ASCE. IEEE, Institute of Engineers etc., Violation of Code of Ethics---conflict, causes and consequences, Engineers as managers, consulting engineers, engineers as experts, Conflict between business demands and professional ideals, social and ethical responsibilities of technologies. Whistle Blowing: Facts, contexts, justifications and case studies Ethics and Industrial Law:

Unit III

Science, Technology and Engineering as knowledge and profession: Practical application of science; Rapid Industrial Growth and its Consequences; Renewable and Non- renewable Resources: Energy Crisis; Industry and Industrialization; Man and Machine interaction; Industrial hazards and safety; Safety regulations and safety engineering; risk benefit analysis Technology Transfer: Definition and Types; The Indian Context.

Unit IV

Environment and Eco- friendly Technology: Ecological Ethics/Environment ethics, Depletion of Natural Resources: Pollution and Pollution Control, Eco-friendly Technology: Implementation, impact and assessment, Sustainable Development: The Modern Trends.

Recommended Books:

1. Human Values, Tripathi, A.N., New Age International, New Delhi, 2006.
2. Narender Singh, Industrial Sociology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012.
3. Sustainable Development, Bhatnagar, D.K., Cyber Tech Publications, New Delhi, 2008.
4. Social Problems in Modern Urban Society, Weinberg, S.K., Prentice Hall,Inc.,USA, 1970.
6. Sociology, Giddens, Anthony 2009, London: Polity Press (reprint 13th Edition)

***Module II*:** Indian Constitution **50 marks /2 Credits**

Meaning of Constitution Law & Constitutionalism

Historical perspectives of the Constitution of India

Salient features & characteristics of the Constitution of India

Fundamental Rights

Fundamental duties and its legal status

The principles of State Policy – its importance & implementation

Federal structure and distribution of legislative and financial powers between state & union

Parliamentary Form of Govt of India – the constitution powers & status of President of India

Amendment of Constitutional Powers & Procedures

The historical perspectives of the Constitutional Amendments in India

Emergency Provisions: National Emergency, Financial emergency & President Rule

Local self Government

Scheme of the Fundamental right to Equality

Scheme of the Fundamental right to certain freedom under Article 19

Scope of the right to life & Personal liberty under Article 21.

Recommended Books:

1. Durga Das Basu, "Introduction to the Constitution of India ", Prentice Hall of India, New Delhi.
2. R. C. Agarwal, (1997) "Indian Political System", S. Chand and Company, New Delhi.

(Practical)

Paper Code: OEC-CT305

Elective III: Organic Technology Lab/ Inorganic Technology Lab 50 marks /1.5 Credits

A. Organic Technology Lab

1. Calibration of thermometers for the determination of melting points and boiling points.
2. Complete qualitative analysis and identification of single organic compound having one or more functional groups.
3. Preparation of organic compounds involving some typical organic reactions and separation and purification -techniques.

4. Isolation of some natural products.
5. Estimation of organic compounds via functional groups.
6. Some Industrial organic estimation.

Recommended Books:

1. Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed. by J Mendham, Pearson
2. Vogel's Textbook of Practical Organic Chemistry, 5th ed., A.I. Vogel, A.R. Tatchell, B.S. Furnis, A.J. Hannaford, P.W.G. Smith, Pearson Education

B. Inorganic Technology Lab

1. Water analysis, Hardness, chlorides, TDS
1. Application of $Hg_2(NO_3)_2$ in estimation of Fe^{3+} in inorganic materials
2. Complexometric method of determination of cations using EDTA: Mg^{2+}, Ca^{2+}, Ba^{2+}, Zn^{2+}, Cd^{2+}, Fe^{3+}, Al^{3+}, Bi^{3+}, Mn^{2+}, Cr^{3+}, Cu^{2+}, Ni^{2+}, Co^{2+} and some of their mixtures.
3. Volumetric method of determination of anions: SO_4^{2-}, Cl^-, P_2O_5.
4. Standardization of HCl and $KMnO_4$ by EDTA.
5. Estimation of some trace elements in inorganic materials by colorimetric, flame photometric titration.
6. Application of atomic absorption spectroscopy for analysis of trace elements.
7. Differential Thermal analysis of some inorganic minerals and ores
8. Neutralization reactions by pH meter.

Recommended Book(s):

1. Quantitative Inorganic Analysis – A. I. Vogel

Paper Code: PCC-CT306

Energy Technology Lab **50 marks /1.5 Credits**

Sampling techniques for solid, liquid and gaseous fuels for analysis.
Test of solid fuels: proximate and ultimate analysis of coal and coke. Calorific value of coal and coke. Sulphur in coal.
Washability tests of coal. Phosphorous in coke.
Carbonization assay of coal.
Tests of liquid fuels: viscosity, flash point, fire point, water content, carbon residue, ash, calorific value, aniline point.
Tests of gaseous fuels: Orsat analysis, calorific value.
Calibration of thermocouples.
Thermal conductivity of insulating materials.

Recommended Books:

1. Fuels & Combustion, 3rd edition, Dr. Samir Sarkar, Universities Press
2. Fuel Combustion Energy Technology, S. N. Saha, Dhanpat Rai Publication Co.
3 Elements of Fuel Technology, Himus

Paper Code: PCC-CT307

Physical Chemistry Lab **50 marks /1.5 Credits**

1. Determination of viscosity coefficient
2. Determination of surface tension
3. Determination of distribution coefficient
4. Determination of equilibrium constant (homogeneous)
5. Determination of phase diagram (ternary system)
6. Determination of adsorption isotherm.

Recommended Books:
1. Advanced Practical Chemistry – Subhas C. Das

Paper Code: OEC-CT308
Elective IV: Biotechnology Lab/Physical Characterization Lab 50 marks /1.5 Credits

A. Biotechnology Lab

1. Microbial culture. Microbial cell growth and kinetics, Staining and microscopy study of microorganisms.
2. Preparation and characterization of immobilized enzyme, Bio-conversion studies with enzymes, Effect of pH and temperature on enzyme activity, Kinetics of enzyme inhibition activity.
3. Production of metabolites in synthetic and complex media, Monod equation, Estimation of monod parameters in batch, fed-batch and continuous cultures and solid state fermentation.
4. Sterilization of medium, sterilization cycle. Inoculation and microbial preservation techniques.
5. Stirred Tank Reactor operation for controlled bacterial growth; Study of rheology of fermentation broth in batch bioreactor.

Recommended Books:

1. Laboratory Manual for Biotechnology Students, A.S. Verma, S. Das, A. Singh, Publisher S. Chand, 2014.

B. Physical Characterization Lab:

1. Determination of Apparent Porosity, Bulk density and Apparent Specific gravity
2. Determination of True density and Specific gravity
3. Determination of True porosity and Closed Porosity
4. Determination of Moisture content
5. Measurement of particle size distribution by standard sieves
6. Pressing and fabrication of ceramic powders and firing
7. Preparation of ceramic specimens for observation of microstructure by optical microscope.
8. Study and operation of an electrical laboratory furnace
9. Mounting and polishing of ceramic samples
10. Determination of packing density of one component system of various particle sizes.
11. Determination of packing density of two component system using various particle sizes having different weight ratios.
12. Determination of packing density of three component system using various particle sizes having different weight ratios.

Semester IV
(Theory)

Paper Code: Course PCC-CT401 100 marks /4 Credits
Engineering Thermodynamics

Module I

Introduction- scope of thermodynamics, Dimensions and Units, Temperature, Pressure, Work, Energy, Heat. Energy conservation & first law of thermodynamics; State functions; Equilibrium; Phase Rule; Reversible process; Constant P,V, T processes; Mass and energy balances for open systems .

Phases, phase transitions, PVT behavior; description of materials – Ideal gas law, van der Waals, virial and cubic equations of state; Reduced conditions & corresponding states theories; correlations in description of material properties and behavior. Heat effects-latent heat, sensible heat, standard heats of formation, reaction and combustion.

Statements of the second law; Heat engines, Carnot's theorem,; 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.

Thermodynamic property of fluids, Maxwell relations, 2-phase systems, graphs and tables of thermodynamic properties. Application of thermodynamics to flow processes-pumps, compressors and turbines.

Thermodynamic analysis of steam power plants; Rankine cycle; Internal combustion engine, Otto engine; Diesel engine; Jet engine. The Carnot refrigerator; Vapor-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes.

Vapor-liquid equilibrium: phase rule, simple models for VLE; VLE by modified Raoult's law; VLE from K-value correlations; G-D Equation, VLE for non-ideal solution (Van Laar equation), Flash calculations.

Module II

Solution Thermodynamics: fundamental property relationships, free energy and chemical potential, partial properties, definition of fugacity and fugacity coefficient of pure species and species in solution, the ideal solution and excess properties.

Liquid phase properties from VLE, Models for excess Gibbs energy, heat effects and property change on mixing. Liquid-Liquid Equilibria; Vapor-Liquid-Liquid Equilibria; Solid-Liquid Equilibria; Solid-Gas Equilibria.

Chemical reaction equilibria: equilibrium criterion, equilibrium constant, evaluation of equilibrium constant at different temperatures, equilibrium conversion of single reactions, multi reaction equilibria.

Introduction to molecular/statistical thermodynamics

Recommended Books

1. Introduction to Chemical Engineering Thermodynamics: Smith, J.M., Van ness, H.C. and Abbot, M.M., 6th Edn. MGH., 2001.
2. A Text Book of Chemical Engineering Thermodynamics, Narayanan, PHI
3. Chemical Engineering Thermodynamics: Y.V.C. Rao.
4. Chemical Engineering Thermodynamics - S. I. Sandler, Wiley, New York, 1977.

Paper Code: PCC-CT402

Chemical Engineering II (Process Heat Transfer) **100 marks /4 Credits**

Module I

Heat transfer fundamentals: Modes of heat transfer

Conductive heat transfer: Conduction mechanism of heat transfer, Fourier's law, Steady state of heat transfer through composite slabs and composite cylinders, Heat transfer from extended surfaces, Concept of unsteady state heat transfer
Convective heat transfer: Heat flow mechanism by convection, Individual and overall heat transfer coefficient, Log-mean temperature difference, Forced convection inside tubes and ducts – Dittus-Boelter equation, Reynold's analogy, Natural convection
Design of heat transfer equipment: Types of heat exchange equipment and design of heat exchangers –shell and tube heat exchangers, double pipe heat exchangers
Basics of heat transfer with phase change: Introduction to boiling, Introduction to condensation, Condensers and reboilers

Module II
Introduction to radiative heat transfer: Concept of black body and laws of black body radiation, Kirchoff's law, Emissivity, Radiant heat transfer between surfaces separated by non-absorbing media
Evaporation: Mechanism of vaporization, Single and multiple effect evaporator, Calculations for optimum number of effects

Recommended Books

1. Process Heat Transfer - D. Q. Kern, MGH.
2. Heat Transfer Principles and Application - B. K. Dutta, PHI.
3. Heat Transfer - A Basic Approach: M. Necati Ozisik, McGraw-Hill International Edition, Singapore.
3. Heat Transfer: A Practical Approach - Yunus A. Cengel, McGraw-Hill.
4. Fundamentals of Heat and Mass Transfer - Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, Adrienne S. Lavine, Wiley.
5. A Heat Transfer Textbook - John H. Lienhard IV and John H. Lienhard V, , Cambridge, Massachusetts : Phlogiston Press.
6. Heat Transfer - J. P. Holman, 8th Ed., McGraw - Hill, 1997.
7. Unit Operations of Chemical Engineering - W. L. McCabe, J. Smith and P. Harriot, 6th Ed., McGraw - Hill, International Edition, 2001.

Paper Code: PCC-CT403
Chemical Technology –III
Module I: Process Instrumentation **50 marks/2 Credits**
Characteristics of Measurement System: Functional elements, classification and performance, characteristics of instrumental system. Instrument as an element of control system. Response characteristics for 1st order and 2nd order instrumental system.
Transducer, signal conditioning and display devices with block diagram.
Errors and Lags associated with instruments. Calibration of instruments.
Temperature measurement: Temperature measurement using change in physical properties. Electrical type temperature sensors. Optical and radiation pyrometers.
Pressure Measurement: Industrial manometers, elastic type pressure gauges, vacuum measuring gauges.
Flow measurement: Head flow and area flow meters, mass flow meters, solid flow measuring methods.
Liquid level measurement: Float type, displacer type devices, hydrostatic method, ultrasonic and nucleonic methods.
Instruments for viscosity, humidity, pH measurements. Instruments for gas analysis and composition analysis.

Module II: Process Dynamics & Control **50 marks/2 Credits**

Degrees of freedom, deviation variables, steady state gain, time constants, review of Laplace transform, input-output model, system response for first order and higher order systems, dynamics with dead time, inverse response.
Transfer function, 1st order system, 2nd order system, Examples of 1st order system & 2nd order system.
Introduction to chemical process control with examples, objectives of process control, control strategies and alternative control schemes, process stability, concept of optimum performance of chemical process.
Mathematical modeling of liquid level problems, stirred tank heater, mixing processes, CSTR, distillation column, absorption column, distributed parameter systems, linearization, SISO and MIMO systems.
Feedback control, P, PI, PID controllers and their response.
Control system instrumentation: sensors for liquid level, flow, pressure, temperature, and pH measurement, transmission line, comparator, controller, and final control elements, control valve sizing, pneumatic and electronic controllers.
Closed loop control systems, transfer function of individual elements, servo and regulator problems, dynamics of P, PI and PID controllers.
Stability of closed loop control systems, Routz-Hurwitz test, root locus analysis.
Feedback controller design, controller tuning, Ziegler-Nichols rules, Cohen and Coon rules, Integral error criteria, controller selection, process identification.
Frequency response, Bode plot and Nyquist diagram.
Introduction to advance control strategies: feed forward, control, cascade control, ratio control, adaptive control and inferential control.
Digital computer control, Z-transformation, discrete time dynamics, digital feedback controller design.
Design of control system for complete process plants.

Recommended Books

1. Process Instrumentation, Control & Dynamics for Chemical Engineers – Uttam Ray Chaudhuri, Asian Books Pvt. Ltd.
2. Fundamentals of Automatic Process Control - Uttam Ray Chaudhuri, Taylor & Francis

Paper Code: PEC-CT404 CER/OLT/PPR/PFC **100 marks /4 Credits**
CER: Ceramics Engineering I

***Module I*: Ceramic Raw materials**
Unit 1: Introduction to different types of clays used in ceramic industries – the availability and applications. Basic features of silicate structures.

Unit 2: Origin and classification of clays – geological aspects. Influence of different internal and external factors on the attributes of clays. Structural classification of clay minerals. Atomic disposition and charge distribution in different layer lattice minerals.

Unit 3: Effect of heat treatment on the phase transformation of clay minerals. Ion exchange properties - its importance and methods of measurement. Clay – water interaction. Behaviour of Newtonian and different non Newtonian fluids. Plasticity of clays.

Unit 4: Brief idea on processing, application areas and limitations of naturally occurring raw materials - Sillimanite, Kyanite, Andalusite, Zircon, Baddeleyite, Bauxite, Limestone, Dolomite, Magnesite, Chromite

Unit 5: Brief idea on processing, application areas and limitations of synthetic raw materials: Bayer process alumina, Calcined Alumina, Tabular Alumina, Fused Alumina, Sea-water Magnesia,

Zirconia, Titania, Magnesio-Aluminate Spinel, Mullite, Fumed Silica etc. Non-oxide synthetic raw materials: Silicon carbide, Aluminium nitride, Silicon nitride, Zirconium Diboride, Tungsten Carbide, Titanium Carbide, Graphite etc

Recommended Books:

1. The Chemistry and Physics of clays and other ceramic materials: Rex W. Grimshaw
2. Clays and ceramic raw materials: W.E. Worral
3. Properties of ceramic raw materials: W. Ryan
4. Industrial Ceramics: F. Singer and S. S. Singer
5. Handbook of Clay Science: F. Bergaya, D.K. G. Theng and G. Lagaly

Module II: Process Ceramics

Unit 1: Introduction and importance of studying Process Ceramics: Importance of different processing steps to the different fabrication processes and powder characteristics on the evolution of different microstructure.

Unit 2: Particle packing: Random packing of powders. One and two component particle packing. McGeary packing theory- binary and ternary packing. Furnas packing diagram, packing of continuous particle size- Andreasen model, Dinger-Funk model.

Unit 4: Ceramic Fabrication Process: Dry pressing, Semidry pressing – powder flow and die filling, compaction behaviour, ejection and transfer, effect of additives and binders, die wall effects, control of compaction defects, Hot pressing and reactive hot pressing, cold and hot isostatic pressing, Plastic forming – Extrusion, Jiggering, Jolleying. Casting process- Slip Casting, properties of the slip, mechanism of slip casting, different types of mould, slip casting rate and casting defects.

Unit 4: Drying: Critical moisture content, different types of dryers. Firing: Physicochemical changes, different type of kilns and furnaces.

Recommended Books:

1. Introduction to the principles of ceramic processing - J. S. Reed
2. Industrial Ceramics: Singer and Singer
3. Ceramic Processing and Sintering –M. N. Rahaman
4. Rheology of Ceramic systems: F. Moore
5. The Chemistry and Physics of clays and other ceramic materials: Rex W. Grimshaw
6. Ceramic Processing before firing: Onoda and Hench

OLT: Oil Technology I
Module I

Chemistry & Analysis of Fats, Oils and Waxes

Basic concept of fats and oils. Introduction to molecular nature and application of fats & oils; Classification of Oils & Fats, demand and supply position of edible and non-edible oils. Source and availability of fats and oils; vegetable source, marine and land animal source, and microbial source. Minor Oil seeds and oils.

Physical properties of fats and oils: thermal rheology, polymorphism, surface active, spectral, and optical properties.

Understanding chemical composition of fats and oils; fatty acids, triglycerides, non-triglycerdes, minor constituents. Nomenclature; understanding and explanation of basic reactions of fats and oils (involving double bonds, ester bonds, hydroxy, epoxy, and cyclic groups, etc.) with a focus on hydrogenation, oxidation, auto-oxidation, polymerization, hydrolysis, esterification, interesterification, sulphonation, amidation, pyrolysis etc. Frying reactions. Blending of Oils & Fats.

Fats and oils analysis: Basics of various methods of analysis; physical and chemical methods of analysis; chromatographic methods of analysis (TLC, GLC, HPLC): Different colour scales, spectroscopic methods of analysis (UV, IR, NMR, MS): detection of adulteration by chemical, spectroscopic, colour and other instrumental methods.
Bio-availability and digestibility of fats & oils; Fats in nutrition, health and disease and dietary guidelines. Nutraceuticals from Fats & Oils Origin.

Module II: **Introduction to Polymer Basics and Surface Coating Technology**
Definition and classification of coatings, application, and importance, present Status of coatings, business potential, coating ingredients, and coating applications.
Corrosion & its prevention.
Understanding of the coating ingredients.
Drying oils, their modification, mechanism of film formation, and film deterioration on aging. Roles of constituents of oils on film performance.
Fundamentals of clear coatings, ingredients, and application. Fundamental of Varnish Clear, Wood Clear & Stoving Clear, composition and application. Defects of varnishes and varnish films, equipment details.
Solvents and Plasticizers: Their characteristics and classifications.

Recommended Books:

1. Chemistry & Technology of Oils & Fats – M.M. Charaborty
2. Principles of Polymer Chemistry - P J Flory
3. Basics of Paint Technology – V.C. Malshe & Meenal Sikchi
4. The Chemical Constitution of Natural Fats- T.P. Hilditch and P.N. Williams
5. Paint and Surface Coatings - R. Lambourne and T.A. Strivens
6. Organic Coating Technology – H F Payne

PPR: Petrochemicals & Petroleum Refinery Engineering I
Module I : Natural Gas, Crude Oil & Petroleum Products overview
Natural Gas & Crude Oil Exploration- Global and Indian Scenario
Production & cross-country transfer of crude oil & gas to refineries & petrochemical plants
Properties of Natural Gas, Shale Gas, Shale Oil, Gas Hydrates, Coal bed Methane
Crude Oil Evaluation, Analysis – Crude assay, Four cut method
Petroleum Products overview with specifications and standard ASTM/IP Test methods – BIS specification.
Module II: Refinery Operations I
Desalting – theory, operating conditions and technology
ASTM, EFV & TBP Distillation
Atmospheric and Vacuum Distillation, Absorber, Stripper, Splitter, Prefractionator; Distillation with trays & packed bed, Divided wall column
Gas Plant operations – gas-liquid separation equipment, separation principles, stage-wise separation, low temperature separation and dehydration & desulfurization
City gas distribution, Gas utilization as fuels in industrial, commercial, residential and power generation.
Recommended Books:
1. Fundamentals of Natural Gas processing – A. J. Kidnay, W. R. Parrish, D. G. McCartney, CRC Press, 2011
2. Petroleum Refinery Engineering – W. L. Nelson, McGraw –Hill
3. Fundamentals of Petroleum and Petrochemical Engineering, U. Ray Chaudhuri, *CRC* Press, Taylor & Francis group, 2013

4. Crude Oil Chemistry, V. Simanzhenkov, R. Idem, Marcel Dekker, Inc., 2016
5. Modern Petroleum Technology, Vol. II, A. G. Lucas, John Wiley & Sons Ltd., 2000
6. Fundamentals of Petroleum Refining, M. A. Fahim, T.A. Alsahhaf, A. Elkilani, Elsevier, 2010
7. Fundamentals of Reservoir Engineering, L. P. Dake, Elsevier, 1998

PFC: Pharmaceutical and Fine Chemical Technology I

Module I: Pharmaceutical Chemistry

Concepts of pharmacokinetics, pharmacodynamics and bioavailability.

Principles of pharmacopoeial analysis, Source of pharmaceuticals and impurities concepts, API and excipients studies.

Source, biogenesis, extraction techniques and chemistry of alkaloids, terpenoids, steroids, glycosides and polyphenols.

Instrumental techniques in drug analysis including UV-Vis, FTIR, NMR, AAS, Flourimetry, HPLC and HPTLC. Principles and applications of optical microscopy, SEM, TEM and AFM.

Module II: *Pharmaceutical Biotechnology*

Unit I: Microbiology

Classification of microbes, identification, isolation, preservation, growth and kinetics.

Sterilization techniques and disinfection. Principles of cell based studies like flow cytometry and confocal microscopy.

Unit II: **Biochemistry**

Metabolic pathways and electron transport chain, proteins biosynthesis, DNA/RNA biogenesis. Enzymes, classification, kinetics, coenzymes, inhibitors, immobilization and biotransformation.

Recommended Books:

1. D. A. Skoog: Principles of Instrumental Analysis (Saunders College Publishing Philadelphia)
2. M. Orchin and H. H. Jaffe – Theory and applications of ultra violet spectroscopy (John Wiley and Sons, N. Y.)
3. Silverstein, Basserler, Moriil – Spectrometric identification of organic compounds (John Wiley and Sons, N. Y.)
4. Willard, Merritt, Dean – Instrumental Methods of Analysis (CBS Publishers and Distributors, Delhi)
5. J. R. Dyer – Applications of Absorption Spectroscopy of Organic compounds (Prentice Hall, London)
6. C. N. R. Rao – Chemical application of Infra-red spectroscopy (Academic press, N.Y.)
7. Higuchi: Instrumental Methods of Analysis (CBS Publishers)
8. Analytical Chemistry by open learning series
9. R. J. Hamilton – Introduction to High Performance Liquid chromatography, (Chapman and hall, London).
10. Ewing – Instrumental Methods of Chemical Analysis (McGraw Hill Book Co. New York)
11. Indian Pharmacopoeia, VIIth Ed, 2014, Indian Pharmacopoeia Commission
12. Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed. by J Mendham**,** Pearson
13. J H Block, F Roche, I O Soine and C O Wilson, Inorganic Medicinal and Pharmaceutical Chemistry, Lea and Febiger, Phildelphia, P A.
14. Handbook of Pharmaceutical Excipients, Raymond C. Rowse, Paul J. Sheskey, Marian E. Quinn, Pharmaceutical Press, 2009.
15. Essentials of Biochemistry by U Satyanarayana. Publisher- Books and Allied (p) Ltd. Edition-5th.

16. The Cell: A Molecular Approach by Geoffrey M. Cooper. Publisher- Sinauer Oxford University Press. Edition- 7th.
17. Lehninger Principles of Biochemistry by David L. Nelson, Michael M. Cox. Publisher W. H. Freeman. Edition- 7th.
18. Biochemistry by Debajyoti Das. Publisher- Academic Publishers. Edition- 14th.
19. Microbiology by Michael Pelczar. Publisher- McGraw-Hill Inc. Edition- 6th.
20. Nester's Microbiology: A Human Perspective by Denise G. Anderson. Publisher-McGraw-Hill Education. Edition- 8th.
21. General Microbiology by Roger Stanier. Publisher- Palgrave Macmillan. Edition- 5th.
22. Fundamental Principles of Bacteriology by Anthony Joseph Salle. Publisher- Tata McGraw-Hill Education. Edition- 4th.

(Practical)

Paper Code: PCC-CT405 **50 marks /1.5 Credits**

Chemical Engineering Lab. I

Experiments on

1. Flow of fluid through packed beds
2. Fluidization
3. Elutriation
4. Flowmeters
5. Pumps
6. Heat transfer coefficients
7. Mass transfer coefficients
8. Evaporation
9. Leaching
10. Valves and fillings
11. Verify Bernoulli's equation
12. Terminal velocity.

Recommended Books:

1. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, 6th Ed., McGraw – Hill, International Edition, 2001.
2. J. P. Holman, Heat Transfer, 8th Ed., McGraw - Hill, 1997
3. R. W. Fox and A. T. McDonald, Introduction to fluid mechanics, 5th Ed., John Wiley & Sons, 1998.
4. R. E. Treybal, Mass Transfer Operations, 3rd Ed., McGraw –Hill, International Edition, 1981.
5. J. T. Banchero, Introduction to Chemical Engineering, Tata McGraw-Hill, International Edition, 1997.
6. C. J. Geankoplis, Transport Processes and Unit Operations, 3rd Ed., Prentice Hall, India,1993.
7. D.Q. Kern, Process Heat Transfer, 2nd Ed.,Tata McGraw - Hill, 1997.

Paper Code: PCC-CT406 **50 marks /1.5 Credits**

Instrumental Method of Analysis

1. Basic Principles, Instrumentation and application of
   a. GC
   b. HPLC
   c. UV and VIS spectrophotometers
   d. IR

e. DTA and
f. TGA.

2. Instrumentation and application of
   a. Conductometry and
   b. Potentiometry.

Paper Code: PEC-CT407 CER/OLT/PPR/PFC **50 marks /1.5 Credits**
Special Lab I

CER: Ceramic Engineering Lab I

(At least five experiments has to be done from the following)

Chemical Analysis of Ceramic Raw Materials and Products:
Opening of different types of ores and minerals by chemical interaction.
Chemical analysis of water and acid soluble materials:
Water glass, Borax, Zeolites, Blast furnace slag, Magnesite, Dolomite, Limestone.
Analysis of materials by fusion method:
Refractories: Bauxite, Kyanite, Sillimanite, Chromite, Quarzite.
Fluxes: Feldspar, Slags, Nepheline Syenite
Clays: China clay, Fire clay, Bentonite, Mica and Vermiculite.
Miscellaneous: Rock phosphate, Gypsum, Hematite, Ilmanite, Talc and Cryolite.
Estimation of some special constituents in:
Zircon, Chromite, Lepidolite, Fluorapatite, Synthetic mullite.

OLT: Oil Technology Lab I
Analysis of oils & meals
Analysis Oils: Physical tests- density, refractive index, slip point, cloud point, cooling curve, solubility – tests in solvents, color measurements, etc. Fatty acid composition analysis by GLC. Conjugated diene, triene content by UV method.
Chemical tests – acid value, peroxide & anisidine values, saponification and iodine values, hydroxyl values, oxirane values, Reichert-Meissl, Reichert-Polenske, Kirchner values, unsaponifiable matter, gum (phospholipids) content, wax content, acetone and benzene insolubles, color reactions of oils. Detection of adulterants.

Recommended Books

1. Official Methods and Recommended Practices AOCS of the AOCS
2. A Treaties on Analysis of Food, Fats & Oils – A. R. Sen, N. K. Pramanik, S. K. Roy
3. FSSAI Manual of Methods of Analysis of Foods, Oils & Fats , 2015

PPR: Petrochemicals & Petroleum Refinery Engineering Lab I
Analysis & Testing of Petroleum and related Products I
Distillation of Petroleum products by ASTM method
Construction of Mid percent and Yield curves
Standard ASTM/IP tests of Lube oil, Grease & Petroleum wax - Softening point, Dropping point, Cone penetration, Needle penetration, Foaming tendency, Roll stability, Leakage tendency, Viscosity & Viscosity Index, Deemulsification number

Recommended Books:

1. IP Standard Test Methods for Analysis & Testing of Petroleum and related Products, Energy Institute, 2012.
2. Annual Book of ASTM Standards, ASTM International, 2019.

3. Petroleum Refinery Engineering (4th Ed) – W. L. Nelson, McGraw –Hill

PFC: Pharmaceutical and Fine Chemical Technology Lab – I
Pharmaceutical Chemistry I

1. Pharmacopoeial tests and assay of representative organic and inorganic compounds like sodium chloride, sodium benzoate, aluminium hydroxide gel etc.
2. Limit tests for arsenic, heavy metals and anions.
3. Laboratory preparation for Pharmacopoeial compounds in one or two step: aluminium hydroxide gel, sodium benzoate, sodium chloride.

Recommended Books:

1. A. H. Beckett & Stenlake, Text Book of Practical Pharmaceutical Chemistry, Vol. I & II.
2. Indian Pharmacopoeia, VIIth Edn, 2014, Indian Pharmacopoeia Commission.

Paper Code: PEC-CT408 CER/OLT/PPR/PFC **50 marks /1.5 Credits**
Special Lab II

CER: Ceramics Engineering Lab II

Chemical Analysis of Ceramic Raw Materials and Products:
Analysis of some redox systems.
Alkalis in feldspar and glass.
Boric Oxide in glass.
Estimation of ceramic material by atomic absorption spectroscopy:
Fe^{3+}, Ti^{4+}, Co^{2+}, Ni^{2+} and Mn^{2+} .
Identification of phases in ceramic raw materials and products by:
Microscopic technology, DTA & TGA.
Evaluation of some solid industrial waste materials and their utilization.
Clay testing: Particle size distribution by Andreasen pipette method, Cation Exchange Capacity, Water of plasticity, Atterberg plasticity Index.

Recommended Books:

Quantitative Inorganic Analysis – A. I. Vogel
Analysis of ceramic raw materials – S. Kumar and D. Ganguli

OLT: Oil Technology Lab II
Fats and Oil Processing
Practical on oilseeds and Oils/Fats etc.; Pretreatment and storage of oil-bearing materials; Extraction of oils and fats from vegetable and animal sources: pressing, solvent rendering; Analysis of seed cakes; Extraction of protein and other non-oil components such as dietary fibre, carbohydrate etc. Detection of adulteration.
Recommended Books

1. Official Methods and Recommended Practices AOCS of the AOCS
2. A Treaties on Analysis of Food, Fats & Oils – A. R. Sen, N. K. Pramanik, S. K. Roy
3. FSSAI Manual of Methods of Analysis of Foods, Oils & Fats , 2015

PPR: Petrochemicals & Petroleum Refinery Engineering Lab II
Analysis & Testing of Petroleum and related Products II

Standard ASTM/IP tests of different liquid fuels – Flash point, Fire point, Pour point, Ramsbottom carbon residue, Burning quality of kerosene, Sulfur content, Water content, Sediment, Smoke point, Ash content, Inorganic acidity, Acid number

Recommended Books:

1. IP Standard Test Methods for Analysis & Testing of Petroleum and related Products, Energy Institute, 2012
2. Annual Book of ASTM Standards, ASTM International, 2019
3. Characterization and Properties of Petroleum Fractions, M. R. Riazi, ASTM International, 2005

PFC: Pharmaceutical and Fine Chemical Technology Lab II

Pharmaceutical Biotechnology-I

1. Different media preparations
2. Sterilization by dry heat, moist heat and filtration.
3. Validation of sterilization
4. Environmental control tests
5. Microbial staining
6. Identification and isolation from soil sources.
7. Tests and quantification for proteins, carbohydrates, fats and amino acids.

Recommended Book(s):

1. Microbes in action: A Laboratory Manual of Microbiology, H.W. Seeley, W.H. Freeman, 4th Edn.

Semester V
(Theory)

Paper Code: PCC-CT501
Material Science & Technology **100 marks /4 Credits**

Unit 1: Engineering materials – classification and application. Structure-property-processing-performance correlations.

Unit 2: Atomic structure and bonding in materials. Crystal structure of materials. Crystal systems, unit cells and space lattices, miller indices of planes and directions, packing geometry and close packed structures. Imperfections in crystalline solids: point, line, surface and volume defects, non-stoichiometry.

Unit 3: Concept of amorphous, single and polycrystalline structures, Nucleation and grain growth. Non-crystalline materials: silicate glasses, glass transition temperature, viscoelasticity.

Unit 4: Phases in metallic system, solid solutions, phase rule, binary phase diagrams, iron-iron carbide phase diagram and its application in iron and steel metallurgy, isothermal transformation, T-T-T diagram, martensite formation, continuous cooling transformation.

Unit 5: Heat treatment of steel – annealing, hardening, tempering, normalizing, spheroidising, flame hardening. Fick's law and its application – carburizing, nitriding, cyaniding etc. Basic principles of powder metallurgy. Corrosion and oxidation of materials, principles and prevention.

Unit 6: Polymerization, classification of polymers – thermoplasts, thermosets, elastomers – structure, properties, processing and applications.

Unit 7: Advanced materials: Optical fiber, Laser glass, Superconductors, Piezoelectric, Ferroelectric, Optoelectric materials, Carbon-based materials, Polymer nanocomposites, Biomaterials, Shape memory alloys, Fuel cells, Sensors, Membranes, Liquid crystals and amphiphiles, Zeolites.

Unit 8: Mechanical properties: Stress-strain diagram of metallic, ceramic and polymeric materials, modulus of elasticity, tensile strength, yield strength, toughness, plastic deformation, hardness, ductile and brittle fracture, creep, fatigue, role of reinforcement-matrix interface strength on composite behavior.

Unit 9: Electronic properties: Band theory of metals, conductors, semiconductors, insulators, electrical conductivity, dielectric properties.

Unit 10: Fundamentals of thermal, electrical, optical and magnetic properties.

Recommended Books:

1. Elements of Materials Science and Engineering – L. H. Van Vlack
2. Materials Science and Engineering: A First Course – V.Raghavan
3. Materials Science and Engineering: An Introduction – W. D. Callister and D. G. Rethwisch
4. Materials Science and Engineering – W. F. Smith, J. Hashemi and R. Prakash
5. The Science and Engineering of Materials – D. R. Askeland

Paper Code: PCC-CT502 **100 marks /4 Credits**

Chemical Engineering III - Mass Transfer Operations

General principles of diffusion and mass transfer, Molecular and eddy diffusion of fluids, Diffusivities,

Convective mass transfer: Mass transfer coefficients and their relationships, Interphase mass transfer, N.T.U., H.T.U. methods.

Mass transfer theories and models

Distillation: Vapour-liquid equilibria, batch and equilibrium distillation, Steam distillation, azeotropic and extractive distillation, Enthalpy concentration diagram, Rectification column design, McCabe – Thiele method, Ponchon – Savarit method.

Simultaneous heat and mass transfer operations: Humidification and Dehumidification principles, psychometric chart, Drying principles and driers.

Recommended Books:

1. 1 Mass Transfer Operations - R. E. Treybal, 3rd Ed., McGraw -Hill International Edition, 1981.
2. Principles of Mass Transfer and Separation Processes - B.K. Dutta, 1st Ed., Prentice Hall of India, 2007.
3. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, 6th Ed., McGraw - Hill International Edition, 2001
4. P. C. Wankat, Equilibrium-Staged Separations, Prentice Hall, 1989
5. C. J. Geankoplis, Transport Processes and Unit Operations, 3rd Ed., Prentice Hall, India, 1993.

Paper Code: OEC-CT503 **100 marks /4 Credits**

Elective V: Reaction Engineering/ Material Characterization Techniques

A. Reaction Engineering

Module I

Effects of process variables on rate of reaction, interpretation of kinetic data in batch and flow systems.

General feature and design equation for batch, plug flow, semi batch, stirred tank reactors.

Elementary problems in the design of homogeneous reactors, batch and flow tubular and stirred tank reactors.

Analysis and correlation of experimental kinetic data – data collection & plotting, linearization of rate equations, differential and integral method of analysis.

Multiple reactions – conversion, selectivity, yield, series, parallel and mixed series –parallel reactions.
Combination of reactors
RTD theory and analysis of non-ideal reactors.

Module II
Introduction to Catalysis, homogeneous and heterogeneous catalysis, preparation and characterization of catalysts
Physical & chemical adsorption, Adsorption Isotherms, measurement of catalyst surface area and catalyst porosity
Mass transfer, Diffusion and chemical reactions in catalysts, Effects of external mass transfer and heat transfer, Effectiveness factor. Design aspects of catalytic reactors.
Laboratory reactors for gas-solid reactions, design concepts.
Gas liquid reactions, film & penetration theories, gas-liquid reactors.

Recommended Books:

1. 1.O. Levenspiel, Chemical Reaction Engineering, 2nd Ed., Wiley Eastern, 1972.
2. J. M. Smith, Chemical Engineering Kinetics, 3rd Ed., McGraw Hill, 1980.
3. H. S. Fogler, Elements of Chemical Reaction Engineering

B. Material Characterization Techniques
Unit 1: Differential Thermal Analysis (DTA), Thermo-gravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC) and Dilatometry – basic principles, instrumentation and analysis of data. Different factors (particle size, packing, purity, environment and heating rate) affecting on DTA/DSC/TG curves. Different case study in ceramic applications. Study of sintering kinetics by dilatometry.
Unit 2: Principles of X-ray Diffractometer (XRD), X-ray generation, diffraction, Bragg law, Diffraction under ideal and non-ideal conditions, Scattering and structure factor, X-ray data file and its analysis, indexing of crystal type.

Unit 3: Principles and different parts of optical and electron Microscope (optical, SEM/FESEM, TEM). Secondary and back-scattered electrons. Bright field and Dark field, Contrast mechanism, indexing of electron ring diffraction pattern. Sample preparation, Image interpretation.

Unit 4: Chemical analysis, EDX and WDX, Principle and operation of spectroscopy.

Unit 5: Particle Size Analysis, Surface area and porosity – basic principle and data analysis.

Paper Code: PEC-CT504 CER/OLT/PPR/PFC
Special Paper II **100 marks /4 Credits**
CER: Ceramic Engineering II

Module I: Refractories: Processing and Properties

Unit1: Definition of refractory. Classification of refractories. Properties of refractories – physical, mechanical, thermal, thermo-mechanical, chemical, wear, thermal shock, etc. Details of evaluation of different types of refractory properties, like, bulk density, porosity, shrinkage, PCE, RUL, HMOR, creep, PLCR, spalling resistance, static & dynamic corrosion, thermal expansion, thermal conductivity, etc. Standard specification and methods for evaluation of different properties.

Unit 2: Silica refractories – raw materials, manufacturing methods, properties, details of application. Fireclay refractories – grog, raw clay, manufacturing method, properties, classification and

applications. Alumina refractory – raw materials, variation of raw materials with purity, processing, properties and details of applications. Magnesia refractories – details of raw materials, processing, manufacturing method, properties, applications. Dolomite refractories - raw materials, processing, manufacturing method, properties, applications.

Unit 3: Spinel-containing refractory- preparation of Magnesium Alumniate (MA) spinel powders and aggregates, MgO–MA refractories, Al2O3–MA Refractories, details of raw materials, processing, manufacturing method, properties, bonding system, applications. Carbon in refractory and its importance, Magnesia carbon refractories – advantages, raw materials, binder and additives, carbon content, processing, properties, applications.

Unit4: Monolithic refractories (castables, plasatic and rammimg mixes, gunning mixes, refractory mortar), ceramic fibres, advantage of monolithic refractories over shaped refractories, insulating refractories of different kinds ,their manufacturing, properties and applications.

Recommended Books:

1. Introduction to Ceramics – W. D. Kingery, H. K. Bowen, D. R. Uholmann
2. The Technology of Ceramics and Refractories – P. P. Budnikov
3. Hand book of Ceramics (Vol. I & II) – S. Kumar
4. Introduction to Refractories for Iron- and Steelmaking- S. Biswas, D. Sarkar
5. Steel plant refractories – J. H. Chester
6. Refractories – F. H. Norton.
7. Refractory Materials-S. Biswas

OLT: Oil Technology II

Module I: Extraction & Refining of Fats & Oils

Extraction:

Basic principle involving extraction of fats and oils from oil-bearing material (Theory and Practice), pretreatment process and equipment, Handling, storage, grading and pretreatments (Mechanical and Heat Treatments) of oil-bearing materials: Extraction of fats and oils (Theory and Practice): extraction by pressing (Expeller, Extruder) Cold Pressing, Solvent Extraction solvents (polar and nonpolar) and renewable solvents (supercritical gases, alcohols, acetone, limonene, water etc.). Advantages and disadvantages of all the processes. Basic extractor design, heat, and solvent recovery. Extraction by biotechnology process including enzyme-assisted processes, extraction technology for recovery of starch, protein, dietary fiber, and other constituents from seeds, cakes, and meals for food, feed, and industrial processes.

Interpretation and understanding of the technology for recovering animal fats and marine oils. Utilization of byproduct after oil extraction from oil-bearing material. Rendering technology for recovering animal fats and marine oils. Utilization of oil cakes; Desolventisation and utilization of oil meals

Refining:

An overview of different undesirable components in oils and fats to be removed, associated techniques, removal of fat insoluble impurities, and associated unit operations (filtration, sedimentation, and centrifugation). Limitations.

Removal of fat-insoluble impurities (filtration, sedimentation, centrifugation, etc.) Removal of fat-soluble impurities: degumming (chemical and enzymatic).

Degumming: Different types of Phospholipids; Various types of Degumming: (chemical and enzymatic), Centrifugation Basics. Monitoring with analytical techniques.

Deacidification/Neutralization: (chemical refining & physical refining: Advantages and disadvantages; Selection of the Process; Esterification, Miscella – single & mixed solvent refining, etc.), Monitoring with FFA determination.

Bleaching (chemical, adsorptive & enzymatic), Design of Different types of Bleachers, Bleaching conditions, Adsorption mechanism, Different types of Adsorbents
Dewaxing/Winterization: Oils like Rice Bran, Sunflower, etc. Dewaxing Conditions, Crystalizer design, and Nucleation & growth of wax crystals. Effect of types of bran, Weather, etc.
Utilization of refinery by-products (gums, soap stocks, deodorizer distillates, fatty acid distillates, waxes, spent bleaching earth, etc.)

Module II: Paints & Pigments
Mechanism of polymerization and kinetics of polymerization process**.**
Polymer structures, molecular weights, mechanical properties, glass transition temperate & the crystallinity of polymers concerning molecular weight, kinetics of free radical and addition polymerization, and thermodynamics of polymerization. 'Alkyd calculation', Polymerization during curing of polymers/resins (Long oil Alkyd, Acrylic/MF, Polyester/MF, Epoxy/Amino, etc.)
Fundamentals of pigmented coatings; Principles of paint colour matching;
Pigment-binder geometry, Role of PVC, CPVC, Oil absorption value, Bulk density on paint formulations. Principle of paint formulation using different types of pigments. Role of Extender pigments, Colouring pigments, Black pigments, Anticorrosive pigments, etc. on paint formulations.

Recommended Books:

1. Baileys's Industrial Oil and Fat Products
2. Physical Chemistry of Polymers - A Tager
3. Organic Coatings - Zeno W. Wicks, Jr. Frank N. Jones, S. Peter Pappas, Douglas A. Wicks
4. Formulating and Processing for Application - Richard D. O'Brien
5. Organic Coating Technology – H F Payne

PPR: Petrochemicals & Petroleum Refinery Engineering II
Module I: Refinery Operations II
Processing of Light Distillates: Alkylation, Isomerization, Catalytic Reforming, Polymerization-stoichiometry and process technologies, operating conditions & application, role of catalyst in reaction
Sweetening by Amine treatment, Merox process – stoichiometry and process technologies, operating conditions and role of catalyst in reaction mechanism. Elemental sulfur recovery by Claus process
Thermal Cracking: Visbreaking and Coking: Delayed Coking, Fluid Coking and Flexicoking
Catalytic Cracking: Fluidized catalytic cracking, Hydrocracking of crude and vacuum distillates, DCC
Hydrotreatment process: Hydrodesulfurization, hydrodenitrification, olefin saturation, aromatic saturation, Resid hydrotreatment & cracking: desulfurization of residue, hydrocracking of residue – theory, process technologies covering operating conditions, catalyst use and application.
Module II: Petrochemicals Fundamentals
Petrochemical Industries Overview: Growth in India, classification of Petrochemicals, C_1, C_2 gas industries
Feedstocks for Petrochemical Industries: Preparation of feedstocks from ethane, propane, naphtha cracking, gas oil & Syn. Gas reforming
Basic Petrochemicals such as Synthesis Gas, Olefins, Aromatics, Naphthenes & Dienes – manufacture, thermodynamic and kinetic aspects

Recommended Books:

1. Petrochemical Processes – Technical & Economical Characteristics – A. Chauvel & G. Lefebvre Institute Francis Du Petrole

2. Petrochemical Industries –Technology & Processes – C. R. Lahiri & Dipa Biswas, CBS Publishers
3. Chemical Process Technology – J. A. Moulijn, M. Makkee, A. van Diepen, Wiley Publishers
4. Handbook of Petroleum Refining Processes, Robert A. Meyers, McGraw-Hill, 2004
5. Fundamentals of Petroleum Refining, M. A. Fahim, T.A. Alsahhaf, A. Elkilani, Elsevier, 2010
6. Petroleum Refining Processes, James Speight, CRC Press, Taylor & Francis group, 2014
7. The Chemistry & Technology of Petroleum, James Speight, CRC Press, Taylor & Francis group, 2006
8. Petroleum Refining, 3 Conversion Processes, P. Leprince, Editions Technip, 2001
9. A Text on Petrochemicals, B. K. Bhaskara Rao, Khanna Publishers, 2022
10. Springer Handbook of Petroleum Technology, Chang Samuel Hsu, Paul R. Robinson, Springer, 2017
11. Petroleum Science and Technology, Chang Samuel Hsu, Paul R. Robinson, Springer, 2019
12. Thermal and Catalytic Processes in Petroleum Refining, Serge Raseev, CRC Press, 2003
13. Handbook of Petroleum Processing, David Jones, Peter Pujado, 2006

PFC: Pharmaceutical and Fine Chemical Technology II

Module I: Medicinal Chemistry-I

Medicinal Chemistry of drugs acting on cardiovascular systems like cardiac glycosides, vasodialators, anti-anginal, anti-hypertensives. Local anaesthetics and NSAIDs.

Module II: Pharmaceutical Technology I

Unit 1: Manufacturing techniques of different solid dosage forms, like tablets, capsules, powders and granules. Testing techniques and compliance for different solid oral dosage forms. Machinery requirements.

Manufacturing techniques and formulation concepts for different semisolid dosage forms including emulsions, suspensions, ointments, lotions, creams and suppositories. Testing techniques and compliance for semisolid dosage forms. Machinery requirements.

Unit 2: Bacterial Genetics. Recombinant DNA Technology and applications.

Types of Immunity, Application principles and manufacturing techniques for different immunological products.

Recommended Books:

1. Goodman and Gilman: Pharmacological Basis of Therapeutics, Pregamon Press, New York.
2. Foye's Principles of Medicinal Chemistry, 7th Ed, Thomas L. Lemke, David A. Williams, Victoria F. Roche, S. William Zito, Wolters Kluwer, 2012.
3. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, Charles Owens Wilson, Lippincott Williams & Wilkins, 2004.
4. Basic Concepts in Medicinal Chemistry, Marc W. Harrold and Robin M. Zavod, American Society of Health-System Pharmacists, 2013.
5. Medicinal Chemistry, Ashutosh Kar, New Age International
6. Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems, Loyd Allen and Howard C. Ansel, Lippincott Williams & Wilkins, 2013.
7. Pharmaceutical Preformulation and Formulation: A Practical Guide from Candidate Drug Selection to Commercial Dosage Form, Mark Gibson, CRC Press, 2016.
8. Remington: The Science and Practice of Pharmacy, David B. Troy, Paul Bering, Lippincott Williams & Wilkins, 2006.
9. The Theory and Practice of Industrial Pharmacy, Herbert Lieberman and Leon Lachman, CBS Publishers, 2013.

10. Aulton's Pharmaceutics: The Design and Manufacture of Medicines, Michael E. Aulton, Kevin Taylo, Elsevier Health Sciences, 2013.
11. Kuby Immunology by Thomas J. Kindt,Barbara A. Osborne, Richard Goldsby. Publisher- W H Freeman & Co (Sd). Edition- 6th.
12. Cellular & Molecular Immunology by Abul K. Abbas and Andrew H. Lichtman. Publisher- Saunders. Edition- 7th.
13. Prescott and Dunn's Industrial Microbiology by Gerald Reed. Publisher- Chapman & Hall. Edition- 4th.
14. Industrial Microbiology by A.H. Patel. Publisher- Trinity Press. Edition- 2nd.

(Practical)

Paper Code: PCC-CT505

Chemical Engineering Lab. II **50 marks /1.5 Credits**

Experiments on:

1. Specific surface area of powders
2. Raleigh equation
3. Vapour-liquid equilibrium data
4. Spray drying
5. Crushing and grinding
6. Distillation
7. Liquid-liquid extraction
8. Absorption
9. Drying and
10. Filtration.

Recommended Books:

1. W. L. McCabe, J. Smith and P. Harriot, *Unit Operations of Chemical Engineering*, 6th Ed., McGraw – Hill, International Edition, 2001.
2. W. L. Badgerand J. T. Banchero, *Introduction to Chemical Engineering*, Tata McGraw-Hill, International Edition, 1997
3. R. W. Fox and A. T. McDonald, *Introduction to fluid mechanics*, 5th Ed., John Wiley & Sons, 1998.
4. R. E. Treybal, *Mass Transfer Operations*, 3rd Ed., McGraw –Hill, International Edition, 1981.
5. C. J. Geankoplis, *Transport Processes and Unit Operations*, 3rd Ed., Prentice Hall, India,1993.

Paper Code: PCC-CT506

Environment Technology Lab **50 marks /1.5 Credits**

1. Classification of chemically hazardous compounds and MSDS. BOD, COD and TOC studies
2. Analysis of heavy metal including arsenic and anions like fluorides, dye and pesticides in water and soil.
3. Estimation of sulphur compounds and carbon monoxide in air

Recommended Book(s):

1. A laboratory manual for environmental chemistry, R. Gopalan, A. Anand, R.W. Sugumar, One K Internal Publishing House Pvt. Ltd., 2008.

Paper Code: PEC-CT507 CER/OLT/PPR/PFC
Special Lab III **50 marks /1.5 Credits**

CER: Ceramics Engineering Lab III

Preparation and testing of refractory Materials:

Raw materials: Hardness, texture

Study of thermal decomposition behavior of dolomite/magnesite/clay. Effect of particle size and heating rate on DTA/DSC/TGA curves. Thermal expansion behavior and determination of thermal expansion coefficient of ceramic samples. Determination of particle size and zeta potential. Determination of surface area and pore size distribution using BET.

Refractory product testing: Testing and evaluation of various important properties of refractories such as Fusion range, Refractoriness under load, Porosity, Modulus of rupture, Thermal expansion, reheat shrinkage, Thermal spalling, Thermal conductivity, Refractory corrosion test as per IS specification

Preparation: Fabrication of some high alumina & basic bricks. Fabrication of refractory shapes by semi dry and dry process, drying and firing characteristics. Synthesis of aggregates, bonding materials and precursors by conventional and non-conventional method. Preparation of silica gel, precipitated silica, microfine silica, alumino-silicate hydrogel.

Processing and casting of castable composition using planetary mixer and vibrator. Curing, drying and firing of the same. Effect of casting parameter on the properties of castable. Study of densification and strength development in the castable with temperature.

Data analysis of an X-ray profile. Determination of crystallite size, lattice parameter, strain and phase analysis using XRD. Study of amorphous, crystalline, cubic, tetragonal, and monoclinic phase using XRD.

Image analysis of optical and SEM/FESM.

Recommended Books:

1. Quantitative Inorganic Analysis – A. I. Vogel
2. Analysis of ceramic raw materials – S. Kumar and D. Ganguli
3. Refractories: Production and Properties– J. H. Chester

OLT: Oil Technology Lab III
Fats and Oil Processing

Refining (degumming, deacidification, bleaching, deodorisation and physical refining) of fats/oils; Modification (hydrogenation, interesterification, fractionation, blending) of fats/oils for edible and industrial products; Hydrolysis of oils/fats (chemical and biochemical); Esterification, epoxidation and hydroxylation of oils. Edible fat products like margarine and cocoa butter substitute.
Preparation and analysis of biodiesel.
Recommended Books

1. Official Methods and Recommended Practices AOCS of the AOCS
2. A Treaties on Analysis of Food, Fats & Oils – A.R.Sen, N.K.Pramanik, S.K.Roy

3. FSSAI Manual of Methods of Analysis of Foods, Oils & Fats , 2015

PPR: Petrochemicals & Petroleum Refinery Engineering Lab III
Refinery Operations
Aromatics Separation by Solvent Extraction and Construction of Equilibrium Curve
Construction of Mid percent and Yield curves
ASTM Distillation of Crude oil, Construction of Mid percent and Yield curves, Blending (pour point, RVP, Flash point, Viscosity)

Recommended Books:

1. Principles of Mass Transfer and separation Processes, B. K. Dutta, Prentice-Hall of India
2. Mass-Transfer operations, Robert E. Treybal, McGraw Hill Education, 2017.
3. Distillation, Matthew van Winkle, McGraw Hill Education, 1967

PFC: Pharmaceutical and Fine Chemical Technology Lab II

Pharmaceutical Chemistry II
1. Extraction and estimation of alkaloids.
2. Tests and quantification of natural products like alkaloids, steroids, terpinoids, polyphenolics.
3. Estimation of alcohol in bonded preparations.
4. Standardization of fats and oils.
5. Analysis of vitamins.

Books Recommended:

1. Trease and Evans Pharmacognosy, William Charles Evans, Daphne Evans, George Edward Trease, Saunders/Elsevier, 2009
2. Practical Pharmacognosy: Techniques and Experiments, 19th Ed K. R. Khandelwal, Nirali Prakashan, 2008.
3. Indian Pharmacopoeia, VIIth Ed, 2014, Indian Pharmacopoeia Commission
4. The Analysis of Fats and Oils, V. C. Mehlenbacher, Garrard Press
5. Vitamin Analysis for the Health and Food Sciences, Ronald R. Eitenmiller, W. O. Landen, Jr, Lin Ye, CRC Press, 2016.

Paper Code: CT508 CER/OLT/PPR/PFC
Special Lab IV **50 marks /1.5 Credits**

CER: Ceramics Engineering Lab IV

Whiteware lab:

Preparation of Whiteware body, milling of raw materials, rheological measurement of slip, fabrication of green body, by slip casting, pressing, drying & firing biscuit and glost firing.
Preparation of glazes & application of glaze on body, and firing.
Determination of water absorption, True density, Bulk density & Modulus of rupture of various fired whiteware bodies.
Determination of thermal shock resistance of fired white ware bodies.
Measurement of glaze thickness by Penetrometer.
Determination of acid solubility of ceramic body & glaze. Determination of alkali solubility of ceramic body & glaze.
Compilation of some triaxial composition and fabrication by slip casting, tape casting technique.

Recommended Books:

1. Bureau of Indian Standard (BIS) manuals

OLT: Oil Technology Lab IV

Surface Coating I

Preparation, analysis and testing of stand oil, blown oil, double boiled oil, dehydrated castor oil, and chemically modified drying oils.

Preparation, analysis and testing of Linoleate, rosinate, octoate, and naphthenate of Lead, Cobalt, Manganese and Zinc;

Analysis and testing of solvents;

Preparation, analysis and testing of ester gum, limed rosin, phenolics, oleoresinous varnish and spirit Varnish

Recommended Books

1. Official Methods and Recommended Practices AOCS of the AOCS
2. A Treaties on Analysis of Food, Fats & Oils – A. R. Sen, N. K. Pramanik, S. K. Roy
3. FSSAI Manual of Methods of Analysis of Foods, Oils & Fats, 2015

PPR: Petrochemicals & Petroleum Refinery Engineering Lab IV

Catalyst preparation and Hydrodesulphurisation & Hydrocracking operations

Catalysts Preparation for Hydrodesulphurization and Hydrocracking

Hydrodesulphurization and Hydrocracking operation in High Pressure Batch Reactor.

Recommended Books:

1. Catalyst in Petroleum Refining and Petrochemical Industries, M. Absi-Halabi, J. Beshara, H. Qabazard, A. Stanislaus, Elsevier, 1996

PFC: Pharmaceutical and Fine Chemical Technology Lab IV

Microbiology

1. Differential staining
2. Isolation of lipase, amylase and protease producing organism and quantitative analysis.
3. Environmental studies like BOD, COD determination
4. CFU of bacteria
5. Pathogenicity testing of E. coli, Salmonella, Staphylococcus and Pseudomonas

Recommended Books:

1. Microbes in action: A Laboratory Manual of Microbiology, H. W. Seeley, W. H. Freeman, 4th Edn.

Semester VI
(Theory)

Paper Code: PCC-CT601

Chemical Technology IV

Module I: Numerical Analysis **50 marks /2 Credits**

Introduction, Approximation and Concept of Error & Error Analysis

Linear Algebraic Equations: Methods like Gauss elimination, LU decomposition and matrix inversion, Gauss-Siedel method, Chemical engineering problems involving solution of linear algebraic equations

Root finding methods for solution on non-linear algebraic equations: Bisection, Newton- Raphson and Secant methods, Chemical engineering problems involving solution of non-linear equations

Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression
Numerical integration: Trapezoidal rule, Simpson's rule, integration with unequal segments, quadrature methods, Chemical engineering problems involving numerical differentiation and integration
Ordinary Differential Equations: Euler method, Runge-Kutta method, Adaptive Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems involving single,and a system of ODEs
Introduction to Partial Differential Equations: Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method

Recommended Books:

1. Numerical Methods for Chemical Engineering: Applications in MATLAB,
2. Kenneth J. Beers, Massachusetts Institute of Technology, Cambridge University Press.
3. Introduction to Numerical Methods in Chemical Engineering, Pradeep Ahuja, PHI publication.
4. Numerical Methods with Chemical Engineering Applications, Kevin D. Dorfman and Prodromos Daoutidis, Cambridge Series in Chemical Engineering.

Module II: Modeling and Simulation **50 marks /2 Credits**

Unit I: Models and model building
Introduction, principles of model formulation, fundamental laws - continuity equation, energy equation, equations of motion, transport equations, equations of state, equilibrium and kinetics, classification of mathematical models.
Numerical solutions of model equations – Linear and non linear algebraic equations in one and more than one variables, ordinary differential equations in one and more than one variables.
Unit II: Lumped Parameter Models
Formulation and solution techniques to be discussed for Vapour liquid equilibrium models, dew point and flash calculations for multicomponent systems, boiling operations, batch and
continuous distillation models, tank models, mixing tank, stirred tank with heating, CSTR with mutiple reactions. Non-isothermal CSTR - mutiplicity and stability, control at the unsteady state.
Non-ideal CSTR models - multi-parameter models with dead space and bypassing, staged operations.
Unit III: Distributed Parameter Models (Steady State)
Formulation and solution of split boundary value problems - shooting technique, quasilinearization techniques, counter current heat exchanger, tubular reactor with axial dispersion, counter current gas absorber, pipe line gas flow, tubular permeation process, pipe line flasher.
Unit IV: Unsteady State Distributed Parameter Models
Solution of partial differential equations using finite difference method, convective problems,
diffusive problems. Unsteady state conduction and diffusion, unsteady state heat exchangers, dynamics of tubular reactor with dispersion. Transfer function models for distributed parameter systems.
Unit V: Model Parameters Estimation
Introduction, method of least squares, curve fitting, parameter estimation of dynamic transfer
function models – step and impulse response models, auto regressive Moving Average models, least square and recursive least square methods, parameter estimation of RTD models – moments method.

Recommended Books:

1. Denn M. M., "Process Modeling", Longman, 1986.
2. Holland C. D., "Fundamentals and Modeling of Separation Processes", Prentice Hall., 1975.
3. Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", 2nd Ed., McGraw Hill, 1990.
4. Najim K., "Process Modeling and Control in Chemical Engineering", CRC, 1990.

Paper Code: PCC-CT602

Chemical Engineering IV

Module I: Separation Process **50 marks /2 Credits**

Absorption of a single component from gas mixtures, Wetted-wall column, Packed columns, Plate column, Design of absorption towers, Desorption.

Liquid-liquid extraction: Equilibrium data, Use of triangular diagrams, Selectivity and choice of solvent, Extraction efficiency.

Principles of leaching.

Crystallization: Theory and crystallizers.

Adsorption

Modern separation processes: Membrane processes, Ion-exchange, Molecular sieve

Module II: Mechanical Operations **50 marks /2 Credits**

Size reduction: Energy and power requirements in comminution, size reduction equipment.

Screening: Particle size analysis, screening equipment, classification, cyclone separation, electrostatic precipitation, elutriation, jigging, flotation.

Filtration: Theory, equipment, filter medium, filter aid, centrifuges.

Mixing and agitation.

Recommended Books:

1. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, 6th Ed., McGraw - Hill, International Edition, 2001.
2. W. L. Badgerand J. T. Banchero, Introduction to Chemical Engineering, Tata McGraw-Hill, International Edition, 1997.
3. C. J. Geankoplis, Transport Processes and Unit Operations, 3rd Ed., Prentice Hall, India,1993

Paper Code: OEC-CT603

Elective VI: Safety & Hazard Analysis / Project Engineering **100 marks /4 Credits**

A. Safety & Hazard Analysis

Introduction: Safety program, engineering ethics, accident and loss statistics, acceptable risk, public perception. Material safety data sheet (msds), storage, handling and use of hazardous chemicals, occupational health hazards.

Toxicology: How toxicants enter & eliminate from biological system.

Industrial hygiene: Government regulations, identification, evaluation, control

Fires and explosions: The fire triangle, distinction between fire and explosions; definitions, flammability characteristics of liquids and vapors, loc and inerting, ignition energy, auto ignition, auto oxidation, adiabatic compression, explosions.

Designs to prevent fires and explosions: Inerting, explosion proof equipment and instruments, ventilation, sprinkler systems.

Introduction to reliefs: Relief concepts, definitions, location of reliefs, relief types, relief systems.

Hazards identification: Process hazards checklists, hazard surveys, hazop & hazan study.

QRA, Logic trees, FTA, ETA, Boolean notation

Safety Audit, Legal aspects of Safety (Factory's Act), On site Emergency plan.

Recommended Books :

1. System Safety Engineering and Risk Assessment: A Practical Approach, Second Edition, By Nicholas J. Bahr, CRC Press.

2. Elements of Industrial Hazards: Health, Safety, Environment and Loss Prevention, by By Ratan Raj Tatiya, CRC Press.

B. Project Engineering

Module I

Role of a project engineer, Development of project- Laboratory bench scale experiment to pilot & semi-commercial plant operation, scale up and scale down techniques, pre-design cost estimation, fixed capital and working capital, Manufacturing cost, plant location factors, selection of plant site, process design development, plant lay-out.

Module II

Time value of money, simple interest, Nominal & effective interest rates, continuous interest, present worth & discount, Annuities, perpetuities and capitalized cost, Depreciation,: Types of depreciation, Depletion, Concepts of service life, Salvage value and Book value; Depreciation calculation by straight line method, Text book and double declining balance method, sum-of-the-years digit method and sinking fund method.

Profitability analysis method: Return on investment (ROI), payout period, Optimum design, Break-even point, Optimum production rate, Optimum conditions in cyclic operations, optimum economic pipe diameters, optimum flow rate, & cooling water.

Module III

Project scheduling: Bar chart, Milestone chart, Concept of network analysis: PERT, CPM, statistical distribution associated with PERT network, Earliest expected time, and latest allowable occurrence time calculation, Slack, determination of critical path, concept of float.

Module IV

Inventory and Quality Systems: Function of Inventories, Category of Stocks, Procurement costs, Inventory Holding costs, Inventory Control, ABC analysis, Inventory control, EOQ, Inventory control modelling, Re Order Point, Lot Sizing and Analysis. Current Approaches: Concepts of MRP and JIT-based production systems, Concept of zero inventory, Computerization of inventory and production management systems.

Managing for Quality: Total quality emphasis, Quality circles, Quality analysis and control, Control Charts, UCL, LCL.

Recommended Books:

1. Projects, 8th Ed. by Prasanna Chandra, McGraw Hill Education
2. Production and Operation Management: Concepts, Models, and Behavior by Everett E Adam, Ronald J Ebert, Prentice Hall
3. Plant design and Economics for Chemical Engineers by Max S Peters, Klaus D Timmerhaus, Ronald E. West, McGraw-Hill Education
4. NPTEL lectures on Project Engineering and Management, https://nptel.ac.in

Paper Code: CT604 CER/OLT/PPR/PFC

Special Paper–III **100 marks /4 Credits**

CER: Ceramic Engineering III

Module 1: Glass Technology

Unit1: Concept of Glassy state, Structural requirement, Role of different glass forming oxides. Silicate and non-silicate glasses. Structure of Glass – XRD, SAXS and other methods of determining glass structure. Different types of commercial glasses and their compositions.

Unit 2: Raw materials for glasses – their availability, processing and batch calculation. Properties imparted by different constituents.

Unit 3: Design of the glass tank furnace and physicochemical considerations involved in the melting operations and refining. Batch melting reactions. Melting operations. Finishing, annealing of glasses. Strains, its detection, measurement and remedial measures,

Unit 4: Devitrification of glass. Viscosity of glass, measurement at different temperatures, its importance in different stages of glass melting , rheology of glass, elastic and visco-elastic properties of glasses.

Unit 5: Different types of furnaces, refractories and fuel required for glass melting. Different types of glass forming processes: Blowing, pressing, drawing by semiautomatic and automatic process. Sheet glass by different methods, fabrication of glass ware.

Recommended Books:

1. Fundamental of inorganic glasses – A. K. Vershneya
2. Chemistry of glasses – A. K. Paul
3. Introduction to glass science and technology – J. H. Shelby

Module-2: Hydraulic Binder

Unit 1: Different types of Hydraulic binders and their classification. Portland cement: Raw materials, quality, availability, processing, granulometry of raw materials, phase diagram of binary systems and some ternary systems. Additives for clinker making. Reactions during clinker formation in rotary kilns. Factors influencing the compound formation. Design of rotary and shaft kilns, Refractories used.

Unit 2: Component of Portland cement and their phase relationships. Properties imparted by different phases. Specifications of different types of cements, their properties and application. Theories of setting and hardening of Portland cement. Cement testing processes as per specifications.

Unit 3: Refractory cement: High alumina cement, their chemistry, manufacturing and characterization of different phases. Applications of high alumina cement.

Unit 4: Different types of cements; White cement, oil well cement, Portland blast furnace slag, expansive cement, sorel cement , polymer modified cement and non calcareors cement. Different types and action of slag activators. Cement concrete: Nature of aggregates and reaction. Fibre reinforced cement concrete.

Unit 5: Pozzolana: classification, factors affecting pozzolanic activity, lime-pozzolana reaction.

Recommended Books:

1. Chemistry of Cement – F. M. Lea

2. Cement Chemistry - F.W. H. Taylor
3. High Alumina Cement - T. D. Robson
4. Concrete Technology – A. M. Neville and J. J. Brook

OLT: Oil Technology III

Module I: Technology of Soaps and Synthetic detergents

Basics of Surface Science.

Definitions of soaps & detergents and their classifications; Present status of soap and detergent industries; Raw materials for soap industry and their selection; Industrial soap-making processes, Kinetics and Phase reactions in soap-making process, recovery of by-products.

Understanding of the physico-chemical properties of soap, types of soaps (various households and industrial soaps, metallic soaps), importance of soap additives, miscellaneous application of soap-based products, Testing and interpretation of soap quality. Plants and Processes employed in soap manufacture. Recovery of by-products, various households and industrial soaps, soap additives, metallic soaps, miscellaneous application of soap-based products; Testing and evaluation of soaps.

Chemistry and Technology of production of synthetic detergents (anionic, cationic, nonionic, and amphoteric), and detergent additives. Formulation and processing of detergent powders, tablets, liquids, and pastes for household and industrial applications;

Bio-surfactants and enzyme detergents, dry cleaning systems; Natural saponin-based surfactants. Bio-degradation and life cycle assessment of surfactants, Eutrophication, and Ecological aspects, Ecofriendly washing systems. Modern trends in detergent formulations; Testing and evaluation of synthetic surfactants.

Module II: Chemistry & Technology of Paints and Paint Additives

Pigments & Extenders.

Technology of natural resins; rosin, copal, damar, shellac, asphalts, pitches, bitumens, and their modifications. The technology of phenolic, maleic, coumarone-indene, and petroleum resins, CNSL and BNSL, their modifications. Technology of synthetic resins like alkyds and other polyesters, polyurethanes, UF, MF, epoxy, silicones, rubber resins, etc.

Types and mechanism of polymerization reactions; concepts of functionality, polymeric resins like NC, acrylic, vinylic, etc. Methods of different polymerization systems, viz., bulk, solution, suspension, and emulsion, and their mechanisms. Kinetics of Emulsion Polymerization, Suspension Polymerization, Ionic Polymerization and Methods of Determination of Polymer Molecular Weight, Gel Permeation Chromatography, Osmometry.

Metallic driers, technology of linoleates, rosinates, napthenates and octoates of lead, cobalt, manganese, zinc, iron, calcium, and rare earth metals.

Functions and uses of additives like anti-skinning agents, anti-mildew agents, flatting agents, dispersing, wetting, anti-blistering, anti-foaming, anti-blocking, anti-floating and anti-flooding etc.

Role of UV absorber and HALS (hindered amine light stabilizer).

Recommended Books:

1. Surface Active Agents and Detergents - Schwartz & Perry
2. Gemini Surfactants - Raoul Zana & Jiding Xia
3. Textbook of polymer science - Fred W. Billmeyer
4. Surfactants and Interfacial Phenomena - Milton J. Rosen & Joy T. Kunjappu

5. Macromolecules, an introduction to polymer science, F. A. Bovey and F. H. Winslow
6. Handbook of Surfactant Analysis - Chemical, Physico-chemical and Physical Methods - Dietrich O. Hummel

PPR: Petrochemicals & Petroleum Refinery Engineering III

Module I: Refinery Operations III

Evaluation of crude oil for lube oil base stock manufacture
Lube base oil processing – solvent deasphalting, solvent aromatic extraction, solvent dewaxing, hydrofinishing, catalytic hydrotreatment and dewaxing
Lube blending and Grease manufacture – formulation, operating conditions and application.
Blending of Products – Octane blending, Pour point blending, Flash point blending, Viscosity Index blending, Penetration blending: calculation method, nomographs & application.

Module II: Petrochemical manufacturing processes and individual Petrochemicals

Individual Petrochemicals viz. Methanol, Urea, Acrylonitrile, Styrene, Phenol, Ethylene & Propylene oxide, Vinyl Acetate, Caprolactum, Purified Terephthalic Acid – manufacture, operating conditions, catalyst, properties and application
Fischer Tropsch synthesis – scope, chemistry, catalysis, product profile & technologies
Methanol to gasoline process

Recommended Books

1. Petrochemical Processes – Technical & Economical Characteristics – A. Chauvel & G. Lefebvre Institute Francis Du Petrole
2. Petrochemical Industries –Technology & Processes – C.R.Lahiri & Dipa Biswas, CBS Publishers
3. Petroleum Refining: Separation Processes, Jean-Pierre Wauquier, Pierre Trambouze, Jean-Pierre Favennec, Editions Technip, 2001
4. Process Chemistry of Lubricant Base Stocks By Thomas R. Lynch, CRC Press, Taylor & Francis group, 2008
5. Chemistry & Technology of Lubricants, R. M. Mortier, M. F. Fox, S. T. Orszulik, Springer, 2010
6. A Text on Petrochemicals, B. K. Bhaskara Rao, Khanna Publishers, 2022
7. Fundamentals of Petroleum Refining, M. A. Fahim, T.A. Alsahhaf, A. Elkilani, Elsevier, 2010
8. Petroleum Refining: Technology and Economics, James H. Gary, Glenn E. Handwerk, Mark J. Kaiser, CRC Press, 2007
9. Refining Processes Handbook, Surinder Parkash, Elsevier, 2003
10. Petroleum Refinery Engineering (4th Ed) – W.L.Nelson, McGraw –Hill
11. Lubricant blending and quality assurance – R. David Whitby, CRC press, 2019
12. Lubricating grease manufacturing technology – Y. L. Ishchuk, New Age International Publishers, 2005

PFC: Pharmaceutical and Fine Chemical Technology III

Module I: Quality Assurance & Regulatory Affairs

Drugs and Cosmetics acts and rules, Responsibilities of regulatory authorities, International patent regulation. ICH guidelines.
GMP regulations; Air and water handling system, CGMP – Status and regulations, GLP, GCP, GDP concepts. Quality audit. Documentation and records. Approval Process.
Principles and techniques in validation, Analytical Method Validation and Process validation.

Module II: Pharmaceutical Technology II

Unit 1: Manufacturing techniques and formulation of liquid and sterile dosage forms, and aerosol preparations. Testing techniques and compliance for sterile dosage forms and aerosols. Machinery requirements.
Unit 2: Pharmaceuticals from cellular origin, examples and applications. Principles of fermentation Technology and reactor design. Antibiotics manufacturing in fermentation and

semi-synthetic pathways. Examples for fermentative production of alcohols, vitamins, dextrans, probiotics and food products.

Recommended Books:

1. Drugs and Cosmetics Act – Schedule M, Schedule L1, Schedule Y; www.cdsco.nic.in
2. Quality Assurance of Pharmaceuticals Volume 1, Volume 2. published by WHO http://www.who.int/medicines/areas/quality_safety/quality_assurance/QualityAssurance PharmVoll.pdf and QualityAssurancePharmVol2.pdf
3. WHO Technical Reports; TRS 992, TRS 986. www.who.int/biologicals/technical_report_series
4. ICH guidelines – www.ich.org
5. Analytical Method Development and Validation, Michael E. Swartz, Ira S. Krul, Marcel Dekker Inc, NY, 1997
6. Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems, Loyd Allen and Howard C.Ansel, Lippincott Williams & Wilkins, 2013.
7. Pharmaceutics: Formulations and dispensing pharmacy, S. Bharath, 2013
8. Pharmaceutical Suspensions: From Formulation Development to Manufacturing, Alok K. Kulshreshtha, Onkar N. Singh, G. Michael Wall, AAPS Press, Springer 2009.

(Practical)

Paper Code: PCC-CT605
Design & Simulation Lab **50 marks /1.5 Credits**

1. Introduction to Software Packages
2. Setting up models for simulation
3. Steady State simulation using ASPEN
4. Flow-sheeting concepts (sequential modular, equation oriented)
5. Dynamic simulation using MATLAB,
6. CFD simulations using FLUENT
7. Geometry & meshing

Paper Code: PCC-CT606
Process Equipment Design **50 marks /1.5 Credits**

Each student is required to submit two bound type-written copies of the design report on the complete design including drawing with specifications of process equipment reactors of a plant manufacturing product(s) related, to one's course / subject to be worked out under the guidance of a faculty member.

The design should be as far as practicable and be based on the consideration of optimum technical process operating condition and shall include proper instrumentation and control. The examination shall include a viva-voce examination on the design report.

Paper Code: PEC-CT607 CER/OLT/PPR/PFC
Special Lab V **50 marks /1.5 Credits**
CER: Ceramics Engineering Lab V

Glass technology lab:

Glass batch calculation and preparation of glass by melting route:

Preparation of Soda-lime-silica glass with different coloring oxides, e.g. cobalt and iron oxides etc.; Borosilicate glass with alkali and alkaline earth oxides; opal glass with different opacifying agents, e.g. fluoride and phosphate; low melting Phosphate glass in various systems.

Measurement of density of different glass samples. Determination of chemical durability of Glass. Alkali resistance test, alkalinity test, acid resistance test different glass samples. Determination of thermal shock resistance of different glass samples. Determination of Tg and Tc by DTA (Differential Thermal Analysis). Stress of glass sample by Polari analysis -meter. Observations of strain in glassware by polariscope, demonstration of cord viewer.

Recommended Books:

1. Quantitative Inorganic Analysis – A. I. Vogel
2. Analysis of ceramic raw materials – S. Kumar and D. Ganguli
3. Refractories: Production and Properties– J. H. Chester

OLT: Oil Technology Lab V

Soaps & Detergents
Technical analysis of soaps and synthetic detergents.
Preparation of different types of soaps and synthetic detergents and evaluation of their various physicochemical and performance characteristics.
Identification, isolation and purification of surfactants from unknown mixtures.
Surface tension, interfacial tension, CMC measurements

Recommended Books:

1. Official Methods and Recommended Practices AOCS of the AOCS
2. A Treaties on Analysis of Food, Fats & Oils – A.R.Sen, N.K.Pramanik, S.K.Roy
3. FSSAI Manual of Methods of Analysis of Foods, Oils & Fats , 2015

PPR: Petrochemicals & Petroleum Refinery Engineering Lab V

Preparation & Testing of Petrochemical Products
Preparation & Testing of some petrochemical products by Polymerization (polystyrene & PMMA), Alkylation, Disproportionation, Condensation.

Recommended Books:

1. Polymer science and technology, P. Ghosh, Tata McGraw Hill, 2011
2. Plastic Materials, J. A. Brydson, B-H publishers, 1999

PFC: Pharmaceutical and Fine Chemical Technology Lab V
Pharmaceutical Chemistry III
1. Synthesis of drugs, fine chemicals and drug intermediates using multistep reactions.
2. Applications of different name reactions in drug synthesis.
3. Synthesis, assay and pharmacopoeial compliance for representative compounds like diphenyl hydantoin, paracetamol, iso-nicotinic acid hydrazide (INH), indole acetic acid, xylocaine.

Recommended Books:

1. Strategies for Organic Drug Synthesis and Design, 2nd Ed. Daniel Lednicer, Wiley, 2009.

2. Advanced Practical Medicinal Chemistry, Ashutosh Kar, New Age International Publisher, 2007.

Paper Code: PEC-CT608 CER/OLT/PPR/PFC
Special Lab VI **50 marks /1.5 Credits**

CER: Ceramics Engineering Lab VI
Cement testing lab:

1. Determination of consistency of cement.
2. Study of initial and final setting of cement by Vicat apparatus.
3. Determination of soundness of cement Le Chatelier method.
4. Making and curing of cement mortar.
5. Compressive strength of cement mortar fine with ageing time.
6. Determination of surface area of cement by Blain Air Permeability apparatus.
7. Determination of fineness modulus and grain size distribution of fine aggregate.
8. Effect of casting process parameters on the properties of cement mortar.
9. Flow property of cement mortar on flow table
10. Effect of admixture on cement mortar
11. Study of the durability of cement mortar
12. Complete Chemical analysis of Portland cement
13. Direct estimation of CaO, Fe_2O_3 and SiO_2 in Portland cement.

Recommended Books:

1. Bureau of Indian Standard (BIS) manuals

OLT: Oil Technology Lab VI
Surface Coating II
Preparation of alkyds, polyesters, acrylics etc.; Preparation of inorganic and organic pigments and their testing according to specifications.
Preparation of different types of paints like primer, ready mixed paints, synthetic enamels, stoving enamels, etc.
Preparation of panels. Testing of surface coating according to specifications. Examinations and reporting of weathered and defective surface coatings.
Preparation of paint additives like anti-settling agent, anti-skinning agent, dispersing agent, etc.

Recommended Books

1. Official Methods and Recommended Practices AOCS of the AOCS
2. A Treaties on Analysis of Food, Fats & Oils – A.R.Sen, N.K.Pramanik, S.K.Roy
3. FSSAI Manual of Methods of Analysis of Foods, Oils & Fats, 2015

PPR: Petrochemicals & Petroleum Refinery Engineering Lab VI
Preparation & Characterization of Resins
Phenol-formaldehyde, Urea-formaldehyde, preparation and their characterization.

Recommended Books:

1. Polymer science and technology, P. Ghosh, Tata McGraw Hill, 2011
2. Plastic Materials, J. A. Brydson, B-H publishers, 1999

PFC: Pharmaceutical and Fine Chemical Technology Lab VI

Industrial Pharmacy

Formulation and testing of different dosage forms, like tablet, capsule, suspension, emulsion, ointment, granules, effervescent granules, syrup and invert syrup.

Recommended Book(s):

Pharmaceutical Compounding and Dispensing, Christopher A. Langley, Dawn Belcher, Fasttrack 2012.

Semester VII
(Theory)

Paper Code: HM-CT701

Social Science & Management

Module I: Industrial Economics **50 marks/2 Credits**

World resources: fuels, water, power, iron and steel, manganese steel alloys, non-ferrous metals, position of India in World Trade.

Industrial Revolution: The historical process, rise of the factory system, social effects of the Industrial Revolution, growth of monopoly capital, the development of machinery, the steel age, the age of electricity, the commercialization of inventions.

Price system and resource allocation; concepts of demand, marginal revenue, demand elasticity, consumer's surplus and the interrelationships between them, concept of time in economics and short run and long run cost curves – total cost, marginal cost, average cost; forms of market and price determination of a commodity in different markets. Concepts of national income; theory of equilibrium national income determination, theory of investment; money market and theory of rate of interest; inflation theories – brief outline; commercial banking and central banking; fiscal policy; balance of trade and balance of payments; measures to correct balance of payments disequilibrium.

Recommended Books :

1. Modern Economic Theory - K.K.Dewett,M.H.Navalur, Janmejoy Khuntia.S. Chand & Co.
2. Modern Economics – H.L.Ahuja, S.Chand & Co.
3. An Introduction to Microeconomics & Indian Economy – Anasuya Kar, S. Chand & Co.

Module II: Business Management **50 marks/2 Credits**

The historical background of industrial development in India. The management function, evolution of management thought, management and social responsibility.

Process of basic management decisions in industry. Fundamental consideration in Industry: basic management decisions.

Organisation development and types of organization: Co-ordination and morale.

Total Quality Management (TQM) ISO 9000/BIS 14000

Product development and research, simplification and standardization of product and materials, processes and materials inspection.

Plant location.

The factory building and plant layout, material handling, the maintenance department.

Motion and time study, establishing time value by time study, utilizing time study data.
The sale and purchase department, budget, managerial control and office administration, classification and identification.
Material and production control: routine, scheduling and mass production industries.
Business statistics, index numbers, charting, trend curves, management ratios, forecasting, trade indices, budgeting, statistical methods in industry, quality control.
Economic planning and policy in India.
Position and problems of chemical industries in India.
Treatment of the subject should have a bias in regard to chemical industry.

Recommended Books:

1. Management – Harold Koontz & Heinz Weihrich
2. Operations Research – V K Kapoor
3. Principles & Practice of Management – Shyamal Banerjee
4. Statistical Methods – N G Das
5. Financial Management – I M Pandey
6. Cost Accounting – B K Bhar
7. Personnel Management & Industrial Relations – P C Tripathi
8. Marketing Management – Philip Kotler

Paper Code: OEC-CT702
Elective–VII **100 marks/4 Credits**

A. Nanotechnology

Module-I
Concepts in nanoscale; Time and length scale in structures; Dimensionality and size dependent phenomena; 0D,1D,2D structures- size effects; Specific surface energy and surface stress; Effect on the lattice parameter; Material properties in nanoscale (optical, mechanical, electronic, magnetic and biological).

Nanoscale phenomenon; Quantum confinement of superlattices and quantum wells; Plasmonic response; Magnetic moment in clusters – Magnetocrystalline anisotropy –Dielectric constant in nanoscale silicon;
General methods for synthesis of nanostrutures – Physical, chemical and biological methods. Aggregation – stability of colloidal Dispersions; Spontaneous condensation of nanoparticles: Post condensation effects – Nanoparticles' morphology.

Module-II
Nanomaterials for electronics, nanophotonics, nanofluidics, nanocomposites etc.
Special materials in nanoscale – Carbon materials, fullerenes, graphene, nanotubes; Metals and metal oxides, Quantum wire, Quantum well, Quantum dots, Biomacromolecules.
Nanoscale devices for different applications (electronics, photovoltaics, medical diagonostics etc). Nanotechnology and environment.

Principles of analysis in Dynamic Light Scattering (DLS); Atomic Force Microscopy (AFM); Field Emission Scanning Electron Microscopy (FESEM), Environmental Scanning Electron Microscopy (ESEM); Transmission Electron Microscopy (TEM), High Resolution Transmission Electron Microscope (HRTEM), Scanning Tunneling Microscope (STM)- Raman Spectroscopy, Nano-litography.

Recommended Books:

1. Introduction to Nanotechnology – C.P.Poole Jr. and F.J.Owens
2. Nanotechnology : Principles and Practices -- S.K.Kulkarni
3. Introduction to Nanoscale Science and Nanotechnology – M.Di.Ventra, S.Evoy and J.R.Heflin Jr.
4. Nanoscience and Nanotechnology : Fundamentals of Frontiers – M.S.R.Rao and S.Singh
5. Nanochemistry : A Chemical Approach to Nanomaterials – G.A.Ozin and A.C.Arsenault

B: Optimization method in Chemical Technology

Module I: Nature and organization of optimization problems, fitting models to data, method of least squares, factorial experimental designs, formulation of objective functions.
Module II: Optimization theory and methods - basic concepts of optimization, optimization of unconstrained functions, one dimensional search, mutivariable optimization.
Module III: Linear programming and applications, nonlinear programming with constraints, optimization of staged and discrete processes.
Module IV: Optimum recovery of waste heat, optimum shell and tube heat exchanger design, optimization of heat exchanger networks, optimization of multistage evaporators, optimization of liquid liquid extraction processes, optimal design and operation of staged distillation columns.
Module V: Optimal pipe diameter, minimum work of gas compression, economic operation of fixed bed filter, optimal design of gas transmission network, optimal design and operation of chemical reactors.

Recommended Books:

1. T. F. Edgar and D. M. Himmelblau, Optimization of Chemical Processes, McGraw Hill, International Editions: Chemical Engineering Series, 1989.
2. G. S. Beveridge, and R.S. Schechter, Optimization Theory and Practice, McGraw Hill, New York, 1970.
3. G. V. Rekllaitis, A. Ravindran and K. M. Ragsdell, Engineering Optimization- Methods and Applications, John Wiley, New York,

C. Sol-Gel Technology

Module I

The colloidal state, Sol and Gel, Basic ideas on kinetic, optical and electrical properties, Colloidal stability, Structure of double layer, DLVO theory, Polymeric and particulate gels.
Synthesis of simple sol–gel precursors of silica, alumina, titania, zirconia etc, fabrication of ceramics via sol gel, gelation, ageing, drying and heat treatment.
Preliminary idea on clay colloids.

Module II

Sol-gel coating techniques e.g. dip, spin, drain and meniscus coatings.
Techniques for characterization of sol-gel materials.
Applications of sol gel glass, coatings, powders, fibres, monoliths, porous gel, membranes, catalysts, gas sensors, novel sol-gel materials, future prospects.

Recommended Books:

1. Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing : C. Jeffrey Brinker, George W. Scherer
2. Handbook of Sol-Gel Science and Technology: Processing, Characterization and Applications: Sumio Sakka
3. Sol-Gel Materials: Chemistry and Applications: J.D. Wright, Nico A.J.M. Sommerdijk

Paper Code: PEC-CT703 CER/OLT/PPR/PFC
Special Paper IV **100 marks /4 Credits**
CER: Ceramics Engineering IV

Module I: Properties of Glass

Unit 1: Physical properties of glass – Density, refractive index of glass, thermal expansion, specific heat of glass, electrical conductivity of glass, dielectric properties, mechanical properties, surface properties.
Unit 2: Optical properties of glasses – refractive index, molar volume, ionic refractivity, birefringence. Ligand Field theory, UV-Visible absorption. Dispersion, Abbe Number, Stress-optic effect. Thermodynamic basis of phase separation in glasses. Immiscibility in glasses. Kinetics of demixing. Application of immiscibility diagrams. Spinoidal and binodal decomposition. Additive rules.
Unit 3: Glass fibre. Toughened glass. Optical Glass- Methods of manufacture, defects. Optical fibre. Coloured glasses: Colour forming constituents, redox equilibria, solarisation, photosensitive and photo-chromic glass, opal glass, chalcogenide glass, IR absorption glass, colloidal colours. Concept of Glass Ceramics. Properties and applications. Bioglass.

Unit 4: Chemical durability of glass: Glass aqueous phase reaction, controlling factors and methods of measurement, improvement of durability.

Unit 5: Different types of glass defects and their elimination.

Recommended Books:

1. Fundamental of inorganic glasses – A. K. Vershneya
2. Chemistry of glasses – A. K. Paul
3. Introduction to glass science and technology – J. H. Shelby

Module II: Fine Ceramics

Unit1: Development and scope of fine ceramics. Characterization and classification of different pottery wares and vitrification nature.

Unit 2: Raw materials: Evaluation, processing and availability, properties and testing of main raw materials for whiteware industries such as Clays, quartz, feldspar, nepheline syenite, whiting, talc, pyrophyllite, wollastonite, sillimanite, bone-ash and zircon. Incorporation of industrial solid wastes in triaxial composition.

Unit 3: Ceramic Bodies: Detailed studies of earthenwares, stonewares, porcelain, vitreous china, cordierite, steatite and cermet bodies including their body preparation, body composition and batch calculations.

Unit 4: Fabrication methods: Details of fabrication methods used to manufacture whitewares such as floor and wall tiles, table wares, sanitary wares, art wares, dental porcelains, bone china, electrical porcelains, chemical stone wares, chemical porcelains, refractory porcelains, steatite and cordierite ceramics, titanate ceramics.

Unit 5: Ceramic glaze: nature of glazes and classification, glazed raw materials and processing, glaze compositions, fritting rules. Application of glazes and firing. Testing of glazes, glaze defects, different types of glazes and decorations. Ceramic color and methods of decorations.

Recommended Books:

1. Ceramic Whitewares – Sudhir Sen
2. Industrial Ceramics – F. Singer & S. S. Singer
3. Fine Ceramics – F. H. Norton

OLT: Oil Technology IV

Module I: Technology and processing of Fats and other derivatives for edible purposes

Oil and Fat modification technologies. Hydrogenation process technology of fats and oil (selectivity, catalyst, process parameters, hydrogenation techniques, low trans hydrogenation, hydrogen production, process control, product characteristics, Government regulations, costing, etc.);
Interesterification processes of fats and oils (chemical and biochemical), types of processes, technology involved in the Interesterification process, and application. Interesterification processes of fats and oils (chemical and biochemical).
Fractionation of fats and oils, assessment of fractionable fats and oils, types of fractionation processes (dry, solvent, and detergent fractionation), and technology involved and applications.
Importance of blending process, prerequisite, selection of the oils and fats as per end application, government regulations, nutritional aspects, shelf life.
Application of fat medication processes for the production of Butter and Ghee; Margarine, low-cost spread fats, shortenings, and confectionery fats. Fat-based structured molecules and Nutraceuticals production technology & applications. Plants and equipments associated with modification techniques.
Design considerations for various process equipment associated with oil processing (extractor, hydrogenator, reaction kettles).

Module II: Manufacturing & application of paints

Process steps and equipment required for paint manufacturing. Design and application of paint manufacturing equipment (ball and pebble mills; sand, bead, and shot mills; attritor and vibration mills). Design and application of Paint mixing and dispersion equipments (HSD, High-speed stone and colloid mills, Pressurized Mill, Blenders/vortex.
Assessment of pigment dispersion, Mill base let-down operations. Various Industrial (Automotive & Marine Coatings, etc.) and Architectural paints; Formulation of various solvent and water-based coatings, specialized paint finishes like wrinkle, polychromatic, flame buoyant, Crackle, hammertone, etc. Coatings for Glass, Brass, Copper, Galvanize, Gold and Silver etc.
Surface preparations, its implication and process and paint application systems.

Recommended Books:

1. Lipid Technologies and Applications - Frank D. Gunstone & Fred B. Padley
2. Outlines of Paint Technology - W.M. Morgans
3. Baileys's Industrial Oil and Fat Products
4. Coatings Materials and Surface Coatings - Arthur A. Tracton

PPR: Petrochemicals & Petroleum Refinery Engineering IV

Module I: Plants & Equipments in Refineries and Petrochemical Industries; Utilities, Offsite facilities & Environment control

Equipments viz. Pumps, Compressors, Heat exchangers, Pipestill Heaters, Reactors – batch &

continuous, fixed bed, fluidized bed, ebullated bed, single stage & multi stage, single stage oncethrough & with recycle, Distillation Columns, Extractors, Absorbers, PSA, TSA
Corrosion & its prevention, Materials of Construction
Refinery Utilities – Power & Steam generation, Plant air, Instrument air, Inert Gas system, Cooling water, DM water, Boiler Feed water, Service water, Treatment chemicals
Offsite facilities: Storage tanks – fixed roof, floating roof, Horton sphere, cryogenic storage tanks; Pipelines for feeding & dispatch ; Classification of tank farms & safety guidelines ;
Various dispatch facilities of products – Tank-truck (road transport), tank-wagon; Fire water network & Fire fighting system, OM&S
Production of hydrogen and purification
Environment control – Effluent treatment plant, Ambient air quality monitoring station, Furnace stack monitoring system, Storm water management, soil treatment, Incineration.

Module II: Preparation & Characterization of Important Polymers

Polyethylene, Polypropylene, PVC, Nylon, PET, Polyacrylates - stoichiometry, operating conditions, catalyst & application.
Synthetic rubber, Synthetic fibre, Synthetic resins, Synthetic detergents
Moulding of Plastics, Vulcanization of Rubber.

Recommended Books:

1. Plastic Materials – J. A. Brydson
2. Principle of Polymer Chemistry – P. J. Flory
3. Textbook of Polymer Science – Fred W Billmeyer, JR
4. Rubber Technology & Manufacture – C M Blow
5. Fundamentals of Petroleum and Petrochemical Engineering, U. Ray Chaudhuri, CRC Press, Taylor & Francis group, 2013
6. Refining Process Handbook, Surinder Parkash, Elsevier, 2003.
7. Petroleum Refining 4. Materials & Equipment, P. Trambouze, TECHNIP, 2000
8. Corrosion Problems and Solutions in Oil refining and Petrochemical Industry, Alec Groysman, Springer, 2017
9. Chemical Process Equipment: Selection and Design, James R. Couper, W Roy Penney, James R. Fair, Elsevier, 2012

PFC: Pharmaceutical and Fine Chemical Technology IV

Module I: Pharmaceutical Technology III

Preformulation studies. Stability analysis.
Novel drug delivery devices and sustained drug delivery. Transdermal drug delivery devices, design, formulation and evaluations.
Compartment models and bioequivalence studies.
Packaging requirements and regulatory requirements. Primary and secondary packaging materials types and quality testing. Bar coding, quarantine and identification.

Module II: Medicinal Chemistry II

Medicinal Chemistry of drugs acting on sympathetic and parasympathetic nervous systems. Drugs acting on central nervous systems like sedative hypnotics, anti-epileptics, and antimicrobial agents, like sulfa-drugs, antitubercular compounds, antifungals, antimalarials and other antiprotozoals. Medicinal Chemistry of antihistaminics, diuretics, antiemetics and oral hypoglycemics.
Classification and chemistry of vitamins.

Recommended Books:

1. Goodman and Gilman: Pharmacological Basis of Therapeutics, Pregamon Press, New York.

2. Foye's Principles of Medicinal Chemistry, 7th Ed, Thomas L. Lemke, David A. Williams, Victoria F. Roche, S. William Zito, Wolters Kluwer, 2012.
3. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, Charles Owens Wilson, Lippincott Williams & Wilkins, 2004.
4. Basic Concepts in Medicinal Chemistry, Marc W. Harrold and Robin M. Zavod, American Society of Health-System Pharmacists, 2013.
5. Medicinal Chemistry, Ashutosh Kar, New Age International
6. Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems, Loyd Allen and Howard
C. Ansel, Lippincott Williams & Wilkins, 2013.
7. Pharmaceutical Preformulation and Formulation: A Practical Guide from Candidate Drug Selection to Commercial Dosage Form, Mark Gibson, CRC Press, 2016
8. Remington: The Science and Practice of Pharmacy, David B. Troy, Paul Bering, Lippincott Williams & Wilkins, 2006
9. The Theory and Practice of Industrial Pharmacy, Herbert Lieberman and Leon Lachman, CBS Publishers, 2013
10. Aulton's Pharmaceutics: The Design and Manufacture of Medicines, Michael E. Aulton, Kevin Taylo, Elsevier Health Sciences, 2013.

(Practical)

Paper Code: PROJ-CT704

Project foundation **50 marks /4 Credits**

Each student shall be required to carry out under the supervision of Faculty member (s) and/or External member as the case may be, an original investigation on an industrial problem related to one's course/subject. She/he shall submit two typewritten bound copies of a report on Research Work at least 15 days before the commencement of final semester examination and shall defend her/his report in a Viva-voce Examination.

Paper Code: PCC-CT705

Plant Design & Feasibility Studies **50 marks /4 Credits**

Each student shall be required to submit two bound type written copies of a project report on a proposed chemical plant manufacturing product/ products related to one's course/ subject to be worked out under the supervision of a faculty member.

The report shall include mass and energy balances, type and capacity of equipment selected and recommended, plant layout, feasibility analysis highlighting market survey, pattern of assistance available from the central and state governmental agencies, banks and financial institutions. Assistance for technology, raw materials, finance.

Legal obligation.

The student has to appear at a viva voce examination.

Paper Code: PCC-CT706

Seminar **50 marks /2 Credits**

Each student shall be required to prepare and submit one typewritten bound copy of seminar paper on selected technological topic related to one's course/subject under the supervision of a faculty member. She/he shall deliver a talk based on his seminar paper through power point presentation in an open seminar in presence of faculty members and external expert. The attendance in the seminar is compulsory for all the students.

Technical report writing skills, basic communication skills, Power point presentation and Group discussions will be in the perspective

Paper Code: INDTRG-CT707

In Plant Training / Institutional Training **50 marks**

Each student shall be required to undergo a course in 'In plant Training' for a specified period (4 - 6 weeks) in an industry related to one's course/subject.

She/he shall submit one copy of training report within 30 days of completion of training and shall appear at a Viva-voce Examination.

Semester VIII
(Theory)

Paper Code: PEC-CT801 CER/OLT/PPR/PFC

Special Paper–V **100 marks /4 Credits**

CER: Ceramics Engineering V

Advanced Ceramic

Unit1: Advanced Processing Technologies of Ceramics: Chemical vapour deposition etc, Sol–gel, Microwave Processing, Sonochemical techniques, Spark Plasma sintering.

Unit 2: Conducting Ceramics:

Broad band and narrow band conduction, Mott's transition. Effect of partial pressure of oxygen and doping in oxide conductors. Grain boundary effects on electrical conduction. Grain Boundary Barrier Layer, Capacitors, Ceramic superconductors.

Unit 3: Ceramic Magnets

Ni-Zn ferrites, Mn-Zn ferrites, Garnets and Hexagonal Ferrites. Processing and manufacture of ferrites. Effect of composition, processing and microstructure on the magnetic properties. Applications of magneticceramics.

Unit 4: Sensors and Actuators

Types of sensors and actuators, Thermal NTC and PTC sensors, electrochemical sensors, gas and humidity sensors, piezoelectric and electro-optic sensors and actuators. Thermoelectric effect in ceramic systems, Magnetoresistance, Colossal Magnetoresistance (CMR)

Unit 5: Varisters and their Applications

Varistor Characteristics, ZnO Varistor materials systems, their processing, microstructure and applications. Varistor models.

Unit 6: Thick film and Multilayer Ceramics

Formulation of conductive, resistive and dielectric inks. Screen printing and firing of hybride devices. Fabrications of multilayer devices and their applications.

Unit 7: Ceramics for Green Energy

Solid oxide fuel cells (SOFC) Cells: Solid electrolytes based on stabilized zirconia, Co-doped ceria, Cathode, Anode and Interconnect materials. Batteries and solar cells.

Unit 8: Bioceramics

Processing, properties and application of Bioceramic materials

Unit 9: Optical Ceramics
Ray theory of fibres, Wave theory of fibres, Types of optical fibres, Transmission and dispersion characteristics, fibre fabrication process, Mechanical strength of fibres, optical fibre systems.

Unit 10: Special Glasses
Laser glass, Zero expansion glass and Bulk metallic glass. Radiation shielding glass. Dosimeter glass, Scintillation glass, Photonic glass, Agricultural glass, Faraday rotator glass, Photo thermo refractive index glass and IR transmission glasses.

Recommended Books:

1. Introduction to Ceramics – W. D. Kingery, H. K. Bowen, D. R. Uholmann
2. Ceramic Materials for Electronics - R.C. Buchanan
3. Glass-Ceramic Technology - Wolfram Holand, George H. Beall
4. Introduction to Bioceramics – L. L. Hench and J. Wilson
5. Electroceramics –A. J. Moulson & J. M. Herbert
6. Ceramic Processing and Sintering: M.N. Rahaman
7. Fundamentals of Ceramics – M. W. Barsoum

OLT: Oil Technology V
Module II: Fat based Industrial Chemicals

An overview of oleochemicals: oleo chemicals raw materials, basic oleochemicals, oleochemical derivatives, etc. Castor Oil Based Oleochemicals. Technological details of Fat splitting (low, medium, and high-pressure splitting), recovery, purification, and distillation of glycerol, separation of fatty acids, distillation of fatty acids and other oleochemicals.
Fatty alcohols and Fatty amines (raw materials, properties, processes, and uses) and their derivatives; Dimer Acids.
Application and principle of fat-based chemicals in synthetic lubricants, plasticizers, Metallic soaps, biodiesel, etc.
Fat-based and synthetic process auxiliary chemicals for application in different chemical industries like leather, paper, textile, rubber, plastics, metal working, etc. Design considerations for various process equipment associated with oil processing (extractor, hydrogenator, reaction kettles, distillation equipments, milling equipments, micronizers). Biotechnological approach for basic and downstream oleochemicals production for food and industrial applications.
Application of green oleochemicals for chemical industries like leather, paper, textile, rubber, plastics, metal working.

Module II: Advanced Paint Technology
Outline of the activities of the petrochemical industries to manufacture the raw materials for paint (Solvents; Xylene, Toluene etc, Phthalic Anhydride, Monomers, Additives, and Production of LDPE, LLDPE, HDPE).
Modern trends in coating systems; waterborne paints; low VOC paints, UV curable coatings, Water base Alkyd emulsion for air drying enamels.
Powder coatings; electro-deposited paints; high solid coatings,
Understanding the application of Nanotechnology and Biotechnology in the paint industry for the production of polymer materials and protection of coating surfaces.

Module III : Essential Oils and Cosmetic Technology

Chemistry & Technology of Natural Essential oils and of synthetics. Extraction/Isolation of these oils and their uses in food and personal care products

Technology of Production of cosmetics like various creams, shavings, lotions, hair oils, tooth paste, tooth powder, lipstick, face powders, herbal cosmetics.

Recommended Books:

1. Industrial uses of vegetable oils – Sevim Z. Erham
2. Paint and Surface Coatings - R. Lambourne and T.A. Strivens
3. The Essential Oils - Ernest Guenther
4. Perfumes, Cosmetics & Soaps - W.A. Poucher
5. Treaties on Fats, Fatty acids & Oleochemicals – Edited by O P Narula
6. Protective Coatings: Fundamentals of Chemistry and Composition - Clive H Hare
7. Perfumery Materials: Production and Applications – D.K. Bhattacharyya

PPR: Petrochemicals & Petroleum Refinery Engineering V

Module I: Management & Process Control of Refinery and Petrochemical Plants

Instrumentation & DCS , Process simulation, LP modeling, Refinery scheduling, Product pricing, Profitability evaluation.

Safety Rules, Safety Audit, Explosive Rules, OISD guidelines, Factories Act, Energy Audit, Material Audit, Conservation Techniques.

HAZOP & HAZAN, Environmental Impact analysis, Disaster management, Pipeline Engineering.

Module II : Polymerization techniques, characterization & processing

Polymerization reactions – Chain growth polymerization, Step growth polymerization, Copolymerization, Concept of functionality.

Polymerization practices – Bulk polymerization, Suspension polymerization, Emulsion polymerization

Polymer properties, Polymer Characterization

Polymer Processing – Extrusion, Calendering, Moulding, Casting

Fundamentals of pigmented coatings and paints

Recommended Books:

1. Principle of Polymer Chemistry – P. J. Flory.
2. Textbook of Polymer Science – Fred W. Billmeyer, Jr.
3. Fundamentals of Petroleum Refining, M. A. Fahim, T.A. Alsahhaf, A. Elkilani, Elsevier, 2010.
4. Fundamentals of Petroleum and Petrochemical Engineering, U. Ray Chaudhuri, CRC Press, Taylor & Francis group, 2013.
5. Fundamentals of Automatic Process Control, Uttam Ray Chaudhuri, Utpal Ray Chaudhuri, CRC Press, 2013.

PFC: Pharmaceutical and Fine Chemical Technology V

Module I: Medicinal Chemistry III

Medicinal Chemistry of antineoplastic, antiviral agents, fluoroquinolones. Herbals & nutraceuticals formulation.

Concepts of drug design and molecular modeling, Quantitative drug design techniques like Hansch analysis, Free Wilson techniques, 2D and 3D approach.

Biostatistics. Principles of drug actions and Receptor concepts, Drug receptor theories.

Module II: Cosmetics and Fine Chemicals

Unit 1: Classification of cosmetics and cosmetic products. Structure of skin, hair, nails, tooth and skin appendages and interactions with cosmetics. Cosmetics common ingredients and processes. Cosmetic formulation and performance. Packaging requirements of cosmetics. Primary and secondary packaging materials types and quality testing.

Unit 2: Chemistry of excipients. Synthesis and application techniques for dyes, dye intermediates, permitted colors, sweetening agents, flavoring agents. Pesticides, trace analysis for pesticides.

Recommended Books:

1. Goodman and Gilman: Pharmacological Basis of Therapeutics, Pregamon Press, New York.
2. Foye's Principles of Medicinal Chemistry, 7th Ed, Thomas L. Lemke, David A. Williams, Victoria F. Roche, S. William Zito, Wolters Kluwer, 2012**.**
3. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, Charles Owens Wilson, Lippincott Williams & Wilkins, 2004.
4. Basic Concepts in Medicinal Chemistry, Marc W. Harrold and Robin M. Zavod, American Society of Health-System Pharmacists, 2013.
5. Medicinal Chemistry, Ashutosh Kar, New Age International
6. Burger's Medicinal Chemistry, Drug Discovery and Development, 7th Edn, Vol 2, Alfred Burger Ed. Donald J. Abraham and David P. Rotella 2010.
7. Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems, Loyd Allen and Howard

C. Ansel, Lippincott Williams & Wilkins, 2013.

8. Pharmaceutical Preformulation and Formulation: A Practical Guide from Candidate Drug Selection to Commercial Dosage Form, Mark Gibson, CRC Press, 2016
9. Remington: The Science and Practice of Pharmacy, David B. Troy, Paul Bering, Lippincott Williams & Wilkins, 2006
10. The Theory and Practice of Industrial Pharmacy, Herbert Lieberman and Leon Lachman, CBS Publishers, 2013
11. Aulton's Pharmaceutics: The Design and Manufacture of Medicines, Michael E. Aulton, Kevin Taylo, Elsevier Health Sciences, 2013
12. Handbook of Pharmaceutical Excipients, Raymond C. Rowe, Paul J. Sheskey, Marian E. Quinn, Pharmaceutical Press, 2009.
13. The Chemistry of Synthetic Dyes, - Vol 5, K Venkataraman, Academic Press, 2012
14. Industrial Dyes: Chemistry, Properties, Applications, Klaus Hunger, Wiley VCH, 2007.
15. Synthesis of Pesticides Chemical Structure and Biological Activity: Advances in Pesticide Science, H. Geissbühler, G. T. Brooks, P. C. Kearney, Pergamon Press, 2013.

(Practical)

Paper Code: PCC-CT802 CER/OLT/PPR/PFC

Grand Viva **50 marks /2 Credits**

Each student shall be required to appear for Grand Viva Voce Examination.

Paper Code: PROJ-CT803 CER/OLT/PPR/PFC

Project Assessment II **50 marks /4 Credits**

Each student shall be required to carry out under the supervision of Faculty member (s) and/or External member as the case may be, an original investigation on an industrial problem to related to one's course/subject. She/he shall submit two typewritten bound copies of a report on Research Work at least 15 days before the commencement of final semester examination and shall defend her/his report in a Viva-voce Examination.