छत्रपति शाहू जी महाराज विश्वविद्यालय, कानपुर

CHHATRAPATI SHAHU JI MAHRAJ UNIVERSITY, KANPUR

(पूर्ववर्ती कानपुर विश्वविद्यालय कानपुर)

Formerly Kanpur University, Kanpur – 208024

A Documentary Support

For

Metric No. – 1.1.1

Programme Outcomes & Course Outcomes

Under the

Criteria - I

(Curriculum Design and Development)

Key Indicator - 1.1

In

Metric No. – 1.1.1

B.Tech. (Chemical Engineering)

Co-ordinator
Internal Quality Assurance Cell
CSJM University, Kanpur

(Registrar)
C.S.J.M.University
Kanpur

REGISTRAR
C.S.J.M. UNIVERSITY
KANPUR

CHHATRAPATI SHAHU JI MAHARAJ UNIVERSITY
KANPUR

SYLLABUS

(B.Tech.)

CHEMICAL ENGINEERING

UNIVERSITY INSTITUTE OF ENGINEERING & TECHNOLOGY

SCHOOL OF ENGINEERING & TECHNOLOGY

Vision

To achieve excellence in engineering education, empower students to be technically competent professionals and entrepreneurs with strong ethical values so as to significantly contribute as agents for universal development and societal transformation

Mission

To provide affordable quality education at par with global standards of academia and serve society with harmonious social diversity

To encourage new ideas and inculcate an entrepreneurial attitude amongst the students, and provide a robust research ecosystem

To practice and encourage high standards of professional ethics and accountability among students

Bachelor of Technology in Chemical Engineering

Program Outcomes (POs)

PO1	**Engineering knowledge:** Apply the knowledge of basic science, mathematics and fundamentals of engineering with specialization to solve the complex problems of chemical engineering.
PO2	**Problem analysis:** Attain the capability to identify, formulate and analyze chemical engineering problems considering the knowledge of engineering mathematics, natural, and engineering sciences and review of the research articles
PO3	**Design/Development of solutions:** Demonstrate and develop the appropriate solutions to chemical engineering design based problems to meet the specified needs of the nation and overall sustainability of the processes, considering the necessary approaches of safety, health hazards, societal and environmental factors.
PO4	**Conduct investigations of complex problems:** Investigate, demonstrate and conduct the design based complex problems using research based knowledge and methodologies, experimental studies, subsequent analysis and interpretation of data to prepare the valid technical reports as per national and global standards
PO5	**Modern tool usage:** Select and apply appropriate available resources, and modern chemical engineering tools such as optimization techniques, simulations, including predictions and modeling to complex process engineering problems with an understanding of their limitations
PO6	**Engineer and society:** Able to carry out their professional practice in chemical engineering by appropriately considering and weighing the issues related to society, health and culture and the consequent responsibilities
PO7	**Environment and sustainability:** Understand and demonstrate the impact of chemical engineering solutions in societal and environmental contexts, and understand the need for global sustainable development
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the chemical engineering practice.
PO9	**Individual and team work:** Work effectively as an individual or in diverse and multidisciplinary global environments showing team solidarity.
PO10	**Communication:** Ability to communicate efficiently with the engineering community, society and able to represent and explain the design documentation effectively with clear instructions, following standard national and international codes

Global needs National needs Regional needs Local needs

PO11	**Project management and Finance:** Demonstrate the knowledge and principles of chemical engineering, management, cost and feasibility studies for the desired projects as an individual, or a member or leader in a team of multidisciplinary settings.
PO12	**Life-long learning:** Possess the attitude of lifelong independent learning as per the need of wider context of technological changes and can pursue higher education for careers in academics, research and development

Program Specific Outcomes (PSOs)

PSO-1	Impart education and training of Chemical Engineering to the students and to make them competent and well qualified Chemical Engineers who can meet global challenges
PSO-2	Provide best knowledge of the Chemical Engineering to the students and nurture their creative talent by motivating them to work on various challenging problems facing the nation
PSO-3	Acquire high end industry centric skills in the field of Chemical Engineering to solve local, regional and national problems
PSO-4	Knowledge of the software used in the field of Chemical Engineering
PSO-5	To prepare Professional Engineer with ethical, social and moral values

Program Educational Outcomes (PEOs)

1. To make the students ready for successful career leading to global higher education and /or in national industry related domains of design, regional research and development, testing, and local manufacturing.
2. To solve diverse real-life national and global engineering problems equipped with a solid foundation in global mathematical, scientific, and chemical engineering principles.
3. To motivate and encourage the students to adopt global professionalism, teamwork, leadership, communication skills, ethical approach.
4. To provide global learning opportunity in a broad spectrum of multidisciplinary field.

Global needs National needs Regional needs Local needs

Curricular Components

Category of courses	Credits offered
Basic Science Core	**31**
Engineering Science Core	**30**
Humanities and Social Science Core	**17**
Departmental Core	**76**
Departmental Electives	**16**
Open Electives	**0**
Projects and Seminars	**16**
Total	**186**

Semester-wise Course Structure

1st Year - Semester 1

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	HSS-S101	Professional Communication	3	0	0	4
2.	MTH-S101	Mathematics-I	3	1	0	4
3.	PHY-S101	Physics-I	3	1	3	5
4.	TCA-S102	Workshop Concepts &Practice	1	1	6	5
5.	ISC-S101	Programming & Computing	3	0	3	5
6.	UHV-S101	Universal Human Values –I (SIP)				-
		Total	**13**	**3**	**12**	**23**

1st Year - Semester 1I

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MTH-S102	Mathematics-II	3	1	0	4
2.	PHY-S102	Physics-II	3	1	3	5
3.	CHM-S101	Chemistry-I	3	1	3	5
4.	ESC-S101	Basic Electrical & Electronics Engg.	3	1	3	5
5.	TCA-S101	Engineering Drawing	2	1	3	5
		Total	**14**	**5**	**12**	**24**

2ndYear - Semester II1

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MTH-S201	Mathematics-III	3	1	0	4
2.	ESC-S201	Engineering Mechanics	3	1	0	4
3.	ESC-S202	Basic Thermodynamics	3	1	0	4
4.	CHE-S201	Process Calculations	3	1	0	4
5.	CHE-S202	Fluid Mechanics	3	1	0	4
6.	CHM-S301	Chemistry-II	3	0	3	4
7.	SST-S201	Summer Internship	0	0	0	2
		Total	**18**	**5**	**3**	**26**

2nd Year - Semester IV

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	CHE-S203	Chemical Engineering Thermodynamics	3	1	0	4
2.	CHE-S204	Heat Transfer	3	1	0	4
3.	CHE-S205	Chemical Process Industries	4	0	0	4
4.	CHE-S206	Mechanical Operations	3	1	0	4
5.	HSS-S401	Engineering Economics	3	0	0	4
6.	EVS-S101	Environmental Science	2	0	0	2
7.	UHV-S201	Universal Human Values -II	2	1	0	3
		Total	**20**	**4**	**0**	**25**

3rd Year - Semester V

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	CHE-S301	Mass Transfer-I	3	1	0	4
2.	CHE-S303	Unit Operations Laboratory -I	0	0	4	4
3.	CHE-S304	Chemical Reaction Engineering-I	3	1	0	4
4.	CHE-S309	Numerical Methods for Chemical Engineers	3	1	0	4
5.	HSS-S301	Communication Practicum	1	0	2	2
6.	CHE-S5**	Departmental Elective	3	1	0	4
7.	SST-S301	Summer Internship	0	0	2	2
		Total	**13**	**4**	**8**	**24**

3rd Year - Semester VI

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	CHE-S305	Mass Transfer-II	3	1	0	4
2.	CHE-S306	Instrumentation & Process Control	3	1	0	4
3.	CHE-S307	Chemical Engineering Design-I	3	1	0	4
4.	CHE-S308	Unit Operations Laboratory-II	0	0	4	4
5.	CHE-S5**	Departmental Elective	3	1	0	4
6.	SSM-S301	Student Seminar	0	0	2	2
		Total	**12**	**4**	**6**	**22**

4^{th} Year - Semester VII

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	CHE-S401	Chemical Engineering Design-II	4	0	0	4
2.	CHE-S402	Chemical Reaction Engineering-II	3	1	0	4
3.	CHE-S406	Process Simulation Lab	0	0	4	4
4.	SST-S401	Summer Training	0	0	2	2
5.	HSS-S201	Industrial Management	3	0	0	4
6.	PRT-S401	Project -I	0	0	6	4
		Total	**10**	**1**	**12**	**22**

4^{th} Year - Semester VIII

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	CHE-S404	Transport Phenomena	4	0	0	4
2.	CHE-S407	Chemical Reaction Engineering and Process Control Laboratory	0	0	4	4
3.	CHE-S5**	Departmental Elective	3	1	0	4
4.	CHE-S5**	Departmental Elective	3	1	0	4
5.	PRT-S402	Project -II	0	0	6	4
		Total	**10**	**2**	**10**	**20**

Total Credits – 186

Detailed Syllabus

Course Code: HSS-S101 **Breakup: 3 –0 – 0 – 4**
Course Name: Professional Communication

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

CO1	Enhance their communication skills for tackling the global professional challenges of a diverse workplace
CO2	Learn effective writing skills and be able to write clear global technical reports
CO3	Improve their verbal and non-verbal communication
CO4	Be fluent orally in the use of the nuances of the English language
CO5	Learn good interpersonal skills and be proficient with the soft skills required for national and global placements

Course Details:

Unit -1 Basics of Technical Communication

Technical Communication**:** features; Distinction between global General and Technical communication; Language as a tool of communication; Levels of communication: Interpersonal, Organizational, Mass communication at global level; Flow of Communication: Downward, Upward, Lateral or Horizontal (Peer group); Importance of technical communication; Barriers to Communication.

Unit - II Constituents of Technical Written Communication

Words and Phrases: Word formation. Synonyms and Antonyms; Homophones; Select vocabulary of about 500-1000 New words; Requisites of Sentence Construction: Paragraph Development: Techniques and Methods - Inductive, Deductive, Spatial, Linear, Chronological etc; The Art of Condensation- various steps.

Unit - III Forms of Technical Communication
Business Letters: global and national Sales and Credit letters; Letter of Enquiry; Letter of Quotation, Order, Claim and Adjustment Letters; Job application and Resumes. Reports: Types; Significance; Structure, Style & Writing of Reports; Technical Proposal; Parts; Types; : global and national Writing of Proposal; Significance; Technical Paper, Project based on global standards. Dissertation and Thesis Writing: Features, Methods & Writing.

Unit - IV Presentation Strategies

Defining Purpose; Audience & Locale; Organizing Contents; Preparing Outline; Audio-visual Aids; Nuances of Delivery; local Body Language; Space; Setting Nuances of VoiceDynamics;Time-Dimension.

Unit - V Value- Based Text Readings
Following essays form the suggested text book with emphasis on Mechanics of writing,
The Aims of Science and the Humanities by M.E. Prior
The Language of Literature and Science by A.Huxley
Man and Nature by J.Bronowski
The Mother of the Sciences by A.J.Bahm
Science and Survival by Barry Commoner

Humanistic and Scientific Approaches to Human Activity by Moody E. Prior
The Effect of Scientific Temper on Man by Bertrand Russell.

Text and Reference Books:

1. V.N. Arora and Laxmi Chandra, Improve Your Writing ed. Oxford Univ. Press, New Delhi (2001)
2. Meenakshi Raman & Sangeeta Sharma, Technical Communication – Principles and Practices, OxfordUniv. Press, New Delhi (2007)
3. Barun K. Mitra, Effective Technical Communication, Oxford Univ. Press, New Delhi (2006)
4. R.C. Sharma & Krishna Mohan, Business Correspondence and Report Writing, Tata McGrawHill & Co. Ltd., New Delhi (2020)
5. M.Rosen Blum, How to Build Better Vocabulary, Bloomsbury Pub. London (2011)
6. Norman Lewis, Word Power Made Easy, W.R.Goyal Pub. & Distributors, Delhi (2015)
7. Meera Banerji and Krishna Mohan, Developing Communication Skills -Macmillan India Ltd. Delhi.(2017)
8. L.U.B. Pandey & R.P. Singh, Manual of Practical Communication, A.I.T.B.S. Publications India Ltd., Krishan Nagar, Delhi (2009)

Course Code: MTH-S101 **Breakup: 3 –1 – 0 – 4**
Course Name: Mathematics-I

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

CO1	Test the convergence & divergence of infinite series
CO2	Understand concepts of limit, continuity and differentiability of function of two variables
CO3	Find the maxima and minima of multivariable functions
CO4	Evaluate multiple integrals, concepts of beta & gamma functions
CO5	Apply the concepts of gradient, divergence and curl to formulate chemical engineering problems

Course Details:

Unit-I
Sequences & Series: Definition, Monotonic sequences, Bounded sequences, Convergent and Divergent Sequences Infinite series, Oscillating and Geometric series and their Convergence, n^{th} Term test, Integral test, Comparison Test, Limit Comparison test, Ratio test, Root test, Alternating series, Absolute and Conditional convergence, Leibnitz test.

Unit II
Differential Calculus: Limit Continuity and differentiability of functions of two variables, Euler's theorem for homogeneous equations, Tangent plane and normal. Change of variables, chain rule, Jacobians, Taylor's Theorem for two variables, Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers**.**

Unit III
Integral Calculus: Review of curve tracing, Double and Triple integrals, Change of order of integration. Change of variables. Gamma and Beta functions, Dirichlet's integral; Applications of Multiple integrals such as surface area, volumes

Unit –IV
Vector Calculus: Differentiation of vectors, gradient, divergence, curl and their physical meaning; Identities involving gradient, divergence and curl Line and surface integrals Green's, Gauss and Stroke's theorem and their applications

Unit–V
Probability and Statistics: Concept of probability, random variable and distribution function: discrete and continuous, Binomial, Poisson and Normal Distributions.

Text and Reference Books:

1. G.B.Thomas and R.L.Finney: Calculus and Analytical Geometry, 9th edition, Pearson Education (2010)
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, (2005).
3. E. Kreyszig, Advanced Engineering Mathematics, 9th edition, John Wiley and Sons, Inc., U.K. (2011).
4. R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, 2nd Edition, Narosa Publishing House. (2005).
5. M.D. Weir, J. Hass, F.R. Giordano, Thomas' Calculus, 11th Edition, Pearson Education.(2008)

Course Code: PHY-S101 **Breakup: 3 –1 – 3 – 5**
Course Name: Physics-I

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

CO1	Understand the behaviour of global Physical bodies
CO2	Understand the basic concepts related to the motion of all the objects around us in our daily life
CO3	Gain the foundation for applications in various applied fields in science and technology
CO4	Understand the concepts of vectors, laws of motion, momentum, energy, rotational motion, central force field, gravitation, collision and special theory of relativity
CO5	Empower the students to develop the skill of organizing the theoretical knowledge and experimental observations into a coherent understanding

Course Details:(Theory)

Unit 1
Revision of vectors, vector differentiation, ordinary derivatives of vectors, space curves continuity and differentiability, partial derivatives of vectors, gradient, divergence, curl,vector differentiation and their geometrical interpretation, various coordinate systems: polar coordinate, orthogonal curvilinear coordinate system, unit vectors and tangent vectors in curvilinear systems, special orthogonal curvilinear coordinate system, cylindrical coordinate system and spherical polar coordinate systems.

Unit 2
Inertial and non-inertial frames, fictitious force, Coriolis force, Newton's laws of motion and its applications, friction, conservative and non-conservative force, work energy theorem, conservation of linear momentum and energy, variable mass system (Rocket motion), simple harmonic motion, small oscillation, equilibrium, condition for stability of equilibrium, energy diagram, small oscillation in a bound system, working of Teetertoy.

Unit 3
Concept of center of mass and calculation of center of mass for different objects, system of particles and collision, conditions for elastic and inelastic collision, collision in center of mass frame, rigid body kinematics, rotational motion, moment of inertia, theorems on moment of inertia, calculation of moment of inertia of bodies of different shapes.

Unit 4
Central force field, properties of central force field, inverse square law force, gravitational field and potential; Kepler's laws of planetary motion and its application
Wave mechanics, wave particle duality, De-Broglie matter wave, Schrodinger wave equations (time dependent and time independent), uncertainty principleand its applications

Unit 5
Frame of reference, Galilean transformation, Michelson-Morley experiment, postulates of special theory of relativity, Lorentz transformations, Length contraction, time dilation, velocity addition theorem, variation of mass with velocity, Einstein's mass energy relation, relativistic relation between energy and momentum, rest mass of photon.

Text and Reference Books:

1. Vector Analysis by M. R. Spiegel, Schaum's Outlines, (2021)
2. Introduction to Mechanics: R. D. Kleppner and J. Kolenkow, Cambridge University Press,

2nd edition, (2014)
3. A textbook of Mechanics by J. C. Upadhyay,Ram Prasas Publications; 1st Ed (2017)
4. Mechanics by D. S. Mathur, S. Chand; New edition, (2000)
5. Theory & Problems of Theoretical Mechanics by M. R. Spiegel, Schaum's Outline Series, (2017)
6. Introduction to Special Theory of Relativity by Robert Resnick, Wiley, 1st edition (2007)
7. Concept of Physics (Part-I) by H. C. Verma, Bharti Bhawan Publisher, (2019).
8. Quantum Mechanics by L.I. Schiff, McGraw-Hill Education (India) Pvt Limited, (2017)
9. A Textbook of Quantum Mechanics by P.M. Mathews and K. Venkatesan, McGraw-Hill Education (India) Pvt Limited, (2010).
10. Introduction to Quantum Mechanics by D.J.Griffiths, 3E, Cambridge University Press, (2018)

Course outcomes (CO): At the end of the lab course, the student will be able to:

CO1	Perform basic experiments related to mechanics
CO2	Be familiar with various measuring instruments and also would learn the importance of accuracy of measurements.

Course Details:(Practical)

1. Graphical Analysis (Ref. UIET Laboratory Manual)
2. Trajectory of projectile (Ref. UIET Laboratory Manual) Apparatus Used (Trajectory Apparatus, Metal Balls, Channels, Vernier Callipers, Carbon & Graph Paper)
3. Moment of Inertia of Bicycle wheel (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Bicycle Wheel, Masses, Thread, Stopwatch, Meter Scale, Vernier Callipers)
4. Spring Oscillations (Ref. UIET Laboratory Manual) Apparatus Used (Spring Oscillation Apparatus, Stop Watch, Masses)
5. Coupled Pendulum (Ref. UIET Laboratory Manual) Apparatus Used (Coupled Pendulum Setup, Stop Watch, Scale)
6. Bifilar Suspension System (Ref. UIET Laboratory Manual) Apparatus Used (Bifilar Suspension System Setup, Stop Watch, Masses)
7. Frequency of AC Mains by Melde's Method (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Electrical Vibrator, String, Pulley, Small Pan, Weight Box & Physical Balance)
8. Kater's(Reversible) Pendulum (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Kater's Pendulum, Stop Watch)
9. Inertia Table (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Inertia Table, Stop Watch, Vernier Callipers, Split Disc, Balancing Weights, and Given Body (Disc))
10. Moment of Inertia of Flywheel (Ref. Book by J. C. Upadhyay and UIET Laboratory Manual) Apparatus used (Fly wheel, weight hanger, slotted weights, stop watch, metre scale)

Course Code: TCA-S102 **Breakup: 1 –1 – 6 – 5**
Course Name: Workshop Concepts

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

CO1	Understand the design and applications of different machine tools and their operations based on global standards
CO2	Gain basic knowledge of casting processes and their applications
CO3	Recognize the different types metal forming process and their operations
CO4	Understand and appreciate thebasic fabrication processes such as welding
CO5	Have knowledge about modern trends in manufacturing, unconventional machining processes and automation

Course Details: (Theory)

Historical perspectives and Classification of Manufacturing processes

Machining: Basic principles of lathe machine & operations performed on it, Basic description of machines & operations of shaper-planer, drilling, milling, grinding Unconventional machining processes, Machine tools

Casting processes: Pattern & allowances, Moulding sands & its desirable properties. Mould making with the use of a core national Gating system, Casting defects & remedies, Cupola furnace, Die-casting & its uses

Metal forming: Basic metal forming operations & uses of such as-forging, rolling, wire& tube drawing/making & extrusion, & its products/applications, press work & die & punch assembly, cutting & forming, its application; Hot working vs Cold working;

Powder metallurgy: powder metallurgy process &its applications, plastic-products manufacturing, galvanizing & electroplating.

Welding: Importance & basic concepts of welding, classification of welding processes, Gas welding, types of flames, Electric arc welding, Resistance welding, Soldering & brazing and its uses,

Modern trends in manufacturing, Automation, Introduction to NC/CNC/DNC, FMS, CAD/CAM, CIM and factory of future

Course Name: Workshop Practice

Course Details: (Practical)

1. Foundry (1turn)
2. Welding (3 turns)
   - (a) Gas Welding (1turn)
   - (b) Arc Welding (2 urns)
     - i. Lap Joint (1 turn)
     - ii. Butt Joint (1 turn)
3. M/C Shop (4Turns)
4. Fitting & Sheet Metal Work (1 turn+1turn)

5. Carpentry Shop(1turn)
6. Black-smithy shop(1turn)

Text and Reference Books:

1. Chapman,W A J & Arnold, E, “Workshop Technology ; vol. I, II & III” Viva Low Priced Student Edition (1972)
2. Raghuwanshi, B S “Workshop Technology; vol. I&II” Dhanpat Rai & Sons (2015)
3. Chaudhary, Hajra “Elements of Workshop Technology; vol. I&II” Media Promoters & Publishers (2008)

Course Code: ISC – S101 **Breakup: 3 –0 – 3 –5**
Course Name: Programming & Computing(C & UNIX)

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

CO1	Recollect various programming constructs and to develop C programs
CO2	Understand the fundamentals of C programming
CO3	Choose the right data representation formats based on the requirements of the problem
CO4	Implement different Operations on arrays, functions, pointers, structures, unions and files

Course Details: (Theory)

Basic concepts of Computers, Basic UNIX Concepts and Vi – Editor

Introduction to C: Basic Programming concepts, Program structure in C, Variables and Constants, Data types, Conditional statements, control statements,
Functions, Arrays, Structures; Introduction to pointers; Introduction to File Systems

Text and Reference Books:

1. Byron S. Gottfried, Programming in C, Schaum Series, 3rd edition, BPB Publication, (2017)
2. Denis Ritchi, The 'C' Programming, Second edition, PHI, (1988)
3. K.R. Venugopal, Mastering C, Second edition, TMH, (2006)
4. Yashavant Kanetkar, Let Us C, 18th Edition, BPB, (2021)
5. E. Balaguruswami,Programming in ANSI C, Eighth Edition, TMH (2019)

Course Name: Computer Programming Lab
Course Details: (Practical)

Learning OS Commands
Practice of all Internal and External DOS Commands, writing simple batch programs, Exposure to Windows environment, Practice of UNIX commands and Vi editor, Writing simple shell script

C Programming:
Practicing programs to get exposure to basic data types, algebraic expressions, Conditional statements, Input Output Formatting, Control structures, arrays, functions, structures, pointers and basic file handling

Course Code: MTH-S102 **Breakup: 3 –1 – 0 – 4**
Course Name: Mathematics-II

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

CO1	Solve the consistent system of linear equations
CO2	Determine the power series expansion of a given function
CO3	Solve arbitrary order linear differential equations with constant coefficients
CO4	Apply Laplace transforms to solve physical problems arising in engineering
CO5	Find eigen values, eigen vectors & diagonalize a matrix
CO6	Understand concept of vector space & linear transformation

Course Details:

Unit–I
Matrix Algebra: Elementary operations and their use in finding Rank, Inverse of a matrix and solution of system of linear equations. Orthogonal, Symmetric, Skew-symmetric, Hermitian, Skew-Hermitian, Normal & Unitary matrices and their elementary properties

Unit–II
Vector Space, Linear transformation, Linear dependent and linear independent, Eigen-values and Eigenvectors of a matrix, Cayley-Hamilton theorem, Diagonalization of a matrix

Unit-III
Ordinary Differential Equations of second order: Solution of linear differential equations with Constant coefficients. Euler-Cauchy equations, Solution of second order differential equations by changing dependent and independent variables; Method of variation of parameters, Introduction to series solution method, Frobenious Methods

Unit- IV
Ordinary differential equations of higher orders: Matrix method

Unit-V
Laplace Transform: Laplace and inverse Laplace transform of somestandard functions, Shifting theorems, Laplace transform of derivatives andintegrals. Convolution theorem, Initial and final value theorem; Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function. Applications of Laplace transform.

Text and Reference Books:

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, (2005).
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, (2005).
3. C. Ray Wylie & Louis C. Barrett, Advanced Engineering Mathematics, Tata McGraw-Hill Publishing Company Ltd. (2003).
4. G.F. Simmons, Differential Equations, Tata McGraw-Hill Publishing Company Ltd. (1981).

Course Code: CHM – S101 **Breakup: 3 –1 – 3 – 5**
Course Name: Chemistry - I

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

CO1	Understand the concept related to atoms and molecules, chemical bonding coordinate compounds and its applications
CO2	Concept of chemical kinetics, electrochemistry, photochemistry and their applications
CO3	Understand the concept of spectroscopy and its applications in various fields
CO4	Understand the basics of stereochemistry, organic reactions and its mechanism for various types of reactions
CO5	Various experiments helps the student to learn the basics of experiments to apply in day today life as well as in industry

Course Details: (Theory)

UNIT-I - Atoms and Molecules:
Need for wave mechanical picture of atomic structure [Photoelectric effect, deBroglie concept of matter waves], Derivation of Schrodinger wave equation [asan example particle moving in uni-dimensional potential well]
Chemical Bonding- Orbital concepts in bonding, V.B. and M.O. theory, M.O.diagrams, Intermolecular interactions

UNIT-II - Reaction Dynamics:
Order, Molecularity, Rate law, Integrated rate equations, Methods of determining of order of reaction, Complex reaction kinetics- chain reactions and reversible reactions in detail, Catalysis and enzyme catalysis

UNIT-III - Electrochemistry:
Arrhenius theory of electrolytic dissociation, Transport number, Kohlrausch's law, Solubility product, Redox reaction, Electrochemical and concentration cells.

UNIT-IV- Stereochemistry:
Introduction, Chirality, Enantiomers, Diastereomers, Projection formula of a tetrahedral carbon, Geometrical isomerism, Conformers

UNIT- V- Application of Spectroscopic Techniques:
Basic working principle on measurement technique: IR, UV visible spectroscopy and NMR

UNIT-VI - Organic Reactions:
Concepts Electron displacement effects, Organic intermediates, Types of reactions [addition, elimination and substitution reactions]

UNIT-VII - Photochemistry:
Principles of photo chemistry, Photo-excitation of organic molecules, Jablonski diagram, Laws of photochemistry and quantum yield, some examples of photochemical reactions, Chemistry of vision and other applications of photochemistry

UNIT-VIII - Transition Metal Chemistry:
Structure of coordination compounds corresponding to coordination number up to 6, Types of ligands, chelation, Isomerism [geometrical, optical, ionization, linkage and coordination], Theories of bonding in coordination compounds- crystal field theory, Valence bond theory.

Text and Reference Books:

Physical Chemistry-

1 Physical Chemistry, P. Atkins and j. De Paul, 8^{th} Edition, International Student Edition, Oxford University Press. (2006)
2 Principles of Physical Chemistry B.R Pure, L. R. Sharma, and M. S. Pathania, 37^{th} Edition Shoban Lal Nagin Chand & Co., Jalandhar (2017)

Organic Chemistry-

1. Organic Chemistry, R. T. Morrison and R. N. Boyd, 6^{th} Edition, Prentice-Hall of India (P) Ltd, New Delhi. (2016)
2. A text book of Organic Chemistry, Arun Bahl & B. S. Bahl, S. Chand Publishers, New Delhi (2019)

Inorganic Chemistry-

1. Concise Inorganic Chemistry, J. D. Lee, 5^{th} Edition Chapman & Hall, London, (1997)
2. Inorganic Chemistry, J. E. Huheey, E. A. Keiter and R. L. Keiter (2017)

Engineering Chemistry-

1. Engineering Chemistry, Shashi Chawla, Dhanpat Rai & Co.(2013)
2. Engineering Chemistry, P. C.Jain and Monika Jain. 16^{th} edition,Dhanpat Rai Publishing Company **(**2015)

Course Name: Chemistry Lab- I

Course Details: (Practical)

1. To estimate the strength of the given unknown solution of Mohr's salt (Ferrous ammonium sulphate (FeSO4.(NH4)SO4.6H2O) using KMnO4 solution as an intermediate.
2. To prepare a sample of p-nitroacetanilide.
3. To prepare a sample of Aspirin.
4. Preparation of Tris (Thiourea) Copper (I) sulphate.
5. Preparation of Hexaamine Nickel (II) chloride [Ni(NH3)6]Cl2.
6. Estimation of commercial caustic soda: Determination of the amounts of sodium carbonate and sodium hydroxide present together in the given commercial caustic soda.
7. Estimation of calcium ions present in tap water.
8. To determine the partition coefficient of acetic acid between n-butanol and water.
9. To study the photochemical reduction of a ferric salt (Blue printing).
10. To determine the viscosity of a given liquid room temperature using Ostwald's viscometer.
11. To separate Ag(I), Hg (I) and Pb(II) ions by paper chromatography and calculate their RF values.
12. Understanding reaction kinetics and calculating the rate and order of a reaction.
13. To study the kinetics of first order reaction (methyl acetate hydrolysis catalysed by o.5 N HCl solution).

Course Code: ESC-S101 **Breakup: 3 –1 – 3 – 5**
Course Name: Basic Electrical & Electronics Engineering

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

CO1	Predict the behaviour of any electrical and magnetic circuits
CO2	Formulate and solve complex AC, DC circuits
CO3	Realize the requirement of transformers in transmission and distribution of electric power and other applications
CO4	Have knowledge of some basic electronic components and circuits
CO5	Understand the basics of diode and transistor circuits
CO6	Understand the working of some I C based circuits
CO7	Study logic gates and their usage in digital circuits

Course Details:(Theory)

Unit – I

Sinusoidal steady state circuit analysis, voltage, current, sinusoidal & phaser presentation single phase AC circuit – behavior of resistance, inductance & capacitance & their combination, impedance concept of power, power factor; Series & parallel resonance – band width & quality factor, Three phase circuits – phase voltage & current, line & phase quantities, phasor diagram, balanced & unbalanced loads, Measurement of R, L, and C.

Unit –II

Network Theory: Network theorems – Thevenin's, Norton, maximum power transfer theorem, star deltatransformation, circuit theory concept – mesh & nodal analysis.

Unit – III

Magnetic circuit concepts: self-inductance, magnetic coupling analysis of single tuned & double tuned circuit involving mutual inductance, introduction to transformer.

Unit – IV

Basic Instruments, electrical measurement – measurement of voltage , current , power & energy, voltmeters& ammeter , wattmeter , energy meter , three phase power measurement , electronics instrument –multimeter, CRO(analog & digital),An overview of voltage regulator.

Unit – V

Introduction to basic electronics devices – junction diode, BJT, amplifier, op-amps & instrumentation amplifier with mathematical operation

Number System: Introduction to binary, octal, decimal & hexadecimal systems, representation of negative, numbers, 1's, 2's, 9's, 10's complement and their arithmetic.

Text and Reference Books:

1. Edward Hughe Electrical and Electronic Technology, 10th Edition, Pearson Education Asia, (2019)
2. P. Kothari, I J Nagrath, Electric Machines, 5th Edition, Tata McGraw Hill, (2017)
3. P. Malvino, Electronic Principles, 7th Edition, Tata McGraw Hill, (2007)
4. A Textbook of Electrical Technology - Volume I (Basic Electrical Engineering) 23 Rev Ed Edition, S. Chand Publishing.(2020)
5. S. K. Bhattcharya, Basic Electrical and Electronics Engineering, Pearson, (2012)
6. Vincent Del Toro, Electrical Engineering Fundamentals, Prentice Hall of India Private Limited, 2nd Edition, (2003)

7. David Bell, Electronic Devices and Circuits, 5th Edition, Oxford University Press, (2008)
8. Michael Tooley A., Electronic circuits: Fundamentals and Applications, 3rd Edition, Elsevier Limited, (2006)

Course Name: Basic Electrical & Electronics Engineering Lab
Course Details: (Practical)

1. Familiarization with the Electronic Instruments.
2. Familiarization with electronic components and Bread board.
3. To verify the Thevenin theorem.
4. To verify the Superposition theorem.
5. Measurement of voltage and frequency with CRO.
6. To study half wave rectifier.
7. To study full wave bridge rectifier.
8. To study full wave bridge rectifier with filter.
9. To study and verify the truth table of different logic gates using digital IC.
10. To study different type of transformer and there operation.
11. To study basic wiring and design a switchboard/extension board.
12. To study the polarity test of a single phase transformer.
13. To study the open & short circuit test of a transformer and calibration losses.
14. To study the load test and efficiency of a single phase transformer.

Course Code: PHY-S102 **Breakup: 3 –1 – 3 –5**
Course Name: Physics-II

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

CO1	Understand the vector integration which they can apply in electricity and magnetism
CO2	Understand the concepts of wave optics such as the phenomena of interference, diffraction and polarization of light
CO3	Understand the concepts of electrostatics, magnetostatics, electromagnetic induction, Maxwell's equations and electromagnetic waves
CO4	Apply the concepts of physics in the engineering courses

Course Details:(Theory)

Unit 1
Vector integration, Stokes' theorem, divergence theorem, electrostatics: Coulomb's law, superposition of electric forces, electric flux, Gauss's law, electric field, potential, calculation of electric fields due to different charge distribution, gradient and curl of electric field, electric dipoles and multipoles, potential energy of a dipole placed in external electric field, Laplace's equation, Poisson's equation.

Unit 2
Magnetostatics, motion of charge in electric and magnetic field, Lorentz force, magnetic flux, torque on a current coil in uniform magnetic field, magnetic dipole, potential energy of a magnetic dipole, Biot-Savart law, Ampere's law, calculation of magnetic field due to different current distribution, divergence and curl of magnetic field.

Unit 3
Electromagnetic induction, Faraday's law, Lenz's law, self-induction, mutual induction, growth and decay of current in L-R circuit, electromagnetic waves, displacement current, Maxwell's equations in free space and matter, verification of Faraday's law of electromagnetic induction and Ampere's law in vacuum by using plane electromagnetic waves and derivation of velocity of light (c) in terms of permittivity and permeability of free space, Poynting vectors, Poynting theorem.

Unit 4
Coherent sources, Interference, Fresnel's biprism, interference in uniform and wedge shaped thin films, necessity of extended source, Newton's rings and its applications, Fresnel and Fraunhofer diffraction at single slit and double slits, absent spectra, diffraction grating, spectra with grating, dispersive power, resolving power of grating, Rayleigh's criterion of resolution

Unit 5
Dispersion of light, angular dispersion, dispersive power, irrational dispersion, angular and chromatic dispersion, deviation without dispersion, dispersion without deviation, polarization of light, Fresnel's theory of optical activity and polarimeter, fundamental idea of optical fiber, types of fibers.

Text and Reference Books:

1. D.J. Griffiths, Introduction to Electrodynamics, 3E, Prentice-Hall of India Private

Limited, (2002)
2. M. R. Spiegel, Vector Analysis, Schaum's Outlines, (2021)
3. Ajoy Ghatak , Optics, McGraw Hill Education (India) Private Limited,7th Edition, (2020)
4. Subrahmanyam, Brijlal and Avadhanulu, A textbook of Optics by, Schand; 23rd Rev. Edition. (2006).
5. J. D. Jackson, Classical Electrodynamics by,Wiley, 3rd edition, (1998).
6. Aurthur Beiser, Concept of Modern Physics by, McGraw-Hill Education,6th Edition (2021).
7. Ajoy Ghatak and K. Tyagrajan, Introduction to fiber optics by, 1E, Cambridge University Press, (2012)

Course Name: Physics Lab-II

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

CO1	Gain practical knowledge about electricity and magnetism and measurements such as resistance, voltage, current etc
CO2	Gain experimental knowledge of interference, diffraction and polarization of light and measurement of the wavelengths of the monochromatic light with the help of Newton's ring experiment, Fresnel's biprism experiment, etc.
CO3	Understand the concept of semiconductor physics through the four probe experiment
CO4	Gain knowledge about the various optical devices: prism, grating, spectrometer.
CO5	Understand the basic concept of modern physics through the determination of Planck's constant

Course Details:(Practical)

1. Newton's Ring (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Traveling Microscope, Support for Glass Plate inclined at 450 to the Vertical, Short Focus Convex Lens, Sodium Lamp, Plano Convex Lens, An Optically Plane Glass Plate)
2. Prism Spectrometer (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Spectrometer, Glass Prism, Reading Lens, Mercury Lamp)
3. Plane Transmission Grating (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Spectrometer, Diffraction Grating, Mercury Lamp)
4. Ballistic Galvanometer (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Ballistic Galvanometer, Morse key, Damping key, Condenser, Rheostat, Volt Meter, Storage Battery, Connection Wires)
5. Carey Foster's Bridge (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Carey Foster's Bridge, Laclanche cell, Resistance Box, Galvanometer, Plug Key, Copper Strip)
6. Fresnel's Biprism (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Sodium Lamp, Biprism, Convex Lens, Optical Bench with Four Uprights)
7. Variation of Magnetic Field (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Stewart and Gee type Tangent Galvanometer, Storage Battery, Commutator, Ammeter, Rheostat, One way Plug Key, Connection Wires)

8. Polarimeter (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Sodium Lamp, Polarimeter, Physical Balance)
9. Planck's Constant (Ref. Book by S.K. Gupta and UIET Laboratory Manual) Apparatus Used (Power supply, photocell, connecting wires)
10. Energy Band Gap by Four Probe Method (Ref. Book by S.K. Gupta and UIET Laboratory Manual) Apparatus Used (An experimental kit)

Course Code: TCA-S101 **Breakup: 0 –2 – 4 – 5**

Course Name: Engineering Drawing

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

CO1	Understand the basics of engineering graphics
CO2	Develop skills to prepare basic engineering drawings
CO3	Understand the concept of projection and acquire visualization skills
CO4	Gain imaginative skills to understand section of solids and developments of surfaces

Course Details:

Introduction-Drawing instruments and their uses, global BIS conventions, lettering dimensioning and free-hand practicing

Orthographic projections: Lines, planes and surfaces of objects, Sectional views, Auxiliary views, Space geometry: lines and planes, True lengths and shapes, Properties of parallelism, Perpendicularity and intersections of lines and planes, Simple intersections of solids and development of lateral simple solids

Isometric Projections: Introduction isometric scale, isometric projection of simple plane figures, isometric projection of tetrahedron, hexahedron(cube), right regular prisms, pyramids, cylinders, cones, spheres, cut spheres and combinations of solids.

Introduction to computer graphics: Some problems on above topics on computer graphics.

Text and Reference Books:

1. K.L. Narayana, &P. Kannaiah, Engg.Graphics, Tata McGraw Hill, New Delhi, (2012)
2. N.D. Bhatt, Elementary Engg. Drawing Charotar Book Stall, Anand.(2014)
3. V. Lakshminarayanan,and R. S. VaishWannar , Engg.Graphics, Jain Brothers, New Delhi (2016)
4. B. Agrawal & C.M. Agrawal, Engineering Graphics, TMH Publication, (2012)
5. M.B. Shah, & B.C. Rana, Engineering Drawing and Computer Graphics, Pearson Education (2008)
6. Narayana, K.L. & P Kannaiah Text book on Engineering Drawing, Scitech Publishers. (2008)

Course Code: MTH-S201 **Breakup: 3 –1 – 0 – 4**
Course Name: Mathematics - III

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

CO1	Obtain the Fourier series expansion of a given function
CO2	Apply Fourier transform for solving Boundary Value Problems
CO3	Determine the solution of linear partial differential equations (PDE) by variable Lagrange's method & some nonlinear PDEs
CO4	Understand and use of complex variable & analyticity
CO5	Expand a function of Laurent series
CO6	Evaluation of real integrals using residues

Course Details:

Unit – I
Function of a Complex variable: Complex numbers- power and roots, limits, continuity and derivative of functions of complex variable, Analytic functions, Cauchy-Reimann equations, Harmonic function, Harmonic conjugate of analytic function and methods of finding it, Complex Exponential, Trigonometric, Hyperbolic and Logarithm function.

Unit – II
Complex Integration: Line integral in complex plane(definite and indefinite), Cauchy's Integral theorem, Cauchy's Integral formula, Derivatives of analytic functions, Cauchy's Inequality, Liouville's theorem, Morera's theorem, Power series representation of analytic function and radius of convergence, Taylor's and Laurent's series, singularities, Residue theorem, Evaluation of real integrals, Improper Integrals of rational functions.

Unit-III
Fourier series: Trigonometric Fourier series and its convergence. Fourier series of even and odd functions, Fourier half-range series; Parseval`s identity, Complex form of Fourier series;

Unit-IV
Fourier Transforms: Fourier integrals, Fourier sine and cosine integrals, Fourier transform, Fourier sine and cosine transforms and their elementaryproperties, Convolution theorem, Application of Fourier transforms to BVP

Unit-V
Partial Differential Equations: Formation of first and second order partial differential equations. Solution of first order partial differential equations: Lagrange`s equation, Four standard forms of non-linear first order equations.

Text and Reference Books:

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, (2005).
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, (2005).

Course Code: ESC-S201 **Breakup: 3 –1 – 0 – 4**
Course Name: Engineering Mechanics

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

CO1	Understand the fundamentals of engineering mechanics and their applications
CO2	Gain knowledge of various types of motion related to body
CO3	Understand the basic concepts of friction and application of friction
CO4	Identify appropriate structural system for studying a given problem and isolate it from its environment
CO5	Carry out kinematic and kinetic analyses for particles and systems of particles
CO6	Apply the principles of mechanics to practical Chemical engineering problems

Course Details:

General Coplanar force systems: Basic concepts, Law of motions, principle of transmissibility of forces, Transfer of a force to parallel position, Resultant of a force system, simplest resultant of two dimensional concurrent & non-concurrent force systems, free body diagrams, equilibrium & its equations, applications

Trusses & Cables: Introductions, simple truss & solutions of simple truss, method of joints & method of sections.

Friction: Introduction, Laws of coulomb friction, equilibrium of bodies involving dry friction, belt friction, applications.

Centre of gravity, centroid, Moment of Inertia: Centroid of plane, curve, area, volume & composite bodies, moment of inertia of plane area, parallel axis theorem, perpendicular axis theorem, principal moment inertia, mass moment of inertia of circulating, disc, cylinder, sphere and cone about their axis of symmetry.

Beams: Introduction, shear force and bending moment, differential equations for equilibrium, shear force & bending moments diagrams for statically determinate beams

Kinematics of rigid body: Introduction, plane motion of rigid bodies, velocity & acceleration under translation & rotational motion, Relative velocity, projectile motion.

Kinetics of rigid bodies: Introduction, force, mass & acceleration, work & energy, impulse & momentum, D'Alembert principles & dynamic equilibrium, Virtual work.

Text and Reference Books:

1. F.P. Beer & F.R. Johnston, Mechanics For Engineers, 11th edition, McGraw Hill, (2017)
2. Shames, I.H., Engg. Mechanics, 4thedition , P H I (2005)
3. J. L. Meriam , Statics, 7th edition, J. Wiley (2011)
4. J. L. Meriam , Dynamics, 7th edition, J. Wiley, (2011)

Course Code: ESC-S202 **Breakup: 3 –1 – 0 – 4**
Course Name: Basic Thermodynamics (CHE)

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

CO1	Use thermodynamic terminology correctly and explain fundamental thermodynamic properties
CO2	Derive and discuss the zeroth, first, second, and third laws of thermodynamics
CO3	Apply the first and second laws of thermodynamics to chemical processes and calculate efficiency
CO4	Solve problems using the properties and relationships of thermodynamic fluids.
CO5	Analyze the behaviour of flow and non-flow processes using mass and energy balances
CO6	Analyze basic thermodynamic cycles

Course Details:

Introduction: Definition and scope of thermodynamics, macroscopic and microscopic viewpoint, system, properties, processes and cycles, homogeneous and heterogeneous systems, thermodynamic equilibrium, quasi-static process, phases of a substance, unit systems, specific volume, pressure.

Temperature: Zeroth law of thermodynamics, measurement of temperature, different temperature scales.

Properties of pure substances: Pure substance, p-v diagram, p-T diagram, T-s diagram, h-s diagram or Mollier diagram, quality or dryness fraction, steam table.

Energy and its transfer: Energy, different forms of energy, energy transfer by heat, energy transfer by work, different forms of work transfer - pdV work or displacement work, shaft work, flow work, etc., pdV work in various quasi-static processes, specific heat and latent heat.

First Law of Thermodynamics: Energy balance, energy conversion efficiency, energy analysis of open and closed systems, PMM1.

Second Law of Thermodynamics: Cyclic heat engine, thermal reservoirs, Kelvin-Planck statement, Clausius’ statement, refrigerator and heat pump, equivalence of Kelvin-Planck and Clausius’ statement, PMM2, conditions for reversibility, Carnot cycle, Carnot’s theorem, corollary of Carnot’s theorem, absolute thermodynamic temperature scale, efficiency of the reversible heat engine.

Entropy: Clausius’ theorem, temperature-entropy plot, Clausius inequality, entropy change in an irreversible process, entropy principle, entropy generation in a closed and open system, entropy and direction, entropy and disorder.

Availability: Available energy, available energy in a cycle, quality of energy, law of degradation of energy, maximum work in a reversible process, second law efficiency.

Thermodynamic relations: Maxwell’s equations, TdS equations, Joule-Kelvin effect, Clausius-Clapeyron equation, Gibbs phase rule for non-reactive system.

Power and refrigeration cycles: Simple steam power cycle, Rankine cycle, comparison of Rankine and Carnot cycles, characteristics of an ideal working fluid in vapour power cycles. Carnot gas power cycle, Refrigeration cycle – reversed heat engine cycle, vapour compression refrigeration cycle, components in a vapour compression plant, refrigerants.

Text and Reference Books:

1. P K Nag, Engineering Thermodynamics, Sixth edition, McGraw Hill Education, Delhi (2017).
2. Y A Cengel, M A Boles, M Kanoglu, Thermodynamics An Engineering Approach, Ninth edition, McGraw Hill Education, Delhi (2019).
3. Y V C Rao, An Introduction to Thermodynamics, Universities Press, Hyderabad (2003).

Course Code: CHE-S201 **Breakup: 3 –1 – 0 – 4**
Course Name: Process Calculations

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

CO1	Demonstrate comprehensive understanding of material and energy balance equations for open and closed systems
CO2	Select appropriate basis and conduct degree of freedom analysis before solving material and energy balance problems
CO3	Make elementary flow-sheets and perform material and energy balance calculations without and with chemical reactions, and involving concepts like recycle, bypass and purge
CO4	Perform process calculations utilizing psychrometric charts and steam tables
CO5	Apply simultaneous material and energy balance calculations for steady state continuous flow systems and unsteady state systems

Course Details:

Introduction: Units, their dimensions and conversions, Dimensional consistency of equations, Dimensional and dimensionless constants,

Fundamental concept of stoichiometry: Mass and volume relations, Stoichiometric and composition relations, Excess reactants, Degree of completion, Conversion, Selectivity and Yield.

Ideal gases and gas mixture: Gas laws-Ideal gas law, Dalton's Law, Amagat's Law, and Average molecular weight of gaseous mixtures.

Vapour pressure: Effect of temperature on vapour pressure, Vapour pressure plot (Cox chart), Vapour pressures of miscible and immiscible liquids and solutions, Raoult's Law and Henry's Law.

Humidity and Humidity charts: Relative Humidity and percent saturation; Dew point, Dry and Wet bulb temperatures; Use of humidity charts for engineering calculations

Material balances for systems with and without chemical reactions: species and elemental balance. Analysis of systems with by-pass, recycle and purge.

Thermophysics: Heat capacity of gases, liquids and solutions, Heat of fusion and vaporisation;

Thermochemistry: Calculations and application of heat of reaction, combustion, formation, neutralisation and solution; Enthalpy-concentration charts;

Steady state energy balance for systems with and without chemical reactions:

Combustion of solids, liquids and gaseous fuels, calculation of theoretical and actual flame temperatures, Degrees of freedom in steady state processes, solution of simultaneous material and energy balance problems using flow sheeting codes;

Unsteady state material and energy balance

Text and Reference Books:

1. D.M. Himmelblau, Basic Principles and calculations in Chemical Engineering, Printice-Hall (2015)
2. O.A. Hougen, K.M.Watson & R.A.Ragatz, Chemical process principles, John Willey & Sons (2018)

Course Code: CHE-S202 **Breakup: 3 –1 – 0 – 4**
Course Name: Fluid Mechanics

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

CO1	Distinguish pressure distribution in static and flowing fluid in closed and open channels
CO2	Apply the basic law of fluid statics to fluid bodies in stationery and flowing fluid
CO3	Write the general and energy balance equations for unsteady state and steady state conditions
CO4	Apply the Bernoulli's equation of Engineering for simple situations of fluid flow in pipe, pump, compressor and various pipe fittings
CO5	Understand the working principle of pressure and measuring devices and fluid machines

Course Details:

Fundamentals of fluid mechanics: Concept of a fluid; Properties of fluid – mass density, specific weight, specific volume, specific gravity, relative density, pressure; Viscosity; Newton's law of viscosity; Newtonian and non-Newtonian fluids; Vapour pressure, boiling point; Bulk modulus and compressibility; Capillarity; Surface tension and its effect.

Fluid pressure and its measurements: Introduction; Pressure at a point – forces on a fluid element, stress, stress at a point, Pascal's law; Pressure variation in a static fluid; Pressure measurement - Barometer, Piezometer, Manometer, Bourdon gauge, Diaphragm pressure gauge.

Buoyancy and floatation: Buoyancy, Buoyant force, Centre of buoyancy; Archimedes' principle; Maximum height of a body floating vertically in water.

Kinematics: Kinematics of fluid flow, scalar, vector, and tensor quantities; Classification of fluid flow – one, two, and three dimensional flow, steady and unsteady flow, uniform and non-uniform flow, laminar and turbulent flow, compressible and incompressible flow, rotational and irrotational flow, ideal and real fluid flow; Lagrangian and Eulerian flow descriptions; Fundamentals of flow visualization – Pathlines, Streaklines, Streamlines, Timelines; Continuity equation.

Fluid dynamics: Euler's equation of motion; Bernoulli's equation; Applications of Bernoulli's theorem - Venturi meter, Orifice meter, Pitot tube; Variable area meter - Rotameter.

Viscous flow: Laminar flow; Turbulent flow; Navier-Stokes equation; Flow through a circular pipe (Hagen-Poiseuille theory); Turbulent flow – Prandtl mixing length theory.

Boundary layer theory: Description of boundary layer; Laminar and turbulent boundary layer in pipes; Boundary layer thickness; Boundary layer separation; Methods of controlling the boundary layer.

Dimensional analysis: Rayleigh's method; Buckingham pi theorem.

Flow through orifices and mouthpieces: Discharge through a sharp edged orifice; Hydraulic coefficients; Discharge through a large rectangular orifice; Discharge through a large circular orifice; Time of emptying a tank through an orifice at its bottom; Time of emptying a conical tank through an orifice at its bottom; Time of emptying a circular horizontal tank through an orifice at its bottom.

Classification of mouthpieces; Loss of head of a flowing liquid due to sudden enlargement, sudden contraction, at the entrance and exit of a pipe, due to an obstruction in a pipe; Discharge through an external and internal mouthpiece.

Flow over notches and weirs: Definition; Types of notches; Discharge over a rectangular notch; Time of emptying a tank over a rectangular notch; Discharge over a triangular notch; Advantages of a V-notch over a rectangular notch; Time of emptying a tank over a triangular notch; Discharge over a trapezoidal notch; Discharge over a stepped notch; Classification of weirs; Discharge over a rectangular weir; Discharge over a triangular weir; Discharge over a trapezoidal weir.

Flow through pipes: Introduction; Reynolds experiment; Loss of energy in pipes; Darcy-Weisbach formula for loss of head in pipes, Moody's chart, Colebrook equation, Haaland equation, Swamee-Jain equation, Chezy's formula; Minor losses; Combination of pipes – pipes in series, equivalent size of a compound pipe, Dupuit's equation, parallel pipes; Flow through nozzles; Water hammer.

Pumps: Introduction; Classification of pumps; Centrifugal pumps – Components of a centrifugal pump, Working of a centrifugal pump, Priming of a centrifugal pump, Definitions of heads and efficiencies of a centrifugal pump, Effect of variation in speed, Specific speed and pump similarity, Characteristic curves of centrifugal pumps, Net positive suction head, Cavitation in pumps. Reciprocating pumps – Types of reciprocating pumps, Working of a reciprocating pump, Discharge of reciprocating pump, Coefficient of discharge, Slip of the reciprocating pump, Power required to drive a reciprocating pump; Comparison between centrifugal pump and reciprocating pump.

Text and Reference Books:

1. C S P Ojha, R Berndtsson, P N Chandramouli, Fluid Mechanics and Machinery, Oxford University Press, New Delhi (2010).
2. P N Modi, S M Seth, Hydraulics and Fluid Mechanics including Hydraulics Machines, Standard Book House, New Delhi (2017).
3. N de Nevers, Fluid Mechanics for Chemical Engineers, Third edition, McGraw Hill, Chennai (2017).
4. Y A Cengel, J M Cimbala, Fluid Mechanics Fundamentals and Applications, Fourth edition, McGraw Hill, Chennai (2019).
5. W L McCabe, J Smith and P Harriot, Unit Operations of Chemical Engineering, Seventh edition, Tata McGraw Hill, New Delhi (2014).
6. C J Geankoplis, Transport Processes and Unit Operations, Third edition, PHI, New Delhi (1993).

Course Code: CHM-S301 **Breakup: 3 –0 – 3 –4**
Course Name: Chemistry II

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

CO1	Understand the theory based ideas in solid state chemistry, phase rule, composites and its importance in engineering
CO2	Understand the basic concepts of polymer chemistry and its importance in engineering chemistry
CO3	Understand the chemistry behind water pollution, its causes and perform experiments related to water pollution
CO4	Understand the concepts related to corrosion and its prevention, fuels, lubricants and its importance in engineering
CO5	Understand the introductory concepts related to nano science, superconductivity, cause of pollution and its prevention benefiting the society

Course Details: (Theory)

UNIT-1
Solid state: Crystal lattices, space lattices and unit cells, crystal systems, Miller indices, Imperfection in crystals: Point defects- Schottky and Frankel defects, Liquid crystals, conducting properties of solids.
Phase Rule- Gibbs's phase rule, phase diagrams of one-component system (water), two component system (lead-silver)
Electronic materials- Composites, Materials related to nanotechnology.

UNIT-II
Polymers: Introduction, Classification of Polymers, Intermolecular forces in Polymers, Structure of Organic and Inorganic polymers of industrial importance, Specialty Polymers: Liquid crystalline polymer, Conducting & electroluminescent polymers.

UNIT-III
Chemistry of cells: Proteins, Nucleic acids, Enzymes, Lipids, Genome.

UNIT-IV
Corrosion: Causes and types of corrosion, Measurement of corrosion, Corrosion prevention methods(electrochemical, inhibitor and coating methods)

UNIT-V
Water Treatment: Hardness of water, softening of water, Reverse osmosis, Treatment of boiler feed water by Calgon process, Ion- exchange resins and Zeolites.

UNIT-VI
Fuels: Coal, Biomass, Biogas, Determination of net calorific values of Bomb calorimeter.

UNIT-VII
Environmental Pollution: Types of pollution and pollutants, Air pollution, Formation and depletion of ozone, Smog and acid rain.

UNIT-VIII
Clusters: Introduction, Types of clusters- Vander Waals clusters, Molecular clusters, Nanoclusters, Macroscopic clusters.

Text and Reference Books:

1. Kuriacose & Rajaram , Engineering Chemistry-, 1st edition, McGraw Hill India, (2004)
2. S.S. Dara, Engineering Chemistry, 1st edition, S. Chand Publication (2019)
3. B. K. Sharma, Engineering Chemistry, Goel Publishing House, Meerut (1996)
4. P. C.Jain and Monika Jain, Engineering Chemistry, Dhanpat Rai Publishing Company (2015)
5. Shashi Chawla, Engineering Chemistry-, 1st edition, Dhanpat Rai & Co (2013)

Course Details: (Practical)

1. To determine the chloride content in supplied water sample using Mohr's method or To determine the percentage of available chlorine in sample of bleaching powder.

2. To determine the Chemical oxygen demand (COD) of polluted water sample using potassium dichromate.

3. To determine the Biological oxygen demand (BOD) /dissolved oxygen (DO) of pollted water sample.

4. To determine the critical micelles concentration (CMC) of surfactant (Sodium dodecyl Sulphate (SDS)) using conductivity meter.

5. To determine the upper Critical Solution Temperature of partially immiscible phenol- water system.

6. To determine the viscosity of addition polymer like polystyrene/PEG.

7. To separate chlorophyll and carotenoids using Column Chromatography.

8. To determine equivalence point of strong acid- strong base, Strong acid-weak base and weak acid-strong base, mixture by conductometric titration.

9. To determine coal sample contents by proximate analysis using muffle furnace.

10. To determine neutralization value of a lubricant oil sample.

Course Code: CHE-S203 **Breakup: 3 –1 – 0 – 4**
Course Name: Chemical Engineering Thermodynamics

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

CO1	Appreciate the scope of the subject as a fundamental subject to calculate thermodynamic properties of substances
CO2	Apply the laws of thermodynamics to closed and open systems and calculate heat effects involved in industrial chemical processes
CO3	Determine thermodynamic properties of ideal and real gaseous mixtures
CO4	Understand and apply the criteria of equilibrium conditions in case of phase equilibria for binary and multi-component systems
CO5	Calculate the important thermodynamic properties of ideal and non-ideal solutions
CO6	Understand reaction equilibrium and determine equilibrium constant and composition of product mixture at given temperature and pressure

Course Details:

Introduction: Macroscopic and microscopic approaches; units; basic concepts of system, property, force, temperature, pressure, work, energy, heat and equilibrium

Review of First and Second law of thermodynamics for closed and open system,

P-v-T behaviour of pure substance: graphical, tabular and mathematical representation Ideal gas, Cubic equations of state; Virial equation of state, laws of corresponding states, compressibility factor, accentric factor, generalized correlation for gases and liquids;

Thermodynamic Potentials and Thermodynamic Property relations: Postulates; Intensive properties; Criteria of equilibrium; Euler relation, Gibbs Duhem relation; Potentials-A,G,H,U; Property relations for homogeneous phases; Maxwell's relation,

Thermodynamic properties of real gases: departure functions; evaluation of departure functions; partial molar properties, fugacity and fugacity coefficient, estimation of fugacity coefficient, thermodynamic properties of real gas mixtures – mixing rules, prediction of P-v-T behaviour, departure functions, fugacity coefficients for real gases; Fugacity of a component in a mixture, Fugacity of liquid and solid,

Thermodynamics of solution: Ideal solution, Raoult's law, phase equilibrium problems; excess properties, activity and activity coefficient, excess Gibbs free energy models; Henry's law, basic equation for vapour liquid equilibrium; VLE at low to moderate pressures and high pressures, excess Gibbs free energy models, azeotropic data, bubble, dew point and flash calculations; dilute solution laws

Chemical reaction equilibrium: standard Gibbs free energy change and equilibrium constant, effect of temperature on equilibrium constant; homogeneous gas and liquid phase reactions

Text and Reference Books:

1. Y.V.C. Rao, Chemical Engineering Thermodynamics, University Press.(1997)
2. Smith & van Ness, Introduction to Chemical Engineering Thermodynamics, McGraw Hill (2019)
3. K. V. Narayanan, Chemical Engineering Thermodynamics, CBS Publication.(2013)

Course Code: CHE-S204 **Breakup: 3 –1 – 0 – 4**
Course Name: Heat Transfer

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

CO1	Understand the difference between thermodynamics and heat transfer and the general principles of conduction, convection and radiation
CO2	Understand steady state conductive heat transfer through simple geometries
CO3	Understand combined heat transfer mechanisms through composite geometries and extended surfaces
CO4	Able to differentiate types of heat exchangers, their detailed construction, operation and design
CO5	Understand heat transfer with phase change (boiling and condensation)
CO6	Understand the process of evaporation and analyzing the functioning and design of evaporators
CO7	Understand the principles of radiation, the radiation laws and calculation of radiative heat transfer between black and Gray bodies

Course Details:

General Principles of heat transfer by conduction, convection, radiation.

Conduction: Fourier's law of heat conduction; steady state conduction in one dimension with and without heat source through plain wall, cylindrical & spherical surfaces; variable thermal conductivity, combined mechanism of heat transfer (conduction and convection), conduction through composite slab, cylinder and sphere; thermal contact resistance; thermal insulations, properties of insulating materials; critical radius of insulation; extended surfaces: heat transfer from a fin, effectiveness and efficiency

Convection: Natural and forced convection; convective heat transfer coefficient; concept of thermal boundary layer; laminar & turbulent flow heat transfer inside and outside tubes; dimensional analysis, Buckingham pi theorem, dimensionless numbers in heat transfer and their significance; determination of individual & overall heat transfer coefficients and their temperature dependency

Forced convection**:** correlation for heat transfer in laminar and turbulent flow in a circular tube and duct, Reynolds and Colburn analogies between momentum and heat transfer

Natural convection – natural convection from vertical and horizontal surfaces, Grashof and Rayleigh numbers

Heat exchangers: Types of heat exchangers like double pipe, shell & tube, plate type, extended surface, multi-pass exchangers; their detailed construction and operation; calculations on design of heat exchangers; effectiveness of a heat exchanger

Heat transfer with phase change: condensation of pure and mixed vapours; film wise and drop wise condensation, calculations on condensers, heat transfer in boiling liquids, boiling curve, nucleate and film boiling; correlations for pool boiling

Evaporation: elementary principles, boiling point elevation and Duhring's plot; types of evaporators – single, multiple (forward, backward, mixed feed), capacity and economy of evaporators simple calculation on single and multiple effect evaporators

Radiation: Basic concepts of radiation from surface, black body and grey body concepts, Planks

Law, Wein's displacement law, Stefan Boltzmann's law, Kirchoff's law, View factor, combined heat transfer coefficients by convection and radiation.

Introduction to unsteady state heat transfer: lumped parameter model, unsteady state heat conduction in various geometries, Heisler charts

Text and Reference Books:

1. B. K. Dutta, Heat Transfer Principles and Applications, PHI (2000)
2. D.Q. Kern, Process Heat Transfer, Mc Graw Hill (2017)
3. J. P. Holman, Heat Transfer, Mc Graw Hill (2017)
4. F.P. Incropera and D. P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley (2018)
5. Y. A, Cengel, A. J. Ghajar, Heat and Mass Transfer: Fundamentals & Applications, McGraw Hill (2020)

Course Code: CHE-S205 **Breakup: 4 –0 – 0 – 4**
Course Name: Chemical Process Industries

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

CO1	Understand the role of chemical process engineer in chemical industry identify different unit operations and unit processes in a given process flow diagram
CO2	Demonstrate thorough understanding of some important process industries (chloro-alkali, fertilizers, soaps and detergents, sugar manufacture, petroleum, paper and fermentation etc)
CO3	Identify and solve engineering problems during manufacturing of the above-mentioned products
CO4	Identify process industry and make a presentation related to present scenario

Course Details:

Overview: Typical chemical processes: unit operations and unit processes; classification of Indian chemical process industry; study aspects of a CPI- raw materials, process, chemical reactions, process and block flow diagram, major engineering issues and uses;

Common utilities such as electricity, cooling water, steam, hot oil, refrigeration and chilled water at national level.

Chlor-alkali industry: Manufacture of soda ash, caustic soda, chlorine and hydrochloric acid, Sulphur industry: Sulphur, sulphuric acid and oleum

Phosphorus industry: Phosphorus, phosphoric acid and superphosphates

Nitrogen industry: Ammonia, urea, nitric acid and ammonium nitrate.

Cement industry: manufacture by cement rock (limestone) beneficiation and Portland process

Natural product industry: pulp and paper, sugar and alcohol, edible oils and fats

Soap and detergent industry: classification of soap, detergent and surfactants and their manufacture

Polymer industry: general polymerization systems: bulk, solution, suspension and emulsion polymerisation; synthesis of polyethylene, polypropylene, polystyrene and PVC, polyester synthetic fibres

Natural and synthetic fibre industry: manufacture of viscose rayon, nylon 6,6 and nylon 6 fibres and polyester fibres on national level.

Petroleum and petrochemical industry: Petroleum refining: Basic distillation, thermal cracking, alkylation and catalytic cracking, other refining unit processes: reforming, hydrodealkylation, isomerisation, hydrogenation, desulphurisation, polymerisation etc.

Important petrochemicals: C1, C2, C3, C4 etc, benzene, toluene, xylene and other petrochemicals from these basic building blocks

Text and Reference Books:

1. M. Gopala Rao, Dryden's Outlines of Chemical Technology, East West Press (2019)
2. G.T. Austin, Shreve's Chemical Process Industries, Mc Graw Hill (2017)

Course Code: CHE-S206 **Breakup: 3 –1 – 0 – 4**
Course Name: Mechanical Operations

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

CO1	Calculate drag force and terminal settling velocity for single particles
CO2	Explain the significance and usage of different particulate characterization parameters, and equipment to estimate them
CO3	Describe size reduction energy requirements, estimate performance of equipment, selection and sizing of equipment
CO4	Select appropriate filter and filter aid for given separation and design a filtration unit for constant pressure and constant flow operation
CO5	Estimate the various operating parameters for fixed bed, fluidized bed,agitation process and continuous thickener units

Course Details:

Introduction: Unit operations; Unit processes; Requirement of separation processes in chemical engineering practice; Classification of separation processes; General introduction of mechanical-physical separation processes.

Properties and storage of solids: Characterization of solid particles - Particle shape and size, mixed particle sizes, average particle sizes; Solids in bulk - angle of repose, angle of internal friction, storage of bulk solids, flow of bulk solids, problems with the flow of bulk solids.

Size reduction of solids: Size reduction methods - compression, impact, attrition, shear, cutting; Principles of size reduction - properties of solids, factors affecting size reduction process, energy and power consumption in size reduction, crushing efficiency, determination of power consumption, laws of comminution; Size reduction equipment, selection criteria of size-reduction equipment; Coarse crushers; Intermediate crushers; Grinders; Ultra-fine grinders.

Solid-solid separation: Screening, Screening equipment; Electrical separation – Magnetic and electrostatic separation; Classification with water – Principles of separation (Free settling and hindered settling), Classifying equipment – nonmechanical and mechanical classifiers; Gravity concentration, equipment; Flotation, equipment.

Solid-liquid separation: Sedimentation, Batch sedimentation, Sedimentation theory, equipment (Thickeners and classifiers); Filtration – Principles of cake filtration, types of cake filtration, filter media, filter aids, filtration theory, batch and continuous filtration; Filtration equipment – Filter press, Leaf filter, Rotary drum filter.

Gas-solid separation: Introduction; Gas cleaning equipment – Gravity settling chamber, Inertial separator, Fabric filter, Wet scrubber, Electrostatic precipitator, Cyclone separator, Air classifier.

Transportation of solids: Introduction; Transportation equipment – Belt conveyors, Screw conveyors, Pipe conveyors, Bucket elevators, conveying of powders.

Mixing of solids: Introduction; Liquid mixing – Use of baffles, power consumption; Solid mixing – Mixing index concept, Rate of mixing, Energy consumption; Mixing equipment – Liquid mixers, Solid mixers, Viscous mixers.

Auxiliary operations: Introduction; Size enlargement; Crystallization; Feeding; Weighing; Coagulation and flocculation.

Text and References Books:

1. A K Swain, H Patra, G K Roy, Mechanical Operations, McGraw Hill, Chennai (2018).
2. B A Wills, J Finch, Wills' Mineral Processing Technology, Eighth edition, Butterworth-Heinemann (2015).
3. A S Foust, Principles of Unit Operations, Second edition, Wiley, New York (1980).
4. W L McCabe, J Smith and P Harriot, Unit Operations of Chemical Engineering, Seventh edition, Tata McGraw Hill, New Delhi (2014).
5. C J Geankoplis, Transport Processes and Unit Operations, Third edition, PHI, New Delhi (1993).

Course Code: HSS-S401 **Breakup: 3 –0 – 0 – 4**
Course Name: Engineering Economics

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

CO1	Have sufficient knowledge about demand and supply problems
CO2	Understand concepts of production and cost analysis
CO3	Use of microeconomic tools in problem solving
CO4	Utilisation of limited resources in meeting the rising demand in the market

Course Details:

UNIT-1
Meaning, definition and global scope of economics, Basic concepts of demand and supply, Market equilibrium, Ceiling price and floor price.

UNIT-2
Price elasticity of demand: Factors affecting price elasticity of demand, Calculation, Relation between marginal revenue, demand and price elasticity, Income elasticity of demand and Cross elasticity of demand, Indifference curves, Budget Line at local and regional level.

UNIT-3
Production and Cost analysis: Basic concepts, Production in the short- run and long-run, cost analysis
Finding the optimal combination of inputs, Returns to scale.

UNIT-4
Market: Characteristics of perfect completion, Profit maximisation in short-run and long-run
Firms with market power: Measurement and determinants of market power, Profit maximisation under monopoly: output and pricing decisions, Price discrimination, capturing consumer surplus, Strategic decision making in oligopoly markets at local and regional level

UNIT-5
National income: Concepts, Sources, Measurement, Difficulties, circular flow of income
Inflation: Cost-push and Demand-pull inflation, Effects and control of inflation, Business cycle, Functions of RBI, GST at local and regional level.

Text and Reference Books:

1. Paul. A. Samuelson, Economics, Mc Graw Hill, 20th Edition (2019)
2. Managerial Economics by Christopher R. Thomas, S. Charles Maurice, Mc Graw Hill, (2020)
3. J. V. Vaishampayan, Financial Management, NRBC (2015)
4. A. Koutsoyannis, Micro Economics, 2nd Edition (2003)

Course Code: EVS-S101 **Breakup: 2 –0 – 0 – 2**
Course Name: Environmental Science

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

CO1	Understand the concepts and definitions associated with ecosystems, environmental pollution and its causes
CO2	Gain knowledge to analyse problems and suggest alternatives and new methods to manage natural resources
CO3	Understand how to Redesign, Recreate & Restore the ecosystems
CO4	Understand the legal aspects and the role of government in environment protection

Course Details:

UNIT-I
Global scope and importance of environmental studies, Need for public awareness, Segments of environment, biodiversities: Genetic diversity, Species diversity, Ecosystem diversity, Landscape diversity, Causes of pollution and detrimental effects.

UNIT-II
Eco systems- Types of systems, energy flow in an ecosystem, Balanced ecosystem,Human activities- Food, shelter, economic and social security, Effects of human activities on environment- Agriculture, housing, Industry, mining and transportation activities, Basics of Environmental Impact Assessment, Sustainable Development.

UNIT-III
Types of natural resources: Water resources-Availability and quality aspects, Water borne diseases, Fluoride problems in portable water, Mineral resources, Food resources, Land resources, Forest Wealth, Material cycles- Carbon, Nitrogen and Sulphur cycle.

UNIT-IV
Energy- Different types of energy (Renewable and Non-renewable), Convectional and non-conventional energy-sources Electromagnetic radiation, Hydro Electric, Fossil fuel based, Nuclear, Solar, Biomass and Bio-gas, Hydrogen as an alternative future source of energyat local and regional level

UNIT-V
Environmental pollution and their effects, Water pollution, Land pollution, Noise pollution, public Health aspects, Air pollution. Current environmental issues of importance and their impact on environmentat local and regional level: Population Growth, Climate change and global warming effect, Urbanization, Automobile pollution, Acid rain, Ozone layer depletion.

UNIT-VI
Preventive measures and control of pollution, Air and Water pollution control, Sold waste management, Case studiesat local and regional level.

UNIT-VII
Role of Government in environment protection, Legal Aspects, Initiatives and protection Acts, public awareness, Initiatives by Non-governmental Organizations (NGOs), Role of IT services, Disaster managementat local and regional level .

UNIT-VIII
Field work/ Activities/ Visit

Text and Reference Books:

1. Benny Joseph, Environmental Studies, Tata McGraw Hill Publication (2017)
   D.L. Manjunath, Environmental Studies, Pearson Education.
2. R. Rajgopalan, Environmental Studies, Oxford Publication (2015)
3. M. Anji Reddy, Textbook of Environmental Science and Technology, BS Publication (2010)
4. P. Venugopala Rao, Principles of Environmental Science and Engineering, Prentice Hall of India (2006)
5. Meenakshi, Environmental Science and Engineering, Prentice Hall of India (2012)

Course Code: UHV-S201 **Breakup: 2 –1 – 0 – 3**
Course Name: Universal Human Values - II

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

CO1	Understand the significance of value inputs in a classroom and start applying them in their life and profession
CO2	Distinguish between values and skills, happiness and accumulation of physical facilities, the Self and the Body, Intention and Competence of an individual, etc
CO3	Understand the role of a human being in ensuring harmony in society and nature
CO4	Distinguish between ethical and unethical practices, and start working out the strategy to actualize a harmonious environment wherever they work

Course Details:
UNIT I: Introduction to Value Education
Value Education, Definition, Concept and Need for Value Education
The Content and Process of Value Education
Basic Guidelines for Value Education
Self-exploration as a means of Value Education
Happiness and Prosperity as parts of Value Education

UNIT II: Harmony in the Human Being
Human Being is more than just the Body
Harmony of the Self ('I') with the Body
Understanding Myself as Co-existence of the Self and the Body
Understanding Needs of the Self and the needs of the Body
Understanding the activities in the Self and the activities in the Body

UNIT III: Harmony in the Family and Society and Harmony in the Nature
Family as a basic unit of Human Interaction and Values in Relationships
The Basics for Respect and today's Crisis: Affection, e, Guidance, Reverence, Glory, Gratitude and Love
Comprehensive Human Goal: The Five Dimensions of Human Endeavour.
Harmony in Nature: The Four Orders in Nature.
The Holistic Perception of Harmony in Existence

UNIT IV: Social Ethics
The Basics for Ethical Human Conduct
Defects in Ethical Human Conduct
Holistic Alternative and Universal Order
Universal Human Order and Ethical Conduct
Human Rights violation and Social Disparities

UNIT V: Professional Ethics
Value based Life and Profession.
Professional Ethics and Right Understanding
Competence in Professional Ethics
Issues in Professional Ethics – The Current Scenario
Vision for Holistic Technologies, Production System and Management Models

Text and Reference Books:

1. R.R. Gaur., R, Sangal. G.P Bagaria., A Foundation Course in Value Education, Excel Books, (2009).
2. R.R. Gaur., R, Sangal. G.P Bagaria, Teachers Manual for A Foundation Course in Human Values and Professional Ethics Excel Books, (2009).
3. A.N. Tripathy, Human Values, New Age International Publishers, (2003)
4. A. Nagaraj, JeevanVidya: EkParichaya, JeevanVidyaPrakashan, Amarkantak, (1999)
5. M.K. Gandhi, My Experiemnts with Truth, Maple Classics (2011)
6. I.C. Sharma, Ethical Philosophy of India, Nagin & Co Julundhar
7. Cecile Andrews, – Slow is Beautiful (2006)

Course Code: CHE-S301 **Breakup: 3 –1 – 0 – 4**
Course Name: Mass Transfer I

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

CO1	To understand the phenomena of mass transfer on macro level
CO2	Understand the concept of equilibrium in all separation operations should be clear
CO3	Able to design Distillation, Extraction, Leaching, Adsorption column by using different methods
CO4	Able to find out optimum conditions for component separation
CO5	To do the design by graphical and analytical method

Course Details:

Distillation: Vapour-liquid equilibria, Relative volatility, Raoult's law, minimum and maximum boiling mixtures, enthalpy-concentration diagrams for binary systems, multicomponent systems – bubble point and dew point calculation, Flash vaporization, Differential distillation, Steam Distillation, Continuous rectification, Azeotropic and Extractive Distillation, Multistage tray towers - Graphical methods of Ponchon-Savarit and McCabe-Thiele, feed-tray location, total reflux, minimum reflux ratio, optimum reflux ratio, open steam, multiple feed and side stream, multi component calculations using short-cut methods.

Liquid Extraction: Introduction, liquid equilibria, equilateral-triangular coordinates systems of three liquids, choice of solvent, single stage and multistage crosscurrent extraction, insoluble liquids, continuous counter current multistage extraction, insoluble liquids.

Leaching: Introduction, lixiviation, decoction, elutriation or elution, preparation of the solid, effect of temperature, types of equilibrium curves, single stage and multistage crosscurrent leaching, multistage counter current leaching.

Adsorption: Introduction, types of adsorption, nature of adsorbents, adsorption equilibria – single gases and vapours, adsorption hysteresis, effect of temperature, heat of adsorption, adsorption of solute from dilute solution, single stage and multistage crosscurrent operation using Freundlich equation, multistage counter current operation using Freundlich equation.

Text and Reference Books:

1. R E Treybal, Mass-Transfer Operations, Third edition, McGraw Hill, New Delhi (2012).
2. K V Narayanan, B Lakshmikutty, Mass Transfer Theory and Applications, CBS Publishers and Distributors, New Delhi (2014).
3. B K Dutta, Principles of Mass Transfer and Separation Processes, Second edition, PHI, New Delhi (2007).
4. A S Foust, Principles of Unit Operations, Second edition, Wiley, New York (1980).
5. W L McCabe, J Smith and P Harriot, Unit Operations of Chemical Engineering, Seventh edition, Tata McGraw Hill, New Delhi (2014).
6. C J Geankoplis, Transport Processes and Unit Operations, Third edition, PHI, New Delhi (1993).

Course Code: CHE-S303 **Breakup: 3 –1 – 0 – 4**
Course Name: Unit Operation Laboratory -1

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

CO1	Understand the concepts of different transport processes and unit operations involved in Chemical process industries
CO2	Perform different unit operations safely
CO3	Develop experimental skills, data analysis, and error analysis
CO4	Work in team and develop interpersonal skills
CO5	Develop skills for technical report writing

Course Details:

Screen Analysis; Crushing efficiency for jaw crusher; Crusher rolls; Disintegrater; etc.; Sedimentation and Thickners; Viscosity measurement; Flow through pipes (Reynold'S experiment); Flow-Through Open Channels; Flow Through fitting and Joints; Orifice meter; Venturi meter; Rotameter; Verification of Bernoulli's Theorem; Characteristics of Centrifugal pumps; Fluidized bed; Spouted bed; Plate and Frame filter press; Rotary drum; Vacuum filter; Agitator and mixing.

Course Code: CHE-S304 **Breakup: 3 –1 – 0 – 4**
Course Name: Chemical Reaction Engineering-1

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

CO1	Estimate the rate expression for various elementary and non-elementary reactions and corresponding the reaction mechanism
CO2	Carry out the kinetic study for various batch and flow reactors for single and multiple reactions
CO3	Determine the best combination of mixed and plug flow reactors on basis of size comparison
CO4	Understand the use of recycle reactors and auto catalytic reactors
CO5	Analyse the effect of temperature and pressure on reaction corresponding to various type of reactors
CO6	Understand the non-ideal flow behaviour inside the reactor and various model to describe this phenomenon

Course Details:

Introduction and overview of chemical reaction engineering

Kinetics of homogeneous reactions, concentration dependent term and temperature dependent term of the rate equation, searching for rate expressions from mechanisms; non elementary homogeneous reactions;

Interpretation of batch reactor data: Constant volume batch reactor; varying volume batch reactor; collection and analysis of batch data – integral and differential method; half-life method, reversible reaction data, temperature and reaction rate;

Introduction to Reactor Design

Single Ideal Reactor: Ideal batch reactor; steady state continuously stirred tank reactor; steady state plug flow reactor; size comparison of single reactions; multiple reactor systems; recycle reactor; autocatalytic reactions;

Design for multiple reactions: parallel reactions-product distribution, fractional yield, reversible and irreversible reaction; series reactions - reversible and irreversible reaction; series-parallel reactions, Denbigh reactions

Non isothermal reactors: temperature and pressure effects on single and multiple reactions, equilibrium conversions, optimum temperature progression, adiabatic and non-adiabatic operations

Non ideal Reactors: Residence time distribution, E, C, F curves, segregation model, dispersion model, chemical reaction and dispersion, tank-in- series model; multiparameter models

Text and Reference Books:

1. O. Levenspiel, Chemical Reaction Engineering, John Willey & Sons (2006)
2. H.S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall (2008)

Course Code: CHE-S309 **Breakup: 3 –1 – 0 – 4**
Course Name: Numerical Methods for Chemical Engineers

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

CO1	Solve problems of algebraic equations
CO2	Solve problems of differential equations and simultaneous equation
CO3	Solve problems of partial differential equations
CO4	Analyze Stirred-tank Reactor System, Distillation in a Plate Column and Unsteady-state operation by solving differential equations
CO5	Assess reasonableness of solutions, and select appropriate levels of solution sophistication

Course Details:

Introduction to Numerical Method: Approximations and errors in computation, commonly used Taylor series, Binomial theorem

Solution of Algebraic and Transcendental equations: bisection methods, Regula-Falsi method, Newton-Raphson methods, Secant method

Solution of simultaneous Algebraic equations:
Gauss elimination method, Gauss Jordan method, Jacobi Iteration method, Gauss-Seidel iteration method

Interpolation and curve- fitting
Graphical method, Least Square method and curve fitting of data, Method of Moments, cubic spline problems, Methods of group averages, approximation of functions interpolation and extrapolation of techniques, Finite differences, forward, backward and central difference,

Numerical differentiation and integration: derivatives from difference tables;Numerical integration – Newton Cotes Integration technique, trapezoidal rule, Simpson's 1/3 rd and 3/8th rule,, Gaussian quadrature; double integration.

Ordinary differential equation: Picard's method, Taylor series method, Euler's method, Euler's modified iteration technique, Runge method, Runge-Kutta 4^{th} order technique, Solutions of ordinary differential equation (initial and boundary value problem)

Linear programming: simplex method, dual simplex, charne penalty method.

Text and Reference Books:

1. S. K. Gupta, Numerical Methods for Chemical Engineers, New Age International (2019)
2. S. Chapra and R. Canale, Numerical Methods for Engineers, McGraw Hill Education (2016)
3. B. S. Grewal, Numerical Methods in Engineering and Science. Khanna Publishers (2013)
4. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI learning (2012)

Course Code: HSS-S301 **Breakup: 1 –0 – 1 – 2**
Course Name: Communication Practicum

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

CO1	Understand the nuances of English language for enhancing presentation skills
CO2	Speak in standard English with clarity and fluency and to write business messages professionally
CO3	Speak and communicate clearly in different professional contexts which would improve their chances of employability
CO4	Understand the importance of ethical practices in their professional life

Course Details:

Unit 1- Presentation techniques
Meaning and importance of presentation technique
Presentation skills required for business organization: Negotiation, Persuasion & Time management
Types of business presentations- meetings, seminars, conferences

Unit 2- Oral presentations
Effective oral delivery- Phonetics
Interviews, Group discussions, debates, speeches
Listening skills, Reading skills

Unit 3- Written communication
Style and tone of writing business messages and documents
Persuasive, sales and goodwill messages, delivering bad news
Writing e-mails and short messages, Resume writing

Unit 4 – Non Verbal communication
Nonverbal communication techniques
Business manners, ethics and personality development
Power point presentations

Text and Reference Books:

1. Bove`e, Thill and Schatzman, Business Communication Today, Pearson Education (Singapore), (2003)
2. H. Dan O'Hair, James S. O'Rourke and Mary John O'Hair, Business Communication-a framework of success", South Western College Publishing, (2001)
3. Raymond V. Lesikar, Marie E. Flatley, Basic Business Communication, Tata McGraw Hill Publishing Company Ltd., (2002)

Course Code: CHE-S305 **Breakup: 3 –1 – 0 – 4**
Course Name: Mass Transfer II

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

CO1	To understand the fundamentals of mass transfer on micro level
CO2	To understand the application of the principles used for diffusion; mass transfer coefficients and inter-phase mass transfer including various theories
CO3	To study the mass transfer between the gas –liquid phase and various equipments used for the mass transfer operation like Absorption and Humidification
CO4	Do analysis of Packed bed equipment to find out HTU, HETP, NTU and height of the column required
CO5	To find the rate of drying, moisture content, time required for drying and various type of drying equipments

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Course Details:

Molecular diffusion in fluids: Introduction; Molecular diffusion; Flux J and N; Steady state molecular diffusion in fluids at rest and in laminar flow; Molecular diffusion in gases through non-diffusing B, equimolal counter diffusion and multi-component mixtures; Factors affecting gas phase diffusion; Experimental determination of the gas phase diffusion coefficient – Twin bulb method, Stefan tube; Pseudo steady state diffusion through a stagnant gas film; Predictive equations for the gas phase diffusivity; Molecular diffusion in liquids; Predictive equations for liquid phase diffusivity; Diffusion through varying cross-sectional area – Spherical geometry, Tapered tube; Types of diffusion – Knudsen, molecular, and transition, surface diffusion.

Mass transfer coefficients: Mass transfer coefficient in different units; Mass transfer from a gas into a falling liquid film; Eddy diffusion; Prandtl mixing length; Theories of mass transfer - Film theory, Penetration theory, Surface renewal theory; Momentum, heat and mass transfer analogies; dimensionless numbers in mass transfer and their analogues in heat transfer; Mass transfer in wetted wall column; Mass transfer for simple situations; j_H and j_D factor.

Diffusion in solids: Fick's law diffusion; Unsteady state diffusion; Diffusion through polymers; Diffusion through crystalline solids; Diffusion in porous solids.

Interphase mass transfer: Equilibrium; Equilibrium relations; Diffusion between phases; Two-resistance theory; Individual and overall mass transfer coefficients; Material balance in continuous contact equipments - steady state cocurrent and countercurrent processes; Stages - continuous cocurrent processes, batch processes, cascades; Kremser equations.

Humidification and Dehumidification: Psychometric chart; Adiabatic saturation curves; Wet bulb temperature; Adiabatic operations - Water cooling with air, Dehumidification of air-water vapour.

Gas absorption: Equilibrium solubility of gases in liquids; Ideal and non-ideal liquid solutions; Choice of solvent for absorption; Material balance for cocurrent and countercurrent gas absorption and stripping; Absorption factor A; Design of packed towers; Concept of HETP, H_{tG}, N_{tG}, H_{tL}, N_{tL}, H_{tOG}, N_{tOG}, H_{tOL}, N_{tOL}.

Drying: Equilibrium; Definitions; Drying operation; Batch drying - rate of batch drying; Mechanisms of batch drying - cross circulation drying, through-circulation drying.

Adsorption: Continuous countercurrent adsorption of one and two components; Rate of adsorption in fixed beds.

Text and Reference Books:

1. R E Treybal, Mass-Transfer Operations, Third edition, McGraw Hill, New Delhi (2012).
2. K V Narayanan, B Lakshmikutty, Mass Transfer Theory and Applications, CBS Publishers and Distributors, New Delhi (2014).
3. B K Dutta, Principles of Mass Transfer and Separation Processes, Second edition, PHI, New Delhi (2007).
4. A. S. Foust, Principles of Unit Operations, Second edition, Wiley, New York (1980).
5. W L McCabe, J Smith and P Harriot, Unit Operations of Chemical Engineering, Seventh edition, Tata McGraw Hill, New Delhi (2014).
6. C J Geankoplis, Transport Processes and Unit Operations, Third edition, PHI, New Delhi (1993).

Course Code: CHE-S306 **Breakup: 3 –1 – 0 – 4**
Course Name: Instrumentation and Process Control

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

CO1	To estimate the mathematical modelling of the control system
CO2	To calculate the solution of linear differential equation using Laplace transform Transfer function and input–output model, Poles & zeros of system
CO3	Study of interacting & non-interacting response, Inverse response, Multicapacity process, over-damped, critically damped, under-damped response their characteristics
CO4	Able to use different types of controller, on-off, P, PI, PID controller, introduction to measuring sensors
CO5	To study the criteria for stability, characteristic equation, Routh –Hurwitz criteria of stability, Root-Locus analysis, Frequency response analysis of linear processes
CO6	To Design the controllers by Simple performance criteria, Time Integral performance criteria, Ziegler Nichols tuning technique, Cohen –coon tuning technique

Course Details:

Introduction to process control: Needs & control aspects of a chemical plant: stirred tank heater, flow in tank, control of heat exchanger, distillation column and reactor, SISO and MIMO control., Types of controller , on-off, P, PI and PID control modes, introduction to measuring sensors for level, flow, temperature and pressure measurements. Transmission lines, final control elements, Control valves and their characteristics.

Introduction to mathematical modeling : State variables and state equations, dead time, modelling with dead time, degree of freedom, linearization of nonlinear system, deviation variables, multivariable system linearization.

Laplace transform: Laplace transform of step, impulse , pulse ,ramp, trigonometric functions, derivative and integral functions, initial value theorem, Final value theorem, Dirac delta functions, Inverse Laplace transform, solution of linear differential equation using Laplace transform, transfer function and input–output model, Poles & zeros of system.

Dynamic behavior of first order system: Time constant, steady state gain, response of the system

Dynamic behaviors of second order system: study of interacting & non-interacting response, Inverse response, multi-capacity process, over-damped, critically damped, under-gdamped response their characteristics, overshoot ,decay ratio, period of oscillation, rise time, ultimate period, delay time.

Feedback control system: concept of feedback control system, types of controller, on-off, P, PI, PID controller, introduction to measuring sensors, transmission lines, final control elements, block diagram reduction and signal flow graph theory to solve feedback loop,

Stability of Closed-Loop Control Systems: Criteria for stability, characteristic equation, Routh –Hurwitz criteria of stability, Root-Locus analysis, Frequency response analysis of linear processes, Bode stability criteria, Nyquist stability criteria , gain margin, phase margin,

Design of controllers: Simple performance criteria, Time Integral performance criteria, Ziegler Nichols tuning technique, Cohen –coon tuning technique.
Introduction to advance control strategies: ratio, cascade, feed forward, override and valve

positioning (optimizing) control. Microprocessor–based controllers and economic plantwide computer control.

Text and Reference Books:

1. D.R. Coughnour, Process system Analysis & Control, Mc Graw Hill (2017)
2. George Stenphanopolous, An Introduction of Process Dynamics & Control (1985)
3. Curtis D. Johnson, Process Control Instrumentation Technology, international eighth edition, Pearson Education Limited (1993)

Course Code: CHE-S307 **Breakup: 3 –1 – 0 – 4**
Course Name: Chemical Engineering Design-I

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

CO1	Understand the General overall design considerations, design steps for chemical processes; types of projects
CO2	Have an understanding of development of design database; process creation; types of process design; Feasibility survey; flow sheet presentation – PFD, PID, utility and safety diagrams
CO3	Carry out cost estimation by cash flow for industrial operations, understand factors affecting investment and production costs, capital investment – fixed capital and working capital investment, cost indices
CO4	Understand Taxes and Insurance: cost of capital, corporate tax, insurance Depreciation: depreciable investments
CO5	Find out the optimum solution methodologies – one variable and two variable, optimum production rates in plant operation

Course Details:

Introduction to Chemical Engineering Plant design: Global design considerations, design steps for chemical processes; types of projects; optimum design – optimum economic design, optimum operation design, practical considerations in design; engineering ethics in design at local and regional level

Process design development: development of design global standard database; process creation; types of process design; feasibility survey; flow sheet presentation – PFD, PID, utility and safety diagrams; vessel and piping layout isometrics; flowsheet symbols; utility streams; equipment design and specifications, equipment specification sheet, scale-up of equipment in design, safety factors at local and regional level

Flowsheet synthesis and development: fundamentals of material balance and energy balance for manual flowsheet calculations, general procedure for flowsheet development – hierarchical and algorithmic methods; conceptual design of a chemical process - hierarchy of decisions; computer-aided flow sheeting

General design considerations: Health and safety hazards; Loss prevention; Environmental consideration; Plant location; Plant layout, Plant operation and control
Cost estimation: cash flow for industrial operations, factors affecting investment and production costs, capital investment – fixed capital and working capital investment, cost indices, cost components and methods for estimating capital investment, estimation of revenue, estimation of total product cost, gross and net profit at local and regional level

Interest and investments costs: simple, compound and continuous interest rates, nominal and effective interest rates, time value of money, annuity, cash flow patterns, capitalized cost;
Taxes and Insurance: cost of capital, corporate tax, insurance
Depreciation: depreciable investments, depreciation and taxes, current value, salvage value, methods for calculating depreciation at local and regional level
Profitability, Alternative investments and Replacements: methods of calculating profitability, alternate investment, replacements, practical factors in alternative investment and replacement analysis

Optimum design and Design strategy: optimum solution methodologies – one variable and two variable, optimum production rates in plant operation, optimum conditions in cyclic operations, optimum operating time, optimum cooling water flowrates in exchangers, optimum reflux ratio Project management – network construction, critical path method (CPM), project evaluation and review technique (PERT) at local and regional level

Material selection for equipment: factors contributing to corrosion, combating corrosion, properties of materials, selection of materials,

Text and Reference Books:

1. M.S. Peters, K. D. Timmerhaus, R. E. West, Plant Design and Economics for Chemical Engineers, Mc Graw Hill (2017)
2. R. K. Sinnott, Coulson and Richardson's Chemical Engineering Series, Chemical Engineering Design Vol 6, Elsevier (1999)
3. J. M. Douglas, Conceptual Design of Chemical Processes, McGraw Hill
4. R. Turton, R. C. Bailie, W. B. Whiting, J. A. Shaeiwitz, Analysis, Synthesis, and Design of Chemical Processes, Prentice Hall (2015)
5. K. H. Humphreys, Jelen's Cost and Optimization Engineering, McGraw Hill (1990)
6. V. V. Mahajani and S. M. Mokashi, Chemical Project Economics, Laxmi Publications (2019)
7. W. D. Seider, J. D. Seader, D. R. Lewin, Product and Process Design Principles, Willy & Sons (2015)

Course Code: CHE-S308 **Breakup: 0 –0 – 4 – 4**
Course Name: Transport Process & Unit Operations Laboratory -2

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

CO1	Understand the concepts of different transport processes and unit operations involved in Chemical process industries
CO2	Perform different unit operations safely
CO3	Develop experimental skills, data analysis, and error analysis
CO4	Work in team and develop interpersonal skills
CO5	Develop skills for technical report writing

Course Details:

Heat conduction through rods of different materials; Thermal conductivity of insulating materials; Boiling and Condensation; Double pipe Heat Exchanger; Shell & Tube Heat Exchanger; Long tube evaporator; Distillation; Batch & Continuous column; Absorption with and without chemical reaction; Liquid-liquid extraction/leaching; Adiabatic humidifier, Water cooler; Driers; Tray, Rotary, Spray; Ion exchange, Reverse osmosis.

Course Code: SSM-S301 **Breakup: 0 –0 – 2 – 2**
Course Name: Student Seminar

Course Details:

Each student is required to present a seminar of 20-30 minutes on a topic related to current research in Chemical Engineering at global, local and regional level

Course Code: CHE-S401 **Breakup: 4 –0 – 0 – 4**
Course Name: Chemical Engineering Design-II

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

CO1	Find out the Design information and data – prediction of physical properties, phase equilibrium data
CO2	Understand the characteristics of different types of pumps, criterion for selection of pumps; theory of compression, equipment for gas compression; Ejectors and Vacuum systems
CO3	Determine the equipment selection and specification for Separation processes, solid-solid separations; liquid solid separators - thickeners and classifiers, filtration, centrifuges, hydro-cyclones; separation of dissolved solids - Evaporation and crystallisation
CO4	Discuss the detailed design of separation column and heat transfer equipment like distillation column; shell and tube heat exchanger; condenser and evaporator
CO5	Estimate the detailed design of pressure vessel and its support

.
Course Details:

Introduction, nature of design, anatomy of a chemical manufacturing process,organization of a chemical engineering project, project documentation, globally accepted codes and standard, factor of safety, degree of freedom and design variables, optimization

Design information and data – prediction of physical properties, phase equilibrium data

Pumps: Theory and characteristics; types of pumps, criterion for selection of pumps; theory of compression, equipment for gas compression; Ejectors and Vacuum systems

Equipment selection, specification and design: Separation processes, solid- solid separations; liquid solid separators - thickeners and classifiers, filtration, centrifuges, hydro-cyclones; separation of dissolved solids - Evaporation and crystallization; liquid- liquid separation-decanters, centrifugal separators; gas – solid separation – gravity settlers, impingement separator, filters, wet scrubbers, cyclones, electrostatic precipitators at local and regional level

Separation columns: Continuous distillation - process description, reflux considerations, feed-point location, selection of column pressure, stage equations, dew point – bubble points, equilibrium flash calculations, design variable in distillation; design method for binary system: basic equations, McCabe –Thiele method, low product concentrations, Smoker equations Multi-component distillation; Key components, number of columns, short –cut method for stage and reflux requirements, pseudo- binary systems, Smith–Brinkley method, empirical correlations, rigorous solution procedures, batch distillation, plate efficiency, column sizing, plate hydraulic design, Packed columns

Heat transfer equipment: Types of exchangers – double pipe, shell and tube, plate, spiral, finned tube, air cooled, fired heater; Overall heat transfer coefficient, fouling factors, double pipe heat exchangers, shell and tube heat exchangers - tube count, shell type, baffles, support plate and tie rods, tube sheet, shell and header nozzles; mean temperature difference, general design consideration - fluid allocation, shell and tube fluid velocity stream temperature pressure drop, tube side heat transfer coefficient and pressure drop, shell side heat transfer coefficient and pressure drop; design methods - Kern’s Method, Bell’s method,

Condensers – Single and mixed vapours, Reboilers and Vaporisers
Evaporators – boiling point elevation, design of multiple effect evaporators

Pressure vessels: design pressure, design temperature, design stress, welded joint efficiency, minimum practical wall thickness, design of thin walled vessels under internal pressure – head and closures; vessel supports – saddle, skirt, bracket support

Text and Reference Books:

1. R. K. Sinnott, Coulson and Richardson's Chemical Engineering Series, Chemical Engineering Design Vol 6, Elsevier (2006)
2. E. E. Ludwig, Applied Process Design for Chemical and Petrochemical Plants, Elsevier (2001)
3. S. M. Walas, Chemical Process Equipment - Selection and Design, Butterworth Series of Chemical Engineering (2012)
4. R. Smith, Chemical Process Design and Integration, Wiley (2016)
5. V. V. Mahajan and S. B. Umarji, Joshi's Process Equipment Design, Laxmi Publications (2016)
6. S. B. Thakore and B. I. Bhatt, Introduction to Process Engineering and Design, McGraw Hill Education (2017)

Course Code: CHE-S402 **Breakup: 4 –0 – 0 – 4**
Course Name: Chemical Reaction Engineering -II

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

CO1	Understand the difference between homogeneous and heterogeneous reactions
CO2	Understand the role of catalysts in chemical reactions and the different types of catalysts used industrially
CO3	Have primary knowledge of catalyst preparation and characterization methods
CO4	Develop rate laws for heterogeneous reactions and kinetic models and design of reactors for heterogeneous catalytic reactions
CO5	Gain knowledge of heat and mass transfer effects (internal and external transport processes) on catalytic reactions
CO6	Understanding the process of deactivation in catalysts, its types and its effect on reaction rate
CO7	Develop kinetic models and design strategy for heterogeneous non-catalytic reactions
CO8	Develop kinetic models and design strategy for heterogeneous fluid-fluid systems with and without chemical reaction

Course Details:

Introduction to heterogeneous reaction; global reaction;

Catalysis: definition, physical properties of catalyst, preparation, testing and characterization of solid catalysts, catalyst selection,

Adsorption: physical and chemical adsorption, isotherms – Langmuir, Freundlich, BET
Rate equation for fluid-solid reaction, surface reaction – dual and single site mechanism, kinetic models (Langmuir-Hinshelwood, Eley-Ridel), heterogeneous data analysis – parameter estimation using regression analysis/Polymath

Internal transport processes: reaction and diffusion with porous catalyst, bulk and Knudsen diffusion, Effectiveness factor, Thiele modulus, Weisz -Prater criterion, falsified kinetics, heat effects during reaction, effect of internal transport on selectivity

External transport processes: overall effectiveness factor, mass transfer coefficient, external temperature gradient, Mear's criterion, effect of external transport on selectivity, non-isothermal condition

Design of solid catalytic reactors: packed bed, mixed flow reactor, bubbling fluidized bed reactor

Deactivation of catalyst: Mechanism of deactivation, rate and performance study of deactivation, effect of pore diffusion on catalysts deactivation, rates for poisoned porous catalyst – uniform poisoning and shell poisoning

Fluid-particle reaction kinetics: Selection of a model, progressive conversion model, shrinking core model for spherical particle of changing and unchanging size, comparison of various model selected, determining controlling resistances and rate equation, fluid particle reactor design

Fluid-fluid reaction kinetics: rate equations for gas -liquid and liquid-liquid systems, Different reaction rates – instantaneous, fast, intermediate, slow; Enhancement factor, Hatta number; fluid-fluid reactor design

Text and Reference Books:

1. H. Scott. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall (2015)
2. J.M. Smith, Chemical Engineering Kinetics, Mc Graw Hill.(2013)
3. O. Levenspiel, Chemical Reaction Engineering, John Willey & Sons (2006)

Course Code: CHE-S406 **Breakup: 0–0 – 3 – 3**
Course Name: Process Simulation Lab

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

CO1	Understand the different models for computing thermodynamic and transport properties
CO2	Building a flowsheet for design purposes of flow network consisting of fittings, pumps and piping
CO3	Estimation the performances of pumps, compressors, expanders, valves etc.
CO4	Design and rating of separation processes
CO5	Quantitative and qualitative use to Simulating performance of different reactor models

Course Details:

CHEMCAD Process simulation software used for

1. Comparing different models for computing thermodynamic and transport properties such as K-values, Enthalpy, VLE data etc. for pure substances and mixtures; Flash calculations and VLE of azeotropic mixtures

2. Design of flow network consisting of fittings, pumps and piping (horizontal, vertical & inclined); single and multiple branches

3. Calculations for performances of pumps, compressors, expanders, valves etc.

4. Preparing steady state process flow sheets (equipment selection, numbering, stream designation) and carrying out mass and energy balances with and without recycle for chemical processes

5. Design and rating of heat exchangers (with and without phase changes); double pipe, shell and tube, plate and frame heat exchangers

6. Design and rating of separation processes – simple distillation column with different reflux ratios (short cut design), rigorous column design; multi-component distillation column design, sequencing of distillation columns, absorption and stripping, liquid-liquid extraction

7. Simulating performance of different reactor models for reversible and irreversible reactions

8. Batch reactor rate regression from process of lab data

9. Control of simple unit operations

Course Code: SST-S401 **Breakup: 0 –0 – 0 – 2**
Course Name: Summer Training

Course Details:

A written report and an oral presentation/ interview during the (following) semester after successful completion of an 8-week industrial in-plant training with a chemical industry at local and regional level taken during the summer break.

Course Code: PRT-S401 **Breakup: 0 –0 – 6 – 4**
Course Name: Project-I
Course Details:

Equipment/Plant design problem related to Chemical engineering at Global, local and regional level to be done by groups of students

Course Code: HSS-S201 **Breakup: 3 –0 – 0 – 3**
Course Name: Industrial Management

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

CO1	Understand the concepts related to business and demonstrate the roles, skills and functions of management
CO2	Understand how the industrial company can be organized and managed
CO3	Understand the complexities associated with management of human resources in the organizations and integrate the learning in handling these complexities
CO4	Express leadership and entrepreneurial attributes through various case studies

Course Details:
UNIT-1
Introduction, Nature and Scope at local and regional level, Evolution of Management, Approaches to Management: Scientific, System and Contingency.

UNIT-2
Taylor'sScientific Management, Fayol's Administrative Management, Contribution of Mayo, Drucker etc., Levels and skills of management

UNIT-3
Organisation: Types and structure, Formal-Informal, Line and Staff relationship, Centralisation-Decentralisation

UNIT-4
Functions of Management Planning: Organisation, Staffing, Directing, Controlling, Decision-Making, Management by objectives, Leadership at local and regional level.

UNIT-5
Psychological foundation of Management at local and regional level: Motivation, Personality, Group dynamics, Models of Herzberg, Maslow etc.

UNIT-6
Plant layout, Plant location, Planning and Control, Materials, Management, Inventory control

Text and Reference Books:

1. O.P. Khanna, Industrial Engineering and Management, Dhanpat Rai Publication (2018)
2. T. R. Banga Industrial Engineering and Management, Khanna Publishing (2008)
3. Mahajan : Industrial Engineering and Production Management, Dhanpat Rai & Co (2015)

Course Code: CHE-S404 **Breakup: 4 –0 – 0 – 4**
Course Name: Transport Phenomena

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

CO1	Understand the transport process on macro and micro level for mass, heat and momentum transfer
CO2	Derive the transport equation for various conservative law with boundary conditions
CO3	Solve the transport problem by applying the shell balance approach
CO4	To model the problem by using differential equation
CO5	To use of various mathematical package to solve the equations

Course Details:

Introduction, classification of fluids, Fluid kinematics, rate of rotation, vorticity, Nature of transport Phenomena, The phenomenological law, Analogies between momentum, heat and mass transfer and defining of dimensionless number, Reynolds transport theorem, Eulerian and Lagrangian approach, Navier stokes equation; Introduction of molecular and convective flux.

Momentum Transport Phenomena: Newton's law of Viscosity, science of rheology, Prediction of viscosity and its dependence on temperature, pressure, Non– Newtonian models at steady state for Newton's law of Viscosity, Momentum transport in laminar flow, Boundary conditions and shell momentum balance approach for stress distribution; profiles for flow of a falling film, flow through circular tube, flow through an Annulus, Adjacent flow of two Immiscible fluids, time derivatives. Equation of continuity, motion and mechanical energy their applications in fluid flow problems for isothermal system

Energy Transport Phenomena: Energy transport in laminar flow, Fourier's law of heat conduction, thermal conductivities and its dependence on temperature, pressure, Boundary conditions, Shell balance approach for different types of heat sources such as Electrical, Nuclear, Viscous and Chemical. Heat conduction through composite walls, Principle of extended surfaces as cooling fin, free and forced convection

Equation of change for Non-isothermal systems, The Equations of energy, Equation of motion for free and forced convection in Non-isothermal flow, use of the equation of change to set up steady state heat transfer problems such as tangential flow in an Annulus with viscous heat generation steady flow of a non-isothermal film, Transpiration cooling , free convection from a vertical plate.

Mass Transport Phenomena: Fick's law of diffusion, Prediction of diffusivity and its dependence on temperature and pressure for gas, liquids and solids, Boundary conditions, Shell balance approach for mass transfer problems, Diffusion through stagnant gas film, Diffusion with homogeneous and heterogeneous chemical reaction, Diffusion in to a falling liquid film, Diffusion and chemical reaction in porous catalyst and the effectiveness factor, equation of continuity for binary mixtures, equation of change to set up diffusion problems for simultaneous heat and mass transfer, thermal diffusion, pressure diffusion, forced diffusion.

Text and Reference Books:

1. Transport Phenomena, Bird Stewart & Lightfoot,. John Wiley & Sons (2007)
2. Introduction to Transport Phenomena, William J.Thomson, Pearson Education Asia (1999)
3. Momentum, Heat and Mass transfer, Bennet and Myers, Tata McGraw Hill.(2014)
4. Transport Phenomena: Aunified approach, R S Broadkey, Tata Mcgraw Hill

Course Code: CHE-S407 **Breakup: 0 –0 –3 – 4**

Course Name: Chemical Reaction Engineering and Process Control Lab

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

CO1	Verify the various theoretical principles of reaction engineering and process control
CO2	Operate instrumentation and automation systems in modern chemical plant operation
CO3	Develop experimental skills
CO4	Work in team and develop interpersonal skills at local and regional level
CO5	Develop skills for technical writing

Course Details:

1. Estimation of activation energy of saponification reaction in a batch reactor
2. Estimation of reaction rate constant in a semi-batch reactor
3. Estimation of reaction rate constant in a plug flow reactor
4. Estimation of reaction rate constant in a continuously stirred tank reactor
5. Residence Time Distribution in a plug flow reactor
6. Residence Time Distribution in a continuously stirred tank reactor
7. Process Control Simulator using electrical analogue
8. Study of Flow Control Trainer
9. Study of Level Control Trainer
10. Study of Temperature Control Trainer
11. Study of Pressure Control Trainer
12. To study the dynamics of two thank interacting and non-interacting system
13. Study of open loop dynamics of first and second order system using MATLAB-SIMULINK

Course Code: PRT-402 **Breakup: 0 –0 – 6 – 4**
Course Name: Project-II

Course Details:

Simulation/Experimental/Research/Design Projects based on Global, local and regional level to be done by groups of students.

List of possible departmental electives:

1. Polymer Engineering (CHE-S501)
2. Safety in Chemical process Industries. (CHE-S502)
3. Petroleum Engineering. (CHE-S503)
4. Environmental Pollution & Control (CHE-S504)
5. Non-conventional energy sources (CHE-S505)
6. Advanced Separation Processes (CHE-S507)
7. Optimization Techniques (CHE-S508)
8. Biochemical Engineering (CHE-S509)
9. Process Modeling and Simulation (CHE-S510)
10. Fluidization Engineering (CHE-S511)
11. Electrochemical Engineering (CHE-S512)
12. Piping Engineering (CHE-S513)

Course Code: CHE-S501 **Breakup: 3-1-0-4**
Course Name: Polymer Engineering

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

CO1	Connect properties of polymeric materials to their structures and explain how different material parameters and external factors affect the mechanical properties
CO2	Decide which test methods are suitable for measurement of mechanical properties
CO3	Correlate structure-processing-properties relationships for polymers, blends and composites
CO4	Select a suitable processing and manufacturing technique for a given polymer
CO5	Identify methods for rheological measurements and analysis of the rheological data using models for non-Newtonian fluids

Course Details:

Introduction – defining polymers, classification, molecular weight distributions, conformations

Addition polymerization or chain growth polymerization, radical, ionic and Ziegler-Natta polymer, kineticsStep growth polymerization, kinetics, Techniques of polymerizations; Characterisation-measurement of molecular weight, thermal behaviour, morphology, viscoelastic behaviour, mechanical properties

Polymer processing; rubbers, plastics and fibres available under local and regional conditions

Text and Reference Books:

1. George Odian, Principles of Polymerization, John Wiley (2007)
2. F. W. Billmeyer, A Textbook of Polymer Science and Engineering, John Wiley (2007)

Course Code: CHE-S502 **Breakup: 3-1-0-4**
Course Name: Safety in Chemical Process Industries

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

CO1	Understand the hazards associated with chemical substances, safety related properties of hazardous substances, Classification of dangerous substances
CO2	Understand the hazards associated with chemical plants, Safety in process plant maintenance, Safety considerations in plant site selection and layout planning
CO3	Understand the Hazard identification and assessment for ,various Hazard identification techniques, Hazard and operability studies (HAZOP), Fire and explosion index and toxicity index, Fault tree and event tree analysis
CO4	Understand the Fault tree and event tree analysis, Emission of toxic and flammable gases and vapours, Dispersion of toxic and flammable gases and vapours
CO5	Understand heat radiation from vapour cloud explosions, jet fires, fire balls and pool fires, Probability of accidents and risk calculation

Course Details:

Introduction: Definition of safety, Hazards in common chemical industries, Need and significance of safety in chemical industries, Important global case histories.

Hazards associated with chemical substances: Safety related properties of hazardous substances, Classification of dangerous substances, Hazards of flammable and explosive materials, Hazards of common unit operations, Hazards of common chemical reactions, Safety in bulk storage of hazardous chemicals, Safety in shelf storage of hazardous chemicals, Corrosion in chemical industries at local and regional level.

Hazards associated with chemical plants: Safety in use of pipelines and their fixtures in industries, Safety in use of cross country pipelines, Safety in process control systems and use of instruments, Safety in pressure system design and operation, Safety in process plant maintenance, Safety considerations in plant site selection and layout planning at local and regional level.

Hazard identification and assessment: Hazard identification techniques, Hazard and operability studies (HAZOP), Fire and explosion index and toxicity index, Fault tree and event tree analysis, Emission of toxic and flammable gases and vapours, Dispersion of toxic and flammable gases and vapours, Heat radiation from vapour cloud explosions, jet fires, fire balls and pool fires, Probability of accidents and risk calculation at local and regional level.

Safety management: On site emergency planning, off site emergency planning, Personnel protection and other safety devices, Safety in chemical laboratories, Reliability engineering.

Text and Reference Books:

1. D A Crowl, J F Louvar, Chemical Process Safety Fundamentals With Applications, Third edition, Prentice Hall, Boston (2011).
2. E Sanders, Chemical Process Safety Learning From Case Histories, Third edition, Elsevier, Oxford (2005).
3. R RTatiya, Elements of Industrial Hazards, CRC Press, London (2011).

4. B O Alli, Fundamental Principles of Occupational Health and Safety, Second edition, International Labour Office, Geneva (2008).
5. V Marshall, S Ruhemann, Fundamentals of Process Safety, Institution of Chemical Engineers, Warwickshire (2001).
6. S Mannan (Editor), Lees' Process Safety Essentials: Hazard Identification, Assessment and Control, First edition, Butterworth-Heinemann, Oxford (2014).

Course Code: CHE-S503 **Breakup: 3-1-0-4**
Course Name: Petroleum Engineering

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

CO1	Understanding the role of petroleum as energy source amidst world energy scenario
CO2	Demonstrate comprehensive understanding of design and operation of petro refineries and petrochemical complexes
CO3	Identify and suggest safe practices in operations of refineries and petrochemical complexes
CO4	Identify challenges, energy security issues and environmental issues
CO5	Perform techno-economic analysis & trouble shooting

Course Details:

Introduction to mineral oils, their origin and mode of occurrence; Oil resources and refineries in India Composition of petroleum, refinery products and their test methods Evaluation of oil stacks introduction to processing of petroleum; general processing & crude distillation, refinery products and their application, natural gas, gasoline, naphtha kerosene, fuel oil and gas oil, petroleum waxes, lubricating oils, tar and asphalts.

Petroleum refining processes and operation: thermal cracking, catalytic cracking, hydro- forming, catalytic reforming, alkylation, polymerization, isomerization and other auxiliary process e.g vis-breaking, de-waxing and de-asphalting operations.
Manufacture of paraffin wax and microcrystalline waxes.

Introduction to lubricants: liquid, solid and gas lubricants and their application.
Lubricating oils: liquids mineral lubricants, synthetic liquids lubricants; Physical properties, additives, manufacture of lubrication oils; Analysis of lubricating oils;

Lubricating Greases: properties, types, ingredients, additives, analysis of lubricating greaser as per BIS test methods; Manufacture of lubricating greases-processes and equipments.

Introduction to petrochemicals; manufacture of alkyl aryl compounds, ethylene oxide; condensation products benzene, toluene, xylene, butadienes, vinyl chloride and styrene etc

Text and Reference Books:

1. W.Nelson, Petroleum Refinery Engineering, McGraw Hill (1958)
2. Dr. Ram Prasad , Petroleum Refining Technology, , Khanna Publishers (1998)
3. O. P. Gupta, Elements of Petroleum Refinery Engineering, Khanna Publishing House (2019)

Course Code: CHE-S504 **Breakup: 3-1-0-4**
Course Name: Environmental Pollution and Control

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

CO1	Assess and understand the sources, causes and effects of air, water and land pollution
CO2	Understanding the metrological aspects of air pollutant dispersion, and the dispersion and control of air pollutants at local regional and global level
CO3	Ability to design air pollutant abatement systems for particulate matter and gaseous pollutants at local regional and global level
CO4	Understanding the types of water pollutants and their effect on human and animal life
CO5	Understanding the physical, chemical and biological methods for wastewater treatment and the different unit operations involved in them
CO6	Ability to design wastewater and industrial treatment units at local regional and global level
CO7	Understanding the processes for sludge treatment and solid-waste disposal
CO8	Understanding the process and modelling of treatment wastewater disposal in water bodies

Course Details:

Introduction and importance of Environmental Pollution, case studies;

Air Pollution – Global sources, causes, effects; meteorological and natural purification processes; control of air pollutants – particulates and gases –design aspects ; automobile pollution;

Water Pollution – classification and characterization of water pollutants, Global sources, causes, effects of water pollution; control processes : physical- design of equalization tanks, sedimentation tanks clarifiers etc., chemical- coagulation, disinfection, adsorption etc.,
biological – introduction to bacterial growth and kinetics, BOD estimation, aerobic and anaerobic treatment methods, activated sludge process, trickling filters- design aspects, sludge disposal, clarified water disposal at local and regional level

Solid-waste management, Noise Pollution, Radioactive Pollution at Global local and regional level

Text and Reference Books:

1. Metcalf & Eddy, Waste Water Engineering- Treatment Disposal and Reuse, Tata McGraw Hill (2017)
2. Noel De Nevers, Air Pollution Control Engineering, McGraw Hill (2010)
3. Wark & Werner, Air Pollution
4. C. S. Rao, Environmental Pollution Control Engineering, CBS Publishers (2018)
5. H. S. Peavy & D. R. Rowe, Environmental Engineering, McGraw Hill (2017)

Course Code: CHE-S505 **Breakup: 3-1-0-4**
Course Name: Non-conventional Energy Sources

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

CO1	Understand the principles of electricity generation from various non-Conventional sources of energy
CO2	Understand the concept of Solar energy, it's collection and utilization at domestic and industrial level
CO3	Understand the concepts involved in Wind energy, Biomass energy and Geothermal energy
CO4	Understand the concepts of Ocean thermal energy conversion, Tidal energy, and Wave energy
CO5	Understand the concepts of Fuel cells, Batteries, and Hydrogen energy

Course Details:

Introduction: Energy and development; Types of energy resources – Conventional and nonconventional; Indian energy scenario at Global, local and regional level.

Solar energy: Introduction; Fundamentals of solar radiation - Structure of Sun, Solar constant, Extraterrestrial solar radiation, Spectral nature of solar radiation, Terrestrial solar radiation, Solar radiation geometry, Solar radiation measurementat Global, local and regional level.

Solar collectors: Flat plate collectors, Liquid-heating and air-heating flat plate collectors; Solar concentrators - Operating principle, Difference between flat plate collector and concentrating collector, Concentrator parameters, Types of concentrators, Concentrating solar power plants.

Solar thermal energy storage: Introduction, Sensible heat storage, Latent heat storage, Thermo-chemical energy storage, Storage material containers, Solar thermal energy storage for buildings, Solar pond – Non-convecting solar pond, Physics of solar ponds, Design considerations of a solar pond at local and regional level.

Solar photovoltaic power generation: Introduction, Basic structure of a photovoltaic cell, Semiconductor materials, Semiconductor junctions, Photovoltaic cell operation, Types of solar cells.

Wind energy: Introduction, Wind resources, Local winds, Global wind patterns, Jet streams, Theoretical power of the wind, Types of wind turbines - Horizontal axis wind turbines, Vertical axis wind turbines, Offshore wind turbines, Near-shore wind turbines, Selection of wind site, Design of a wind turbine rotor blade, Major components of wind electric system - Wind turbine blades or rotor, Transmission System (Hub, Main shaft, Main bearings, Clamping unit, Gear box, Coupling), Generator, Controller, Towers, Advantages and disadvantages of wind energy, Environmental concerns of wind energy.

Bioenergy: Introduction, Feedstock properties, Chemistry of biomass, Biomass conversion processes - Direct combustion, Thermal conversion, Biochemical conversion; Gasification process - Types of Gasifiers, Properties of Producer gas, Advantages of gasification, Difference between gasification and combustion; Anaerobic digestion process - Types of microorganisms, Anaerobic digestion process, Anaerobic digestion operation modes, Feedstock propertiesat Globallocal and regional level; Biogas plants, Design of biogas plants, Benefits of biogas technology to rural economy; Fuels from biomass – Biogas, Alcohols, Biodiesel, Charcoal.

Geothermal energy: Introduction, Geothermal resources – Hydrothermal, Geopressured, Hot Dry Rock, Magma; Technology and resource type - High temperature resources, Medium temperature resources, Low temperature resources, Advantages and disadvantages of geothermal energy.

Ocean Thermal Energy Conversion: Introduction, Solar energy absorption by water, Cycle types - Closed cycle OTEC, Open cycle OTEC, Hybrid; Selection of working fluids, Potential sites and plant design - Land-based and near-shore facilities, Shelf-mounted facilities, Floating facilities; Advantages and disadvantages of OTEC systems.

Tidal energy: Introduction, Fundamental principles of tides, Creation of tides, Effect of gravity and inertia on tidal bulges, variations in tides due to position and distance of Sun, Moon and Earth, Other factors affecting tidal characteristics, Coriolis forces, Energy of tides, Tidal current velocity, Extraction of tidal energy, Advantages and disadvantages of tidal energy.

Wave energy: Introduction; Formation of waves; Power in waves; Ocean wave energy technologies - Terminator, Attenuator, Point absorber, Overtopping Device; Advantages and disadvantages of wave energyat Global, local and regional level.

Fuel cells: Introduction, Thermodynamics of a fuel cell, Types of fuel cells - Polymer electrolyte membrane fuel cell, Direct methanol fuel cell, Alkaline fuel cell, Phosphoric acid fuel cell, Molten carbonate fuel cell, Solid oxide fuel cell.

Batteries: Introduction; Generation of electricity by a battery; Basic parameters - Free energy, Theoretical voltage, Theoretical capacity (Coulombic), Theoretical energy; Types of batteries - Primary (non-rechargeable) batteries, Secondary (rechargeable) batteries, Reserve batteries; Discussion on some examples of different battery types; Major considerations in selecting a battery; Advantages and limitations of batteries.

Hydrogen energy: Introduction; Production of hydrogen from fossil fuels, water splitting, biomass, and chemical hydrides; Storage of hydrogen in gaseous, liquid, and solid form; Technical issues in hydrogen storage; Pipeline transport of compressed hydrogen gas; Road delivery of hydrogen; Liquid hydrogen transport; Hydrogen fueled vehicular transport.

Energy from waste: Introduction, Definitions of waste, Characteristics of municipal solid wastes, Energy from waste, Incineration of municipal solid waste, Advantages and disadvantages of incineration, Pyrolysis, Other methods.

Text and Reference Books:

1. U C Sharma, Non-conventional Sources of Energy, Studium Press, Texas (2014).
2. T K Ghosh, M A Prelas, Energy Resources and Systems, Vol. 1: Fundamentals and Non-Renewable Resources, Springer (2009).
3. T K Ghosh, M A Prelas, Energy Resources and Systems, Vol. 2: Renewable Resources, Springer (2011).
4. E E Michaelides, Alternative Energy Sources, Springer (2012).
5. J Twidell, T Weir, Renewable Energy Sources, Second edition, Taylor & Francis (2006).
6. V V N Kishore, Renewable Energy Engineering and Technology: Principles and Practice, Fundamentals of Renewable Energy Processes, Earth scan (2009).
7. A V da Rosa, Fundamentals of Renewable Energy Processes, Elsevier (2009).

Course Code: CHE-S507 **Breakup: 3-1-0-4**
Course Name: Advanced Separation Processes

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

CO1	Understand important features, advantages and limitations of advanced separation processes
CO2	Write the governing principle and law of the transport processes involved in membranes separation, electrochemical separations, ion-exchange, chromatographic separations and supercritical extractions
CO3	Classify different membrane separation processes and write their governing principles and areas of application
CO4	Understand the structure of different membrane modules and membrane plant configurations
CO5	Possess introductory knowledge working principle of membrane contactors and membrane reactor

Course Details:

Introduction to membrane separations, advantages and limitations; equilibrium and rate governed processes, separation factor for rate governed separation processes, Film theory, Sherwood number, Classification of membrane separation processes, Membrane type and materials; Membrane Modules; Principles, transport mechanisms, governing equations and applications of the following Membrane Separation Processes - Microfiltration, Ultrafiltration, Nanofiltration, Reverse Osmosis, Dialysis, Gas Separation and Pervaporation;
Similarty parameter (concentration boundary layer); unstirred batch cell; one, two dimensional model of Gel layer; module design (rectangular, spiral and tubular)

Surfactant based separation processes- Liquid Membranes, cloud point extraction, micellar enhanced ultrafiltration; External field induced membrane separations for colloidal particles: electro-osmosis, streaming potential, sedimentation potential, zeta potential, Eelectrophoretic separations; Electrodialysis;

Introduction to membrane contactor and membrane reactor; membrane fouling and concentration polarization; Membrane plant configurations and plant design; Ion-exchange and chromatographic separations, molecular sieve separations; supercritical fluid extraction

Text and Reference Books:

1. J. D. Seader & E. J. Henley, Separation Process Principles and Applications, Wiley & Sons (2015)
2. M. Mulder, Basic Priciples of Membrane Technology, Kluwer Academic Publishers (1996)
3. K. Scott and R. Hughes, Industrial Membrane Separation Technology, Blackie Academic and Professional (1995)

Course Code: CHE-S508 **Breakup: 3-1-0-4**
Course Name: Optimization Techniques

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

CO1	Identify different types of optimization problems
CO2	Explain different optimization techniques
CO3	Solve various multivariable optimization problems
CO4	Solve problems by using Linear Programming
CO5	Solve optimization problems of staged and discrete processes, understand the concept of specialized & Non-traditional Algorithms

Course Details:

Introduction of optimization, classification of models, model building, degree of freedom, Analytical method necessary and sufficient conditions for optimum in single and multi-variable unconstrained and constrained problems

Unconstrained one dimensional search, Newton, Quasi-Newton and Secant method for uni-dimensional search, region elimination methods (Golden Section, Fibonacci, Dichotomusetc)

Linear Programming, Graphical simplex method, revised simplex method, duality and transportation problems

Unconstrained multi-variable search, Direct methods, Indirect method, Finite difference approximation

Dynamic Programming, Principle of optimality, Discrete and continuous dynamic programming

Text and Reference Books:

1. T.E. Edger, D.M. Himmelblau, Optimization of Chemical Processes, McGraw Hill (2001)
2. Hameed S. Taha, Operational Research: An Introduction, Pearson (2014)
3. G. C. Onwubolu, B.V. Babu, New Optimization Techniques in Engineering, Springer (2010)
4. S.S. Rao, Engineering Optimization, New Age Publication (2013)

Course Code: CHE-S509 **Breakup: 3-1-0-4**
Course Name: Biochemical Engineering

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

CO1	Understanding of biological basics and bioprocessing for cell Structure and Cell Types
CO2	Understanding the Kinetics of Enzyme Reactions, Applied Enzyme Catalysis,
CO3	Define the transport Phenomena in Biosystems and Analysis of Biological Reactors
CO4	Design the downstream Product Recovery and Purification system
CO5	Interaction of Mixed Microbial Populations, biological wastewater treatment

Course Details:

Cell Structure and Cell Types, Chemicals of Life (RNA, DNA, enzymes etc.),

Kinetics of Enzyme Reactions, Applied Enzyme Catalysis, Metabolic Stoichiometricand Energetics, Molecular Genetics and Control, Biomass Production,

Transport Phenomena in Biosystems, Design and Analysis of Biological Reactors, Fermentors, Downstream Product Recovery and Purification, Interaction of Mixed Microbial Populations, Biological Wastewater Treatmentat Global, local and regional level.

Text and Reference Books:

1. M.L. Shular, F. Kargi, Bioprocess Engineering: Basic Concepts, Prentice Hall (2015)
2. J.E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, Mc Graw Hill (2017)
3. P.M. Doran, Bioprocess Engineering Principles, Academic Press Limited (2012)

Course Code: CHE-S510 **Breakup: 3-1-0-4**
Course Name: Process Modeling and Simulation

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

CO1	Model deterministic systems and differentiate between nonlinear and linear models
CO2	Numerically simulate linear and non linear ordinary differential equations for deterministic systems
CO3	Estimate and validate a model based upon input and output data
CO4	Create a model prediction based upon new input and validate the output data
CO5	Develop steady state models for flash vessels, equilibrium staged processes, distillation columns, absorbers, strippers, CSTR, heat exchangers and packed bed reactors
CO6	Demonstrate the knowledge of various simulation packages and available numerical software libraries

Course Details:

Introduction to mathematical modeling; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes;

Classification of models – Simple vs. rigorous, Lumped parameter vs. distributed parameter; Steady state vs. dynamic, Transport phenomena based vs. Statistical; Concept of degree of freedom analysis.

Simple examples of process models; Models giving rise to nonlinear algebraic equation (NAE) systems, - steady state models of flash vessels, equilibrium staged processes distillation columns, absorbers, strippers, CSTR, heat exchangers, etc.; Review of solution procedures and available numerical software libraries.

Steady state models giving rise to differential algebraic equation (DAE) systems; Rate based approaches for staged processes; Modeling of differential contactors – distributed parameter models of packed beds; Packed bed reactors; Modeling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs), Partial Differential Equations (PDEs), and available numerical software libraries.

Unsteady state (time dependent) models and their applications; Simple dynamic models of Batch reactors, Adsorption columns, Multistage separation systems; Model reduction through orthogonal collocation; Review of solution techniques and available numerical software libraries.

Introduction to flow sheet simulation; Sequential modular approach; Equation oriented approach; Partitioning and tearing; Recycle convergence methods; Review of thermodynamic procedures and physical property data banks.

Text and Reference Books:

1. W.L. Luyben, Process Modeling, Simulation, and Control for Chemical Engineering, Wiley (2013)
2. A. Hussain, Chemical Process Simulation, Wiley Eastern Ltd., New Delhi,
3. D. C. Holland, Fundamentals of Modelling Separation Processes, Prentice Hall (2016)

Course Code: CHE-S511 **Breakup: 3-1-0-4**
Course Name: Fluidization Engineering

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

CO1	Understand the fluidization phenomena, industrial applications of fluidized beds and their operational and design aspects.
CO2	Understand the behaviour of fluidized bed.
CO3	Estimate pressure drop, bubble size, TDH, voidage, heat and mass transfer rates for the fluidized beds
CO4	Write model equations for fluidized beds
CO5	Design a fluidized bed reactor

Course Details:

Introduction: Phenomenon of fluidization, Liquidlike behaviour of a fluidized bed, Comparison with other contacting methods, Advantages and disadvantages of fluidized beds for industrial operations, Selection of a contacting mode for a given application.

Industrial applications: History, Physical operations, Synthesis reactions, Hydrocarbon cracking, Combustion and incineration, Carbonization and gasification, Calcination, Reactions involving solids, Biofluidization.

Fluidization and mapping of regimes: Fixed bed of particles, Fluidization without carryover of particles, Types of gas fluidization without carryover, Fluidization with carryover of particles, Mapping of fluidization regimes.

Dense bed: Distributor types, Gas entry region of a bed, Gas jets in fluidized beds, Pressure drop requirements across distributors, Design of gas distributors, Power consumption.

Bubbles in dense beds: Single rising bubbles, Coalescence and splitting of bubbles, Bubble formation above a distributor, Slug flow.

Bubbling fluidized beds: Experimental findings, Estimation of bed properties, Physical models, scale-up and scale-down, Flow models for bubbling beds.

Entrainment and elutriation from fluidized beds: Freeboard behaviour, Location of the gas outlet of a vessel, Entrainment from tall vessels (H_f> TDH), Entrainment from short vessels (H_f< TDH).

High velocity fluidization: Turbulent fluidized beds, Fast fluidization, Freeboard-entrainment model applied to fast fluidization, Pressure drop in turbulent and fast fluidization.

Solid movement: Vertical movement of solids, Horizontal movement of solids, Segregation of particles, Large solids in beds of smaller particles, Staging of fluidized beds, Leakage of solids through distributor plates.

Gas dispersion and gas interchange in bubbling beds: Dispersion of gas in beds, Gas interchange between bubble and emulsion, Estimation of gas interchange coefficients.

Text and Reference Books:

1. D Kunni, O Levenspiel, Fluidization Engineering, Second edition, Butterworth Heinemann, USA (1991).
2. J R Grace, J M Matsen, Fluidization, Plenum Press, New York (1980).L G Gibilaro, Fluidization Dynamics, Butterworth Heinemann, Oxford (2001).
3. M L Passos, M A S Barrozo, A S Mujumdar, Fluidization Engineering Practice, Second expanded edition, Laval, Canada (2014).
4. W C Yang, Handbook of fluidization and fluid-particle systems, First edition, Marcel Dekker, New York (2003).
5. M Pell, Gas Fluidization, Elsevier, Amsterdam (1990).

Course Code: CHE- S512 **Breakup: 3-1-0-4**
Course Name: Electrochemical Engineering

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

CO1	Understanding of Faraday's laws, ion-conduction electrode processes, Nernst equation and equilibrium constant, Porbaix diagram
CO2	Estimation of electrochemical potential, Debye-Huckel theory
CO3	Understanding Nernst-Plank equation, mass transport boundary layer
CO4	Determine the experimental methods for Nernst-Plank equation, mass transport boundary layer
CO5	Applications of energy storage and conversion, fuel cells, electrochemical reactions, electric vehicles

Course Details:

Review of fundamental principles of electrochemistry: Faraday's laws and ion-conduction electrode processes, transport number and transference number, Nernst equation and equilibrium constant, Porbaix diagram.

Phase equilibrium: electrochemical potential, Debye-Huckel theory, liquid junction potential

Electrode kinetics: electric double layer, simplified electrode kinetics models

Ionic mass transport: Nernst-Plank equation, mass transport boundary layer, concentration over potential, limiting current density

Experimental methods: potentiometry and galvanometry, impedance methods, scanning probe techniques, electrochemical instrumentation

Applications: energy storage and conversion, fuel cells, electrochemical reactions, electric vehicles, electro-dialysis, ion exchange membrane separations at Global, local and regional level.

Text and Reference Books:

1. Geoffrey Prentice, Electrochemical Engineering Principles, Prentice Hall, (1991)
2. Bard, A. J. And Faulkner, L. R., Electrochemical Methods- Fundamentals and Applications , Wiley India, 2nd ed, (2004)
3. Newman, John and Alea, K. E. Thomas, Electrochemical Systems, John Wiley, 3rd ed. (2004)
4. Strathmann, H., Ion-Exchange Membrane Separation Processes, Elsevier, 1st ed. (2004)

Course Code: CHE- S513 **Breakup: 3-1-0-4**
Course Name: Piping Engineering

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

CO1	Understand the basics of Piping Engineering
CO2	Understand the purpose of Piping Engineering
CO3	Learn the responsibilities of piping engineer in a project
CO4	Learn types of calculations involved in piping engineering project.
CO5	Learn requirements of piping modelling and analysis.

Course Details:

Introduction to piping: Pipe, Pipe size, Pipe wall thickness, Piping classification, Basic definitions, Forces, moments, and equilibrium, Work, power, and energy, Heat and temperature, Lengths, areas, surfaces, and volumes.

Piping components: Pipe and tube products; Traps; Strainers; Expansion joints; Threaded joints; Welded and brazed joints; Joining cast-iron pipe; Concrete, cement, and cement-lined pipe.

Piping materials: Material properties of piping materials, Metallic materials, Physical metallurgy of steel, Alloying of steel, Classification of steels, Steel heat treating practices, Degradation of materials in service, Material specifications.

Piping codes and standards: American standards – API, AISI, ANSI, ASME, ASTM, AWS, AWWA, MSS-SP, Unified numbering system (UNS); British standards; German standards; Indian standards.

Bolted joints: Cost of a leak, Flange joint components, Function of gaskets, Function of bolts, Gasket selection, Bolt selection, Flange stress analysis.

Selection and application of valves: Valve terminology, Reference codes and standards, Classification of valves, Valve components, Materials, Valve categories, Valve types, Pressure relief devices, Actuators, Selection and application guidelines.

Piping layout: Piping layout considerations, Specific system considerations, Application of CAD to piping layout.

Stress analysis of piping systems: Theories of failure, Stress categories, Stress limits, Fatigue; Load Classification, Service limits, and code requirements; Local stresses; Types of pipe loading conditions; Methods of analysis.

Piping supports: Introduction, Determination of support locations; Determination of loads and movements; Selection of pipe-supporting devices; Support requirements for specific piping materials; Design detail considerations; other support considerations.

Thermal insulation of piping: Fundamentals of heat transfer, Design parameters, Design conditions, Service considerations, Insulation materials, Accessory materials.

Flow of fluids: Basic fluid properties, Dimensions and units, Viscosity, Pressure variation in a static fluid, Continuity equation, Conservation of energy; Steady single-phase incompressible flow in piping; Steady single-phase compressible flow in piping; Single-phase flow in nozzles, venturi, and orifices; Steady two-phase flow; Transient flow analysis.

Pressure and leak testing of piping systems: Piping codes, Leak testing methods, Selection of a test method and fluid test medium, Pressure testing procedures.

Process systems piping: Introduction, Reference codes and standards, Design conditions, Design loading considerations, Pressure design of piping components, Selection and limitations of piping components, General process piping system considerations, Special design piping systems, System layout considerations, global Case histories.

Nonmetallic piping: Thermoplastics piping - Introduction, Piping materials, Joining methods, Dimensioning systems, Physical and mechanical properties, Chemical resistance, Common design considerations. Fiberglass piping - Typical applications, Resins, Joining systems, Resistant properties, Physical properties, Advantages and limitations of fiberglass piping systems, Pressure ratings, Connection to other equipment and piping material.

Text and Reference Books:

1. M L Nayyar (Editor), Piping Handbook, Seventh edition, McGraw-Hill (2000).
2. M W Kellogg, Design of Piping Systems, Revised Second edition, John-Wiley (1956).
3. P Smith, Process Piping Design Handbook Vol. 1: The Fundamentals of Piping Design, Gulf Publishing Company, Texas (2007).
4. G A Antaki, Piping and Pipeline Engineering, Marcel Dekker, New York (2003).
5. J P Ellenberger, Piping and Pipeline Calculations Manual, Second edition, Butterworth-Heinemann (2014).
6. ITT Grinnel Industrial Piping, Inc., Piping Design and Engineering, Sixth edition (1981).
7. Tube Turns, Inc., Piping Engineering, Sixth edition (1986).