HERITAGE INSTITUTE OF TECHNOLOGY

(An Autonomous Institution affiliated to MAKAUT, West Bengal)

DEPARTMENT

OF

CHEMICAL ENGINEERING

B.TECH. PROGRAMME

Curriculum and Detailed Syllabus

Release Date: JULY 2023

(Applicable from 2023 admitted batch)

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Preamble

The curriculum for the B. Tech. in Chemical Engineering program has been modified as per the guidelines of AICTE and MAKAUT, and considering the new education policy (NEP) under Academic Regulation 2022 from the academic session 2023 - 2024. In addition, this outcome-based curriculum (OBC) is created with a choice-based credit system (CBCS), which enables students to develop professional competency through a multidisciplinary approach that satisfies the requirements of industry, academics and the different Accreditation bodies like NBA and NAAC. Courses such as Industrial Safety and Hazard Analysis, Novel Separation Processes, Petrochemical Technology and Design Thinking and Idea Lab etc. are included in the syllabus incorporating the suggestions of NBA experts in the very recent visit. Advanced software e.g. COMSOL are being taught in the 8^{th} semester in Design and Simulation Laboratory. Multidisciplinary subjects e.g. Transport Processes in Biological Systems and Nanotechnology are introduced to enable students to navigate various non-traditional areas of Chemical Engineering to equip themselves for careers in diverse fields.

Algebraic structures, linear algebra, and optimization theory are included to strengthen students' mathematical skills that enables them to learn latest developments of computer science and be more innovative. Students are being motivated to select and study MOOC subjects of their choice towards attaining the degree with honors. Apart from this, the course code is now changed from 4 letters to 3 letters from the session 2023 – 2024 as per the suggestions of the office of the Controller of examinations to distinguish the new courses from the old ones. In accordance with this, the curriculum and syllabi are revised in a structured manner by implementing Feedback Mechanism on Curriculum from various stakeholders, including potential employers, alumni, and parents.

Institutional Vision & Mission

VISION:

To prepare dynamic and caring citizens to meet the challenges of global society while retaining their traditional values.

MISSION:

- To prepare students with strong foundation in their disciplines and other areas of learning.
- To provide an environment for critical and innovative thinking, and to encourage life-long learning.
- To develop entrepreneurial and professional skills.
- To promote research and developmental activities and interaction with industry.
- To inculcate leadership qualities for serving the society.

Departmental Vision & Mission

VISION:

To be a nationally recognized centre of excellence for studies in Chemical Engineering and Renewable Energy together with emerging inter-disciplinary fields.

MISSION:

M1: To educate students to become qualified chemical engineers practicing their profession with integrity and honesty.

M2: To conduct innovative research in chemical engineering and related interdisciplinary areas i.e. Material Science, Renewable Energy, Electrochemistry, Artificial Intelligence, High throughput simulation and Computer aided modeling.

M3: To nurture leadership qualities and develop entrepreneurial and professional skills in the students.

M4: To promote departmental interaction with the industry and collaborate on joint value-added projects.

Program Educational Objectives (PEOs) of B.Tech. in CHE Programme

The graduate students with the B.Tech. degree in Chemical Engineering from Heritage Institute of Technology, Kolkata are expected to achieve the following qualities after a few years of getting this degree.

PEO1. To have established themselves as practicing professionals in reputed industries including PSUs and MNCs or have achieved higher educational qualifications and innovative research skill for pursuing research in R&D laboratories as well as in academic sectors.

PEO2. To have adapted themselves with latest developments in the discipline, including application of modern technologies in the field of Chemical Engineering Science and allied interdisciplinary areas.

PEO3. To demonstrate their ability to work in a team with leadership qualities.

Program Outcomes (POs)

Engineering Graduates will be able to:

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Program Specific Outcomes (PSOs) of B.Tech. in CHE Programme

Engineering Graduates will be able to:

PSO1. Apply the concepts of Transport processes such as mass, heat and momentum, Chemical Reaction Engineering and Chemical Engineering Thermodynamics to the design, operation, troubleshooting and maintenance of chemical process plants.

PSO2. Apply the principles of process control and instrumentation, high throughput simulation and computer aided modeling, materials science, electrochemistry, and Safety & HAZOP analysis to the design, operation, troubleshooting and maintenance of chemical process plants.

Credit Summary for B Tech programmes in CHEwith effect from 2023-2024

Sl. No.	Course Type	Credit CHE	AICTE recommended credits (2018 Vol II)
1.	Humanities and Social Sciences including Management Courses	9	12
2.	Basic Science Courses	16	27
3.	Engineering Science Courses including Workshop, Drawing, Basics of Electrical / Mechanical / Computer, etc.	31.5	27
4.	Professional Core Courses	63	55
5.	Professional Elective Courses relevant to chosen Specialization / Branch	15	12
6.	Open Subjects – Electives from other Technical and/or Emerging Subjects	12	12
7.	Project Work, Seminar and Internship in industry or elsewhere	16.5	12
8.	Mandatory Courses (Non-credit) [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Traditional Knowledge]	(NON-CREDIT)	
	Total	**163**	**157**
9	Honours Courses (MOOCS or otherwise)	20	
	Grand Total	**183**	

Definition of Credit (as per National Credit Framework 2022):

- Total notional learning hours = 1200 Hours/ Year
- Minimum credits to be earned = 40/ Year
- 1 Credit = 30 notional learning hours

Range of Credits (as per AICTE):

- A student will be eligible to get B Tech degree with Honours if he/she completes an additional 20 CREDIT s.
- These could be acquired through MOOCs. For details kindly refer to APPENDIX – A.
- A student will be eligible to get B.Tech. degree certificate, if he/ she acquires 100 MAR points in 4 years of their study.
- Lateral entry students must acquire 75 MAR points in their 3 years of study.
- For details kindly refer to APPENDIX – B

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Curriculum

1st Year 1stSemester

	A. Theory							
Sl.	Code	Subject	L	Contacts Periods/ Week T	P	SL	Total	Credit
1	CHM1001	Chemistry I	3	0	0	3	6	3
2	MTH1101	Mathematics I	3	1	0	6	10	4
3	CSE1001	Programming for Problem Solving	4	0	0	6	10	4
4	ELE1001	Basic Electrical Engineering.	3	1	0	6	10	4
5	HUM1001	English for Technical Writing	2	0	0	3	5	2
Total Theory			**15**	**2**	**0**	**24**	**41**	**17**
	B. Practical							
1	CHM1051	Chemistry I Laboratory	0	0	2	1	3	1
2	CSE1051	Programming for Problem Solving Laboratory	0	0	3	1	4	1.5
3	ELE1051	Basic Electrical Engineering Laboratory	0	0	2	1	3	1
4	HUM1051	English for Technical Writing Laboratory	0	0	2	1	3	1
Total Practical			**0**	**0**	**0**	**4**	**13**	**4.5**
Total of Semester			**15**	**2**	**9**	**28**	**54**	**21.5**

1st Year 2nd Semester

Sl.	Code	Subject	L	T	P	SL	Total	Credit
	A. Theory							
1	PHY1001	Physics I	3	0	0	5	8	3
2	MTH1201	Mathematics II	3	1	0	6	10	4
3	ECE1001	Introduction to Electronic Devices and Circuits	3	0	0	5	8	3
4	HUM1002	Universal Human Values and Professional Ethics	3	0	0	5	8	3
5	IKS	Course Provide By Indian Knowledge System						0
Total Theory			**12**	**1**	**0**	**21**	**34**	**13**
	B. Practical							
1	PHY1051	Physics I Laboratory	0	0	2	1	3	1
2	ECE1051	Introduction to Electronic Devices and Circuits Laboratory	0	0	2	1	3	1
3	MEC1051	Workshop/ Manufacturing Practices	1	0	3	3	7	2.5
4	MEC1052	Engineering Graphics & Design	1	0	3	3	7	2.5
Total Practical			**2**	**0**	**10**	**8**	**20**	**7**
Total of Semester			**14**	**1**	**10**	**29**	**54**	**20**

2nd Year 1st Semester

	A. Theory							
				Contacts Periods/ Week				Credit
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**SL**	**Total**	
1	CHE2101	Particle & Fluid Particle Processing	3	0	0	5	8	3
2	CHE2102	Chemical Engineering Fluid Mechanics	2	1	0	5	8	3
3	CHE2103	Industrial Process Calculations	2	1	0	5	8	3
4	CHE2104	Introduction to Engineering Thermodynamics	3	0	0	5	8	3
5	CHE2105	Energy Engineering	3	0	0	5	8	3
6	CHE2106	Material Science	3	0	0	5	8	3
Total Theory			**16**	**2**	**0**	**30**	**48**	**18**
	B. Practical							
1	CHE2151	Fluid Mechanics (ChE) Laboratory	0	0	2	1	3	1
2	CHE2152	Particle & Fluid Particle Processing Laboratory	0	0	2	1	3	1
3	CHE2153	Instrumental methods of Analysis Laboratory	0	0	3	1	4	1.5
Total Practical			**0**	**0**	**7**	**3**	**10**	**3.5**
Total of Semester			**16**	**2**	**7**	**33**	**58**	**21.5**

2nd Year 2nd Semester

Sl.	Code	Subject	L	T	P	SL	Total	Credit
	A. Theory							
1	CHE2201	Process Heat Transfer	2	1	0	5	8	3
2	CHE2202	Chemical Process Technology	3	0	0	5	8	3
3	CHE2203	Chemical Engineering Thermodynamics	3	0	0	5	8	3
4	CHE2204	Chemical Reaction Engineering I	2	1	0	5	8	3
5	CHE2205	Transport Phenomena	3	0	0	5	8	3
6	CHM2201	Chemistry II	3	0	0	5	8	3
7	EVS2016	Environmental Science	2	0	0	2	4	0
Total Theory			**18**	**2**	**0**	**32**	**52**	**18**
	B. Practical							
1	CHE2251	Heat Transfer Laboratory	0	0	3	1	4	1.5
2	CHE2252	Programming Basics for Numerical Computation	0	0	3	1	4	1.5
3	CHE2253	Engineering Graphics & AUTOCAD Laboratory	0	0	2	1	3	1
4	CHE2254	Idea Lab & Design Thinking(CHE)	0	0	2	1	3	1
Total Practical			**0**	**0**	**10**	**4**	**14**	**5**
Total of Semester			**18**	**2**	**10**	**36**	**66**	**23**

3rd Year 1st Semester

	A. Theory							
Sl.	Code	Subject	L	Contacts Periods/ Week T	P	SL	Total	Credit
1	CHE3101	Numerical Methods in Chemical Engineering	3	0	0	5	8	3
2	CHE3103	Mass Transfer I	2	1	0	5	8	3
3	CHE3104	Industrial Safety & Hazard Analysis	3	1	0	6	10	4
4	CHE3105	Chemical Reaction Engineering II	2	1	0	5	8	3
5	CHE3131 - CHE3132	Professional Elective-I						
	CHE3131	Petroleum Refinery Engineering	3	0	0	5	8	3
	CHE3132	Environmental Engineering and						
6	CHE3121 - CHE3122	Open Elective I						
	CHE3121	Water and Liquid Waste Management	3	0	0	5	8	3
	CHE3122	Plastic Waste Recycle and Management						
Total Theory			**16**	**3**	**0**	**31**	**50**	**19**
	B. Practical							
1	CHE3151	Numerical computation Laboratory	0	0	3	1	4	1.5
2	CHE3152	Chemical Reaction Engineering Laboratory	0	0	3	1	4	1.5
3	CHE3153	Energy Laboratory	0	0	2	1	3	1
Total Practical			**0**	**0**	**8**	**3**	**11**	**4**
Total of Semester			**16**	**3**	**8**	**34**	**61**	**23**

3rd Year 2nd Semester

Sl.	Code	Subject	L	T	P	SL	Total	Credit
	A. Theory							
1	CHE3201	Process Control &Instrumentation in Chemical Industries	3	1	0	6	10	4
2	CHE3202	Mass Transfer II	2	1	0	5	8	3
3	CHE3231-CHE3232	Professional Elective-II						
	CHE3231	Bioprocess Engineering	3	0	0	5	8	3
	CHE3232	Petrochemical Technology						
4	CHE3241-CHE3242	Professional Elective-III						
	CHE3241	Fluidization Engineering	3	0	0	5	8	3
	CHE3242	Nanotechnology						
5	CHE3221-CHE3222	Open Elective II						
	CHE3221	Fuel Cell Technology	3	0	0	5	8	3
	CHE3222	Energy Transition with Hydrogen						
6	INCO3016	Indian Constitution & Civil Society	2	0	0	2	4	0
Total Theory			**16**	**2**	**0**	**28**	**46**	**16**
	B. Practical							
1	CHE3251	Mass Transfer Laboratory	0	0	3	1	4	1.5
2	CHE3252	Process Equipment Design & Drawing Laboratory	0	0	4	1	5	2
Total Practical			**0**	**0**	**7**	**2**	**9**	**3.5**
	C. Sessional							
1	CHE3291	Term Paper & Technical Seminar	0	0	0	1	1	1.5
2	CHE3295	Project I	0	0	6	2	8	3
Total Sessional			**0**	**0**	**9**	**3**	**9**	**4.5**
Total of Semester			**16**	**2**	**16**	**33**	**64**	**24**

4th Year 1st Semester

	A. Theory							
Sl.	Code	Subject	L	Contacts Periods/ Week T	P	SL	Total	Credit
1	CHE4131-CHE4132	Professional Elective-IV						
	CHE4131	Novel Separation Processes	3	0	0	5	8	3
	CHE4132	Polymer Engineering						
2	CHE4141-CHE4142	Professional Elective-V						
	CHE4141	Transport Processes in Biological Systems	3	0	0	5	8	3
	CHE4142	Project Engineering & Economics						
3	CHE4121-CHE4122	Open Elective III						
	CHE4121	Introduction to Solar and Wind Technology	3	0	0	5	8	3
4	CHE4126-CHE4127	Open Elective IV						
	CHE 4126	Nptel courses: Sustainable Energy Technology- https://onlinecourses.nptel.ac.in/noc24_me144/preview Or Energy economics and policy https://onlinecourses.nptel.ac.in/noc24_hs172/preview	3	0	0	5	8	3
5	HUM4101	Principles of Management	3	0	0	5	8	3
Total Theory			**15**	**0**	**0**	**25**	**40**	**15**
	B. Practical							
1	CHE4151	Process Control Laboratory	0	0	2	1	3	1
2	CHE4152	Design & Simulation Laboratory	0	0	4	1	5	2
Total Practical			**0**	**0**	**6**	**2**	**8**	**3**
	B. Sessional							
1	CHE4191	Industrial Training	0	0	0	1	1	2
2	CHE4195	Project II	0	0	10	3	13	5
Total Sessional			**0**	**0**	**10**	**4**	**14**	**7**
Total of Semester			**15**	**0**	**16**	**31**	**62**	**25**

4th Year 2nd Semester

Sl.	Code	Subject		Contacts Periods/ Week				Credit
			L	T	P	SL	Total	
1	CHE4295	Project III	0	0	6	8	14	2
2	CHE4297	Grand Viva	0	0	0	5	5	2
3	SKD4296	Skill India Course*						1
Total Sessional			**0**	**0**	**6**	**13**	**19**	**5**
Total of Semester			**0**	**0**	**6**	**13**	**19**	**5**

* This course is to be done online and can be taken either in 6th, 7th or 8th semester. The final credit will be added in the 8thsemester after the skill development certificate has been provided by students.

Open Electives to be offered to Chemical Engineering Students by Other Departments			
Semester V **Open Elective I**	Principles of Sustainable Engineering (CIV 3121)	Introduction to Machine Learning (ECE 3122)	Introduction to MEMS (AEI3121)
Semester VI **Open Elective II**	Biopolymer (BTC3224)	Computational Biology (BTC3225)	Elementary Spanish for Beginners (HUM3221)
Semester VII **Open Elective III**	Micro and Nano Manufacturing (MEC4121)	Biosensor (BTC4127)	
Semester VII **Open Elective IV**	Introduction to Industrial Sociology (HUM4121)	Modern Manufacturing Technology (MEC4130)	

DETAILED SYLLABUS

1st Year

Course Name: Chemistry 1					
Course Code: CHM1001					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

The subject code CHM-1001 corresponds to Chemistry Theory classes (**Chemistry-1**) for the first year B. Tech students, offered as Chemistry for Engineering and is common to all Branches of Engineering Disciplines. The course provides basic knowledge of theory and applications in the subjects like Thermodynamics, Quantum mechanics, Electrochemistry, & Energy conversion, Structure and reactivity of molecules. Spectroscopic techniques and their applications, Synthesis & use of Drug molecules. The Course Outcome for the subject code **CHM1001**, is furnished below:

1. Knowledge acquisition of bulk properties of materials and understanding of reaction processes using thermodynamic considerations.
2. Conception of energy conversion and its importance in clean energy scenario, the operating principles for batteries, fuel cells and the materials and reactions involved there in, their applications as sustainable energy devices, particularly in automobiles sectors to reduce environmental pollution.
3. Analytic view of microscopic chemistry in terms of atomic structure, molecular orbital and intermolecular forces to reinforce strong background on materials science and engineering.
4. Rationalize periodic trends of elements to explain various physico - chemical properties.
5. Understanding of the spectrum of electromagnetic radiation used for exciting different molecular energy levels in various spectroscopic techniques.
6. Knowledge of stereochemistry and conception of the mechanism of major chemical reactions involved in synthesis of drug molecules.

Module I [9L]

Thermodynamics:

The 1st and 2nd laws of thermodynamics and thermodynamic functions like free energy, work function and entropy; Carnot cycle, Joule-Thomson effect, Gibbs-Helmholtz equation; Chemical Potential, Gibbs- Duhem Equation and Clausius-Clapeyron Equation.

Electrochemical Cell:

Generation of electromotive force in electrochemical cells and application of Nernst equation; Electrode potentials and the redox reactions; Cell configuration and half cell reactions; Standard Hydrogen Electrode, Reference electrode, evaluation of thermodynamic functions; Electrochemical corrosion.

Electrochemical Energy Conversion: Primary & Secondary batteries, Fuel Cells.

Module II [9L]

Molecular Structure:

Molecular geometry, Hybridization, Ionic, dipolar and van Der Waals interactions; Molecular Orbital Theory and its application in diatomic molecule; Pi-molecular orbital of unsaturated system; Band structure of solids, intrinsic and extrinsic semiconductors and the role of doping on band structures.

Periodic Properties:

Effective nuclear charge, penetration of orbitals; variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes; ionization energies, electron affinity and electro-negativity, polarizability, oxidation states, coordination numbers and geometries; hard-soft acid base theory.

Module III [9L]

Atomic structure and Wave Mechanics:

Brief outline of the atomic structure, wave particle duality, Heisenberg uncertainty principle; Introduction to quantum mechanics, Schrodinger wave equation for particle in one dimensional box.

Spectroscopic Techniques & Applications:

Electromagnetic spectrum: Interaction of EMR with matter; Principle and applications of Fluorescence & Phosphorescence, UV-Visible, , Infrared and NMR spectroscopy.

Module IV [9L]Stereochemistry:

Representations of 3-dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis.

Organic reactions and synthesis of drug molecule:

Introduction to reaction mechanisms involving substitution, addition, elimination and oxidation-reduction reactions. Synthesis of commonly used drug molecules.

Text Books:

1. Atkins' Physical Chemistry, P.W. Atkins (10th Edition).
2. Organic Chemistry, I. L. Finar, Vol-1 (6th Edition).
3. Engineering Chemistry, Jain & Jain,(16th Edition).
4. Fundamental Concepts of Inorganic Chemistry, A. K. Das, (2nd Edition).
5. Engineering Chemistry -I, Gourkrishna Dasmohapatra, (3rd Edition).

Books of reference:

1. General & Inorganic Chemistry, R. P. Sarkar.
2. Physical Chemistry, P. C. Rakshit, (7^{th} Edition).
3. Organic Chemistry, Morrison & Boyd , (7^{th} Edition).
4. Fundamentals of Molecular Spectroscopy, C.N. Banwell, (4^{th} Edition).
5. Physical Chemistry, G. W. Castellan, (3^{rd} Edition).
6. Basic Stereo chemistry of Organic Molecules, Subrata Sen Gupta, (1^{st} Edition).

Course Name: Mathematics I					
Course Code: MTH1101					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**1**	**0**	**4**	**4**

Course Outcomes:

After successfully completing this course the students will be able to:

1. apply the concept of rank of matrices to find the solution of a system of linear simultaneous equations.
2. develop the concept of eigen values and eigenvectors.
3. combine the concepts of gradient, curl, divergence, directional derivatives, line integrals, surfaceintegrals and volume integrals.
4. analyze the nature of sequence and infinite series.
5. choose proper method for finding solution of a specific differential equation.
6. describe the concept of differentiation and integration for functions of several variables with their applications in vector calculus.

Module I [10L]Matrix:

Inverse and rank of a matrix; Elementary row and column operations over a matrix; System of linear equations and its consistency; Symmetric, skew symmetric and orthogonal matrices; Determinants; Eigen values and eigen vectors; Diagonalization of matrices; Cayley Hamilton theorem; Orthogonal transformation.

Module II [10L] Vector Calculus:

Vector function of a scalar variable, Differentiation of a vector function, Scalar and vector point functions, Gradient of a scalar point function, divergence and curl of a vector point function, Directional derivative, related problems on these topics.

Infinite Series:

Convergence of sequence and series; Tests for convergence: Comparison test, Cauchy's Root test, D' Alembert's Ratio test(statements and related problems on these tests), Raabe's test; Alternating series; Leibnitz's Test (statement, definition); Absolute convergence and Conditional convergence.

Module III [10L]

First order ordinary differential equations:

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

Ordinary differential equations of higher orders:

General linear ODE of order two with constant coefficients, C.F. & P.I., D-operator methods, Method of variation of parameters, Cauchy-Euler equations.Module IV [10L]

Calculus of functions of several variables:

Introduction to functions of several variables with examples, Knowledge of limit and continuity, Determination of partial derivatives of higher orders with examples, Homogeneous functions and Euler's theorem and related problems up to three variables.

Multiple Integration:
Concept of line integrals, Double and triple integrals. Green's Theorem, Stokes Theorem and Gauss Divergence Theorem.

Books of reference:

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 2000.
2. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2006.
3. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi,2008.
4. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11thReprint, 2010.
5. K. F. Riley, M. P. Hobson, S. J. Bence. Mathematical Methods for Physics and Engineering, Cambridge University Press, 23-Mar-2006.
6. S. L. Ross, Differential Equations", Wiley India, 1984.
7. G.F. Simmons and S.G. Krantz, Differential Equations, McGraw Hill, 2007.
8. M.R. Spiegel, Seymour Lipschutz, Dennis Spellman, Vector Analysis (Schaum's outlineseries), McGraw Hill Education.
9. S. S. Sastry, Engineering Mathematics, PHI.
10. M.C. Potter, J.L. Goldberg and E.F. Abonfadel (OUP), Advanced Engineering Mathematics, Indian Edition.
11. Seymour Lipschutz, Marc Lipson, Linear Algebra (Schaum's outline series), McGrawHill Education.

Course Name: Programming for Problem Solving					
Course Code: CSE1001					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	4	**0**	**0**	**4**	**4**

Course Outcomes:

After completion of the course, students will be able to

CSE1001.1: Remember and understand the functionalities of the different hardware and software components present in a computer system, the standard representations of various types of data in a computer system.

CSE1001.2: Illustrate how a computer system with one way of representation can be converted to one another equivalent representation.

CSE1001.3: Construct flow charts for any arithmetic or logical problems in hand.

CSE1001.4: Remember and understand the C programming development environment, writing, compiling, debugging, linking and executing a C program using that development environment, basic syntax and semantics of C programming language and interpret the outcome of any given C program.

CSE1001.5: Use loop constructs, conditional branching, iteration, recursion to solve simple engineering problems.

CSE1001.6: Apply pointers, arrays, structures, files to formulate simple engineering problems.

Learning Objectives: Introduction to the concept of computer and computation and solving of problems using C as a programming language. Coverage of C will include basic concepts, arithmetic and logic, flow control, and data handling using arrays, structures, pointers and files.

Module I [12L]

Fundamentals of Computer:

History of Computers, Generations of Computers, Classification of Computers.

Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. Basic Concepts of Assembly language, High level language, Compiler and Assembler.

Binary & Allied number systems (decimal, octal and hexadecimal) with signed and unsigned numbers (using 1's and 2's complement) - their representation, conversion and arithmetic operations. Packed and unpacked BCD system, ASCII. IEEE-754 floating point representation (half- 16 bit, full- 32 bit, double- 64 bit).

Basic concepts of operating systems like MS WINDOWS, LINUX How to write algorithms & draw flow charts.

Module II [12L]

Basic Concepts of C:

C Fundamentals:

The C character set identifiers and keywords, data type & sizes, variable names, declaration, **statements. Operators & Expressions:**

Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence and order of evaluation. Standard input and output, formatted output -- printf, formatted input scanf.

Flow of Control:
Statement and blocks, if-else, switch-case, loops (while, for, do-while), break and continue, go to and labels.

Module III [12L]
Program Structures in C
Basic of functions, function prototypes, functions returning values, functions not returning values. Storage classes -
auto, external, static and register variables – comparison between them. Scope, longevity and visibility of variables. C preprocessor (macro, header files), command line arguments.
Arrays and Pointers:
One dimensional arrays, pointers and functions – call by value and call by reference, array of arrays. Dynamic memory usage– using malloc(), calloc(), free(), realloc(). Array pointer duality.
String and character arrays; C library string functions and their use.

Module IV [12L]
Data Handling in C
User defined data types and files:
Basic of structures; structures and functions; arrays of structures.
Files – text files only, modes of operation. File related functions – fopen(), fclose(), fscanf(), fprintf(), fgets(), fputs(), fseek(), ftell();

Text Books:

1. Schaum's outline of Programming with C – Byron Gottfried
2. Teach Yourself C- Herbert Schildt
3. Programming in ANSI C – E Balagurusamy

Books of reference:

1. C: The Complete Reference – Herbert Schildt
2. The C Programming Language- D.M.Ritchie, B.W. Kernighan

Course Name: Basic Electrical Engineering					
Course Code: ELE1001					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**1**	**0**	**4**	**4**

Course Outcomes:

After attending the course, the students will be able to

ELE1001.1 Analyse DC electrical circuits using KCL, KVL and network theorems like Superposition Theorem, Thevenin's Theorem, Norton's Theorem and Maximum Power Transfer Theorem.

ELE1001.2 Analyse DC Machines; Starters and speed control of DC motors.

ELE1001.3 Analyse magnetic circuits.

ELE1001.4 Analyse single and three phase AC circuits.

ELE1001.5 Analyse the operation of single phase transformers.

ELE1001.6 Analyse the operation of three phase induction motors.

Module I [11L]

DC Network Theorem:

Kirchhoff's laws, Nodal analysis, Mesh analysis, Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem, Star-Delta conversion. [6L]

Electromagnetism:

Review of magnetic flux, Force on current carrying conductors, Magnetic circuit analysis, Self and Mutual inductance, B-H loop, Hysteresis and Eddy current loss, Lifting power of magnet. [5L]

Module II [10L]

AC single phase system:

Generation of alternating emf, Average value, RMS value, Form factor, Peak factor, representation of an alternating quantity by a phasor, phasor diagram, AC series, parallel and series-parallel circuits, Active power, Reactive power, Apparent power, power factor, Resonance in RLC series and parallel circuit.

Module III [11L]

Three phase system:

Generation of three-phase AC power, Balanced three phase system, delta and star connection, relationship between line and phase quantities, phasor diagrams, power measurement by two wattmeter method. [4L]

DC Machines:

Construction, EMF equation, Principle of operation of DC generator, Open circuit characteristics, External characteristics, Principle of operation of DC motor, speed-torque characteristics of shunt and series machine, starting of DC motor, speed control of DC motor.[7L]

Module IV [10L]

Transformer:

Construction, EMF equation, no load and on load operation and their phasor diagrams, Equivalent circuit, Regulation, losses of a transformer, Open and Short circuit tests, Efficiency, Introduction to three phase transformer.[6L]

Three-phase induction motor:

Concept of rotating magnetic field, Principle of operation, Construction, Equivalent circuit and phasor diagram, torque-speed/slip characteristics, Starting of Induction Motor.[4L]

Text Books:

1. Basic Electrical engineering, D.P Kothari & I.J Nagrath, TMH, Second Edition
2. Basic Electrical Engineering, V.N Mittle& Arvind Mittal, TMH, Second Edition
3. Basic Electrical Engineering, Hughes
4. Electrical Technology, Vol-I,Vol-II,Surinder Pal Bali, Pearson Publication
5. A Text Book of Electrical Technology, Vol. I & II, B.L. Theraja, A.K. Theraja, S.Chand& Company

Books of reference:

1. Electrical Engineering Fundamentals, Vincent Del Toro, Prentice-Hall
2. Advance Electrical Technology, H.Cotton, Reem Publication
3. Basic Electrical Engineering, R.A. Natarajan, P.R. Babu, Sictech Publishers
4. Basic Electrical Engineering, N.K. Mondal, Dhanpat Rai
5. Basic Electrical Engineering, Nath&Chakraborti
6. Fundamental of Electrical Engineering, Rajendra Prasad, PHI, Edition 2005.

Course Name: English for Technical Writing					
Course Code: HUM1001					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	2	**0**	**0**	**2**	**2**

Course Outcomes:

After the completion of the course, students will be able to:

1. Communicate effectively in an official and formal environment.
2. Use language as a tool to build bridges and develop interpersonal relations in multi-cultural environment.
3. Use various techniques of communication for multiple requirements of globalized workplaces
4. Learn to articulate opinions and views with clarity.
5. Write business letters and reports.
6. Apply various communication strategies to achieve specific communication goals.

Module I [6hrs]

Introduction to Phonology and Morphology:

- Phonetics- Vowel and Consonant Sounds (Identification & Articulation).
- Word- stress, stress in connected speech.
- Intonation (Falling and Rising Tone).
- Vocabulary Building-The concept of Word Formation.

Module II [6hrs]

Communication Skills:

- The Basics of Business Communication- Process, types, levels.
- Barriers to Communication Common obstacles to effective communication.
- Approaches and Communication techniques for multiple needs at workplace: persuading, convincing, responding, resolving conflict, delivering bad news, making positive connections.
- Identify common audiences and design techniques for communicating with each audience.

Module III [6hrs]

Organizational Communication:

- Business Letters .
- Organizational Communication: Agenda & minutes of a meeting, Notice, Memo, Circular.
- Organizing e-mail messages, E-mail etiquette.
- Techniques for writing precisely: Creating coherence, organizing principles –accuracy, clarity, brevity. Different styles of writing: descriptive, narrative, expository.

Module IV [6hrs]

Principles, techniques and skills for professional writing:

- Logic in writing, thinking and problem-solving; applying deductive and inductive reasoning; Use of infographics in writing.
- Report Writing: Importance and Purpose, Types of Reports, Report Formats, Structure of Formal Reports, Writing Strategies. Interpreting data and writing reports.
- Writing proposals and Statement of purpose.

Text Books:

1. Kumar,S. &Lata, P. Communication Skills, OUP, New Delhi 2011.
2. Rizvi,Ashraf,M. Effective Technical Communication, Mc Graw Hill Education(India) Pvt. Ltd..Chennai,2018.
3. Raman, M. and Sharma, S., Technical Communication: Principles and Practice, 2nd Ed., 2011.

Reference Books:

1. Professional Writing Skills, Chan, Janis Fisher and Diane Lutovich. San Anselmo, CA: Advanced Communication Designs.
2. Hauppauge, Geffner, Andrew P. Business English, New York: Barron's Educational Series.

LABORATORY

Course Name: Chemistry I Laboratory					
Course Code: CHM1051					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

The subject code CHM1051 corresponds to chemistry laboratory classes for the first year B. Tech students. This course enhances the students' experience regarding handling of various chemicals along with various laboratory equipments. Hands on experiments increase the depth of knowledge that is taught in the theory classes as well as it increases research aptitude in students because they can see the direct application of theoretical knowledge in practical field. The course outcomes of the subject are

1. knowledge to estimate the hardness of water which is required to determine the usability of waterused inindustries.
2. estimation of ions like Fe^{2+}, Cu^{2+} and Cl^{-} present in water sample to know the composition ofindustrial water.
3. study of reaction dynamics to control the speed and yield of various manufactured goodsproduced in polymer, metallurgical and pharmaceutical industries.
4. handling physico-chemical instruments like viscometer, stalag mometer, pH-meter, potentiometer and conductometer.
5. understanding the miscibility of solutes in various solvents required in paint, emulsion, biochemical and material industries.
6. knowledge of sampling water can be employed for water treatment to prepare pollution freewater.

List of Experiments:

1. Estimation of iron using KMnO4: selfindicator.
2. Iodometric estimation of Cu^{2+}.
3. Determination of Viscosity.
4. Determination of surface tension.
5. Adsorption of acetic acid by charcoal.
6. Potentiometric determination of redox potentials.
7. Determination of total hardness and amount of calcium and magnesium separately in a givenwater sample.
8. Determination of the rate constant for acid catalyzed hydrolysis of ethyl acetate.
9. Heterogeneous equilibrium (determination of partition coefficient of acetic acid in n-butanol andwater mixture).
10. Conductometric titration for the determination of strength of a given HCl solution against astandard NaOH solution.
11. pH-metric titration for determination of strength of a given HCl solution against a standardNaOH solution.
12. Determination of chloride ion in a given water sample by Argentometric method (using chromateindicator solution).

Books of reference:

1. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, Vogel's Textbook of Quantitative ChemicalAnalysis.
2. S. C. Das., Advanced Practical Chemistry.
3. P. S. Sindhu, Practicals in Physical Chemistry.

Course Name: Programming for Problem Solving Laboratory					
Course Code: CSE1051					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:
After completion of this course the students should be able to:

1. Write simple programs relating to arithmetic and logical problems.
2. Interpret, understand and debug syntax errors reported by the compiler.
3. Implement conditional branching, iteration (loops) and recursion.
4. Decompose a problem into modules (functions) and amalgamating the modules to generate a complete program.
5. Use arrays, pointers and structures effectively in writing programs.
6. Create, read from and write into simple text files.

Software to be used: GNU C Compiler (GCC) with LINUX NB: Cygwin (Windows based) may be used in place of LINUX
Topic 1: LINUX commands and LINUX based editors
Topic 2: Basic Problem Solving
Topic 3: Control Statements (if, if-else, if-elseif-else, switch-case)
Topic 4: Loops - Part I (for, while, do-while)
Topic 5: Loops - Part II
Topic 6: One Dimensional Array
Topic 7: Array of Arrays
Topic 8: Character Arrays/ Strings Topic
Topic 9: Basics of C Functions
Topic 10: Recursive Functions
Topic 11: Pointers
Topic 12: Structures
Topic 13: File Handling

Text Books:
1. Schaum's outline of Programming with C – Byron Gottfried
2. Teach Yourself C- Herbert Schildt
3. Programming in ANSI C – E Balagurusamy

Course Name: Basic Electrical Engineering Laboratory					
Course Code: ELE1051					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

The students are expected to

ELE1051.1 Get an exposure to common electrical apparatus and their ratings.

ELE1051.2 Make electrical connections by wires of appropriate ratings.

ELE1051.3 Understand the application of common electrical measuring instruments.

ELE1051.4 Understand the basic characteristics of different electrical machines.

List of Experiments:

1. Characteristics of Fluorescent lamps
2. Characteristics of Tungsten and Carbon filament lamps
3. Verification of Thevenin's & Norton's theorem.
4. Verification of Superposition theorem
5. Verification of Maximum Power Transfer theorem
6. Calibration of ammeter and voltmeter.
7. Open circuit and Short circuit test of a single phase Transformer.
8. Study of R-L-C Series / Parallel circuit
9. Starting and reversing of speed of a D.C. shunt Motor
10. Speed control of DC shunt motor.
11. No load characteristics of D.C shunt Generators
12. Measurement of power in a three phase circuit by two wattmeter method.

Course Name: English for Technical Writing Laboratory					
Course Code: HUM1051					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

Students will be able to

1. Communicate in an official and formal environment.
2. Effectively communicate in a group and engage in relevant discussion.
3. Engage in research and prepare presentations on selected topics.
4. Understand the dynamics of multicultural circumstances at workplace and act accordingly.
5. Organize content in an attempt to prepare official documents.
6. Appreciate the use of language to create beautiful expressions.

Module I [6hrs]

The Art of Speaking:

- Techniques for Effective Speaking.
- Voice Modulation: Developing correct tone.
- Using correct stress patterns: word stress, primary stress, secondary stress. Rhythm in connected speech.
- Encoding Meaning Using Nonverbal Symbols,
- How to Improve Body Language.
- Eye Communication, Facial Expression, Dress and Appearance.
- Posture and Movement, Gesture, Paralanguage.
- Encoding meaning using Verbal symbols: How words work and how to use words.
- Volume, Pace, Pitch and Pause.
- Structuring content for delivery in accordance with time, platform, and audience.

Module II [6hrs]

Group Discussion:

- Nature and purpose and characteristics of a successful Group Discussion.
- Group discussion Strategies: Getting the GD started, contributing systematically, moving the discussion along, promoting optimal participation, Handling conflict, Effecting closure.

Module III [6hrs]

- Interviewing:
  Types of Interviews, Format for Job Interviews: One-to-one and Panel Interviews, Telephonic Interviews, Interview through video conferencing.
- Cover Letter & CV.
- Interview Preparation Techniques, Frequently Asked Questions, Answering Strategies, Dress Code, Etiquette, Questions for the Interviewer, Simulated Interviews.

Module IV [6hrs]
Professional Presentation Skills:

- Nature and Importance of Presentation skills.
- Planning the Presentation: Define the purpose, analyze the Audience, Analyze the occasion and choose a suitable title.
- Preparing the Presentation: The central idea, main ideas, collecting support material, plan visual aids, design the slides.
- Organizing the Presentation: Introduction-Getting audience attention, introduce the subject, establish credibility, preview the main ideas, Body-develop the main idea, present information sequentially and logically, Conclusion-summaries, re-emphasize, focus on the purpose, and provide closure.
- Improving Delivery: Choosing Delivery methods, handling stage fright.
- Post-Presentation discussion: Handling Questions-opportunities and challenges.

Books of reference:

1. Carter, R. And Nunan, D. (Eds), The Cambridge guide to Teaching English to Speakers of Other Languages, CUP, 2001
2. Edward P. Bailey, Writing and Speaking At Work: A Practical Guide for Business Communication, Prentice Hall, 3rd Ed., 2004
3. Munter, M., Guide to Managerial Communication: Effective Business Writing and Speaking, Prentice Hall, 5th Ed., 1999
4. R. Anand, Job Readiness For IT & ITES- A Placement and Career Companion, , McGraw Hill Education.2015
5. Malhotra, A., Campus Placements, McGraw Hill Education.2015

1st Year 2nd Semester (Semester 2)

THEORY

Course Name: Physics I					
Course Code: PHY1001					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After successfully completing this course the students will be able to:

1. Understanding physical systems in terms of their modeling of time evolution.
2. Comprehending wave interpretation of natural phenomena and implications of allied observations.
3. Understanding theoretical backgrounds associated to some experiments based on wave phenomena.
4. Grasping an analytic view of micro and macroscopic world.
5. Accessing the knowledge of the behaviour of a particle under the influence of different potential.
6. Understanding conservative systems based on their particle and wave nature.

Module I [10L]

Mechanics:

Plane-polar coordinate system-velocity and acceleration of a particle-trajectory under central force-conservation principle-Kepler's laws -Rotating frame of reference-Five point acceleration formula-Coriolis effect-deflection of a moving particle.

Module II [10L]

Oscillation:

Constitutive equation of damping-nature of solutions for large, critical and weak damping-relaxation time, logarithmic decrement, energy decay (qualitative discussion) -Forced oscillation-transient and steady state-amplitude and velocity resonance---power transfer theorem-quality factor-series LCR circuit with AC source.

Module III [10L]

Optics:

Plane Progressive Wave-phase/wave-length/frequency-qualitative description of light as an electromagnetic wave-Huygens principle-polarization (state of polarization, general equation of ellipse, transformation of polarized lights)-interference (basic theory from superposition principle)-Division of wave front (Young's double slit experiment)-Division of amplitude (thin film, wedge, Newton's ring)-Diffraction (single slit, double slit, grating, Resolving Power).

Module IV [10L]

Quantum Mechanics:

An informal discussion from Planck to de Broglie as the historical context of quantum mechanics-Quantum Mechanics of a particle-operator-eigenvalue problem- Unitary-Hermitian frame work-position and momentum operator-Canonical Commutation Relations (CCR)-

Schrodinger equation-time dependent/time independent Schrodinger equation-wave function-stationary states-probability density-probability current density-normalization-expectation value-uncertainty-Bound state problem-particle in a one dimensional box- scattering state problem-potential step-reflection and transmission coefficients- tunnelling.

Books of reference:

1. Theoretical Mechanics : M R Spiegel (Schaum Series) McGrow-Hill Book Company
2. Classical Mechanics : N C Rana and P S Joag Tata- McGrow-Hill Publishing Company Limited.
3. Vibrations and Waves : A P French, W W Norton and Company,
4. The Physics of Waves and Oscillations : N K Bajaj, Tata- McGrow-Hill Publishing Company Limited.
5. Optics : A Ghatak, Tata McGraw-Hill Publishing Company Limited.
6. Optics : E. Hecht, Addison Wesley
7. Fundamentals of Optics : F A Jenkins and H E White, McGrow-Hill Higher Education.
8. Atomic Physics (Modern Physics): S N Ghosal, S. Chand and Company.
9. Practical Quantum Mechanics : S Flugge, Springer (Reprint of the 1994 Edition)
10. Concepts of Modern Physics : A Baiser, Tata McGraw-Hill Publishing Company Limited.
11. Refresher Course in B.Sc. Physics – Voll and Vol 2 – C.L.Arora.

Course Name: Mathematics- II					
Course Code: MTH1201					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**1**	**0**	**4**	**4**

Course Outcomes:

After successfully completing this course the students will be able to:

1. demonstrate the knowledge of probabilistic approaches to solve wide range of engineeringproblem.
2. recognize probability distribution for discrete and continuous variables to quantify physical andengineering phenomenon.
3. develop numerical techniques to obtain approximate solutions to MTHematical problems whereanalytical solutions are not possible to evaluate.
4. analyze certain physical problems that can be transformed in terms of graphs and trees andsolving problems involving searching, sorting and such other algorithms.
5. apply techniques of Laplace Transform and its inverse in various advanced engineering problems.
6. interpret differential equations and reduce them to mere algebraic equations using LaplaceTransform to solve easily.

Module I [10L] Basic Probability:

Random experiment, Sample space and events, Classical and Axiomatic definition of probability, Addition and Multiplication law of probability, Conditional probability, Bayes' Theorem, Random variables, General discussion on discrete and continuous distributions, Expectation and Variance, Examples of special distribution: Binomial and Normal Distribution.

Module II [10L]

Basic Numerical Methods:

Solution of non-linear algebraic and transcendental equations: Bisection Method, Newton-Raphson Method, Regula-Falsi Method. Solution of linear system of equations: Gauss Elimination Method, Gauss-Seidel Method, LU Factorization Method, Matrix Inversion Method. Solution of Ordinary differential equations: Euler's Method, Modified Euler's Method, Runge- Kutta Method of 4th order.

Module III [10L] Basic Graph Theory:

Graph, Digraph, Weighted graph, Connected and disconnected graphs, Complement of a graph, Regular graph, Complete graph, Sub-graph, Walk, Path, Circuit, Euler Graph, Cut sets and cut vertices, Matrix representation of a graph, Adjacency and incidence matrices of a graph, Graph isomorphism, Bipartite graph, Dijkstra's Algorithm for shortest path problem. Definition and properties of a Tree, Binary tree and its properties, Spanning tree of a graph, Minimal spanning tree, Determination of spanning trees using BFS and DFS algorithms, Determination of minimal spanning tree using Kruskal's and Prim's algorithms.

Module IV [10L] Laplace Transformation:

Basic ideas of improper integrals, working knowledge of Beta and Gamma functions (convergence to be assumed) and their interrelations. Introduction to integral transformation, Functions of exponential order, Definition and existence of Laplace Transform(LT) (statement of initial and final value theorem only), LT of elementary functions, Properties of Laplace Transformations , Evaluation of sine , cosine and exponential integrals using LT, LT of periodic and step functions, Definition and properties of inverse LT, Convolution Theorem (statement only) and its application to the evaluation of inverse LT, Solution of linear ODEs with constant coefficients (initial value problem) using LT

Books of reference:

1. E. Kreyszig, Advanced Engineering Mathematics, Wiley Publications.
2. S. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier.
3. S.S. Sastry, Introductory methods of Numerical Analysis, PHI learning.
4. B. West, Introduction to Graph Theory, Prentice-Hall of India.
5. B.S. Grewal, Engineering Mathematics, S. Chand &Co.

Course Name: Introduction to Electronics Devices and Circuits					
Course Code: ECE1001					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

1. categorize different semiconductor materials based on their energy bands and analyze the characteristics of those materials for different doping concentrations based on previous knowledge on semiconductors acquired.
2. describe energy band of P-N Junction devices and solve problems related to P-N JunctionDiode both from device and circuit perspectives.
3. design different application specific circuits associated with diodes operating both in forward and reverse bias.
4. analyze various biasing configurations of Bipolar Junction Transistor and categorize different biasing circuits based on stability.
5. categorize different field-effect transistors based on their constructions, physics and working principles and solve problems associated with analog circuits based on operational amplifiers.
6. design and implement various practical purpose electronic circuits and systems meant forboth special purpose and general purpose and analyze their performance depending on the type of required output and subsequently the applied input.

Module I [10L]

Basic Semiconductor Physics:

Crystalline materials, Energy band theory, Conductors, Semiconductors and Insulators, Concept of Fermi Energy level, intrinsic and extrinsic semiconductors, drift and diffusion currents in semiconductor.

Diodes and Diode Circuits:

Formation of p-n junction, Energy Band diagram, forward & reverse biased configurations, V-I characteristics, load line, breakdown mechanisms, Zener Diode and its Application.

Rectifier circuits: half wave & full wave rectifiers: ripple factor, rectification efficiency.

Module II [8L]

Bipolar Junction Transistors (BJT):

PNP & NPN BJT structures, current components in BJT, CE, CB, CC configurations, V-I Characteristics of CB & CE modes, regions of operation, Base width modulation & Early effect, thermal runaway, Concept of Biasing: DC load line, Q-point, basics of BJT amplifier operation, current amplification factors, different biasing circuits: fixed bias, collector to base bias, voltage divider bias.

Module III [9L]

Field Effect Transistors (FET):

hannel Junction Field Effect Transistor (JFET) structure & V-I characteristics.

Metal Oxide Semiconductor Field Effect Transistor (MOSFET): enhancement & depletion type MOSFETs (for both n & p channel devices), drain & transfer characteristics. MOSFET as a digital switch, CMOS inverter, voltage transfer characteristic (VTC), NAND & NOR gate realization using CMOS logic.
Moore's Law, evolution of process node, state of integration (SSI, MSI, LSI, VLSI, ULSI), Classification of Integrated circuits (IC) and their applications.

Module IV [9L]
Feedback in amplifiers:
Concept of feedback, advantages of negative feedback (qualitative), Barkhausen criteria.
Operational Amplifier:
Ideal OPAMP characteristics, OPAMP circuits: inverting and non-inverting amplifiers, Adder, Subtractor, Integrator, Differentiator, Basic Comparator.

Special Semiconductor Devices:
Light Emitting Diode (LED), Silicon Controlled Rectifier (SCR), Photodiode: Operations, characteristics & applications.

Books of reference:

1. Boylestad & Nashelsky, Electronics Devices & Circuit Theory.
2. R.A Gayakwad, Op Amps and Linear IC's, PHI.
3. Chattopadhyay, P. C Rakshit, Electronics Fundamentals and Applications.
4. Adel S. Sedra, Kenneth Carless Smith, Micro Electronics Engineering.
5. Millman & Halkias. Integrated Electronics.
6. Salivahanan, Electronics Devices &Circuits.
7. Albert Paul Malvino, Electronic Principle.

Course Name: Universal Human Values And Professional Ethics					
Course Code: HUM1002					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

1. appreciate the essential complementarily between 'values and 'skills' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
2. Develop a Holistic perspective towards life and profession
3. Develop a correct understanding of the Human reality and the rest of existence
4. Appreciate the relationship of values in terms of ethical human conduct.
5. Understand the importance of trustful and mutually fulfilling human behaviour and mutually enriching interaction with Nature.
6. Differentiate between the characteristics and activities of different orders and study the mutual fulfilment among them.

Module I

Introduction to Value Education (6hrs):

Understanding Values: Historical perspective to the development of values and its importance for the integration and harmony of the self and body.
Understanding Human being as the Co-existence of the Self and the Body.
Exploring Harmony of Self with the Body.
Distinguishing between the Needs of the Self and the Body.
Understanding and appreciating basic human aspirations-Maslow's Hierarchy of Needs Theory
Strategies, Methods to fulfil the Basic Human Aspirations.
Continuous Happiness and Prosperity – the Basic Human Aspirations.

Module II

Harmony in the Family and Society (10hrs):

The self as a social being starting with the family as the smallest unit—the process of socialisation.
Development of the self in relation to the society – Cooley's and Mead's theories of socialization.
Self and Integrated personality-Morality, Courage and Integrity.
Conflict of interest at home and society and its resolution through the implementation of the HumanValues.
Societal Values – Justice, Democracy and Rule of law.
Establishing harmony in the society with the help of ethical conduct based on values- Ethics of Rights and
Duties, Ethics of care, Ethics justice and Fairness, Work Ethics and quality of life at work.
Value crisis- disharmony in relationships, understanding harmony in the society.
Solutions - contribution of the individual in establishing harmony in the society.
'Trust' and 'Respect'--the Foundational Values in Relationship.
Exploring the Feeling of Trust and Respect.

Module III

Implications of the Holistic Understanding – a Look at Professional Ethics (10hr.):

Ethics and Ethical Values.

Principles and theories of ethics--Consequential and non-consequential ethics, Utilitarianism, Kant's theory and other non-consequential perspectives.

Professional Ethics- Right understanding of Professional Ethics.

Canons of professional Ethics.

Technology – various perspectives-its use, overuse and misuse .Privacy, data security and data protection, Artificial intelligence-harmony or disharmony, misinformation, deep fake, cyber-crime - a sociological perspective.

Code of Ethics, Violation of code of ethics, Whistle blowing, Institutionalising Ethics.

Vision for the Universal Human Order, Exploring Systems to fulfil Human Endeavours.

Module IV

Harmony in the Nature/Existence (10hrs.):

Understanding Harmony in the Nature -Ecological Ethics.

Sustainable development- Definition and Concept.

Strategies for sustainable development- Small is beautiful, Slow is Beautiful. Sustainable Development--- The Modern Trends.

Sustainable Development Goals- Case studies and Best practices.

Exploring the Four Orders of Nature -Interconnectedness, self-regulation and Mutual Fulfilment among The Holistic Perception of Harmony in Existence.

Text/ Books of reference:

1. Foundation Course in Human Values and Professional Ethics, R.R. Gaur, R. Asthana, G.P. Bagaria, Excel Books Pvt. Ltd. New Delhi.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi .
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews.

LABORATORY

Course Name: Physics-I Laboratory					
Course Code: PHY1051					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

After successfully completing this course the students will be able to:

PHY1051.1 Applying practical knowledge using the experimental methods to correlate with the Physics theory.

PHY1051.2 Understanding the usage of electrical and optical systems for various measurements.

PHY1051.3 Applying the analytical techniques and graphical analysis to the experimental data.

PHY1051.4 Understanding measurement technology, usage of new instruments and real time applications in engineering studies.

PHY1051.5 Evaluating intellectual communication skills and discuss the basic principles of scientific concepts in a group.

PHY1051.6 Construct the new idea by compiling their knowledge and can develop the new or improve the methodology.

MINIMUM OF SIX EXPERIMENTS TAKING AT LEAST ONE FROM EACH OF THE FOLLOWING FOUR GROUPS:

Optics Group

1. Determination of dispersive power of the material of a prism.
2. Determination of wavelength of a monochromatic light by Newton's ring.
3. Determination of specific rotation of sugar solution by using a Polarimeter.
4. Determination of wavelength of the given laser source by diffraction method.

Electricity & Magnetism Group

1. Determination of the magnetic field using circular current carrying coil.
2. Determination of dielectric constant of a given dielectric material.
3. Determination of Hall coefficient of a semiconductor by four probe method.
4. Determination of unknown resistance using Carey Foster's bridge.

Quantum Physics Group

1. Determination of Stefan-Boltzmann constant.
2. Determination of Planck constant using photocell.
3. Determination of Rydberg constant by studying Hydrogen spectrum.
4. Determination of Band gap of semiconductor.

Miscellaneous Group

1. Determination of Young's modulus of elasticity of the material of a bar by the method of flexure.
2. Determination of modulus of rigidity of the material of a rod by static method.
3. Determination of rigidity modulus of the material of a wire by dynamic method.
4. Determination of coefficient of viscosity by Poiseulle's capillary flow method.

Books of reference:

1. Optics – Eugene Hecht Pearson Education India Private Limited.
2. David J. Griffiths, Introduction to electrodynamics, Pearson Education India Learning Private Limited.
3. N.K. Bajaj, Waves and Oscillations.
4. David Halliday, Robert Resnick Jearl Walker, Principles of Physics, 10ed, Wiley.
5. Wayne M. Saslow, ELEtricity, Magnetism, and Light, Academic Press.
6. Narayan Rana, Pramod Joag, Classical mechanics, McGraw Hill Education.
7. R Takwale, P Puranik, Introduction to Classical Mechanics, McGraw Hill Education.
8. Ghatak, Optics, McGraw Hill Education India Private Limited.
9. C.L. Arora, Refresher Course in B.Sc. Physics , Vol1 and Vol 2.

Course Name: Introduction to Electronic Devices and Circuits Laboratory					
Course Code: ECE1051					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

1. The students will correlate theory with diode behavior.
2. They will design and check rectifier operation with regulation etc.
3. Students will design different modes with BJT and FET and check the operations.
4. They will design and study adder, integrator etc. with OP-AMPs.

List of Experiments (from)

1. Familiarization with passive and active electronics components such as Resistors, Inductors, Capacitors, Diodes, Transistors (BJT) and electronics equipment like DC powersupplies, multi-meters etc.
2. Familiarization with measuring and testing equipment like CRO, Signal generators etc.
3. Study of I-V characteristics of Junction diodes.
4. Study of I-V characteristics of Zener diodes.
5. Study of Half and Full wave rectifiers with Regulation and Ripple factors.
6. Study of I-V characteristics of BJTs Effect Transistors.
7. Determination of input-offset voltage, input bias current in CB mode
8. Study of I-V characteristics of BJTs in CE mode
9. Study of I-V characteristics of Field and Slew rate of OPAMPs.
10. Determination of Common-mode Rejection ratio, Bandwidth and Off-set null of OPAMPs.
11. Study of OPAMP circuits: Inverting and Non-inverting amplifiers, Adders, Integrators and Differentiators..

Course Name: Workshop/ Manufacturing Practices					
Course Code: MEC1051					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	1	**0**	**3**	**4**	**2.5**

Course Outcomes:

On successful completion of the course, students will be able to

CO1: **Follow** the various safety practices in workshop and personal protective elements.

CO2: **Identify** tools, work material and measuring instruments useful for fitting, carpentry and sheet metal practices.

CO3: **Operate** machine tools, components and processes to prepare jobs of specific shape and size.

CO4: **Acquire** knowledge of foundry process and casting of a product.

CO5: **Perform** welding, brazing and soldering processes.

CO6: **Assemble** a simple product.

Lectures : (13 hours)

(i) Detailed contents

Introduction on Workshop and familiarization with safety norms. **(1 lecture)**

2. Carpentry and Fitting **(2 lectures)**

3. Sheet metal **(1 lecture)**

4. Metal casting **(1 lecture)**

5. Welding (arc welding & gas welding), brazing and soldering **(2 lectures)**

6. Manufacturing Methods- machining (Lathe, Shaping and Milling) **(4 lectures)**

7. Additive manufacturing**(1 lecture)**

8**.** Assembling of a product **(1 lecture)**

(ii) Workshop Practice:(39 hours)

1. Safety practices in workshop**(3 hours)**

2. Carpentry shop**(3 hours)**

3. Fitting shop**(6 hours)**

4. Foundry shop**(3 hours)**

5.Machine shop**(9 hours)**

6. Welding shop-Arc welding **(3 hours)**

7. Sheet metal shop and brazing**(6 hours)**

8. Soldering operation**(3 hours)**

9**.** Assembling of a product **(3 hours)**

Books of reference:

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., "Elements ofWorkshop Technology", Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
2. Kalpakjian S. And Steven S. Schmid, "Manufacturing Engineering and Technology",4th edition, Pearson Education India Edition, 2002.
3. Gowri P. Hariharan and A. Suresh Babu,"Manufacturing Technology – I" PearsonEducation, 2008.
4. Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, Prentice HallIndia, 1998.
5. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata Mc Graw Hill House,2017.

Course Name: Engineering Graphics & Design					
Course Code: MECH1052					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	1	**0**	**3**	**4**	**2.5**

Course Outcomes:

After going through the course, the students will be able to

1. **Visualize** the basic concept of engineering drawing.
2. **Use** engineering drawing tools (conventional / modern tools).
3. **Apply** the various standards and symbols followed in engineering drawing.
4. **Implement** the concept of projections used in engineering graphics.
5. **Relate** the concept of sections to determine its true shape.
6. **Execute** the concept of isometric projections.

Lecture Plan (13 L)

1. Importance and principles of engineering drawing (1 L)
2. Lettering (1 L)
3. Concepts of Scale, dimensioning and Conic sections (3 L)
4. Introduction to concept of projection (Projections of points, lines and surfaces) (3 L)
5. Definitions of different solids and their projections (1 L)
6. Section of solids and sectional view (1 L)
7. Isometric projection (1 L)
8. Introduction to CAD (1 L)
9. Viva-voce (1 L)

Detailed contents of Laboratory hours (39 hours)

Module I [3HR]

Introduction to Engineering Drawing:

Principles of Engineering Graphics and their significance, usage of Drawing instruments, lines, lettering & dimensioning, Conic sections like Ellipse (General method only); Involute; Scales – Plain, Diagonal.

Module II [9HR]

Orthographic Projections:

Principles of Orthographic Projections - Conventions - Projections of Points and lines inclined to both planes; Projections on Auxiliary Planes; Projection of lamina.

Module III [6HR]

Projections of Regular Solids:

Those axes inclined to both the Planes- Auxiliary Views.

Module IV [3HR]

Sections and Sectional Views of Right Angular Solids:

Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular

Solids - Prism, Pyramid, Cylinder and Cone; Sectional orthographic views of geometrical solids.

Module V [6HR]
Isometric Projections:
Principles of Isometric projection -Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions.

Module VI [3HR]
Overview of Computer Graphics:
Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids.

Module VII [3HR]
Customization & CAD Drawing:
Consisting of set up of the drawing page and the printer, including scale settings, setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerance; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles.

Module VIII [3HR]
Annotations, layering & other functions:
Applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation.

Module IX [3HR]
Demonstration of a simple team design project that illustrates:
Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame.

Books of reference:

1. Bhatt, N.D., Panchal V.M. & Ingle P.R. (2014), Elementary Engineering Drawing, Charotan PublishingHouse.
2. Narayana, K.L. and Kannaaiah P Engineering Graphics, TMH.
3. Lakshminarayanan, V. and Vaish Wanar, R.s Engineering Graphics, Jain Brothers.
4. Shah, M.B. & Rana B.C. (208), Engineering Drawing and Computer Graphics, Pearson Edication .
5. Agarwal B. & Agarwal C. M (2012)., Engineering graphics, TMH Publications.

2nd Year 1st Semester (Semester3)

THEORY

Course Name: Particle and Fluid Particle Processing					
Course Code: CHE2101					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

The objective of the course is to provide an elaborated concept of different unit operations that are required in an industry. After completion of the course students will be able to:

CHE2101.1: Determine the average particle diameters for a mixture of solid particles and select different screens according to specifications.

CHE2101.2: Analyze the type of crushers/grinders for a particular comminution operation and calculate the energy consumption and get knowledge on drag force and terminal velocity of fluid particles.

CHE2101.3: Categorize the type of classifier required for a given operation and given a particular thickening operation, design the thickener required.

CHE2101.4: Analyze the power consumption for an agitation operation and scale up the agitator as per the problem given.

CHE2101.5: Analyze the filtration data and select filtration equipment based on requirements.

CHE2101.6: Estimate the knowledge on nanoparticles and their applications.

Module I [10L]

Characterization of particulate solids:

particle size, shape and particle size distribution; concepts of mass-mean diameter, volume-surface-mean diameter, arithmetic-mean diameter and volume- mean diameter, specific surface area of a mixture of solid particles, measurement of specific surface area of a mixture of particles.

Screen analysis:

concept of mesh number, types of standard screens, differential and cumulative analysis, concept of cut diameter and screen efficiency; industrial screening equipment eg. stationary screens, vibratory screens, grizzlies and trammels.

Handling and storage of solids:

Operation and performance criteria of screw, belt, pipe, apron and flight conveyors, bucket elevators. Operation of pneumatic and hydraulic conveyors. Storage of solids in bins, silos and hoppers.

Module II [10L]

Comminution (size reduction) of solids:

Different forces for comminution, laws of comminution - Rittinger's law, Kick's law, Bond's law and their validity limits, crushing efficiency and power consumption.

Primary crushing equipment: Blake jaw crusher, gyratory crusher, Taggart's law.

Secondary crushers:

Smooth and toothed roll crushers, concepts of nipping and angle of nip.

Grinders:

Operation of ball mill, critical speed of ball mil, operation of rod mill and hammer mill,

applicability of these mills for different sizes of feed, vertical roller mill and attrition mill, concepts of dry and wet grinding. Ultrafine grinders:
Colloid mill and fluid-energy mill, Close-circuit and Open-circuit size reduction.

Size enlargement:

Nucleation and growth of particles, Extrusion of solids.

Module III [10L]

Flow of particles in fluids:

Concepts of drag, boundary layer separation, skin and form drag, drag correlations.

Gravitational settling of particles:

Concepts of terminal settling velocity, Stokes's law and Newton's law regimes of settling, free and hindered settling, Richardson-Zaki equation, use of gravitational settling for solid-fluid separation, settling tank and its design principles, spitzkasten, elutriator and rake classifier, clarification and thickening, operation of Lamelar clarifiers, Hirate thickeners, design of continuous thickener using Kynch theory.

Flow through packed bed:

Ergun and Kozeny Carman equation, Darcy's law and permeability, Blaine's apparatus.

Agitation and Mixing:

Agitation equipment, different types of agitators, flow patterns in agitation, calculation of power consumption in agitated vessels, scale up of agitated vessels using concepts of geometric, kinematic and dynamic similarity, Mixing effectiveness and mixing index, solid-solid mixing equipment.

Froth flotation:

Theory, operation, flotation agents.

Module IV [10L] Solid-liquid filtration:

Cake and clarifying filters, constant pressure and constant rate filtration, compressible and incompressible filter cakes, pressure drop through filter cake; Operation of plate and frame filter press, cake washing and filtration cycle; continuous filtration, operation of a rotary drum vacuum filter, filter aids and filter media; Centrifugal filtration.

Solid-gas filtration:

Bag filters and electrostatic filters - design principles.

Centrifugal separation:

Design and operation of cyclone separators and hydrocyclones.

Introduction to nanoparticles:

Properties, characterization, synthesis methods and applications.

Text Books:

1. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.
2. Harker J.H., Backhurst J.R. & Richardson J.F. Coulson and Richardson's Chemical Engineering (Volume 2), Butterworth-Heinemann, 5th edition, 2002.

Books of reference:

1. Kulkarni A.P. & HireMTH R.S., Mechanical Operations – Unit Operations of Chemical Engineering (Volume 1), Everest Publishing House.
2. Gavhane K.A. Unit Operations-I, Fluid Flow & Mechanical Operation, Nirali Prakashan, 2019.
3. Coulson J. M. and Richardson J. F., Chemical Engineering (Volume 1), 4th Edition, Asian Books Pvt Ltd., India, 1998

Course Name: Chemical Engineering Fluid Mechanics					
Course Code: CHE2102					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	2	**1**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE2102.1: Analyze the rheological behavior of fluids and classify them as Newtonian or non-Newtonian fluids.

CHE2102.2: Determine force on submerged bodies and apply the working principle of manometric devices for pressure-drop measurement.

CHE2102.3: Apply continuity equation, momentum balance equation, Bernoulli's equation to solve engineering problems on fluid flow.

CHE2102.4: Categorize different flow measuring devices/fluid moving devices and determine the optimum operating conditions for pumps/blowers/compressors based on the given requirements.

CHE2102.5: Analyze practical problems that may occur in fluid machineries and suggest suitable solutions.

CHE2102.6: Estimate pressure drop in a packed bed as well as minimum fluidization velocity for a given fluidized bed.

Module I [10L]

Fundamental Concepts: Introduction to Fluid mechanics:

Definition of Fluid, Continuum concept of fluid, concept of Knudsen number. Shear stress field, Rheological properties of fluids.

Fluid Statics:

Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices– manometer, U-tube, inclined tube, force on submerged bodies (straight, inclined), centre of pressure.

Fluid kinematics:

Eulerian and Lagrangian approach, Streamline, pathline, timeline, streak line.

Fluid dynamics:

Velocity field, mass, volumetric flow rate, dimensionality of flow; stress field; Reynolds number—its significance, laminar, transition and turbulent flows, steady, unsteady and uniform, non-uniform flows.

Boundary layers:

Flow in boundary layers, transition length for laminar and turbulent flow, boundary layer separation.

Module II [10L]

Basic laws for a system; relation of system derivatives to the control volume ; conservation of mass; continuity equation.

Momentum balance equation:

Derivation of Equation of motion, Introduction to Navier - Stokes equation in rectangular, cylindrical coordinates and its applications, Couette flow, Introduction to rotational and

irrotational flow.

Mechanical Energy equation:
Introduction to Bernoulli's equation, Euler's Equation, kinetic energy correction factor, momentum correction factor, pump work in Bernoulli's equation.
Internal incompressible viscous flow:
Velocity distribution of fluid flowing in a closed conduit – local, average, maximum velocity. Turbulent flow- universal velocity distribution laws, Reynolds stress, Prandtl's mixing length.
Head loss in different flow condition:
Hagen Poiseuille equation, Fanning's equation, friction factor, Moody's diagram, effect of roughness, friction from changes in velocity or direction.

Module III [10L] Flow measurement:
Introduction; Orifice meter; Venturimeter;
Concept of area meters:
rotameter; Local velocity measurement: Pitot tube. Hot wire anemometer, mass flow meter.
Open channel flow:
Introduction, Flow classification, importance of Froude number, Chezy formula, Manning roughness correction, flow measurement by weirs.
Fluid moving machines:
Introduction;
Basic classification of pumps:
Non-Mechanical Pumps— acid egg, steam jet ejector, air lift pump,
Mechanical pump: Centrifugal pumps - cavitation, NPSH, basic characteristics curves for centrifugal pumps, positive displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification; parallel operation of Centrifugal pumps; system resistance curves; fan, blower and compressor.
Valves and fittings:
Pipe fittings and valves, schedule no, equivalent diameter.

Module IV [10L]
Flow past immersed bodies:
Introduction; concept of drag and lift; variation of drag coefficient with Reynolds number; stream-lined body and bluff body.
Flow through beds of solids:
Concept of sphericity; Ergun equation, modified friction factor.
Motion of particles through fluids:
Terminal velocity, criteria for settling regime.
Fluidization:
Introduction; different types of fluidization; minimum fluidization velocity; governing equation; advantages and disadvantage, industrial applications.

Introduction to compressible flow:
Concept of speed of sound, Mach number, subsonic, sonic, supersonic flow.

Text books:

1. Pritchard P.J., Fox and McDonald's Introduction to Fluid Mechanics, John Wiley &Sons Inc., 8th edition,2011.
2. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.
3. Munson Bruce R., Young Donald F. Fundamentals of Fluid Mechanics, Wiley Student Edition, 6th Edition .

Books of reference:

1. Jain A.K. Fluid Mechanics including Hydraulic Machines, Khanna Publishers, 1998.
2. Bird R.B., Stewart W.E. & Lightfoot E.N. Transport Phenomena, John Wiley & Sons, 2nd Edition, 2010.
3. Karassik I.J., Messina J. P., Cooper P. & Heald C. C. Pump Handbook, McGraw Hill, 4th
4. Edition.
5. Singh S. Fluid Mechanics, Khanna Book Publishing, 1st Edition, 2016.
6. Som S.K., Biswas G. & Chakraborty S. Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw Hill, 3rd Edition, 2017.

Course Name: Industrial Process Calculations					
Course Code: CHE2103					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	2	**1**	**0**	**3**	**3**

Course Outcomes:

The objective of the course will to be served as a basis for all further chemical engineering courses that are part of the curriculum. After completion of the course students will be able to:

CHE2103.1: Solve material balance problems in chemical engineering using units, dimensions, and dimensionless groups.

CHE2103.2: Solve material balance problems in chemical processes, including complex systems with recycle, bypass, and purge.

CHE2103.3: Apply equations of state, vapor pressure concepts, and tools to solve gas/vapor/liquid problems.

CHE2103.4: Calculate and interpret humidity properties using charts and analyze data using linear regression.

CHE2103.5: Analyze energy transfer (heat, work) in chemical systems (open/closed) and calculate enthalpy changes.

CHE2103.6: Perform energy balances involving chemical reactions (heat of reaction, combustion, calorific value, adiabatic flame temperature).

Module I [10L]

Introductory concepts of units, physical quantities in chemical engineering, dimensionless numbers, dimensionless groups, "basis" of calculations.

Material Balance:

Introduction, solving material balance problems without chemical reaction for industrially relevant unit operations like Evaporation, Drying, Distillation, Crystallization, Absorption, Extraction.

Module II [10L]

Material Balance:

With chemical reaction, Concept of stoichiometry and mole balance, examples, including combustion, Material Balances with recycle, bypass and purge – examples.

Module III [10L]

Gases,Vapours and Liquids:

Equations of state, Vapour pressure, Clausius-Clapeyron equation, Cox chart, Duhring's plot, Raoult's law.

Humidity and Saturation, humid heat, humid volume, dew point, humidity chart and its use.

Linear regression analysis of linear and nonlinear data, log and semilog plotting for nonlinear data.

Module IV[10L]

Energy balance:

Open and closed system, heat capacity, calculation of enthalpy changes, adiabatic and isothermal

process, non-adiabatic and non-isothermal process.

Energy balances with chemical reaction:

Heat of reaction, Heat of combustion, calorific value of fuel, adiabatic flame temperature.

Text Books:

1. Felder R. M. & Rousseau R. W. Elementary Principles of Chemical Processes, John Wiley & Sons, 3rd edition, 2000.
2. Himmelblau D. M. & Riggs J. B. Basic Principles and Calculations in Chemical Engineering, Pearson India Education Services, 8th edition, 2015.

Books of reference:

1. Bhatt B. I. & Vora S.M. Stoichiometry, Tata McGraw Hill Publishing Company Ltd, 4thedition, 2004.
2. Hougen O. A., Watson K. M. & Ragatz R. A. Chemical Process Principles, Part-I Material & Energy Balances, , CBS Publishers & Distributors, 2nd edition,2004.
3. Venkataramani V., Anantharaman N., Begum K.M. & Sheriffa M. Process Calculations, Prentice Hall of India, 2nd Edition,2011.
4. Sikdar D. C. Chemical Process Calculations, Prentice Hall of India, 2013.
5. Narayanan K.V. & Lakshmikutty B. Stoichiometry and Process Calculations, PHI, 2010.

Course Name: Introduction to Engineering Thermodynamics					
Course Code: CHE2104					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

The objective of this course is to elaborate principles and application of first and second law of thermodynamics, and phase equilibrium. After completion of the course students will be able to:

CHE2104.1: Grasp core thermodynamic concepts and analyze closed systems using the first law.

CHE2104.2: Apply principles to analyze open/closed systems, solve for various components using SFEE, and identify isenthalpic processes.

CHE2104.3: Students will be able to use equations of state (ideal gas, virial, cubic) to predict P-V-T behavior and critical properties of pure substances.

CHE2104.4: Apply concepts like Carnot cycle and entropy to evaluate engine limitations and efficiency.

CHE2104.5: Utilize thermodynamic properties, Maxwell relations, and heat effects (latent/standard heats, Hess's Law) for reaction analysis.

CHE2104.6: Students will analyze power & refrigeration cycles using diagrams & tables to assess performance & efficiency.

Module I [10L]

Basic concept of thermodynamics:

Definition and classification of thermodynamic systems, Temperature, Pressure, Work, Energy, Heat.

Energy conservation & first law of thermodynamics; State functions; Thermodynamic Properties; Equilibrium; Phase Rule; Reversible and Irreversible process.

Energy balance for open & closed system:

Energy relation for steady flow process; Application of Steady Flow Energy Equation (SFEE) in Turbine, Compressor, Pump, Heat Exchangers, Condenser, Boilers; Isenthalpic process and Joule-Thompson Coefficient.

Module II [10L]

Thermodynamic properties of pure substance,

P-V-T behavior of pure substance:

Diagram and P-V diagram, Critical Properties (Pc, Tc & Vc) of pure substance.

Equation of State:

Ideal gas equation of state; Virial equation of state; Virial equation of state at low to moderate pressure;

Cubic equation of state:

Two parameter cubic equation of state (Van-der-waals equation of state, Redlich-Kwong equation of state), Compressibility factor; Cubic equation in reduced form; Laws of corresponding state; Compressibility factor chart; Definition of Acentric factor and its application.

Module III [10L]

Limitations of first law of thermodynamics; Statements of the second law; Concept of Heat engines and Heat pump; Carnot Cycle; Carnot's theorem; Concept of Entropy; Calculation of entropy change; Mathematical statement of the second law; Entropy balance for open systems; Calculation of ideal work, Lost work; Clausius inequality.Thermodynamic energy properties; Fundamental property relation; Maxwell relation.

Heat effects:

latent heat, sensible heat, standard heats of formation, reaction and combustion; Hess's law of constant heat summation; Effect of temperature on heat of reaction.

Module IV [10L]

Temperature-Entropy diagram; Mollier diagram; Steam table.

Ideal Power cycle; Ideal Rankine cycle; Practical Rankine cycle; Reheat cycle; Internal combustion engine: Otto cycle; Diesel cycle.

Ideal Refrigeration cycle; Vapour Compression cycle; Absorption refrigeration cycle; Thermodynamic criteria of selecting refrigerant.

Gas Liquefaction process:

Linde and Claude liquefaction process.

Text Book:

1. Smith J.M., Van Ness H.C. & Abbott M.M., Introduction to Chemical Engineering Thermodynamics, McGraw-Hill International Edition, 7th edition, 2005.

Books of reference:

1. Nag P.K., Engineering Thermodynamics, McGraw-Hill Education (India) Private Limited, 5th edition, 2013.
2. Rao Y.V.C., Chemical Engineering Thermodynamics, University Press (India) Private limited, 1st edition, 2004.

Course Name: Energy Engineering					
Course Code: CHE2105					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE 2105.1 Apply knowledge of the various conventional and non conventional energy resources and their production and consumption pattern.

CHE 2105.2 Develop understanding on proximate and ultimate analysis of solid fuels, coal washing, storage and coal carbonization techniques.

CHE 2105.3 Gain understanding of the composition, characterization of crude oil as well as various parameters and properties of various fractions derived from crude oil.

CHE 2105.4 Acquire knowledge of various refining processes such as like cracking, reforming, visbreaking etc..

CHE 2105.5 Acquire knowledge on the different types of gaseous fuels and production of importantgaseous fuels and their calorific values.

CHE 2105.6 Gain a basic understanding of the non-conventional energy resources including hydrogen energy and fuel cells.

Module I [10L]

Introduction:

Conventional (fossil energy) and non-conventional (alternative energy) resources & reserves. Global Energy production & consumption pattern. Production &consumption pattern in India.

Solid Fuels:

Biomass, Wood and Charcoal. Classification & Rank of Coal, Peat, Lignite, Sub- Bituminous coal, Bituminous coal, Anthracite coal, Cannel &Bog head coal.

Coal Reserves in India Physical Properties of coal, Proximate & Ultimate Analysis of Coal, Cleaning, washing & Storage of coal.

Theory of coal pyrolysis and Carbonization:

Low Temperature Carbonization (LTC), High Temperature Carbonization (HTC), Horizontal & Vertical Gas Retorts, Coke Ovens-Beehive & Byproduct Slot type. Recovery of byproducts. Details of Structural configuration and operating principles of Coke ovens including Charging and Discharging Mechanism.

Module II [10L]

Liquid Fuels:

Constitution of petroleum, theory of formation of crude petroleum oil. Characterization of crude oil & petroleum fuels, on shore and off-shore oil exploration.

Parameters and testing logistics of petroleum products:

Octane no., Cetane no., Pour point, Smoke point, Cloud point, Flash point, Fire point, Aniline point and Diesel index. Processes of a typical Indian refinery involving Operation and flow-sheet of crude distillation plant; Thermal & catalytic cracking and reforming processes; coking, visbreaking, Fluid catalytic cracking and Hydrocracking.

Concept of Modern Refinery integrated with downstream petrochemicals units which

manufacture naphtha-based aromatics as well as propylene-based polymers.

Liquid fuel from coal:
Fischer Tropsch process.

Module III [10L]Gaseous Fuels:
Classification of gaseous fuel; Physico-chemical principles, Calorific Value, Wobbes index, and flame speed. Producer gas, Water gas with Carburetion, oil gas, coke-oven gas, blast furnace gas, Flow sheet & operation of Natural Gas and LPG. Coal Bed Methane. Integrated Gasification Combined Cycle.Removal of carbon dioxide from flue gas and utilising it for preparation of methanol or injecting high pressure CO_2 in the oil field etc.

Bio Gas:
Principles and Operation of Aerobic & Anaerobic digestors, Biogas generation and management& flow sheet with special reference to waste utilization.

Module IV [10L]Solar Energy:
Devices for measurement of solar flux. Solar thermal and solar PV, Different types of solar collectors (Flat plate, parabolic, concentric & heliostat), Solar Pond, Photovoltaic cells, Chemical storage, Efficiency of Solar devices – Tracking.

Geothermal Energy & Wind Energy:
Utilization of Geo thermal Energy; Ocean Thermal Energy Conversion (OTEC).

Nuclear energy:
Sources of Nuclear fuels, Indian scenario; Nuclear reactions and power generation by Nuclear reactors- Breeder reactor- reaction &operation.
Generation of hydrogen and use as source of energy which in turn also reduce CO_2 generation.

Hydrogen Energy and Fuel Cells:
Types, Construction, Principle of Operation, Applications.

Fuels from Renewable Sources and green hydrogennergy production :
Bio Fuels, Preliminary concepts of Illumination Engineering—CFL and LED lights.

Text Books/Books of reference:

1. Mc Cabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.
2. Sarkar S. Fuels and Combustion, Universities Press, 3rd Edition, 2009.
3. Gupta O.P. Elements of Fuels, Furnaces and Refractories, Khanna publishers, 1989.
4. Bhatia S.C., Gupta R.K. Textbook of Renewable Energy, Woodhead Publishing India, 2018.
5. Sukhatme S. P., Solar Energy, Tata McGraw Hill, 1996.
6. Srinivasan S. Fuel Cells: From Fundamentals to Applications, Springer, 2006.

Course Name: Material Science					
Course Code: CHE 2106					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:
After completion of this course students will be able to:
CHE 2106.1: Understand structure of various materials and inherent defects.
CHE 2106.2: Identify the mechanical, electronic and optical properties of various materials
CHE 2106.3: Classify different metal extraction processes from their ores and Analyze solid and liquid phase behavior from phase equilibrium study.
CHE 2106.4: Explain the process flow in the manufacturing/extraction of relevant metal/alloy.
CHE 2106.5: Understand and quantify elastic behavior of deformable bodies.
CHE 2106.6: Categorize the different types of materials used in engineering applications and identify the specific application oriented accurate materials

Module I [10L]
Structure of materials:
Various types of bonds; Crystalline Structure of Solids- concepts of unit cell and space lattice, packing factor, Classification of materials, selection of materials.
Mechanism of plastic deformation, slipandtwinning, Elastic, An elastic and visco-elastic behavior of materials ;electrical, Electronic, Magnetic, Optical & Opto Electronic properties of material; Inorganic & organic amorphous materials and their structural & property characteristics; Optical fibers.
Structural imperfections:
Elementary concepts of point ,line, surface & volume imperfections; Influence of dislocations/Line imperfections on the mechanical properties of materials; Strain hardening and re crystallization; Elementary aspects of creep, fatigue fracture.

Module II [10L]
X – ray diffraction instruments and principles for determining crystal structure;
Phase Diagrams:
Solidification and structure of metals, Grain boundaries; Phase equilibrium and phase diagrams of binary alloys; Phase diagram of ternary systems; Iron-Carbon diagram;
Heat Treatment:
Introduction and purposes of heat treatment; T-T-T diagram; Corrosion-Concepts and forms of corrosion; Corrosion Mechanism and prevention; Protective materials and coating.

Module III [10L]
Basic principles of metal extraction:
Pyrometallurgy: Smelting, calcinations, roasting—oxidizing, predominance area diagrams, multiple hearth, flash and fluo-solid, sintering, smelting, slag and its classification.
Iron making in Blast furnace.
Steel making process flow diagram:
Steel making (oxygen blown converter–LD)–Secondary steel making/refining(ladle processing, vacuum degassing, ladle furnace processing) – Continuous casting – with emphasis on

application of the concepts of physicochemical principles involved, moving/packed bed reactor, gas-liquid two-phase flow ,heat transfer with phase change(solidification).
Principles of Hydrometallurgy and Electrometallurgy,

Extraction of Aluminum:

Hall-Heroult process, Electrolytic refining, Pyro metallurgical & Hydrometallurgical extraction of copper & Zinc; Extraction of Lead, Nickel, Titanium, Recent advances on nano materials.

Module IV [10L]

Mechanical properties:

Introduction to Stress and Strain & Mechanical properties of engineering materials:

Concept of simple stress and strain ; normal stress , shear stress , normal strain, shear strain; Generalized Hooke's Law for isotropic materials, Poisson's ratio, relationships between Young's modulus, shear modulus and bulk modulus. Stress- strain diagram of ductile and brittle material; proportional limit, elastics limit, yield point , ultimate stress, breaking point , Strength, hardness, toughness, ductility, brittleness of Engineering Materials**;** Factor of safety for design calculations. Transformation of Plane stresses, strain energy in tension and compression.

Text Books:

1. Raghavan V. Material Science and Engineering, Prentice-Hall of India Pvt. Ltd., 5th.Edition, 2004.
2. Ray H.S., Sridhar R. & Abraham K.P. Extraction of nonferrous metal, Affiliated East-West Press Pvt. Limited, 2008.
3. Callister W.D. Jr & Rethwisch D.G. Material Science and Engineering: An Introduction,John Wiley & Sons, 8th Edition, 2010.
4. Smith W.F., Hashemi J. & Prakash R. Material Science and Engineering, McGraw HillEducation, 5th Edition, 2017.
5. Nag D. & Chanda A. ,Strength of Materials, Wiley India, 2nd Edition.
6. Nag D. & Chanda A. Strength of Materials, Wiley India, 2nd Edition.

Books of reference:

1. Vlack L.H.V. Elements of Material Science and Engineering, Addison-WesleyEducational Publishers Inc., 1980.
2. Lakhtin Y. & Weinstein N. Engineering Physical Metallurgy, MIR Publishers, Moscow,1975.
3. Bogdandy L.V. & Engell H.J. The Reduction of Iron Ores, Springer-Verlag, New York,1971.
4. Guthrie R.I.L. Engineering in Process Metallurgy, Oxford University Press, 1992.
5. Beer , Johnston, De Wolf, Mezurek , Mechanics of Materials , McGraw Hill, 7th Edition.
6. Beer P Ferdinand., Johnston & John E. Russell , Dewolf T. , Mechanics of Materials , McGraw Hill, 8th Edition, 2020

LABORATORY

Course Name: Fluid Mechanics (ChE) Laboratory					
Course Code: CHE2151					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

After completion of the course students will be able to:

CHE2151.1: Measure & Analyze Flow: Use instruments (orifice meters, etc.) to measure flow rates, discharge coefficients, and velocity profiles

CHE2151.2: Distinguish Flow Regimes: Identify and understand laminar vs. turbulent flow through experiments and analysis

CHE2151.3: Apply Fluid Mechanics Principles: Apply concepts like the Ergun equation and Fanning friction factor to analyze packed bed and fluidized bed.

CHE2151.4: Evaluate Fluid Machinery Performance: Analyze centrifugal pump performance

CHE2102.5: Analyze practical problems that may occur in fluid machineries and suggest suitable solutions.

Experiments to be performed:

1. Determination of coefficient of discharge at various Reynolds number during fully developed fluid flow through orificemeter.
2. Determination of coefficient of discharge at various Reynolds number during fully developed fluid flow through venturimeter.
3. Determination of loss coefficient of pitot tube and construction of fully developed velocity profile through pipe in laminar and turbulent flow regime.
4. Analysis of open channel flow and determination of coefficient of discharge V- notch and rectangular notch.
5. Determination of pressure drop for flow through packed bed and verification of Ergun equation.
6. Determination of characteristic curve of a centrifugal pump.
7. Experiments on Reynolds apparatus for determination of flow regime and construction of fanning's friction factor vs Reynolds number plot.
8. Determination of pressure drop and bed height profile with varying modified Reynolds number during flow through a fluidized bed & determination of incipient fluidization.
9. Calibration of rotameter.
10. Assembling of pipe line and fitting according to a given layout.

Text Books:

1. P Pritchard P.J. Fox and McDonald's Introduction to Fluid Mechanics, John Wiley & Sons Inc., 8th edition,2011.
2. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.
3. Harker J.H., Backhurst J.R. & Richardson J.F. Coulson and Richardson's Chemical Engineering (Volume 2), Butterworth-Heinemann, 5th edition, 2002.

Books of reference:

1. Jain A.K. Fluid Mechanics including Hydraulic Machines, Khanna Publishers, 1998.
2. Bird R.B., Stewart W.E. & Lightfoot E.N. Transport Phenomena, John Wiley & Sons, 2nd Edition, 2010.

Course Name: Particle & Fluid-Particle Processing Laboratory					
Course Code: CHE2152					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

After completion of this course students will be able to:

CHE2152.1: Identify mechanical instruments required for particles processing before downstream applications.

CHE2152.2: Estimate average particle diameter of a given solid mixture by sieve analysis.

CHE2152.3: Determine the reduction ratios and capacities for comminution in jaw crushers, ball millsand hammer mills.

CHE2152.4: Determine the overall efficiency of a screening operation based on a given cut diameter.

CHE2152.5: Analyze the specific cake resistance and filter medium resistance for filtration of given slurry through a plate and frame filter press.

Experiments to be performed:

1. Sieve Analysis: To analyze a given powder for its particle size distribution. / Cumulative and Differential methods of particle size distributions.
2. Overall Screen Effectiveness: To find out screen efficiency through a suitable material balance with respect to a single screen.
3. Jaw Crusher: To find out the reduction ratio and capacity and to verify Rittinger's law.
4. Ball Mill: To determine the reduction ratio, capacity and the critical speed of the ball mill.
5. Rod Mill: To determine the reduction ratio and capacity and compare the reduction ratio for the same feed sample to that in a ball mill.
6. Hammer Mill: To find out the reduction ratio and capacity.
7. Batch sedimentation: To determine the settling and sedimentation characteristics of given slurry.
8. Filtration: To determine the specific cake resistance and filter medium resistance in the given plate and frame filtration.

Text Books:

1. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.
2. Harker J.H., Backhurst J.R. & Richardson J.F. Coulson and Richardson's Chemical.

Books of reference:

1. Badger W.L., Banchero J.T. & Bancheo J.T. Introduction to Chemical Engineering, McGraw Hill, 1955.
2. Narayanan C.M. & Bhattacharya B.C. Mechanical Operations for Chemical Engineers, Khanna Publications, 2014.

Course Name: Instrumental Methods of Analysis Laboratory					
Course Code: CHE2153					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:

After completion of this course students will be able to:

CHE 2153.1: Determine the turbidity of a water sample using Nephelo Turbidimeter after calibration of the instrument, if necessary.

CHE 2153.2: Prepare a standard Curve of absorbance versus concentration of a standard protein solution using a UV-VIS spectrophotometer and hence determine the unknown concentration of the same.

CHE 2153.3: Understand the working principle of a colorimeter and determine the concentration of the unknown Fe^{3+} sample using a Colorimeter.

CHE 2153.4: Calibrate Abbe refractometer and polarimeter and determine the concentration of ethanol and dextrose respectively in unknown samples.

CHE 2153.5: Understand the principles and operation of 1) DO meter, 2) Flame Ionization Detector of Gas Chromatography 3) Conductivity Meter.

Experiments to be performed:

1. Determination of Turbidity of Water using Nephelo Turbidimeter.
2. Construction of standard curve (Absorbance vs. concentration) of a pure protein by Folin's Method using Spectrophotometer.
3. Determination of Fe3+ in a solution by Colorimeter Method.
4. Determination of Dissolved Oxygen in water by DO Meter.
5. Estimation of Ethanol concentration in a mixture of Ethanol & Water by Abbe Refractometer.
6. Determination of concentration of any optically active substance in presence of nonactive species by a Polarimeter.
7. Determination of TDS of Water Sample by Conductivity Meter. **(As per earlier syllabus, this experiment was there, if we delete it, the instrument will not be provided by the management afterwards, the instrument is very much necessary for project work)**
8. Demonstration of principle and operation of Gas Chromatograph.

Text/ Book of reference:

1. Dash D.C. Analytical Chemistry, PHI, 2nd Edition,2017.

2nd Year 2nd Semester (Semester4)

THEORY

Course Name: Process Heat Transfer					
Course Code: CHE2201					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	2	**1**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE2201.1: Justify the practical importance and relevance of energy transfer and its conservation in chemical industry.

CHE2201.2 : Categorize the technological methods related to heat transfer in process plant.

CHE2201.3: Identify a detailed overview of heat transfer equipment and problems associated at preliminary stage of design.

CHE2201.4: Construct a bridge between theoretical and practical concept used in industry.

CHE2201.5: Analyze heat transfer processes of industrial operation and identify modes of heat transfer.

CHE2201.6: Design suitable heat exchange equipment, for given problem specifications.

Module I [10L]

Introduction to basic modes of heat transfer and their application in chemical process,

Heat transfer by conduction:

Fourier law, thermal conductivity, thermal resistance; general heat conduction equation, thermal diffusivity; steady state heat conduction with heat generation for plane wall, cylindrical body and spherical body;

Conduction-convection system:

Critical insulation thickness of curved surface, steady state heat conduction through fin, fin efficiency, unsteady state heat conduction in solid with large thermal conductivity, significance of Biot no and Fourier no, transient heat conduction in solid.

Module II [10L]

Convective heat transfer without phase change:

Newton-Rikhman law, local and average heat transfer coefficient, Reynold-Colburn analogy, concept of individual heat transfer coefficient and overall heat transfer coefficient, LMTD, empirical correlation for heat transfer coefficient in forced convection; elementary concept of thermal boundary layer, temperature distribution in laminar flow, analysis of free convection and correlation of free convection, Grash of number.

Module III [10L]

Heat transfer with phase change:

Film-wise and drop-wise condensation, laminar film condensation on vertical plate, Nusselt equation; analysis of heat transfer during boiling, different boiling regimes during pool boiling. Characteristics of radiation, properties of radiating surface,

Black body radiation:

Plank's distribution law,

Total emissive power:
Stefan-Boltzman law, use of radiation function table; Wien's displacement law; Kirchoff's law; emissivity of black body, gray body and real body;
Radiation between surfaces:
View factor, electrical network approach for radiation heat exchange, radiation shields and their application, radiation heat exchange for three radiating surfaces; radiation heat transfer through absorbing emitting medium.

Module IV [10L]
Heat exchangers and their classification,
Performance analysis of heat exchanger:
Fouling factor, LMTD correction factor, effectiveness and NTU of heat exchangers, sizing and rating problems of heat exchangers, construction details of shell and tube heat exchanger, Shell and Tube heat exchanger design, elementary note on heat exchanger network.
Evaporators and their classification, capacity and steam economy, Boiling Point Elevation (BPE), material and energy balance of single effect evaporator, classification of multiple effect evaporator, design of single effect and multiple effect evaporator.

Text Books:

1. Kern D. Q. Process Heat Transfer, Tata McGraw-Hill, 1997.
2. Dutta B. K. Heat Transfer Principles and Application, PHI Learning Pvt. Ltd., 2015.
3. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.

Books of reference:

1. Ozisik M. N. Heat Transfer: A Basic Approach, McGraw-Hill International Edition, Singapore, 1984.
2. Sikdar D.C. Process Heat Transfer & Chemical Equipment Design, Khanna PublishingHouse, 1st Edition, 2018.

Course Name: Chemical Process Technology					
Course Code: CHE2202					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE 2202.1: Describe sources and processes of manufacture of various industrially important chemicals.

CHE 2202.2: Prepare the process flow charts or block diagram of the processes used for manufacture of industrially important chemicals.

CHE 2202.3: Explain and calculate economic aspects of Projects involved in manufacturing of Chemicals.

CHE 2202.4: Understand the applications of various unit operations involved in the manufacture of various chemicals and other useful materials.

CHE 2202.5: Understand the implications of heat & mass transfer and fluid mechanics in chemical engineering industries.

CHE 2202.6: Identify the major engineering problems perceived in manufacturing processes.

Module I [10L]

Chlor-alkali industries:

Production and consumption pattern, manufacture of Chlorine-caustic soda: Raw materials, principles of manufacture,

Mercury-cathode & Membrane process:

Flow sheet and sequence of operation, other processes, advancement of process technology and major engineering problems, uses.

Soda-ash:

Production and consumption pattern, Raw materials, Solvay process: Physicochemical principles of manufacture, carbonation and ammonia recovery step, flow-sheet and sequence of operation, other processes, advancement of process technology and modified Solvay process, major engineering problems, uses.

Industrial Inorganic Acids:

Hydrochloric Acid:

Manufacturing methods, by product Recovery from other production processes, conventional raw materials and principles of manufacture, flow-sheet and sequence of operation, major engineering problems, uses.

Sulphuric acid:

Raw materials resources, sulphuric acid production processes, Contact process, Physico-chemical principles and general theory of contact reaction with thermodynamic and reaction engineering aspects, different types of catalyst – preparation methodology and relative merits, flow-sheet and sequence of operation, details of major equipments, advancement of process technology and major engineering problems, DCDA process, uses.

Nitric Acid:

Raw materials resources, Ostwald Process–physico-chemical principles, catalyst, process flow sheet and sequence of operation, details of major equipments, uses.

Module II [10L] Fertilizer Industries:

Nitrogenous fertilizers:

Ammonia - Source of hydrogen; methods of obtaining hydrogen from different sources, source of nitrogen-liquefaction of air and distillation of liquid air; Synthesis of Ammonia- Physico chemical principles, catalyst for synthesis of ammonia, process flow sheet and sequence of operation, details of major equipments.

Urea - Raw materials, manufacturing process with flow sheet, sequence of operation, major equipments details.

Phosphatic fertilizers:

Manufacturing process of super phosphate of lime, single and triple super phosphate, Diammonium phosphate.

Petroleum refining:

Production and consumption pattern, manufacturing technology of petroleum refining: Raw materials, principles of manufacture, flow sheet and sequence of operation, other processes, advancement of process technology and major engineering problems for the production of fuels, lubricants and various other products and by products from petroleum crude

Refinery operations:

Cracking operation**,** Hydrodesulphurisation (HDS & DHDS), Delayed coking, Visbreaking etc Steam & catalytic cracking of naphtha and downstream products, separation scheme of naphtha cracking. Catalytic reforming of naphtha, catalyst and process variable of BTX reformer.

Synthesis gas and hydrogen production and its use: Steam reforming operation of Naphtha and natural gas.

Module III [10L]

Manufacture of Petrochemicals based on Ethylene:

Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of EDC, VCM, VAM, Ethylene oxide, Ethanol amine

Manufacture of Petrochemicals based on Propylene:

Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of Acrylonitrile, Acrolein, Propylene oxide, glycerine (acrolein route), Isopropanol Production

Manufacture of Petrochemicals based on C4:

Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of Butadiene from C4 cut. Basic building blocks for manufacture of Benzene, Toluene and Xylene from BTX reformate petroleum crude. Coal based chemicals, fuels.

Module IV [10L]

Common utility services:

Electricity, steam, cooling water, hot oil, refrigeration and chilled water generated from industrially relevant fuels & coal.

Water treatment:

Water for the chemical process industry, Boiler feed-water, Cooling tower water, Demineralised water, Drinking water;

Treatment methodology:
Conventional water treatment procedures, Ion-exchange, Membrane technology etc.

Cement and ceramic materials:

Cement:

Chemical composition of Portland cement, raw materials, dry and wet process for manufacturing cement clinker, setting and hardening of cement.

Ceramic:

Basic raw materials, white-wares, manufacturing process of porcelain and their forming operations.

Refractories:

Properties of Refractories, raw materials, manufacturing techniques of acid refectories, basic Refractories, sintered and fused refractories, insulating refractories.

Glass:

Different types of glass ns their raw materials, manufacturing principles.

Oils and Fats:

Elementary idea, Composition (Fatty acid profile), Methods of extracting vegetable oils; Hydrogenation of oils, Major engineering problems and improved technology; Transesterification and Interesterification through enzymatic route; their applications. Method of soap production.

Text Books:

1. Dryden, C. E., and Rao, M.G. (Ed.), Outlines of Chemical Technology Affiliated East West Press
2. Austins, G.T., Sherve's Chemical Process Industries, McGraw-Hill, 5th Edn.
3. Jacob A. Moulijn, Michiel Makkee, Annelies E. van Diepen, Chemical Process Technology, A John Wiley & Sons, Ltd., Publication, Second edition.

Books of reference:

1. Venkateswarlu, S. (Ed.) Chemtech (II) Chemical Engineering Development Centre, Indian Institute of Technology, Madras.
2. Kirk & Othmer (Ed.), Encyclopedia of Chemical Technology.

Course Name: Chemical Engineering Thermodynamics					
Course Code: CHE2203					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

To introduce the concepts of fugacity, activity coefficient, vapour -liquid equilibrium, reaction equilibrium, and introduction to molecular thermodynamics. After completion of the course students will be able to:

CHE2104.1:Analyze energy transfer in closed/open systems (steady/unsteady) using first & second laws.

CHE2104.2: Relate properties of pure substances & mixtures to fugacity, chemical potential, and phase equilibrium.

CHE2104.3: Analyze mixtures using partial molar properties and predict property changes.

CHE2104.4: Understand phase rule, utilize VLE models, and perform K-value calculations.

CHE2104.5:Predict phase behavior (VLE, non-ideal solutions) and equilibria (liquid-liquid, etc.) in mixtures using solution thermodynamics. Solve related problems.

CHE2104.6: Predict reaction behavior and solve equilibrium problems in single/multi-reaction systems using equilibrium constants and thermodynamics.

Module I [10L]

Review of first and second law of thermodynamics:

First law for closed and open systems (steady and unsteady), entropy and second law,

Thermodynamic property of pure substances and mixture:

Residual properties, fugacity and fugacity coefficient/in solution, relation between fugacity coefficient and compressibility factor , chemical potential, chemical potential as criterion of phase equilibrium, free energy and chemical potential, excess properties, numerical problems.

Module II [10L]

Solution thermodynamics:

Concept of partial molar properties, Gibbs- Duhem equation, fundamental excess property relation, evaluation of partial properties, property change on mixing,

Vapour –liquid equilibrium:

Phase rule, simple models for VLE, VLE by modified Raoult's law, VLE from K- value correlations, Numerical problems.

Module III [10L]

Application of Solution thermodynamics:

Liquid phase properties from VLE data,

Non-ideal VLE:

Models for excess Gibbs free energy, UNIFAC and UNIQUAC models, property changes of mixing, heat effect of mixing processes, liquid- liquids equilibrium, solid liquid equilibrium, vapour-liquid-liquid equilibrium, solid-vapour equilibrium, numerical problems.

Module IV [10L]

Chemical reaction equilibrium:

Reaction coordinate, equilibrium criterion, equilibrium constant, Relation of Equilibrium constant to composition, Standard Gibbs Free Energy change, effect of temperature on equilibrium constant, evaluation of equilibrium constant, equilibrium conversion of single reaction, Phase Rule and Duhem's Theorem for Reacting Systems, Multi reaction equilibria, Thermodynamics of Fuel Cell, numerical problems.

Text Book:

1. Smith J.M., Van Ness H.C. & Abbott M.M. Introduction to Chemical Engineering Thermodynamics, McGraw-Hill International Edition, 7th. Edition, 2005.

Books of reference:

1. Sandler S. Chemical, Biochemical and Engineering Thermodynamics, Wiley, 5th. Edition, 2017.
2. Kyle B.G. Chemical Process Thermodynamics, Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Edition, 2000.
3. Narayanan K.V. A Text Book Chemical Engineering Thermodynamics, PHI Learning Pvt. Ltd, 2013.
4. Rao Y.V.C. Chemical Engineering Thermodynamics, University Press (India) Ltd. Reprint, 2004.

Course Name: Chemical Reaction Engineering I					
Course Code: CHE2204					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	2	**1**	**0**	**3**	**3**

Course Outcomes:
After completion of the course students will be able to:
CHE 2204.1: Determine rate equation of a chemical reaction from its kinetic experimental data.
CHE 2204.2: Design a suitable reactor for a single chemical reaction
CHE 2204.3: Optimize the size and combination of chemical reactors in view to maximize yield and productivity of a material
CHE2204.4: Compute the product distribution and maximum yield, selectivity for multiple reactions carried out in ideal reactors
CHE 2204.5: Compare the performance of ideal and non-ideal reactors using residence time distribution curves.
CHE 2204.6: Analyse a non-ideal reactor and predict conversion of a given chemical reaction using different non-ideal reactor models

Module I [10L]
Definition of reaction rate; Stoichiometry of chemical reaction; extent of reaction, limiting reactant; excess reactant; conversion, yield and selectivity. Kinetics of homogeneous reaction; Elementary & Non-elementary reactions; Molecularity and order of reaction. Constant volume and variable volume reaction; determination of rate equation of non-elementary reactions. Temperature dependence of rate constant. Analysis and correlation of experimental kinetic data-data collection and plotting, linearization of rate equations, differential and integral method of analysis.

Module II [10L]
Ideal Reactors:
Introduction and classification; generalized material balance equation, Design equation of batch Reactor, Concept of flow reactors, Space-time and Space-velocity
Steady-state Mixed Flow Reactor:
Design Equation, Graphical Representation of Design Equation
Steady-state Plug Flow Reactor:
Design equation, graphical representation.
Multiple-Reactor Systems:
PFRs in Series and/or in Parallel, Equal-size MFRs in Series, MFRs of different sizes in Series, Reactors of Different Types in Series, Recycle Reactor: Definition of Recycle Ratio, Design Equation, and Optimum Recycle ratio.

Module III [10L]
Classification of Multiple Reactions;
Reactions in Parallel:

Qualitative aspects of Product Distribution, Quantitative Treatment of Product Distribution, Definition of Instantaneous and Overall fractional yield, graphical representation;

Reactions in Series:

Successive First- Order Reactions, First-Order Followed by Zero-Order Reaction, Zero-Order Followed by First-Order Reaction, Product Distribution, Quantitative Treatment of PFR, MFR and Batch Reactor for series, parallel reaction.

Module IV [10L]

Non-ideal reactors, definition of residence time distribution function, E(t) and F(t) curve,

Moments of RTD Function:

Determination of mean residence time and variance from E(t) curve. Residence time distribution (RTD) function of ideal reactors, laminar flow reactor.

Introduction to compartment model of RTD of non-ideal reactors. Non-ideal reactor modelling with the RTD:

Zero-parameter model:

Segregation model, maximum mixedness model,

One-parameter model:

Tank-in-series model, dispersion model.

Text Book:

1. Levenspiel O. Chemical Reaction Engineering, 3rd. editions, John Wiley & Sons, 2001.
2. Fogler H.S. Elements of Chemical Reaction Engineering, 3rd Edition, Prentice Hall, 2004.

Books of reference:

1. Smith J.M. Chemical Engineering Kinetics, 3rd. Edition, McGraw-Hill, 1983.
2. Li S, Li L, Xin F. Reaction Engineering, Chemical Industry Press, 2017.
3. Carberry J.J., Chemical and Catalytic Reaction Engineering, Dover Publications, Inc., 2001
4. Froment G.F., Bischoff K.B., De Wilde J., Chemical Reactor Analysis and Design, 3rd Edition, John Wiley & Sons, Incorporated, 2010.

Course Name: Transport Phenomena					
Course Code: CHE2205					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**1**	**0**	**4**	**4**

Course Outcomes:
After completion of the course, students will be able to:
CHE 2205.1: Identify the inherent analogy between momentum, energy and mass transport processes.
CHE 2205.2: Apply the concepts of momentum transport for solving momentum transfer problems involving different flow geometries.
CHE 2205.3: Apply the concepts of energy transport for solving energy transfer problems arising in industrial process equipment.
CHE 2205.4: Apply the concepts of mass transport for solving mass transfer problems arising in industrial process equipment.
CHE 2205.5: Apply the concepts of momentum, energy and mass transport in boundary layers to solve engineering problems related to flow past solids.
CHE 2205.6: Suggest solutions and develop designs for engineering problems based on the concepts of Transport phenomena.

Module I [10L]
Understanding of unified approach in transport phenomena for momentum, mass and energy transport; Fundamental variables and units used in describing a transport process; Concept of closed and open system; Concept of non-dimensional form of the basic transport equation and dimensionless number; Concept of diffusion and convection mechanism; Idea on tensor and vector approach in describing a transport process; Understanding of thermodynamic equilibrium and transport process; Concept of different steady state condition (steady state and quasi-steady state condition) and its importance in analyzing transport process; Role of intermolecular forces (and potential) in quantification of system intrinsic properties for transport process.

Module II [10L]
Description of Newtonian and Non-Newtonian fluid; Newton's law of motion; Concept of momentum diffusivity; Basic idea on Lennard-Jones potential (from collision theory) to understand viscosity of gas with low density; Pressure and temperature dependence of viscosity; Tensor form for momentum transport; Shell momentum balance and boundary condition; Equation of Continuity in rectangular (Cartesian) coordinate system; Development of Navier-Stokes equation in rectangular (Cartesian) coordinate system; Concept of Euler's equation of motion; Concept of laminar and turbulent flow; Velocity profile prediction for (a) falling film (b) flow in a circular tube (c) flow through annulus (d) flow of two adjacent immiscible fluids; Coutte flow; Creeping flow and Drag force; Boundary Layer over a flat plate; Determination of boundary layer thickness and average flow velocity determination.

Module III [10L]
Fourier's law of heat conduction; Temperature and pressure dependence of thermal conductivity; Shell energy balance and boundary conditions; Development of convection-diffusion energy equation; Concept of thermal diffusivity; Heat conduction through laminar flow when (a) heat

conduction with an electrical heat source (c) heat conduction with a viscous heat source conduction through composite wall; Unsteady heat conduction – case studies Solution for temperature profile using similarity solution; Concept of thermal boundary layer; Forced convective heating of a fluid flowing through a circular tube at laminar condition; Laminar free convection of fluid flowing between two parallel plates at two different temperatures.

Module IV [10L]

Fick's law of diffusion; Temperature and pressure dependence of diffusivity; Shell mass balance and boundary conditions; Development of convection-diffusion equation for mass transport; Equation of continuity for a multi-component mixture in rectangular (Cartesian) coordinate system; Evaluation of concentration profile for diffusion (a) through a stagnant gas film (b) with heterogeneous chemical reaction (c) with homogeneous chemical reaction (d) during gas absorption in a falling liquid film (e) during solid dissolution in a falling liquid film; Unsteady state mass diffusion – solution by Laplace Transformation; Concept of analogy between momentum, heat and mass transport; Derivation of Reynolds analogy; Colburn Analogy and its benefits over Reynolds analogy.

Text Book:

1. Bird R.B., Stewart W.E. & Lightfoot E.N. Transport Phenomena, Wiley, 2nd Edition, 2006.

Books of reference:

1. Brodkey R.S. & Herskey H.C. Transport Phenomena, McGraw- Hill, 1988.
2. Geankoplis C.J. Transport Processes and Unit Operations, Prentice Hall of India, 3rdEdition, 1993.
3. Roy S.C. & Guha C. Introduction to Transport Phenomenon, Dhanpat Rai & Co., 2014.
4. Plawsky Joel L. Transport Phenomena Fundamentals , 4th Edition, 2020.

Course Name: Chemistry II					
Course Code: CHEM2201					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

1. understand the theoretical principles underlying molecular structure, bonding and properties.
2. understand the quantum mechanics makes students to learn illustrative case studies that organize molecular modeling for designing of reactors and derivation of thermo-chemical functions.
3. identify and formulate different types of complexes can be of further use in dye and pigment industry.
4. understand of the role of transition metal in living cell will be introduced through the knowledge of bioinorganic chemistry has tremendous scope in future research.
5. apply the knowledge of structure and reactivity of alicyclic and acyclic organic molecules in pharmaceuticals industries and natural product synthesis.
6. apply the concept of adsorption isotherms for the development of heterogeneous catalysis that are widely used in oil refinery and petroleum industry.

Module I [9L]

Introduction to Quantum Theory for Chemical Systems:

Schrodinger equation, applications to Hydrogen atom, atomic orbitals, many electron atoms.

Kinetic Theory of Gases:

Maxwell distribution law, kinetic energy distribution, equipartition principle.

Colloids:

Introduction, classification of colloids, size and shape, preparation of sols, origin of charge in colloidal particles, stability of colloids, kinetic, optical & electrical properties, electro-kinetic phenomena, electrical double layer, applications of colloids.

Module II [9L]

Basic Idea of Coordination Chemistry:

IUPAC nomenclature of coordination complexes (up to two metal centres), idea of coordination number and isomerism in coordination compounds.

Properties of Coordination Compounds:

Effective atomic number, elementary crystal field theory: splitting of d^nconfigurations in octahedral, and tetrahedral fields, crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy. spectrochemical series. Jahn-Teller distortion, magnetism and colour: orbital and spin magnetic moments, d-d transitions, charge transfer spectra.

Organometallic Chemistry:

Definition and classification of organometallic compounds on the basis of bond type, 18-electron Rule, applications of 18-electron rule to metal carbonyls, nitrosyls, cyanides. Zeise's salt: Preparation, structure, evidences of synergic effect.

Module III [9L] Acyclic System:
Conformation of alkanes, halogeno-alkanes, stability, intra-molecular hydrogen bonding, optical activity, racemic mixture and their resolution.
Alicyclic Compounds:
Concept of I-strain, ring-size and ease of cyclisation, characteristics of chair conformation, conformation of cyclohexane, mono and di substituted cyclohexane, considering steric and stereo electronic requirements reactivity of cyclohexane towards elimination, nucleophilic substitution, rearrangements.
Strategies for Synthesis of Organic Compounds:
(a) Substitution at sp^3 centre: mechanisms, relative rates & stereochemical features, role of crown ethers and phase transfer catalysts, (b) Elimination reactions: formation of alkenes and alkynes.

Module IV [9L]
Bio-inorganic Chemistry:
(a) Elements of life, essential trace and ultra trace elements in biological systems, role of metal ions in biological systems. (b) Toxic effects of metal ions and detoxification by chelation therapy (BAL, Unithiol, D-penicillamine, triethylene tetramene, ferrichrome, desferrioxamine B, EDTA), (c) Active site structure and basic function of O2 uptake proteins-haemoglobin and myoglobin and electron transportproteins-Ferredoxins.
Adsorption:
Introduction, Gibb's adsorption equation, Surface Excess, adsorption isotherms-Langmuir, BET adsorption equations, surface Films, Langmuir Balance, two dimensional equation of state.
Synthesis and applications of industrially important materials:
(a) Phenol formaldehyde resins (Bakelite, Novalac), (b) Conducting Polymers, (polyacetylene, polyaniline), (c) Pharmaceuticals (Ibuprofen, anticancer drug), (c) Battery industry materials (Li ion batteries).

Text Books:

1. Castellan G.W. Physical Chemistry, Narosa, 2004.
2. Finar I.L. Organic Chemistry, Vol I & II, Pearson Education, 6th Edition, 2002.
3. Morrison R.T., Boyd R.N. & Bhattacharjee S.K. Organic Chemistry, PHI/Pearson Education, 7th Edition, 2010.
4. Rakshit P. C. Physical Chemistry, Sarat Book House, 7th Edition, 2014.
5. Nasipuri D. Stereochemistry of Organic Compounds, New age international (P) limited, 3rd Edition, 2018.
6. Gupta S.S. Basic Stereochemistry of Organic Molecules, Oxford Higher Education, 1stEdition, 2014.Huheey J. E., Keiter E. A. & Keiter R. L. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education, 4th Edition,1997.
7. Cotton F.A., Wilkinson G. & Gaus P.L. Basic Inorganic Chemistry, Wiley, 3rd Edition, 1994.

Course Name: Environmental Science					
Course Code: EVSC2016					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	2	**0**	**0**	**2**	**0**

Course Outcomes:

The subject code EVSC2016 corresponds to basic environmental chemistry for the 2nd year B.Tech students, which is offered as Environmental Sciences and is mandatory for all branches of engineering. The course provides basic knowledge of various environmental pollutions as well as its impact and ways to curb it. After completion of the course students will be able to:

1. understand the natural environment and its relationships with human activities.
2. characterize and analyze human impacts on the environment.
3. integrate facts, concepts, and methods from multiple disciplines and apply to environmental problems.
4. educate engineers who can work in a multi-disciplinary environment to anticipate and address evolving challenges of the 21stcentury.
5. Understand and implement scientific research strategies, including collection, management, evaluation, and interpretation of environmental data.
6. design and evaluate strategies, technologies, and methods for sustainable management of environmental systems and for the remediation or restoration of degraded environments.

Module I [6L]

Socio Environmental Impact:

Basic ideas of environment and its component.

Population growth:

Exponential and logistic; resources; sustainable development. Concept of green chemistry, green catalyst, green solvents.

Environmental disaster and social issue, environmental impact assessment, environmental audit, environmental laws and protection act of India.

Module II [6L]

Air Pollution:

Structures of the atmosphere, global temperature models.

Green house effect, global warming; acid rain: causes, effects and control.

Lapse rate and atmospheric stability; pollutants and contaminants; smog; depletion of ozone layer; standards and control measures of air pollution.

Module III [6L]

Water Pollution:

Hydrosphere;

Pollutants of water:

Origin and effects; oxygen demanding waste; thermal pollution; pesticides; salts. Biochemical effects of heavy metals; eutrophication: source, effect and control.

Water quality parameters: DO, BOD, COD.Water treatment:Surface water and waste water.

Module IV [6L]Land Pollution:
Sources and control;
Solid waste:
Classification, recovery, recycling, treatment and disposal.
Noise Pollution:
Noise: definition and classification; noise frequency, noise pressure, noise intensity, loudness of noise, noise threshold limit value; noise pollution effects and control.

Text Books:

1. Mahapatra G.K.D. Basic Environmental Engineering and Elementary Biology, Vikas Publishing House P. Ltd., 1st Edition, 2011.
2. De A.K. Environmental Chemistry, New Age International, 2003.
3. DasA.K.&DasM.EnvironmentalChemistrywithGreenChemistry,BooksandAllied P. Ltd.

Books of reference:

1. Santra S. C. Environmental Science, New Central Book Agency P. Ltd, 3rd Edition, 2011.
2. De D. & De D. Fundamentals of Environment & Ecology, S. Chand & Company Ltd., 2010.

LABORATORY

Course Name: Heat Transfer Laboratory					
Course Code: CHE2251					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:

The objective of this course is to provide the practical exposure to the students regarding the application of various heat transfer phenomenon and correlations in various engineering processes. Hands on experience will enable them to analyze working principles of various heat transfer devices including heat exchangers, condensers. After completion of this course students will be able to:

CHE 2251.1: Identify and compare different modes of heat transfer and basic laws of heat transfer.

CHE 2251.2: Analyze problems involving steady state heat conduction and develop solutions for transient heat conduction in simple geometries.

CHE 2251.3: Evaluate the heat transfer coefficients for forced convection inside duct.

CHE 2251.4: Analyze radiation heat transfer between black body surfaces.

CHE 2251.5: Estimate the heat transfer rate and heat transfer coefficient for different heat exchanger/ condenser.

Experiments to be performed:

1. Determination of thermal conductivity of a metal bar using Fourier's heat conduction equation.
2. Estimation of heat loss through a lagged pipe and determination of thermal conductivity of insulating material.
3. Determination of heat transfer coefficient of air during heat transfer by forced convection and to study the effect of air velocities on heat transfer co-efficient.
4. Determination of overall heat transfer coefficient in a counter current / parallel flow double pipe heat exchanger and to study the effect of fluid flow rate on overall heat transfer coefficient.
5. Determination of overall heat transfer coefficient and efficiency of a shell and tube heat exchanger and to study the effect of fluid flow rate on overall heat transfer co-efficient.
6. Determination of Stefan Boltzmann constant experimentally.
7. Determination of Biot number for a conductive convective system and validation of lumped system assumption.
8. Determination of heat transfer co-efficient in film-wise & drop-wise condensation.
9. Determination of emissivity of a given radiating surface by applying Kirchhoff's law of thermal radiation.

Text Books:

1. Kern D. Q. Process Heat Transfer, Tata McGraw-Hill, 1997.
2. Dutta B. K. Heat Transfer Principles and Application, PHI Learning Pvt. Ltd., 2015.
3. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.

Book of reference:

1. Ozisik M. N. Heat Transfer: A Basic Approach, McGraw-Hill International Edition, Singapore, 1984.

Course Name: Programming Basics for Numerical Computation					
Course Code: CHE2252					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:

After completion of the course students will be able to:

CHE 2252.1: Apply relevant algorithm to solve a simple mathematical problem.

CHE 2252.2: Generate code with user defined function for the implementation of the programming logic and algorithm.

CHE 2252.3: Read data from formatted input file for further processing of it through written code.

CHE 2252.4: Execute loops, functions comparison operations.

CHE 2252.5: Analyze the output of the program by representing the output in graphical format.

Programmes to be performed using MATLAB / OCTAVE:

1. Introduction to MATLAB/OCTAVE interface. Execution of statements from command lines, data input for scalars, 1D and 2D arrays, extract elements of arrays, evaluate array size.
2. Write and execute programs through .m file (editor file). Call in-built functions in MATLAB/OCTAVE.
3. Concept of loops (for, while and do-while), "break" and "continue" statement.
4. Usage of comparison operators and conditional statements (if, else and elseif).
5. Write a program to find out the adjoint and transpose of a 2D array.
6. Write a program to find out the determinant and inverse of a 2D array.
7. Write a program to check whether a matrix is diagonally dominant or not?
8. Write a program using a user defined function to evaluate the function $y=e^{-x}$ against different values for 'x' taken as input and plot y versus x.

Text Books:

1. Pratap R. Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Oxford, 2010.
2. Nagar S. Introduction to Octave: For Engineers and Scientists, Apress, 1st Edition, 2017.

Books of reference:

1. Attaway S. Matlab: A Practical Introduction to Programming and Problem Solving, Butterworth-Heinemann, 3rd Edition, 2013.
2. Nakamura S. GNU Octave Primer for Beginners, Create space Independent Publishing Platform, 2nd Edition, 2016.

Course Name: Engineering Graphics & AUTOCAD Laboratory					
Course Code: CHE2253					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

The objective of the course is to provide an elaborated concept of engineering drawing and idea on the relevant software for engineering drawing. After completion of the course students will be able to:

CHE 2253.1: Understand basics of engineering drawing.

CHE 2253.2: Draw different angular projection view of engineering equipment.

CHE 2253.3: Draw isometric projection view of engineering equipment and cut-section view of engineering equipment.

CHE 2253.4: Use AutoCAD software for developing engineering drawing layouts.

CHE 2253.5: Prepare a virtual 3-D representation of an engineering equipment.

Problems to be solved:

1. Introduction to AutoCAD software for drawing in 2D: Drawing and editing commands. Knowledge of setting up layers, dimensioning, hatching, making block, plotting and printing, working with external reference file.
2. Drawing any three of the following item using AutoCAD software.
3. Flange coupling for shaft and vessel or pipe.
4. Pipe joints and fittings, single line and double line pipe line assembly.
5. Stuffing box.
6. Detailed cut section drawing of Globe valve and Stop valve.
7. Piping and instrumentation diagram of any given chemical process.
8. Assembly drawing of a single stirred jacketed pressure vessel with all its accessories using AutoCAD software. Introduction to AutoCAD software for drawing in 3D: Working in 3- dimensions, Drawing and editing commands, viewing 3D objects, basic solid and wireframe models, extruding, simple revolved objects. Generation of orthographic projections from 3D drawing.

Books of reference:

VenugopalK.,EngineeringDrawingandGraphics+AutoCAD,NewAgeInternational

1. (P) Limited, Fourth edition, 2001.
2. Agarwal B. & Agarwal C.M., Engineering Drawing, McGraw Hill Education (India) Private Limited, 2nd Edition, 2014.
3. Lockhart S., Tutorial Guide to AutoCAD 2016, SDC Publication, 2016.

Course Name: Idea Lab & Design Thinking(CHE)					
Course Code: CHE2254					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

CHE2254.1: Describe various phases of Design Thinking and various tools for Empathizing in Design Thinking.

CHE2254.2: Describe various tools for Ideation, Prototyping in Design Thinking.

CHE2254.3: Outline the Design process for new Product development in startups and techniques to design Radically New Products.

CHE2254.4: Give examples for empathizing and defining phases in Design Thinking.

CHE2254.5: Give examples for Ideation, Prototyping in Design Thinking.

CHE2254.6: Apply Design Thinking principles, methodologies, phases and tools to design a New/Radically new Process/Service/Product.

Theory

Introduction:

Definition of Design Thinking, Need for Design Thinking, Objective of Design Thinking, Concepts & Brainstorming, Sustainability, Stages of Design Thinking Process (explain with examples) – Empathize, Define, Ideate, Prototype, Test.

Problem Identification & Ideation process in Design Thinking

Empathize: Goals and methods, Usage of Tools (Design Briefs - Nine Criteria with example), Usage of Tools (Creation of Personas, Illustrative application of Personas), Student Activity on Empathize phase.

Define: Importance of Define Phase, activities, Usage of Tools (Experience Mapping process with example).

Ideate: Importance of Ideate Phase, 77 Design Heurisitics, Diverge Ideas, Converge Ideas Student Activity on Ideate phase

Introduction to usage of basicinstruments and equipments in chemical engineering laboratories.

What is Proof Of Concept? Why Proof Of Concept?

Prototype & Test: "A Design Thinking Product Development Framework", What Is a Story? What Is a Prototype?, "Putting It Together—Combining Stories and Prototypes", Employing Stories and Prototypes in Your Process

What is Prototype? Why Prototype? Rapid Prototype Development process.

Case Study Implementation

Case Study Discussion mapping the End to End Design. Each student group performing a case study will be assigned one faculty mentor. Each case study will be conducted to cover the following 5 phases.

Case Study –Phase 1 Application of Problem Identification Processes in Design Thinking

Case Study –Phase 2 Application of Problem Solving Processes in Design Thinking

Case Study –Phase 3Application of Empathize Phase Application
Case Study –Phase 4 Application of Ideate Phase Build Prototype; Test the solution
Case Study –Phase 5Evaluation Phase

Text Books:

1. E Balaguruswamy (2022), Developing Thinking Skills (The way to Success), Khanna Book Publishing Company
2. Design think new product development essentials from the PDMA – Wiley edition
3. https://web.mit.edu/jrankin/www/engin_as_lib_art/Design_thinking.pdf

Books of reference:

1. Reference Material Handout in Class

3rd Year 1st Semester (Semester 5)

THEORY

Course Name: Numerical Methods in Chemical Engineering					
Course Code: CHE3101					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE 3101.1: Identify different computational errors and evaluate them for a given mathematical problem to be solved numerically. Students will be able to know how to perform relative and absolute error in each case.

CHE 3101.1: Evaluate different intermediate points for a function within a specified domain using different interpolation algorithms to create a continuous domain.

CHE 3101.1: Formulate a linear or nonlinear form of the equation and solve equations for a given linear multivariable problem.

CHE 3101.1: Create ODE and PDE along with the associated boundary conditions followed by an application of appropriate numerical algorithm for a given engineering problem.

CHE 3101.1: Calculate numerical integration to find out area under the function curve for a given engineering problem.

CHE 3101.1: Design constrained and unconstrained optimization problem for a given engineering problem.

Module I [10L]

Approximation in numerical computation:

Truncation and rounding errors, Error analysis;

Interpolation: Newton and Lagrange polynomial, Spline interpolation.

Numerical Differentiation: Forward, backward and central difference scheme using Taylor Series; chemical engineering applications.

Root Finding methods for solution of non-linear equations:

Bisection, Newton-Raphson and Secant methods; chemical engineering applications.

Module II [10L]

Linear Algebraic Equations:

Gauss Elimination, LU Decomposition and inversion of matrix, Gauss Siedel method.

Numerical Integration:

Trapezoidal Rule, Simpson's rule, integration with unequal segments; chemical engineering applications.

Module III [10L]

Ordinary Differential Equations:

Euler method, Runge-Kutta Method, Adaptive Runge-Kutta method, Initial and boundary value problem; chemical engineering applications to single and multiple ODEs.

Module IV [10L]

Introduction to partial differential equation, Characterization of PDE; Heat conduction and diffusion problem; Explicit, Implicit and Crank-Nicholson scheme.

Numerical Optimization:
Concept and utility of process optimization; one variable optimization e.g. Golden Search and Newton's Method;
Unconstrained optimization:
Direct search technique and gradient search technique; Constrained Optimization: Simplex method.

Text Book:

1. R. Chapra and S. Canale, Numerical Methods for Engineers, 6th Edition, McGraw-Hill Science/Engineering/MTH, 2009.

Books of reference:

1. Amos Gilat and Vish Subramaniam, Numerical Methods for Engineers and Scientists, 3rd Edition, John Wiley & Sons Inc, 2014.
2. Gupta S.K., Numerical Methods for Engineers, New Age International (P) Limited Publishers, 1995.
3. Constantinides A., Mostoufi N., Numerical Methods for Chemical Engineers with MATLAB, Prentice Hall PTR, 1999.

Course Name: Mass Transfer I					
Course Code: CHE3103					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	2	**1**	**0**	**3**	**3**

Course Outcomes:

After completing this course, students will be able to:

CHE 3103.1 Frame mathematical equations for a given steady-state or transient diffusion problem and solve them.

CHE 3103.2 Select either plate or packed column (whichever is appropriate) for a given absorption operation and design the selected type of column considering various operational criteria.

CHE 3103.3 Understand the significance of Hatta number and to determine its effect in case of absorption with chemical reaction.

CHE 3103.4 Acquire knowledge related to vapor-liquid equilibria, relative volatility and to understand the mechanism of flash distillation, continuous rectification etc..

CHE 3103.5 Gain knowledge on effect of reflux ratio and thermal conditions of feed on operation of distillation and design a fractional distillation column (plate-type) for a given binary distillation as well as gain knowledge of FUG method for multi-component distillation column design.

CHE 3103.6 Determine suitable adsorption isotherm as well as design a fixed bed adsorption column.

Module I [10L]

Principles of diffusion, Constitutive equations for steady state and transient diffusion, Fick's Law, Diffusivity and correlations for diffusivity for liquids and gases, convective mass transfer, mass transfer coefficients and their correlations, inter phase mass transfer and related theories.

Module II [10L]

Mechanism of absorption, industrial application, difference between continuous and staged gas-liquid contacting devices and selection criteria, loading and flooding in a packed tower, types of packing, design of a packed absorption tower based on film coefficients and overall coefficients, transfer unit (number and height), design of a tray column for absorption (graphical method and Kremser equation), significance of absorption factor, operating characteristics in tray tower, stage efficiency,

Absorption with chemical reaction, significance of Hatta number, effect of reaction regimes (slow, fast, instantaneous), analysis of diffusion with chemical reactions by Film and Penetration theory

Module III [10L]

Distillation:

Industrial utility, vapor-liquid equilibria, ideality and deviations from ideality, relative volatility. Batch distillation, Rayleigh equation, Flash distillation**,** Industrial applications, continuous binary rectification, different types of reflux arrangements (top-tray, pump-back, pump-around) and concept of minimum and optimum reflux ratio, application of McCabe-Thiele method for

calculation of number of trays in a distillation column, Fenske equation, Outline of Ponchon Savarit method, basic idea of rate-based models for distillation. Distillation for Multi Components: Key components; Pinch points; Approximate method using Fenske equation for minimum equilibrium stages, Underwood equation for minimum reflux ratio and Gilliland equation for estimation of the number of theoretical plates, Derivations and applications using simple problems.

Module IV [10L]

a. Distillation column internals, Extractive and azeotropic distillation-Industrial techniques and applications, basic idea of multi-component distillation.
b. Adsorption: Introduction, Properties of adsorbent and applications, Batch Adsorption, Adsorption isotherms, Break through curves, LUB, scale up, design of fixed bed adsorption column.

Text Books:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill, 3rd edition, 1983.
2. Dutta B.K., Principles of Mass Transfer and Separation Processes, Prentice Hall of India, 2nd edition, 2007.
3. Geankoplis, C.J., Transport Processes and Unit Operations, Prentice Hall of India, 3rd edition, 1993.

Books of reference:

1. Henley E.J., Seader J. D., Roper D.K., Separation Process Principles, Wiley, 3rd Edition (International Student Version), 2011.
2. McCabe W.L., Smith J.C., Harriot P., Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.
3. Coulson J.M., Richardson J.F., Harker J.H., Backhurst J.R., Coulson and Richardson's Chemical Engineering: Particle Technology and Separation Processes, Vol. 2, Butterworth Heineman, 5th Edition 2002
4. Rosseau R.W., Handbook of Separation Process Technology, Wiley India Pvt. Ltd., 2009
5. Wankat P.C., Separation Process Engineering, Prentice Hall, 2nd edition, 2010.

Course Name: Industrial Safety and Hazard Analysis					
Course Code: CHE3104					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE 3104.1: Use important technical fundamentals of chemical process safety and to impart basic knowledge that allows the students to evaluate occupational safety and health hazards in the workplace.

CHE 3104.2: Analyze the effects of work place exposures ,injuries and illnesses, fatalities.

CHE 3104.3: Use safety programs to prevent or mitigate damage or losses and to develop preventative measure to avoid accident.

CHE 3104.4: Use logic based quantitative risk analysis.

CHE 3104.5: Carry out HAZOP analyses.

CHE 3104.6: Use knowledge of safety and hazards in chemical plant layout.

Module I [10L]

Definition of safety, Hazard and Risk, Safety program, Engineering ethics, Inherent safety, Safety regulations, OSHA, Process safety management, Hazards due to fire, explosions and toxic chemicals, Distinction between fire and explosion, Upper Flammability limit and Lower Flammability Limit, Fire Triangle, BLEVE, Runaway reaction.

Module II [10L]

Tools for hazards identification:

HAZOP, Fault Tree, Event Tree, FMEA, Dow Fire and Explosion Index, Mond Index. .

Module III [10L]

Risk analysis concept and methodology:

Risk concept and measure of risk, Risk acceptance criteria, Quantitative risk analysis, Probit number.

Module IV [10L]

Control of chemical plant hazards, Intensification and attenuation of hazardous materials, Industrial plant layout, Ventilation, Fire prevention, Personnel protection devices, Laboratory safety, Emergency safety, Safety systems and disaster management. Case studies, Flixborough (England), Bhopal (India), Seveso (Italy), Pasadona (Texas).

Text Book:

1. D.A. Crowl and J.F. Louvar, Chemical Process Safety: Fundamentals with Applications:, Prentice Hall, 1990.

Books of reference:

1. Kharbanda O.P.and Stallworthy E. ., Safety in Chemical Process Industries: Heinmann
2. Professional Publishing LTD.1988.
3. Wentz C.A. Hazardous Waste management: Mc-Graw Hill.
4. Cutter S.L. Environmental Risks & Hazards, Prentice Hall, 1994.
5. Trevor A. Kletz, What went wrong? Case Histories of Process Plant Disasters and how They Could Have Been Avoided, 5th, Edition, Butterworth-Heinemann / IChemE.

Course Name: Chemical Reaction Engineering-II					
Course Code: CHE3105					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	2	**1**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE 3105.1: Participate in catalyst development program.
CHE 3105.2: Characterize newly developed catalyst and to design catalytic reactors.
CHE 3105.3: Design non catalytic reactors involving solid fluid reaction.
CHE 3105.4: Design reactors involving mass transfer with chemical reactions.
CHE 3105.5: Design non-isothermal reactor.
CHE 3105.6: Understand the principles of reactors used for solid fluid reactions.

Module I [13L]

Introduction to Catalysis, homogeneous and heterogeneous catalysis. Preparation and characterization of catalysts, Promoter and inhibitors, Physical and chemical adsorption, Adsorption isotherms, Determination of surface area by BET method and pore volume distribution of the Catalyst.

Module II [13L]

Kinetics of solid catalysed gas phase reaction, Diffusion and Chemical Reactions in catalysis, Effectiveness factor, Identification of rate controlling regime, Experimental methods for finding rates, Differential and Integral reactors, Comparison of Experimental Reactors, Design concept.

Module III [13L]

Non Catalytic Solid Fluid Reactions; Un-reacted Core Model for spherical particles of unchanging size, Identification of rate controlling regimes, Rate of Reaction for Shrinking Spherical particles, Application to Design.

Module IV [13L]

Fluid- Fluid Reactions; Kinetic regime for Mass Transfer and Reaction, Rate equation for Instantaneous Reactions, Rate equation for Fast Reactions, Rate equation for Intermediate Reactions, Rate equation for Slow Reactions, Slurry Reaction Kinetics, Application to Design, Reactive Distillation and Extractive Reactions, Mass and Energy Balance of non-isothermal Reactor, Design of Adiabatic Reactor, Details of Two-parameter model for non ideal reactor.

Text Books:

1. Foggler H. S. Elements of Chemical Reaction Engineering, Prentice Hall, 2001.
2. Levenspiel O. Chemical Reaction Engineering, 3rd. ed. Wiley Eastern Limited**.**

Books of reference:

1. Carberry, J. Dover J., Chemical and Catalytic Reaction Engineering, Books on Chemistry, 2001.
2. Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde. Chemical Reactor Analysis and Design, John Wiley & Sons, Incorporated, 2010.

Course Name: Petroleum Refinery Engineering					
Course Code: CHE3131					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Prerequisites: Chemical Technology, Basics of Material & Energy Balance

Course Outcomes:
At the end of the course the students should be able to:
CHE 3131.1: Estimate characterization properties for crude oil samples.
CHE 3131.2: Suggest reasoning and suitable solutions for various problems occurring with use of crude oil and petroleum products.
CHE 3131.3: Suggest suitable solutions for different problems arising in refinery processing units.
CHE 3131.4: Explain the economics behind refinery operations.
CHE 3131.5: Select between different grades of lubricating oil based on application requirements.
CHE 3131.6: Select the appropriate processing technology for a particular feedstock based on its properties and product specifications.

Module I [10L]Introduction:
Origin and formation of petroleum, reserves and deposits of the world, Indian petroleum Industry, composition of petroleum, crude oil analysis.
Refinery feedstock and Product: Crude pretreatment, dehydration and desalting, pipe still heater, atmospheric and vacuum distillation of crude oil, natural gas, associated gas, dissolved gas, refinery off gas, LPG, reid vapour pressure, ASTM distillation, octane number and cetane number.
Evaluation of crude oil properties and design of crude oil distillation column:
Dehydration and desalting of crude, ASTM and TBP distillation of crude, properties of crude oil fractions, design of crude oil distillation column.

Module II [10L]
Treatment of refinery products, additives, blending of gasoline, treatment of gasoline, kerosene, lubes and lubricating oils, waxes, Furnace Design.
Thermal and catalytic cracking:
Coking and thermal process, delayed coking, catalytic cracking, cracking feed stocks and reactors, effect of process variables, FCC cracking, catalyst coking and regeneration, design concepts, new designs for fluidized-bed catalytic cracking units.
Catalytic Reforming:
Objective and application of catalytic reforming process reforming catalysts, reformer feed reforming reactor design continuous and semi regenerative process.

Module III [10L]
Hydro treating and Hydrocracking:
Objectives & hydrocracking reactions, hydrocracking feed stocks, modes of hydrocracking,

effects of process variables, hydro treating process and catalysts Resid hydroprocessing, effects of process variables, reactor design concepts.

Isomerization, Alkylation and Polymerization:

Isomerization process, reactions, effects of process variables. alkylation process, feedstocks, reactions, products, catalysts and effect of process variables.

Polymerization: Objectives, process, reactions, catalysts and effect of process variables.

Module IV [10L]

Lube Oil Manufacturing:

Propane deasphalting solvent extraction, dewaxing, additives production from refinery feedstocks.

Environmental issues and New Trends in petroleum refinery operations:

Ecological consideration in petroleum refinery, waste water treatment, control of air pollution, new trends in refinery, alternative energy sources, biodiesel, hydrogen energy from biomass.

Text Books:

1. W.L..Nelson " Petroleum Refining Engineering " Mc Graw- Hill.
2. R.N.Watkins, " Petroleum Refinery distillation " Gulf Publishing Co.
3. Robert A Mayers " Hand book of petroleum refining process ".
4. James G Speight " The chemistry and technology of petroleum ".
5. J.H. Gary and G.E. Handwerk " Petrolem Refinery Technologies and economics ".

Course Name: Environmental Engineering and Pollution Control					
Course Code: CHE3132					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Prerequisites: Environmental Science, Chemical Reaction Engineering

Course Outcomes:

At the end of the course the students should be able:

CHE3132.1 Apply the knowledge of Legislation concerning Environmental Engineering & Pollution Control prevalent in India.

CHE3132.2 Utilize the knowledge of Solid Waste Management in order to achieve Swachh Bharat Mission

CHE3132.3 Practice the Concepts of Circular Economy.

CHE3132.4 Solve problems of Air Pollution in batch and flow system and design suitable instruments/equipments .

CHE3132.5 Solve problems of Water Pollution in batch and flow system and design suitable instruments/equipments .

CHE3132.6 Design Environmental Management Plan for chemical industries.

Module I [9L]

Types of environments and their pollutants. Classification of pollutants. Legislative aspects including Bengal Smoke Nuisance Act, Water Act. 1974, Air Act 1981 and effluent standards, Genesis and Role of EPA,

Air pollution:

Sources and effects of different air pollutants, Sampling and analysis of air pollutants, Air pollution control methods and equipment, Cyclone Separator, Baghouse, ESP, Venturi Scrubber.

Module II [9L]

Water pollution:

Sources, sampling and classification of water pollutants, determination of basic parameters and computations associated with: BOD, COD, TS, TDS, SS;

Waste water treatment:

Primary, secondary, tertiary and advanced; aerobic treatment with special reference to activated sludge, trickling filter, RBDC and RBRC, EA;

WSP, anaerobic treatment with special reference to AFFR, UASB.

Module III [9L]

Solid waste management:

Sources and classification, public health aspects, Methods of collection and disposal methods: open dumping, landfill, incineration, composting, vermiculture; Solid waste management using bioremediation for specific pollutants like chromium. Mercury, ammonia / urea, phenolic sludges. Management and handling of Biomedical waste; E-waste – classification and re-use and

disposal; Hazardous waste management – electro-chemical and photo-chemical oxidation - dye waste, chrome slag, Concepts of Circular Economy – Applications and Challenges–case studies.

Module IV [9L]

Pollution control in selected process industries:

Fertilizer industries, petroleum refineries and petrochemical units, pulp and paper industries, Tanning industries, Sugar industries, Dairy, Alcohol industries, electroplating and metal finishing industries, Radioactive wastes, Root Zone and Reed Bed Treatment for Effluents of small scale industries, Ranking of wastewater treatment alternatives Case Studies.

Text Books:

1. Rao, C.S., Environmental Pollution Control Engineering, New Age International, 2nd Edition,
2. Metcalf & Eddy, Wastewater Engineering, Tata Mc-Graw Hill – 2002.
3. Arceivala, S.J., Wastewater treatment for pollution control, TMH, 2nd Edition.

Books of reference:

1. Mahajan, S.P, Pollution Control in Process Industries, Tata Mc Graw Hill, 2008.
2. M. Davis, Cornwell, D, Introduction to Environmental Engineering, Tata Mc Graw
3. Hill, 2012.
4. M. N. Rao, H V N Rao, Air Pollution, Tata Mc Graw HilL, 2007.
5. Stern, Arthur (Ed.), Air Pollution Vol I-- VIII, Elsevier, 3rd Edition, 2014.
6. Standard Methods for Examination of Water and Wastewater, APHA /AWWA, 20th Edition.
7. Venkata Mohan, S. et. al. (Editor) Biomass, Bio-fuels, Bio-chemicals : Circular Bio-economy: Technologies, Elsevier, 1st Ed., 2021

Course Name: Water and Liquid Waste Management					
Course Code: CHE3121					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

The objective of this course is to provide approaches of Domestic/ Industrial Water and Liquid Waste Management for interdisciplinary B Tech students. After completion of the course students will be able to:

CHE 3121.1 Identify the importance of Legislative orders prevalent in India concerning Water and Liquid Waste Management.

CHE 3121.2 Develop the methodology of Establishing and Operating Water and Liquid Waste intensive processes.

CHE 3121.3 Develop the knowledge base on various water conservation technologies.

CHE 3121.4 Understand the suitable parameters for wastewater treatment and their computation methodologies.

CHE 3121.5 Design the Drinking Water and Wastewater Treatment plants following the standard code of practice.

CHE 3121.6 Design the Liquid Waste Management Plan for selected process Industries.

Module I [10L]

Introduction to Water Quality and its Storage. Methodology of Water flow measurement; Classification and various Water and Wastewater Standards prevalent in India. Legislative aspects including Water Act. 1974 and its revisions; Consent to Establish and Consent to Operate water intensive industries; Water conservation methodologies in 1) Process industry, 2) Construction industry and 3) Service industry; Rainwater Harvesting and various recharge techniques. Principles of Water Audit.

Module II [10L]Water pollution:

Sources, sampling and classification of water pollutants, determination of basic parameters and computations associated with BOD, COD, TS, TDS, SS; Waste water treatment: primary, secondary, tertiary and advanced; aerobic treatment with special reference to activated sludge, trickling filter, RBDC and RBRC, EA;

Non-conventional:

WSP, anaerobic treatment with special reference to AFFR, UASB, numerical problems associated with all topics sited here.

Module III [10L]

Preliminaries of Water treatment processes;

Basic design consideration:

Pre-design, Raw water intake, Screening and aeration, Water conveyance, Coagulation, Flocculation and Precipitation, Sedimentation, filtration, colour, taste and odor control, Disinfections and fluoridation,

Water quality :

Physico Chemical and Bacteriological quality. Water Treatment Plant with design criteria: Slow

sand bed and Rapid sand bed filter, layout, Process control, Non conventional water treatment processes and its design, numerical problems associated with all topics sited here.

Module IV [10L]
Liquid Waste Management in selected process industries:
Fertilizer, refineries and petrochemical units, pulp and paper industries, Tanneries, Sugar industries, Dairy, Alcohol industries, electroplating and metal finishing industries, Root Zone and Reed Bed Treatment for Effluents of small scale industries, Ranking of wastewater treatment alternatives. Case Studies.

Text Books:

1. Wendell P. Ela, Gilbert M. Masters, Introduction to Environmental Engineering and Science, PHI, Ed 3rd Edition.
2. Metcalf & Eddy, Wastewater Engineering, Tata Mc-Graw Hill – 2002.
3. Arceivala S.J., Wastewater treatment for pollution control, TMH, 2nd Edition.
4. Montogomery, J.M., Water Treatment Principles and Design, John Willey and Sons.

Books of reference:

1. Mahajan, S.P., Pollution Control in Process Industries, Tata Mc Graw Hill, 2008.
2. Davis M., Cornwell, D, Introduction to Environmental Engineering, Tata Mc GrawHill, 2012.
3. Standard Methods for Examination of Water and Wastewater, APHA / AWWA, 20th Edition.
4. Manual of Water Supply and Treatment: CPHEEO, Ministry of Urban Development, Govt. of India, 1999.
5. Water Treatment Plant Design, 5th Edition: ASCE and AWWA, 1912.
6. Design of Water treatment Plant - Part I, A G Bhole, Indian Water Works Association.

Course Name: Plastic Waste Recycle and Management					
Course Code: CHE3122					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE 3122.1: Understand the Fundamentals of Plastic Recycling and Waste Management

CHE 3122.2: Analyze the Environmental and Economic Impacts of Plastic Waste.

CHE 3122.3: Design and Evaluate Plastic Recycling and Waste Management Systems.

CHE 3122.4: Apply Advanced Technologies and Strategies for Plastic Recycling and Waste Management

CHE 3122.5: Develop and Implement Effective Plastic Waste Management Policies and Regulations

CHE 3122.6: Communicate and Collaborate with Stakeholders on Plastic Recycling and Waste Management Issues

Module 1 [10L]

Fundamentals on Plastic recycling:

Introduction to Plastic Recycling; Types of Plastics and Their Recycling; concepts of reduce, reuse and recycle before examining plastic types; Mechanical Recycling of Plastics; Chemical Recycling of Plastics; Biological Recycling of Plastics; Plastic Recycling Equipment and Machinery; Quality Control in Plastic Recycling; Economic and Environmental Benefits of Plastic Recycling; Separation using recycling codes; Case Studies on Plastic Recycling; Describe recycling methods of following plastics – PVC, PET, PMMA, HDPE, LDPE, and Polystyrene.

Module II [10]

Primary recycling:

Non-degradable plastic, degradable and biodegradable plastics, biopolymers and bioplastics. explain the sources of waste and their routes into the environment, and provide systematic coverage of plastic waste treatment methods.

Equipment's for primary recycling. Specific recycling techniques – PE films, PP battery case – Crushing and separation – PET films. Recycling of plastics from urban waste – rheology, density, mechanical behavior. Secondary recycling Plastics wastes containing paper – hydrolytic treatment – processing methods – processing of mixed plastics waste – household waste – industrial sector. Microplastic – its impacts in the environment, source, and recovery and reuse.

Module III [10L]

Introduction to plastic waste management:

Indian context and Global Scenario Understanding global impact of plastic pollution; Statistics on plastic waste generation and its environmental consequences; Solutions & Strategies for Plastic Waste Management; Plastic waste generation: Sources, quantities, and composition; Effective waste segregation and collection methods; Composting options **for organic waste.**

Production of Gaseous and Liquid Fuels by Pyrolysis and Gasification of Plastics; Biodegradable plastic waste management.

Module IV [10L]

Plastic Waste Management Rule and its Guidelines & EPR:

Introduction guidelines on Extended Producer Responsibility (EPR) for plastic packaging. Mandatory guidelines to achieve set targets for EPR, recycling of plastic packaging waste, reuse of rigid plastic packaging, and the use of recycled plastic content. Responsibilities of local bodies, gram panchayats, waste generators, retailers, and street vendors to manage plastic waste.

Municipal Solid Waste (MSW) Handling and Challenges for the plastic waste; Toxicity of plastic waste in the environment; Plastic Waste Management Policies and Regulations.

Text Book/ Reference Book:

1. Plastic Waste and Recycling: Environmental Impact, Societal Issues, Prevention, and Solutions, Letcher Trevor M., Wiley, (2020), Academic press.
2. Plastic Waste Management: Methods and Applications, Kalim Deshmukh, Jyotish Kumar Parameswaran Pillai, Wiley, 2024.
3. Polymer Recycling: Science, Technology and Applications, By John Scheirs · 1998,

Course Name: Principles of Sustainable Engineering					
Course Code: CIV 3121					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:
After going through this course, the students will be able to:
CIV3121.1: Understand the relevance and concept of sustainability and reasons of unsustainability. [Understanding (LO)]
CIV3121.2: Examine the green building rating systems and its contribution to sustainability; recognize and communicate sustainability issues. [Applying (IO)]
CIV3121.3: Explain local and global environmental issues; relate the understanding of building materials and construction technique that are sustainable and energy efficient and interpret lifecycle report. [Applying (IO)]
CIV3121.4: Estimate the environmental and economic impacts of material and energy use. [Applying (IO)]
CIV3121.5: Differentiate between carbon emissions for regular and sustainable cities and explain different practices to move industries towards sustainability; discuss different renewable resources and explain methods to implement green technology. [Applying (IO)] CIV3222. 6. After completing this course, students should be able to grasp the burning issues of sustainability, propose and evaluate solutions for sustainable products and processes for industries in order to implement sustainable technologies. [Applying (IO)]

Module I [12 Hr]
Issues in sustainability: Principles of Sustainable Engineering: practices and principles. Economic development along with energy use and carbon emission, energy conservation and renewable energy, energy and construction. Environmental Ethics and Legislations Environmental ethics and education, multilateral environmental agreements and protocols, enforcement of environmental laws in India – The Water Act, The Air Act, The Environment Act.

Module II [12 Hr]
Sustainable Habitat Concept of green building, green building materials, green building certification and rating: green rating for integrated habitat assessment (GRIHA) , leadership in energy and environmental design (LEED) rating, energy efficient buildings, sustainable cities, sustainable transport, sustainable pavements, case studies in sustainability engineering: Green building, sustainable city, sustainable transport system.

Sustainable Industrialization and Urbanization – Sustainable urbanization, industrialization, material selection, pollution prevention, industrial ecology, industrial symbiosis, poverty reduction.

Module III [12 Hr]
Local Environmental Issues Solid waste, impact of solid waste on natural resources, zero waste concept and three R concept, waste to energy technology: thermo-chemical conversion, biochemical conversion. Global Environmental Issues Resource degradation: deterioration of

water resources, land degradation, air pollution, climate change and global warming, ozone layer depletion, carbon footprint, carbon trading. Life Cycle Assessment: Life Cycle assessment: Quantitative approach of decisions.

Module IV [12 Hr]
Renewable energy resources Conventional and non- conventional forms of energy, solar energy, fuel cells, wind energy, small hydro plants, biogas systems, biofuels, energy from ocean, geothermal energy, conservation of energy. Green Technology and Green Business Sustainable business, green technology, green energy, green construction, green transportation, green chemistry, green computing

Text Book:

1. Jason F. McLennan, The Philosophy of Sustainable Design, Ecotone Publishing co., 2004.
2. R. L. Rag and Lekshmi Dinachandran Remesh, Introduction to Sustainable Engineering, 2nd Edition, PHI Learning Pvt. Ltd., 2016.
3. Mike Montoya, Green Building Fundamental, Pearson, 2nd edition, 2010.

Reference Book:

1. D. T. Allen and D. R. Shonnard. Sustainability Engineering: Concepts, Design and Case Studies, 1st Edition, Prentice Hall, 2011.
2. A.S. Bradley, A. O. Adebayo, P.Maria. Engineering applications in sustainable design and development, 1st edition, Cengage Learning, 2016

Course Name: Introduction to Machine Learning					
Course Code: ECE 3122					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**0**	**3**

Course Outcomes:

After going through this course, the students will be able to:

ECE3122.1: Apply fundamental engineering knowledge for analyzing data in a given feature space.

ECE3122.2: Explain the fundamental concepts of different Machine learning models and can evaluate a machine learning problem.

ECE3122.3: Apply machine learning techniques for classification and regression approaches in real-world applications.

ECE3122.4: Distinguish between supervised and unsupervised learning and able to apply machine learning tools for clustering approaches.

ECE3122.5: Analyze a machine learning problem with ensemble and reinforcement learning techniques.

ECE3122.6: Understand different techniques to create application using deep learning algorithms.

Introduction to Machine Learning:

Module I [9L]

Introduction: Foundations for ML: What is Machine Learning, Examples of Various Learning Paradigms, Perspectives and Issues, Version Spaces and Candidate Elimination Algorithm, Data Normalization, Feature Reduction/Dimensionality reduction, Validation Techniques (Cross Validations), Bias-Variance Trade-off.

Module II [11L]

Supervised Learning: Classification: Learning from Examples, Linear, Non-linear, Multi-class and Multi-label classification, Regression and Classification Trees, Decision tree, Naïve Bayes, k-Nearest Neighbor. Support vector machines: Linear and Non-Linear, Kernel Functions. Artificial neural networks: Introduction, Introduction, Perceptron, Multilayer Perceptron, Back propagation algorithm Regression: Ordinary Least Squares, Linear Regression, Multiple Linear Regression: Ridge Regression, Lasso Regression, Non-Linear Regression: Logistic Regression.

Module III [7L]

Unsupervised Learning: Introduction to clustering, A Categorization of Major Clustering Methods, Partitioning Methods, Density-Based Methods, Grid-Based Methods, Model-Based Clustering Methods, Hierarchical: AGNES, DIANA, Partitional: K-means clustering, Self-Organizing Map, Expectation Maximization, Gaussian Mixture Models.

Module IV [8L]

Feature Selection and Dimensionality Reduction: Principal Components Analysis (PCA), Independent Component Analysis (ICA), and Linear Discriminate Analysis (LDA).

Ensemble Learning: Ensemble Learning Model Combination Schemes, Voting, Error Correcting Output Codes, Bagging: Random Forest Trees, Boosting: Adaboost. Reinforcement Learning: Introduction to reinforcement learning, Learning Framework and Markov Decision Process with some examples. Deep Learning: Auto encoder, Convolutional Neural Networks, Recurrent Neural Networks- with some real life examples.

Text Book:

1. Ethem Alpaydin, 'Introduction to Machine Learning", MITPress, Prentice Hall of India.
2. R.O. Duda, P.E. Hart, and D. G. Stork," Pattern Classification" ,John Wiley. M. Bishop, "Pattern Recognition and Machine Learning", Springer."The Elements of Statistical Learning" y Jerome H. Friedman, Robert Tibshirani, and Trevor Hastie.
3. Andreas C. Mueller ,Sarah Guido , "Introduction to Machine Learning with Python: A Guide for Data Scientists" ,O'Reilly. 6) Sebastian Raschka, "Python Machine Learning".

Reference Book:

1. T.M. Mitchell, "Machine Learning", McGraw Hill Education.
2. Murphy, Kevin, "Machine learning: probabilistic perspective", MITpress. Stuart Russell, and Peter Norvig, "Artificial intelligence: a modern approach", Prentice Hall.
3. "Deep Learning "byIan Goodfellow, Yoshua Bengio, Aaron Courville.
4. Richard S. Sutton and Andrew G. Barto, "Reinforcement learning: An introduction", Second Edition, MITPress.

Course Name: Introduction to MEMS					
Course Code: AEI3121					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After going through this course, the students will be able to:

AEI3121.1: Familiarise with working principles of MEMS devices.

AEI3121.2: Identify the fabrication procedure like deposition, lithography and etching.

AEI3121.3: Understand the issues related to deposition and etching.

AEI3121.4: Select the materials related to different types of micro sensors and actuators.

AEI3121.5: Learn different types of micro-manufacturing techniques.

AEI3121.6: Acquire knowledge regarding wafer bonding and FEM.

Module I [12L]

Introduction and Historical Background of MEMS, Scaling Laws – Scaling in geometry. Concepts of sensing and actuation: Electrostatic sensing and actuation-parallel plate capacitor – Application-Inertial, pressure and tactile sensor; parallel plate actuator- comb drive. Thermal sensing and Actuations-thermal sensors – Actuators – Applications - Inertial, Flow and Infrared sensors. Piezoresistive sensors- piezoresistive sensor material- stress in flexural cantilever and membrane Application-Inertial, pressure, flow and tactile sensor.

Module II [8L]

Basic MEMS fabrication modules: Different types of Deposition Techniques, Oxidation, Ion implantation, CVD, PVD, Photo Lithography and Dry and wet Etching. Reactive Ion Etching. Isotropic Etching and Anisotropic Etching.

Module III [9L]

Materials for MEMS and Microsystems: Overview of Semiconductors, Silicon as a MEMS material – mechanical properties of silicon; Mechanical components in MEMS; Introduction to MEMS and MOEMS materials: Detailed overview of Poly Silicon, Quratz, SiO2, SiC, GaAs etc. Piezoelectric sensing and actuation- piezoelectric material properties-quartz.

Module IV [8L]

Micromachining: Bulk Micromachining and Surface Micromachining, Issues related to Bulk and surface micro-manufacturing. Introduction to LIGA process. Concept of Wafer Bonding. Overview of Finite Element Method, Modeling of Coupled Electromechanical Systems.

Text Book/ Reference Book:

1. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalkrishnan K. N. Bhat, V. K. Aatre, Micro and Smart Systems, Wiley India, 2012.
2. S. E. L. Yshevski, Nano-and Micro-Electromechanical systems: Fundamentals of Nano- and Microengineering (Vol. 8). CRC press, (2005).
3. S. D. Senturia, Microsystem Design, Kluwer Academic Publishers, 2001.

4. M. Madou, Fundamentals of Microfabrication, CRC Press, 1997.
5. G. Kovacs, Micromachined Transducers Sourcebook, McGraw-Hill, Boston, 1998.
6. M. H. Bao, Micromechanical Transducers: Pressure sensors, accelerometers, and Gyroscopes, Elsevier, New York, 2000.

LABORATORY

Course Name: Numerical Computation Laboratory					
Course Code: CHE3151					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:

After completion of the course the students will be able to

CHE3151.1: Formulate the logic for the chosen numerical method to solve a chemical engineering problem.

CHE3151.2: Write MATLAB/OCTAVE code to apply the logic of the algorithm

CHE3151.3: Acquireskillsto debug MATLAB/OCTAVE code forsyntaxerror.

CHE3151.4: Acquireskillstotroubleshoot codeto obtainappropriate solutions of the physical problem.

CHE3151.5 : Acquire skills to make code modular through the help of function statements.

CHE3151.6: Acquireskillstographicallydepictsolutions to the problem.

Programmes on Numerical Computations (Tool for programming: MATLAB):

1. Basic MATLAB programming on matrix operations (multiplications, divisions, addition, subtraction, transpose, determinant). Programming on loop and conditional blocks.
2. Solution of Linear System by Gauss Elimination method: Steady state solution of isothermal CSTR in Series in which a first-order reaction is taking place.
3. Solution of Linear System by Gauss-Seidel iterative method: Steady state solution of isothermal CSTR in Series in which a first-order reaction is taking place.
4. Solution of a non-linear equation by Newton-Raphson method.
5. Evaluation of any intermediate value for a continuous function using Lagrangian interpolation scheme.
6. Solution to find the volume of a PFR for a first order steady state isothermal reaction using Simpson's $1/3^{rd}$ rule for integration.
7. Numerical solution of ODEs by Euler's method: Unsteady-state solution of multiple reactions in a CSTR or Binary distillation column.
8. Numerical solution of ODEs by 4^{th} order Runge-Kutta method: Unsteady-state solution of multiple reactions in a CSTR or Binary distillation column.
9. Solution of one-dimensional unsteady state heat conduction problem using Taylor series based Finite Difference Method – Implicit scheme using Tri-diagonal Matrix Algorithm (TDMA).

Text Book:

1. Pratap R., Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Oxford, 2010.

Book of reference:

1. Al-Malah, K. MATLAB Numerical Methods with Chemical Engineering Applications, 1^{st} Edition, McGraw-Hill Education, 2013.

Course Name: Chemical Reaction Engineering Laboratory					
Course Code: CHE3152					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:

After completion of the course students will be able to:

CHE 3152.1 Determine the rate constant and activation energy as well as the effect of temperature on rate constant in an isothermal CSTR for a non-catalytic homogenous reaction.

CHE 3152.2 Analyze a non catalytic reaction in an isothermal semi batch reactor and determine the rate constant.

CHE 3152.3 Compute the rate constant for a non-catalytic homogenous reaction in PFR (coiled type) at ambient condition.

CHE 3152.4 Estimate the rate constant for a non-catalytic homogeneous reaction in a packed bed reactor at ambient condition.

CHE 3152.5 Analyze photo catalytic oxidation reaction in a UV annular reactor and determine the rate constant for a heterogeneous catalytic reaction.

At least eight experiments are to be performed

1. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in an isothermal high pressure and/or atmospheric batch reactor.
2. Experimental studies on kinetics of a homogeneous liquid phase reaction in an isothermal semi-batch reactor.
3. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in a Spiral plug flow reactor.
4. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in an isothermal CSTR.
5. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in a packed bed reactor.
6. Experimental studies on RTD in a tubular PFR using pulse input of tracer and measurement of axial dispersion coefficient.
7. Experimental studies on kinetics of a heterogeneous catalytic reaction in a UV photoreactor.
8. Experimental studies on RTD in a packed bed reactor using pulse input of tracer and measurement of axial dispersion coefficient.
9. Experimental studies on kinetics of hydrolysis of ethyl acetate in presence of acid catalyst in an adiabatic batch reactor.
10. Experimental studies on kinetics of sulfonation of toluene in an isothermal batch reactor.

Text Books:

1. Fogler H. S. Elements of Chemical Reaction Engineering, 4th. Edition, Prentice Hall, 2006
2. Levenspiel O. Chemical Reaction Engineering, 2nd. & 3rd. editions, Wiley Eastern Ltd. 1987.

Books of reference:

1. Rawlings J. B. and Ekerdt J. G. Chemical Reactor Analysis and Design Fundamentals, Nob Hill Publishing, 2002.
2. Smith J.M. Chemical Engineering Kinetics, 3rd. Edition, MGH, 1956.
3. Hill C.G. Chemical Engineering Kinetics and Reactor Design, Wiley, 2014.
4. Schmidt L. D. The Engineering of Chemical Reactions, 2nd. Edition, Oxford, 2007.
5. Berty J. N. Experiments in Catalytic Reaction Engineering, Elsevier, 1989.

Course Name: Energy Laboratory					
Course Code: CHE3153					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

After completion of the course students will be able to:

CHE 3153.1: Perform analysis of solid, liquid and gaseous fuel and non-conventional energy source.

CHE 3153.2: Determine important properties including carbon residue, aniline point of fuel oil.

CHE 3153.3: Determine flash point, fire point and kinematic viscosity of oil using appropriate apparatus.

CHE 3153.4: Determine calorific values of solid, liquid and gaseous fuel using suitable apparatus.

CHE 3153.5: Determine vapour pressure of petroleum product and perform atmospheric distillation of petroleum product in suitable equipment.

At least eight experiments are to be performed: Theoretical basis for the experiment will be discussed in detail before each experiment starts.

1. Proximate analysis of Coal.
2. Determination of carbon residue of fuel oil.
3. Determination of aniline point of a fuel oil.
4. Determination of moisture content of fuel oil by Dean & Stark apparatus.
5. Atmospheric Distillation of a petroleum product.
6. Determination of Flash Point & Fire Point of an oil by Abel apparatus.
7. Determination of Flash Point & Fire Point of oil by closed-cup Pensky Marten apparatus.
8. Determination of kinematic viscosity of oil by Redwood Viscometer.
9. Determination of calorific value of gaseous fuel by Junker's apparatus.
10. Determination of calorific value of solid and liquid fuel by Bomb Calorimeter.

Books of reference:

1. Sarkar S. Fuels and Combustion, Universities Press, 3rd Edition, 2009.
2. Gupta O.P. Elements of Fuels, Furnaces and Refractories, Khanna publishers, 1989.

3rdYear 2ndSemester (Semester6)

THEORY

Subject Name: Process Control and Instrumentation in Chemical Industries					
Paper Code: CHE3201					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**CREDIT s**
	3	1	0	4	4

Course Outcomes:

After completion of the course, students will be able to:

CHE 3201.1 Develop models of simple chemical processes, understand the dynamic and static behavior of the processes.

CHE 3201.2 Understand the functions of different types of controllers and perform stability analysis and controller tuning.

CHE 3201.3 Analyze and suggest the type of controller necessary for a particular industrial application.

CHE 3201.4 Acquire knowledge on advanced control systems and design of control system for multivariable processes.

CHE 3201.5 Understand the working principles of different measuring elements, control valves.

CHE 3201.6 Develop basic concepts on process flow diagram and piping and instrumentation diagrams of chemical process plants.

Module I [10L] Introductory concept:

Introduction to process dynamics and control: need for control and automation in chemical industries, classification of variables, general modeling principles: input output models, lumped and distributed parameter systems, steady state and dynamic behavior, concept of linearity and deviation variables, introduction to different forcing functions, transfer functions of single input, single output processes (SISO), transfer functions of multiple input multiple output (MIMO) processes, dynamic response of first and second order systems to different forcing functions, concept of damping, pure capacitive, pure dead time processes, first order plus dead time process, Padé approximation, interacting and non-interacting processes.

Module II [10L]

Case studies of simple process models:

Stirred tank heater, continuous stirred tank reactor, distillation column, U-tube manometer Introduction to feedback control, servo and regulatory problem concept, P, PI, PD, PID, on-off controllers and their transfer function, concept of open loop and closed loop transfer function, characteristic equation, Routh-Hurwitz criteria, root-locus analysis, frequency response analysis and their applications: Bode plot, Bode stability criteria, Cohen Coon and Ziegler Nichols controller tuning.

Module III [10L]

Alarm and trip system, advanced control systems: cascade, feed forward, ratio control, programmable logic control, distributed control, sequential logic control, internal model control, supervisory control and data acquisition etc, Design of control system for multivariable processes, case studies on control operations of reactor, separator units, flash drums, interaction of control loops, fuzzy logic controllers, control loop configuration of integrated chemical plant.

Module IV [10L]

Measuring instruments (sensors) and final control elements (actuators):

Principles of measurement, error analysis, static and dynamic characteristics of instruments.

Final control elements/Actuators:

Different types of control valves, characteristic curve and transfer function, applications.

Measuring instruments/sensors:

Temperature, pressure, flow, viscosity, composition measuring instruments, smoke and chemical sensors and their applications.

Concepts on process flow diagram, Piping and instrumentation diagram.

Text Books:

1. Coughanowr D.R. Process system analysis and control, Tata McGraw-Hill, Inc., 2nd edition, 1991
2. Stephanopoulos G. Chemical Process Control: An Introduction to Theory and Practice—pHI Learning Pvt. Ltd., 1st edition, 1984
3. Eckman D.P. Industrial Instrumentation, Wiley Eastern Ltd., 1st edition, 2004.
4. Fundamentals of industrial instrumentation and process control, William C. Dunn, Mc-Graw Hill, 2005
5. Designing control for the process industries, Wayne Seames, Taylor Francis, 2018.

Books of reference:

1. Patrnabais D. Principles of Industrial Instrumentation, Tata McGraw Hill, Publishing Ltd., 1st edition, 1999.
2. Seborg D.E., Edgar T.F., & Mellichamp D.A. Process Dynamics and Control, John Wiley and Sons, 2nd edition, 2004.
3. Fribance A.E. Industrial Instrumentation Fundamentals, McGraw-Hill, Kogakusha, 1962.
4. Bequette B.W. Process Control Modelling, Design and Simulation, Prentice Hall, 1957.
5. Luyben W.L. Process Modelling, Simulation and Control for Chemical Engineers, McGraw Hill.

Course Name: Mass Transfer II					
Course Code: CHE3202					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	2	**1**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE 3202.1: Analyze various humidification, dehumidification processes and will be able to design cooling towers.

CHE 3202.2: Analyze commercial extraction and leaching operation and determine number of equilibrium stages required for a given separation.

CHE 3202.3: Understand mechanism of drying, calculate drying time for batch dryers and compute rate of drying in batch and continuous modes of drying operation.

CHE3202.4: Develop concepts on crystal properties, kinetics and thermodynamics associated with crystallization process, and design the crystallization equipments.

CHE 3202.5: Classify membrane separation processes based on driving forces, understand their applications and develop ideas on some of these processes and their applications in industries.

CHE 3202.6: Apply the concepts of membrane separation processes in real time applications, namely, designing of ultrafiltration, dialysis, reverse osmosis units for treatment and purification purposes.

Module I [10L]

Humidification and Dehumidification:

Introduction, terminology and definitions, dry and wet-bulb thermometry, adiabatic saturation curve, the psychrometric chart and its use, psychrometric line & Lewis relation, recirculating liquid gas humidification-cooling, dehumidification of gas.

Cooling Tower:

Introduction, classification of cooling tower, construction and operation, theory of counter flow cooling towers, design of cooling tower, make up water requirement.

Module II [10L]

Liquid- Liquid Extraction:

Introduction, liquid-liquid equilibria, ternary diagram, selectivity, distribution coefficient, choice of solvent, stage wise extraction, single stage, multistage extraction – cross current counter current, determination of number of equilibrium stages by graphical method, differential extractor, super critical fluid extraction.

Leaching:

Introduction to leaching, factors affecting leaching operation, leaching equipment, batch process, continuous multistage processes- calculation of number of stages, constant / variable underflow.

Module III [10L]

Drying:

Introduction to drying, mechanism of drying and drying equilibria; drying rate curve, rate of drying for batch dryers, rate of drying for continuous dryers, drying time calculation from drying

rate curve, through and cross-circulation drying, classification and selection of dryer, novel drying technologies, industrial applications.

Crystallization:
Introduction to crystallization, solid-liquid phase equilibria, crystallization kinetics, crystal properties, crystallization technology, crystallization equipments, design of crystallizer, industrial applications

Module IV [10L]
Overview of membrane separation:
Classification of membrane separation processes, types of membranes and their applications, various models and applications, membrane fouling.
Membrane separation processes:
Ultrafiltration, dialysis, reverse osmosis, reverse osmosis in water treatment plant, pervaporation, electric field enhanced membrane separation, micellar enhanced ultrafiltration, liquid membrane

Text Books:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill, International Edition, 1981.
2. Dutta B.K., Principles of Mass Transfer and Separation Processes, Prentice Hall of India, 2007.
3. Geankoplis C.J., Transport processes and Separation Process Principles, Prentice Hall of India, Fourth Edition, 2004.

Books of reference:

1. Coulson J.M., Richardson J.F. Chemical Engineering Vol. 2, Elsevier Science, 5th Edition, 2002
2. McCabe W.L., Smith J.C., Harriott P. Unit Operations in Chemical Engineering, McGraw-Hill Education, 7th Edition, 2005.
3. King C.J. Separation Processes, Dover Publications, Inc., 2nd Edition, 2013.
4. Seader J.D., Henley E.J., Roper D.K., Separation Process Principles, John Wiley Inc., 3rd Edition, 2010.
5. Rosseau R.W., Handbook of Separation Process Technology, Wiley India Pvt. Ltd., 2009.
6. Wankat P.C., Separation Process Engineering, Prentice Hall, 2nd edition, 2010.

Course Name: Bioprocess Engineering					
Course Code: CHE3231					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

The objective of this course is to provide basic approaches pertaining to Bio-chemical Engineering and Bio-Separation Technology to B. Tech students of Chemical Engineering. After completion of the course students will be able to:

CHE 3231.1: Solve biochemical reaction engineering problems for predicting rate equation for enzymatic fermentation process.

CHE 3231.2: Design bioreactors for free enzymatic reaction under enzyme uninhibited/inhibited conditions.

CHE 3231.3: Understand fundamental metabolic pathways of microorganisms and apply microbial growth rate equations for designing fermenters/bioreactors for whole cell catalyzed reactions.

CHE3231.4: Develop the concepts of aeration and agitation, sterilization, bioreactor control, enzyme and cell immobilization, and their applications in biochemical reactions.

CHE 3231.5: Select suitable bioreactor and its design and scale up for whole cell catalysed reactions.

CHE 3231.6: Choose suitable modern separation techniques for isolation, purification and quantitative separation of target biomolecule from live cells and gain an understanding on microorganism catalyzed industrial processes.

Module I [10L]

Principles of enzyme catalysis Proteins as enzymes; Michaelis- Menten kinetics; Briggs Haldane theory Kinetics and Statistics; Inhibition; Effect of pH and temperature; Enzymology; methods of immobilization, diffusional limitations in immobilized enzyme systems.

Module II [10L]

Microbial growth Introduction to metabolism; Nutrient transport; Glycolysis; TCA cycle and other pathways; Control of metabolism; Factors affecting microbial growth; Stoichiometry: mass balances; Stoichiometry: energy balances; Growth kinetics; Measurement of growth.

Agitation and aeration:

Types of impellors and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (kLa), measurement of kLa, power requirement for agitation in gaseous and non gaseous systems.

Module III [10L]

Bioreactors Introduction to bioreactors; Batch and Fed-batch bioreactors, Continuous bioreactors; Immobilized cells; Bioreactor operation; Sterilization; Aeration; Sensors; Instrumentation and control; Culture-specific design aspects: plant/mammalian cell culture reactors.

Operation and control of bioreactors:
Concepts of various bioreactor configurations, scale-up, various criteria for scale-up, scale-down.

Module IV [10L]
Bio-separations,Biomass removal; Biomass disruption;
Membrane-based techniques:
Membrane Modules and quantification techniques to assess their performances;
Extraction; Adsorption and Chromatography. Industrial Processes and Process economics Description of industrial processes;

Text Books:

1. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002.
2. Coulson & Richardson, Chemical Engineering, Vol-2, Butterworth Heinemann, 5th Edition, 2002.

Books of reference:

1. Pauline Doran, Bioprocess engineering principles, 1 Edition, Academic Press, 1995.
2. Biochemical Engineering, Marcel Dekkar, Inc, 2007.
3. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.

Course Name: Petrochemical Technology					
Course Code: CHE3232					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE 3232.1: Classify the variety of petrochemical feed stocks, petroleum refinery products and categorizes the synthesis gas productions feed stocks.

CHE 3232.2: Understand different flow sheets and select the appropriate technologies to maximize fuel yield and quality.

CHE 3232.3: Identify the suitable technologies to get cleaner products and demonstrate the various applications of products.

CHE 3232.4: Understand the requirement of different secondary operation and demonstrate the appropriate technologies to meet the demand of petroleum products.

CHE 3232.5: Classify the catalytic reforming operation and select the appropriate technologies to obtain the lighter petroleum product from heavier feed.

CHE 3232.6: Compare and contrast major polymerization processes in industry and describe various process technologies for fibers, elastomers and resins etc.

Module I [10L]

Evolution of petrochemical industry in India, recent trend of petrochemical industry in India,

Petrochemical industry feedstock:

Overview of petroleum refinery industry and its product, natural gas processing; impurities in feedstock for petrochemical industry and the process of their removal.

Synthesis gas production and its use:

Steam reforming operation of Naphtha and natural gas, fuel oil partial oxidation method, Methanol production, synthetic liquid fuel production by Fischer Tropsch process, aldehyde and alcohol production from synthesis gas, ammonia production and its application.

Module II [10L]

Steam cracking operation of naphtha and C_2 to C_4 saturates, downstream separation scheme of naphtha cracking.

Manufacture of Petrochemicals based on Ethylene:

EDC, VCM, VAM, Ethylene oxide, Ethanol amine;

Manufacture of Petrochemicals based on Propylene:

Acrylonitrile, Acrolein, Propylene oxide, glycerine (acrolein route, allyl chloride route, propylene oxide route), Isopropanol ;

Production of Butadiene from C_4 cut.

Module III [10L]

Catalytic reforming of naphtha, catalyst and process variable of BTX reformer, separation of Benzene, Toluene and Xylene from BTX reformate, pyrolysis gasoline hydrogenation and separation of aromatics, separation of meta xylene from mixed xylenes, alkylation of benzene,

production of styrene, cumene and phenol, production of Phthalic anhydride. Synthetic detergent and its classification, production of linear alkyl beanzene and keryl benzene sulfonate from kerosene cut, additives for detergent.

Module IV [10L]
Overview of plastic industry:
Production of LDPE, LLDPE, HDPE, PP, PVC, Polystyrene and their application. Comparative study of Plastic, fibre and elastomer; production of SBR, Butadiene rubber, production of ABS plastic, polyamide, polyester, acrylic fibre, polycarbonates, production of phenol-formaldehyde resin; overview of polymer processing.

Text Books:

1. A Text on Petrochemicals: B.K.B. Rao, Khanna Publishers, 2011, ISBN 9788174090447 / 8174090444.
2. Advanced Petrochemicals: Dr. G. N. Sarkar, Khanna Publishers,2008, ISBN8174090967.
3. Introduction to Petrochemicals, Sukumar Maity. Oxford and IBH Publishing Co, 2002 ISBN 8120415558.

Books of reference:

1. The Petroleum chemicals Industry: R. F. Goldstein and A. L. Waddams, E & F N Spon (An imprint of Routledge), 1967, ISBN 0419025308.
2. Petrochemical processes: Chauvel, Gulf Publishing Co, 1989, ISBN 0872017729.

Course Name: Fluidization Engineering					
Course Code: CHE3241					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE 3241.1: Identify different applications of fluidized bed and understand operation procedure of fluidized bed.

CHE 3241.1: Categorize different particles along with particle to gas - mass and heat transfer under fluidized condition.

CHE 3241.2: Identify fluidization regime and evaluate pressure drop across the bed.

CHE 3241.3: Construct distributor arrangement in fluidized bed

CHE 3241.4: Evaluate bed properties at different gas and bubble flow conditions.

CHE 3241.5: Understand the entrainment in fluidized bed and effect of different parameters on entrainment.

Module I [10L]

Fluidiztion phenomenon; Comparison with other contacting methods; Advantages and disadvantages of fluidized beds. Industrial applications of fluidized beds: Coal gasification; FCCU; Fluidized combustion of coal; Activation of carbon; Particle size distribution; Zeta potential; Sphericity; Effect of particle size on fluidization quality.

Module II [10L]

classification, Geldart classification; drag coefficient; Terminal velocity; Particle-fluid interaction; Fluidization regime; Frictional pressure drop in bed-fluid-solid; Frictional pressure drop in fluidized bed-gas-liquid-solid system; Models of frictional pressure drop in fluidized bed.

Module III [10L]

Different types of distributors; Gas entry region analysis; Penetration length calculation for gas jets in fluidized bed; Pressure drop requirements across distributor; Criterion for stable operation; Interactions of bubbles with small, fine and large particles; Mixing and solid movement in fluidized bed; Estimation of bed properties – bubble gas flow, bubble size and growth, bubble size correlation, bubble rise velocity; Davison model for gas flow at bubbles.

Module IV [10L]

Entrainment – freeboard, transport disengaging height (TDH), saturation carrying capacity, elutriation; Effect of gas velocity, solid velocity, viscosity of fluid, density of solid, particle and bubble characteristics, pressure, temperature, bed properties on entrainment; Estimation of TDH; Freeboard-entrainment model; Concept of fast fluidization; Particle-to-gas mass transfer and heat transfer under fluidized bed condition.

Text Books:

1. Kunii and O. Levenspiel, Fluidization Engineering, 2nd ed., Butterworth-Heinemann, London, 1999.

Books of reference:

1. L.G. Gibilaro, Fluidization Dynamics, 1st Edition, Butterworth – Heinemann, 2001.

Course Name: Nanotechnology					
Course Code: CHE3242					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE3242.1: Identify and explain the underlying physics contributing to the special property of materials in reducing from macro to nano-dimension.

CHE3242.2: Understand the synthesis process and equipment used in the fabrication of 1D, 2D and 3D nanostructures.

CHE3242.3: Identify and explain the principles and process for building hetero structures using organic, inorganic or biological entities.

CHE3242.4: Understand the instruments used for characterizing measuring specific structure and properties of nano-material and explain the measurement data.

CHE3242.5: Understand various forms of lithography to create patterned arrays of nanostructures.

CHE3242.6: Understandthe properties, synthesis and applications of special materials used in nanotechnology.

Module I [10L]

Introduction:

Introduction to nano dimensions and nano materials;

Structure of Solids:

Imperfections in Crystal Structure, Relations between surface properties and imperfections, Relations between surface properties and thermal/mechanical properties, Wave diffraction, Lattice vibration, energy bands, semi conductors types with energy bands; Introductory concepts of Density of States and Quantum Well, Potential Well; Bohr radius, band gaps and quantum confinement effects; Quantum tunneling effect; Excitons and Plasmons; Super paramagnetism; Mechanical, Optical, electronic and Magnetic property changes due to sizereduction.

Module II [10L]

Nano-Synthesis:

Solid Synthesis :

Mechanical, thermal and laser processing, sputtering, arc-discharge.

Liquid Synthesis:

electrochemical etching, sol-gel process, colloidal process; micro emulsion process, Langmuir-Blodgett Process.

Gas Phase and Hybrid Synthesis:

Physical and Chemical Vapor Deposition, Molecular beam epitaxy; plasma enhanced process

Biological Synthesis:

Plant-based synthesis, fungi and bacteria based methods; Synthesis using biological templates e.g. s-layers, ferritin etc.; concept of self-assembly, alkanethiol-bond and synthesis using DNA.

Module III [10L]

Instruments and Characterization:

Principles and uses of Optical microscope, confocal microscope; electron microscope, Transmission electron microscope; Principles and uses of different types scanning probe microscope; Principles and use of Atomic Force Microscope; Principles and uses of X-ray diffractometer ; Principles and uses of UV-Vis-NIR Spectroscope ; X-ray spectrometer; Elements of FTIR and Raman spectroscopy ;Principles and uses of Auger electron microscope.

Module IV [10L]

Nano-Lithography, Applications of Nanomaterials:

Introduction to photolithography:

Principles and applications; Ebeam / Ion and X ray Lithography - principles and applications;

Nanolithography:

Types, principles and applications;

Soft Lithography:

Types, principles and applications;

Nanomaterials:

Synthesis and applications of various nano materials e.g. carbon nano tubes, porous silicon, aerogel, cryogel, coreshell nanoparticle and others.

Text Book:

1. Sulabh K. Kulkarni, NANOTECHNOLOGY: Principles &Practices ;Springer International Publishing,2015.
2. Daniel L. Schodek, Michael F. Ashby, Paulo Ferreira , Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects, Butterworth-Heinemann Ltd (2 June 2009)

Books of reference:

1. Reference Material Handout in Class.

Course Name: Fuel Cell Technology					
Course Code: CHE3221					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE3221.1: Analyze the fundamentals of electrochemistry, thermodynamics, heat and mass transferfor the design of fuel cells components and fuel cell systems.

CHE3221.2: Categorize the fuel cell technology and compare different types of fuel cell systems.

CHE3221.3: Determine the various losses in fuel cells and analyze the fuel cell power plant and sub systems.

CHE3221.4: Determine the significance of fuel cell technology as compared to global energy scenario.

CHE3221.5: Analyze the important of hydrogen-based energy generation system.

CHE3221.6: Estimate the knowledge on the application of fuel cell in various portable, domestic and agricultural sectors.

Module I [10L]

Fundamentals of Fuel Cell:

Introduction to fuel cell and its important, classification of fuel cells, thermodynamic efficiency and comparison with Carnot efficiency.

Electromotive force of fuel cells:

Standard electrode potentials; effect of concentration; Nernst equation, over potential, Taffel plot.

Fuel Cell Components:

Types of electrodes and their role in fuel cell, synthesis process of electrode and active catalyst, surface reactions; oxygen electrodes; hydrogen electrodes. Role of bipolar plates, gas diffusion layers, proton exchange membrane.

Module II [10L]

Low temperature fuel cells:

Important of low temperature fuel cell,Hydrogen–oxygen fuel cells, methanol fuel cells, hydrocarbon fuel cell etc.

High temperature fuel cells:

Advantagesand disadvantages; Molten electrolyte fuel cell; Solid electrolyte fuel cell; Construction. Other non-hydrogen fuel cells.

Water and Heat management:

Heat and water management in the single cell and fuel cell stack, construction and design; limiting problems.

Polarization:

Description of Polarization curve- Activation loss, Ohmic loss, and Mass transport loss, power curve.

Module III [10L]

Hydrogen Energy:

Introduction to hydrogen economy, production, storage and transportation systems, hydrogen from fossil fuels, electrolysis of water,thermoschemical cycles, transmission and infrastructure requirements, safety and environmental impacts, economics of transition to hydrogen systems, regenerative fuel cell.

Fuel Cell Design and Performance:

Stoichiometric coefficients and utilization percentages of fuels and oxygen, mass flow rate calculation for fuel and oxygen in single cell and fuel cell stack, total voltage and current for fuel cells in parallel and serial connection.

Module IV [10L]

Application of fuel cell systems:

Large scale power generation; Power plant for vehicles; Domestic power; Fuel cells in space.Fuel cell economics; Future trends in fuel cells, life cycle analysis, US-DoE target.

Text Books:

1. Basu S., (Ed.), Recent Trends in Fuel Cell Science and Technology, 2007.
2. Kordesch, K.; Simader, G. FuelCells and Their Applications. VCH: 1996.

Book of reference:

1. Fuel Cell Handbook (Seventh Edition), EG&G Technical Services Inc., Eg&g Technical Services Inc, U. S. Department of Energy, 2016.
2. Liu, H., Principles of fuel cells, Taylor & Francis, N.Y., 2006.
3. Bard, A. J., L. R., Faulkner, Electrochemical Methods, Wiley, N.Y, 2004.

Course Name: Energy Transition with Hydrogen					
Course Code: CHE3222					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Prerequisites: Chemical Reaction Engineering, Physics, Chemistry

Course Outcomes:
The objective of this course is to provide an idea about the fabrication technology of thin film devices installed for different applications. After completion of the course students will be able to:
CHE3222.1: Analyze the Global Hydrogen supply-demand characteristics.
CHE3222.2: Identify hazards associated with Hydrogen and suggest safe transport and storage solutions.
CHE3222.3: Device efficient production and purification systems for Hydrogen.
CHE3222.4: Determine the various fuel cell losses and suggest application methodologies for fuel cells in various sectors.
CHE3222.5: Design integrated systems combining Hydrogen and Renewable energy systems according to latest policies.
CHE3222.6: Perform cost analysis and market research for Hydrogen-based systems.

Module I [10L]
Introduction to Hydrogen economy:
Classification of Hydrogen (Grey, Blue, Green etc.); Properties of Hydrogen as a fuel; Physical and Chemical properties, Transport properties; Current status of Hydrogen as a fuel globally; Global Supply-demand characteristics of Hydrogen.
Limitations to Hydrogen as a fuel:
Brief idea about the storage and transportation problems associated with Hydrogen; Hazards associated with Hydrogen – their classification; Compressed and Liquid Hydrogen related hazards.

Module II [10L]
Hydrogen Production Processes:
Hydrogen from Hydrocarbons – Steam reforming, Methane decomposition, Partial Oxidation.
Hydrogen from Biomass – Gasification and Pyrolysis.
Hydrogen from Water – Thermochemical water splitting; Electrolysis of water; Water electrolyser operation; Photoelectrochemical Hydrogen production; Use of renewable energy for Hydrogen production.

Hydrogen Separation and Purification:
Membrane Separation; Cryogenic Separation; Solvent absorption techniques.

Module III [10L]
Hydrogen Applications and Utilization:
Hydrogen Fuel Cells: Principles of fuel cell operation, Fuel cell types and applications, Hydrogen Internal Combustion Engines, Hydrogen engine operation and performance,

Emissions, and efficiency.
Hydrogen Transportation and Mobility: Hydrogen fuel cell electric vehicles, Hydrogen internal combustion engine vehicles, hydrogen powered train.

Module IV [10L]
Hydrogen System Design and Integration: Hydrogen system design and layout, Integration with renewable energy sources.
Energy Transition and Policy Analysis: Energy transition scenarios and pathways, Policy analysis and recommendation.
Hydrogen Storage: Storage technologies (compressed, liquid, and materials-based).
Hydrogen Energy Policy and Regulations: Overview of hydrogen energy policy and regulations, International and national frameworks.
Hydrogen Energy Economics and Business: Hydrogen energy economics and cost analysis, Business models and market analysis.

Text Books:

3. Gupta, R. B., Hydrogen Fuel: Production, Transport and Storage, CRC Press, Taylor & Francis Group, 2009.
4. Agata Godula-Jopek, Hydrogen Production by Electrolysis, Wiley-VCH, Germany, 2015.
5. Design of Hydrogen Energy Systems" by S.A. Sherif, et al., CRC Press, 2019.

Book of reference:

1. Fuel Cell Handbook (Seventh Edition), EG&G Technical Services Inc., Eg&g TechnicalServices Inc, U. S. Department of Energy, 2016.
2. Liu, H.,Principles of fuel cells, Taylor & Francis, N.Y., 2006.
3. Bard, A. J., L. R., Faulkner, Electrochemical Methods, Wiley, N.Y, 2004.
4. J. Van Herle, et al , Hydrogen Energy Systems, CRC Press, 2017.

Course Name: Indian Constitution and Civil Society					
Course Code: INCO3016					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	2	**0**	**0**	**2**	**0**

Course Outcomes:

After completion of the course students will be able to:

1. analyse the historical, political and philosophical context behind the Indian Constitution-making process.
2. appreciate the important principles characterizing the Indian Constitution and institute comparisons with other constitutions.
3. understand the contemporaneity and application of the Indian Constitution in present times.
4. critique the contexts for constitutional amendments in consonance with changing times and society.
5. establish the relationship between the Indian Constitution and civil society at the collective as well as the individual levels.
6. consciously exercise the rights and the duties emanating from the Indian Constitution to one's own life and work.

Module I

Introduction to the Constitution of India:

Historical Background,

Making of Indian Constitution:

The process of framing the constitution, the constituent assembly.

Module II

Salient Features of the Indian constitution Comparison with the constitutions of other countries.

Module III

Relevance of the Constitution of India.Constitution and Governance.
Constitution and Judiciary.
Constitution and Parliament-Constitutional amendments.

Module IV

Constitution and Society- democracy, secularism, justice.
Constitution and the individual citizen- Fundamental Rights, Directive Principles of state policy and Fundamental duties.

Books of reference:

1. C.M. Elliot, (ed.), Civil Society and Democracy, OUP, Oxford, 20012.
2. David Held et.al (ed), The Idea of the Modern State, Open Univ. Press, Bristol, 1993.
3. Neera Chandoke, State and Civil Society, Sage, Delhi, 19953.

LABORATORY

Course Name: Mass Transfer Laboratory					
Course Code: CHE3251					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:
After completion of the course students will be able to:
CHE 3251.1: Perform batch distillation and verify the validity of Rayleigh's equation for a given binary solution.
CHE 3251.2: Conduct gas absorption experimentally in a packed bed and wetted wall tower.
CHE 3251.3: Analyze continuous and batch mode of drying operation in rotary and tray dryer respectively.
CHE 3251.4: Construct adsorption isotherm based on removal of dye using adsorbent.
CHE 3251.5: Estimate diffusivity of vapour in air using Stefan's apparatus.

Experiments to be performed:
1. Study on batch distillation and verification of Rayleigh's equation.
2. Determination of mass transfer coefficient during absorption study in a packed bed.
3. Determination of mass transfer coefficient during absorption study in a wetted wall column
4. Study on batch drying operation to plot drying rate characteristic curve under a constant drying condition in a tray dryer.
5. Study of drying in rotary dryer & finding out correlation between volumetric heat transfer coefficient and mass velocity of air.
6. Verification of adsorption isotherm for batch adsorption of dye on activated charcoal.
7. Determination of diffusivity of an organic vapour in air.

Text Books:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill, International Edition, 1981.
2. Dutta B.K., Principles of Mass Transfer and Separation Processes, Prentice Hall of India, 2007.
3. Geankoplis C.J., Transport processes and Separation Process Principles, Prentice Hall of India, Fourth Edition, 2004.

Books of reference:

1. King, C. J. Separation Processes: McGraw Hill, Chemical Engineering Series.
2. Mc Cabe W.L., Smith J.C. Harriot P. Unit Operations in Chemical Engineering: McGraw Hill, Seventh Edition.
3. Richardson J. F. and Harker J.H. with J.R. Backhurst J.R. Coulson and Richardson's Chemical Engineering, Volume 2, Fifth Edition, Pergamon Press.
4. Perry's Chemical Engineers' Handbook, 8th Edition, McGraw Hill.

Course Name: Process Equipment Design & Drawing Laboratory					
Course Code: CHE3252					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**4**	**4**	**2**

Course Outcomes:
After completion of the course students will be able to:
CHE 4251.1: Apply their theoretical knowledge for the design of engineering equipments relevant to chemical engineering.
CHE 4251.2: Design a suitable flow-meter for the measurement of fluid flow through a pipe.
CHE 4251.3: Select a suitable storage vessel for storing a given amount of fluid.
CHE 4251.4: Design important process equipment like heat exchangers, distillation column or reactor of given duty.
CHE 4251.5: Develop engineering drawing reports as per their design using AutoCAD.
CHE 4251.6: Design mechanical aspect of the process equipments like flange, gasket, nozzle, nut & bolt, support etc.

Each student shall be allotted design problems on sl. no 1, 2 & 3 at the beginning of the 6th semester and the student shall carryout complete process and mechanical design under supervision of a faculty member. The student shall also prepare engineering drawing of the equipment in AutoCAD and submit complete design report at specified time during 6th semester to the supervising faculty member. Assessment would be made on the basis of the submitted report and the viva voce examination conducted during the practical examination at the end of 6th semester.

Design to be performed:
1. Design and Drawing of Orifice meter / Venturimeter / Rotameter. (Any one)
2. Design and Drawing of Pressure vessel.
3. Design and Drawing of Shell & tube heat exchangers/ Distillation column/ Reactor (Any one).

Books of reference:

1. Mahajani, V.V., Umarji S.B; Joshi's Process Equipment Design; 5th Edition, Trinity press, 2014.
2. Brownell L.E and Young E.H. Process Equipment Design, J Wiley & Sons, 1959.
3. Sinnott R.K. Chemical Engineering Design, 4th Edition, Vol 6, Elsevier Publication, 2005.
4. Kern D.Q, Process Heat Transfer, Indian Edition, McGraw Hill Education (India) PVT LTD, 1997.

Course Name: Project I					
Course Code: CHE3295					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**8**	**8**	**4**

Course Outcomes:

After completion of this training Course, the students will be able to:

1. identify a real-life industrial and engineering problem.
2. plan and organize experiments for obtaining necessary data for solving the problem.
3. analyze and interpret the data obtained from the appropriate experiments.
4. work as part of a team which may be multidisciplinary in some cases.
5. present the results by **oral(viva-voce, presentation)** communication.
6. understand the impact of various socio-economic, environmental and political factors on the design and implementation of a solution to a real-life engineering problem.

Each student shall be required to carry out a project work or investigation on an industrial/academic research problem under the supervision of a faculty. The project/research work has to be carried out by the student himself occasionally consulting his supervisor. The project/research problem will be allotted to the student at the beginning of the 6^{th} semester.

An internal committee, chaired by the departmental head, will perform **one final** assessment at the end of semester in presence of student supervisor. Evaluation by the committee will be based on **regularity of attendance and quality** of work done during the semester. The committee will comprise of the student supervisor and at least two members of faculty as appointed by the Department Head.

For the final assessment, a presentation must be prepared according to the template given for PROJECT I (CHE 3295). The examination shall include oral presentation of the research work with a Q&A session. Equal weightage shall be given on oral presentation and Q&A.

4th Year 1st Semester (Semester 7)

THEORY

Course Name: Novel Separation Processes					
Course Code: CHE4131					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE 4131.1 Compare different membrane separation processes and gain knowledge on various applications and challenges of these processes.

CHE 4131.2 Acquire knowledge on membrane fabrication methods as well as membrane characterization methods.

CHE 4131.3 Construct the transport equations through membranes for various membrane separation processes including pervaporation, dialysis.

CHE 4131.4 Understand external field assisted separation processes including centrifugal separation, thermal diffusion and surfactant based separation processes.

CHE 4131.5 Understand the techniques of ion exchange membrane chromatography and elctro-chromatography.

CHE 4131.6 Understand principles of electrophoresis as well as electrophoresis coupled with other separation techniques.

Module I [10L]

Basic membrane separation process:

Size exclusion based membrane separation process (Microfiltration, ultrafiltration, nanofiltration, reverse osmosis); transport equations (concept of knudsen diffusivity and molecular diffusion); Models for water and solute transport in RO, Types of membrane material; Difference between symmetric membrane and composite membrane in view of the mechanical properties of the membrane; Membrane characterization techniques; Membrane modules, Applications of different membrane modules and a concept of shear enhanced membrane modules like VSEP.

Module II [10L]

Fabrication of membrane (Inorganic and organic); overview on phase inversion technique;

Concentration driven processes:

Concept of dialysis and fabrication of dialysis membrane, Haemodialysis, Electro dialysis; Understanding VLE and its application in pervaporation and membrane distillation; Gas absorption and permeation in a polymer; Concept of chromatographic separation techniques like gel filtration model ; Overview on membrane chromatography process.

Module III [10L]

External field assisted separation processes: **Centrifugal separation:**

Basic principle, separation of liquids by centrifugation techniques, types of centrifuges and their applications;

Thermal diffusion:

Principles and applications, extraction: ultrasound and microwave assisted extraction processes, supercritical fluid extraction, extraction with pulse electric field, applications, field flow fractionation;

Surfactant based separation processes:
Liquid membranes: fundamentals and modeling, types of liquid membrane, preparation of liquid membranes, applications; micellar enhanced separation processes and applications, cloud point extraction.

Module IV [10L]
Electrophoresis: Electro-kinetic effects;

Principles of electrophoresis:
Concept of electrical double layer and Debye length; concept of zeta potential, electrophoretic velocity and mobility calculation, types of electrophoresis: gel and capillary.

Electrophoresis coupled with separation:
Coupling electrophoresis with ultrafiltration system**:** Effect of electric field in gel layer and osmotic pressure controlled ultrafiltration, enhancement ofpermeate flux in ultrafiltration using electric field; electroosmosis: flow profile in open tube, thickness of double layer, electroosmotic flow velocity in packed columns, applications; elctrochromatography: principles and applications, ion exchange processes and applications, ion exchange chromatography in electric field, applications .

Text Books:

1. Rousseau R.W. Handbook of Separation Process Technology, John Wiley & Sons, 2009.
2. Seader J.D., Henley E.J., Roper D.K. Separation Process Principles, Wiley Publications, 1957.
3. Li N.N. Advanced Membrane Technology and Applications, John Wiley and Sons, 2008.
4. Tsuda T. Electric Field Applications in Chromatography, Industrial and Chemical Processes VCH Publishers, New York 1995.
5. Lundanes E., Reubsaet L., Greibrokk T. Chromatography basic principles, sample preparations and related methods, Wiley Publications, 2013.

Books of reference:

1. De S., Sarkar B., Dasgupta S. Electric Field enhanced Membrane separation system: principles and typical applications, Nova Science Publishers, 2009.
2. Kislik V.S. Liquid Membranes, Principles and Applications in Wastewater treatment, Elsevier publications, 2009.
3. Coulson J.M., Richardson J.F. Chemical Engineering Vol. 2, Elsevier Science, 5th Edition, 2002
4. Wankat P.C. Separation Process Engineering, 2nd edition, Pearson Education, Inc. 2007.
5. McHugh M., Krukonis V. Supercritical Fluid Extraction, Butterworth Heineman, 1994.
6. Wankat W.C. Large Scale adsorption and chromatography, CRC Press Inc., 1986.
7. Ramirez C., Peters K. Extraction Techniques for Food Processing, ED-Tech Press, 2018.
8. Fong Leung W.W. Centrifugal separations in biotechnology, Elsevier Academic Press, 2007.
9. Bungay P.M., Lonsdale H.K., de Pinho M.N., Synthetic Membranes:: Science, Engineering and Applications, Springer,1986.
10. Ho W. S., Sircar K.K. Membrane Handbook, Springer, 1992.
11. Nath K. Membrane Separation Processes, Prentice Hall Learning Pvt. Ltd., 2008.
12. Cheryan M. Ultrafiltration and Microfiltration Handbook, CRC Press, 1998.

13. Wilson K. Wilson, Walker J. Principles and Techniques of Practical Biochemistry, Cambridge Univ. press, 2000.

Course Name: Polymer Engineering					
Course Code: CHE4132					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

At the end of the course students will be able to

CHE 4132.1 Understand the classification of polymers, molecular weight distribution and control of molecular weight of polymer.

CHE 4131.2 Acquire knowledge on types of polymerization and polymer rheology basics.

CHE 4131.3 Apply the knowledge of polymer reaction engineering towards design of reactors and understand the various unit operations in polymer industries.

CHE 4131.4 Develop an understanding on polymer fibres and composites, polymer processing techniques and applications.

CHE 4131.5 Acquire knowledge on industrially important polymers and detail manufacturing processes.

CHE 4131.6 Analyze the applications of polymers in various fields including catalysis, membrane separation, fuel cells etc .

Module I [10L]:

Introduction to polymers

Basic concept of polymer, polymer chemistry, classification of polymers, molecular weight distribution, control of molecular weight of polymer, glassy state and glass transition temperature, surface tension and contact angle measurement, Types of polymerization- free radicals, step growth, coordination, ionic., emulsion polymerization, dispersion polymerization etc, polymer rheology, an introduction to biopolymer.

Module II [10L]:

Polymer reaction engineering

Reaction kinetics of polymerization, ~~polymer reaction engineering,~~ reaction engineering of step growth polymerization, radical chain polymerization, ionic chain, emulsion polymerization etc, Reactors for polymerization: analysis of polymerization reactions, Design of reactor for polymer system

Module III [10L]:

Unit operations in polymerization

Brief idea of unit operations in polymerization industries, Polymer processing: molding, calendaring, extrusion, mixing of additives etc Polymer alloys, polymer eutectics, plastomers, plastomer – elastomer blends, fibres for polymer composites - Glass fiber, cotton fiber, jute, polyester, rayon. Different processing techniques for composites, polymer composites and their applications.

Module IV [10L]:

Applications

Industrially important polymers: Cellulose Plastics, Phenolic Resins, aminoplastics, unsaturated polyesters, plastic additives & compounding, Manufacturing process of some industrially important polymers, viz, polyethylene, Styrene butadiene rubber and nylon 66. Applications of polymers in catalysis, membrane separation, fuel cells, printing ink technology, surface coating, conducting polymers, smart polymers etc.

Text Books/ Reference:

1. Fundamentals of Polymer Science and Engineering – A. Kumar & S.K. Gupta, Tata Mc.Graw Hill.
2. Fundamental principles of polymeric materials, Stephen L. Rosen, Wiley, 1993.
3. Polymer Processing Principles and Design – D.G. Baird & D. I. Collias, Wiley.
4. Polymer Handbook – J. Bandrup& E.H. Immergat (Ed.), John Wiley & Sons.
5. L. A. Utracki, Polymer Blends Handbooks, Springer (Vol.1 and 2)
6. Robeson, L., Polymer Bends -A comprehensive review, Hans
7. Plastics Materials, 7th Edition, A. Brydson, Butterworth-Heinemann
8. Andre Knop, Louis A. Pilato. Phenolic resins-Chemistry, application and performance

Course Name: Transport Processes in Biological Systems					
Course Code: CHE4141					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completing this course, students will be able to:

CHE 4141.1: Compute blood viscosities, velocity profiles and pressure profiles for blood flow in large and small blood vessels.

CHE 4141.2: Compute blood flow characteristics in specific arteries as well as through heart valves.

CHE 4141.3: Estimate transport parameters for gas diffusion between blood and tissues.

CHE 4141.4: Analyze different drug transport techniques and simulate the transport of drugs through tumours.

CHE 4141.5: Compute bioheat transport parameters for human body

CHE 4141.6: Develop suitable transport models for transport of biomolecules in different tissues

Module I [10 L]

Static equilibrium; surface tension; membrane and cortical tension; Time dependent viscoelastic behavior; Flow induced by a sliding plate ; pressure driven flow through a narrow rectangular channel; pressure driven flow of a power law fluid in a cylindrical tube ; Rheology and flow of blood : measurement of blood viscosity; rheology of blood flow in large vessels; Plasma layer thickness expressions; blood flow in small tubes; blood flow in capillaries ; regulation of blood flow.

Module II [10 L]

Bernoulli's Equation applied to Stenoic Heart Valves ; oscillating flow in a cylindrical tube; flow in branching vessels ; flow in curved vessels; flow in specific arteries : carotid artery and coronary arteries ; arterial fluid dynamics and atherosclerosis ; heart valve hemodynamics; turbulent flow around heart valve; artificial heart valve.

Module III [10 L]

Transport properties of Proteins; Effects of surface hydration ;Transport of gases between blood and tissues: oxygen hemoglobin equilibria and binding kinetics, dynamics of oxygenation of blood in lung capillaries, oxygen delivery to tissues: Krogh cylinder transport model; Anoxic regions; Diffusion in the plasma layer.

Module IV [10 L]

Transport in Porous media ; Darcy's law for flow through porous media; Starling's law; drug delivery in cancer treatment; routes of drug administration; Drug transport in solid tumors:

interstitial hypertension in solid tumors; Bioheat transport equation, Thermoregulation in humans.

Text Books:

1. Truskey, GA, Yuan F, Katz DF. 2009. Transport Phenomena in Biological Systems. II ed. Prentice Hall, New Jersey.

Books of reference:

1. Bird, RB, Stewart, WE, Lightfoot, EN. 2001. Transport Phenomena, II edition, John Wiley and Sons, New York.

Course Name: Project Engineering & Economics					
Course Code: CHE4142					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the subject the students will be able to:

CHE4142.1 Understand the basics of an organization/industrial establishment from the standpoint of Industrial Economics.

CHE4142.2 Apply the concepts of project engineering for analysis of the project.

CHE4142.3 Provide insights of the different accounting concepts and apply related concepts like costs, revenues, assets, liabilities, capital, profit.

CHE4142.4 Understand the various Depreciation calculation methods practiced globally.

CHE4142.5 Implement innovative ideas to optimization of the plant design components in regard to requirement of energy, time and ultimately cost.

CHE4142.6 Perform network analysis of the project and critically examine the schedule for the completion and cost impacts for the project.

Module I [9L]

Basic preliminaries of Project Engineering and Economics

Role of a Project Engineer, Types of business, Proprietorship, Partnership, Joint-stock company, and cooperative society – their characteristics.

Plant location and plant lay out-- different considerations including SEZ and its specialties, plant utilities, Time value of money, simple interest, nominal and effective interest rates, compound and continuous interest, fixed capital and working capital, basics of Cash Flow Diagram and its applications, present worth and discount, annuity, perpetuity, capitalized costs and revenues, GDP and national growth.

Module II [9L]

Financial Analysis

Profit & Loss Account, concepts of Assets and Liabilities, Balance Sheet, concepts of various funds, Budgeting, various ratios for analysis of financial stability of an organization .

Depreciation:

Types of depreciation, Depletion, concepts of service life, salvage value, and book value, straight-line method, Declining balance method, double declining balance method, sum of the years digit method and sinking fund method for determination of depreciation.

Module III [9L]

Optimum Design and Design strategy:

Basic principle of Optimum Design, general procedure for determining optimum conditions, Scale up and scale down techniques, Alternative investment, Choices among various alternatives, Replacements, Various methods of profitability evaluation for replacements, Calculation on

Return on investment and Pay-back period, Breakeven analysis, Optimum production rate in plant, determination of optimum economic pipe diameter and optimum flow rate in condenser, minimum cost analysis, economics in selection of materials.

Module IV [9L]

Project scheduling:

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

Text Books:

1. R**.** Narayanswami, Financial Accounting- A Managerial Perspective. Prentice-Hall of India Private Limited. New Delhi.
2. H. L. Ahuja., Modern Economic Theory. S. Chand. New Delhi.
3. Peters, Max S and Timmerhaus, Claus D, Plant Design and Economics for Chemical Engineers, Mc Graw Hill, 4th Ed., 1991.
4. Sinnot, R K, Chemical Engineering Design, Coulson & Richardson's Chemical Engineering Series, Vol. 6, Elsevier, 4th Ed. 2005.
5. Srinath, L S, PERT and CPM – Principles and Applications, Affiliated East West Press, 3rd Ed., 1989.

Books of reference:

1. Horne, James C Van, Fundamentals of Financial Management. Prentice-Hall of India Private Limited, New Delhi.
2. Newman, Donald G., EsCHEbach, Ted G., and Lavelle, Jerome P. Engineering Economic Analysis. New York: Oxford University Press.2012.
3. Vilbrandt, F C, Dryden, Charles E, Chemical Engineering Plant Design, Mc Graw Hill, 2nd Ed., 1942.
4. SEZ Act and Policies, 53rd Amendment, Ministry of Commerce and Industry, Department of Commerce, 31.12.2019.

Course Name: Introduction to Solar and Wind Technology					
Course Code: CHE4121					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completing this course students will be able to:

CHE4127.1:Analyze radiative heat transfer considering blackbody radiation, solar geometry, and atmospheric impacts**.**

CHE4127.2: Apply knowledge of radiative heat transfer and collector design principles to analyze the performance characteristics of flat-plate and concentrating solar thermal collectors.

CHE4127.3: Explain the fundamental physical processes that govern solar cell operation and evaluate the impact of various factors on their performance metrics, including efficiency and power output.

CHE4127.4: Understand core concepts like wind power potential, understand wind turbine operation (power, torque, rotors), and classify horizontal vs. vertical axis turbines.

CHE4127.5: Analyze wind regimes (local effects, turbulence) and leverage anemometers to assess wind resource potential and future wind turbine performance.

CHE4127.6: design efficient wind energy systems considering components, operation modes, and wind pump selection for various applications.

Module I [10L]

Introduction to Radiation heat transfer:

Blackbody radiation, Stefan-Boltzman Law, Wien's Displacement Law, emissivity, absorptivity, radiation view factor, radiation shield.

Solar radiation:

Sun earth geometric relationship, solar angles, sun's trajectories in different seasons, zenith solar time, air mass, solar beam, total solar radiation & diffuse radiation, solar radiation on different surfaces at different angles, extraterrestrial radiation. Attenuation of solar radiation by the atmosphere, beam and diffuse components of hourly and daily radiation, clearness index.

Module II [10L]

Solar Thermal Collector:

Flat plate collector, Unglazed, Single and double glazed solar collectors, Optical losses and thermal losses, thermal analysis and performance characteristics. Concentrating solar collectors: General description; concentrators, receivers, Orienting/tracking requirements, Parabolloid dish collectors, Scheffler dish, Linear Fresnnel Reflector Collector.

Introduction to Solar PV:

Crystal structure, band theory, energy band diagrams, Fermi level, intrinsic and extrinsic semiconductor, Standard solar cell structure, I-V characteristics, FF, Voc, Isc, Pmax, conversion efficiency, losses in solar cell, Rs, Rsh, impact of radiation and temperature; Silicon wafer based solar PV technology, Single and poly crystalline silicon solar cells; Thin film technology of solar cell, Merits and demerits of thin film technologies.

Module III [10L]

Basics of Wind Energy Conversion:

Power available in the wind spectra, Wind turbine power and torque,

Classification of wind turbines: Horizontal axis and Vertical axis,

Characteristics of wind rotors, Rotor design, Rotor performance.

Analysis of wind regimes:

The wind (Local effects, Wind shear, Turbulence, Acceleration effect, Time variation), Measurement of wind (Ecological indicators, Anemometers, Cup anemometer, Propeller anemometer, Pressure plate anemometer, Pressure tube anemometers, Sonic anemometer, Wind direction).

Module IV [10L]

Wind energy conversion systems:

Wind electric generators (Tower, Rotor, Gear box, Power regulation, Safety brakes, Generator; Induction generator, Synchronous generator. Fixed and variable speed operations, Grid integration), Wind farms, Offshore wind farms, Wind pumps (Wind powered piston pumps, Limitations of wind driven piston pumps; The hysteresis effect, Mismatch between the rotor and pump characteristics, Dynamic loading of the pump's lift rod, Double acting pump, Wind driven roto-dynamic pumps, Wind electric pumps).

Text Books:

1. Sukhatme S. &Nayak J.,Solar Energy: Principles of Thermal Collection and Storage, Third Edition, Tata McGraw Hill, 2008.
2. Solanki C.S.; Solar Photovotaics – Fundamentals, Technologies and Applications; PHI Learning, 3rd edition, 2015.
3. Efstathios E. (Stathis) Michaelides, Renewable Energy Sources, Springer, 2012.
4. Sathyajith Mathew, Wind Energy: Fundamentals, Resource Analysis and Economics, Springer, 2006.

Books of reference:

1. Goswami D.Y., Kreith F.&Kreider J.F.; Principles of solar Engineering, Tyalor and Francis, Philadelphia, 2000.
2. N.K. Bansal and M. K. Kleeman, Renewable Sources of Energy and Conversion Systems,Tata McGraw-Hill, 1984.

Course Name: Industrial Total Quality Management					
Course Code: CHE4122					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

CHE4121.1 Identify the quality of the processes and hence that of products or goods & services by applying basic statistical tools.

CHE4121.2 Control the quality of processes and hence that of products or goods & services by applying basic statistical tools.

CHE4121.3 Draw the various types of Control Charts and analyze to ascertain the state of the process.

CHE4121.4 Develop the different sampling plans to evaluate the quality of various types of defects.

CHE4121.5 Apply the techniques of Quality Circles and Kaizen in order to enhance work culture and Total Quality status in an organization.

CHE4121.6 Get acquainted with the different Standards of Certification and their role in developing an organization.

Module I [10L]Basic concepts:

Three paradigms of management and evolution of concept of quality management,

Organization:

Its basic objectives and goal, Mission and Vision, customer and secondary customer, Deming's wheel, bottom line: profit vs quality, historical developments with contribution of different scientists. Basic statistical concepts associated with quality management, measurement of central tendency and dispersion, range versus variance, Random variables and expected value calculations, quality and process capability, probability distributions, concept of statistical quality control.

Module II [10L]

Tools and techniques for improvement in TQM: type A and type B techniques with a special reference to SWOT Analysis, brainstorming, stratification, Pareto Analysis, Ischikawa diagram, check sheet. Use of control charts and process engineering techniques for implementing the quality plan: X—R chart, moving average chart, p-chart and c-chart.

Module III [10L]

Principles of Acceptance sampling:

Single–double and multiple sampling, AOQ, AQL, LTPD, Chain sampling plan, Dodge-Romig plan.

Philosophy and concept of quality circle:

Formation, steering committee, power and functions of leader, dy. Leader, coordinator, facilitator, case studies.

Module IV [10L]
Principles of Kaizen and Gemba principles. Concept of Six Sigma standards, case studies.
Different standards:
ISO, BS and Bureau of Indian Standards, details of ISO 9000 series, ISO 14000 series and SA 8000, OSHAS 18000 and the certification authorities.

Text Books:
Grant, Eugene and Leavenworth, Richard, Statistical Quality Control, TMH, 7thEdition2012.
Udpa, S R , Quality Circles: Progress through Participation, TMH, 1992.
Bedi, Kanishka, Quality Management, Oxford University Press.

Books of reference:
1. H. Lal Total Quality Management- A Practical Approach (1st Edition): New Age International, 1990.
2. Sundararaju, S. M., Total Quality Management – A Primer: TMH, 1995.
3. Mitra, Amitava, Fundamentals of Quality Control and Improvement, 2nd Edition.; Prentice- Hall of India, 1998.
4. Subburaj Ramasamy, Total Quality management, Mc-Graw Hill Education (India) Pvt. Ltd, 2012.

Course Name: Principles of Management					
Course Code: HUM4101					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

After completion of the course students will be able to:

1. study the evolution of Management.
2. understand various management functions and have some basic knowledge on different aspects of management.
3. understand the planning process in an organization.
4. understand the concept of organizational structure.
5. demonstrate the ability to direct, lead and communicate effectively.
6. analyse and isolate issues and formulate best control methods.

Module I [8L]

Management:

Definition, nature, purpose and scope of management Skills and roles of a Manager, functions, principles;

Evolution of Management Thought:

Taylor Scientific Management, Behavioural Management, Administrative Management, Fayol's Principles of Management, Hawthorne Studies.

Types of Business organization:

Sole proprietorship, partnership, company-public and private sector enterprises -Organization culture and Environment –Current trends and issues in Management.

Module II [8L]

Planning:

Types of plans, planning process, Characteristics of planning, Traditional objective setting, Strategic Management, premising and forecasting.

Organizing:

Nature and Purpose-Formal and informal, organizational chart, organization structure-types-line and staff authority, departmentalization, delegation of authority, centralization and decentralization.

Controlling:

Concept, planning-control relationship, process of control, Types of Control, Control Techniques;

Human Resource Management:

HR Planning, Recruitment, Selection, Training and Development, Performance Management, Career planning and management.

Module III [8L]

Directing:

Foundations of individual and group behaviour –motivation –motivation theories –motivational-

Techniques –job satisfaction –job enrichment –leadership –types and theories of leadership – Communication –process of communication –barrier in communication – effectivecommunication –communication and IT.

Decision-Making:

Process, Simon's model of decision making, creative problem solving, group decision-making.

Coordinating:

Concepts, issues and techniques.

Module IV [8L]

Leading:

Managing Communication: Nature & function of communication, methods of interpersonal communication, barriers of effective communication, direction of communication flow, role of technology in managerial communication.

Motivating Employees:

Define motivation, compare and contrast early theories of motivation, compare and contrast contemporary theories of motivation & current issues.

Being an Effective Leader Define leader/ leadership, compare and contrast early theories of leadership, understand three contingency theories, understand modern views on leadership. Motivation, Leadership, Communication, Teams and Teamwork.

Management by Objectives (MBO):

Management by exception; Styles of management: (American, Japanese and Indian), McKinsey's 7-S Approach, Self-Management.

Books of reference:

1. Stephen P. Robbins and Mary Coulter, "Management", Pearson Education, 2017, 13th edition.
2. Koontz H. and Weihrich H., "Essentials of Management", Mcgraw Hill Int. Ed., 2015,10th edition.
3. Bhat Aand Kumar A. "Management: Principles, Processes & Practices", Oxford University Press, 2016, 2nd edition.
4. Robbins, Coulter, and Decenzo, "Fundamentals of Management", Pearson Education, 2016, 9th edition.
5. Richard L. Daft, "Management", Cengage Learning, 10th edition.

LABORATORY/SESSIONAL

Course Name: Process Control Laboratory					
Course Code: CHE4151					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

After completion of the course students will be able to:

CHE 4152.1 Understand the basics of instrumentation and process control through a hands-on practicalexperience.

CHE 4152.2 Determine the dynamics and characteristics of first order and inherently second-order systems.

CHE 4152.3 Analyze the dynamics of first order systems in series.

CHE 4152.4 Identify open and closed loop control system and to design process control systemcomponents to meet desired needs within realistic constraints.

CHE 4152.5 Evaluate control valves characteristics and estimate control valve coefficient.

At least any eight of the following experiments are to be performed:

1. Study on the dynamic characteristics of first order liquid level system.
2. Study on the dynamic characteristics of U-tube manometer (second order system).
3. Study on the dynamic characteristics of compound (interacting) second order system.
4. Study on the dynamic characteristics of compound (non-interacting) second order system.
5. Study on the response of controlled variable for a feedback control system with P, PI & PID controller.
6. Study on the flow characteristics and determination of discharge coefficient for different type pneumatic control valves.
7. Experiment on calibration of a load cell.
8. Liquid level measurement using air-purge method.
9. Determination of time constant of thermocouple during temperature measurement.
10. Experiment on calibration of pressure gauge using Dead-weight tester.
11. Experiment on flow measurement using wet gas meter.

Text Books:

1. G. Stephanopoulos. Chemical Process Control: An Introduction to Theory and Practice, pHI, 1st ed., 1984.
2. D.R. Coughanowr. Process system analysis & Control, McGraw-Hill, Inc., 2nd ed., 1991.
3. D. Patranabis. Principles of Industrial Instrumentation, Tata McGraw Hill, Publishing Ltd., 1st ed., 1999.

Course Name: Design & Simulation Laboratory					
Course Code: CHE4152					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**4**	**4**	**2**

Prerequisites: MATLAB Basics, Basic course on CFD, Modeling and Simulation

Course Outcomes:

After completion of the course students will be able to:

CHE 4252.1: Illustrate basic theory of MATLAB SIMULINK for dynamic simulation of chemical reaction.

CHE 4252.2: Apply their knowledge with COMSOL for performing CFD simulations of chemical engineering processes.

CHE 4252.3: Perform basic CFD simulations for obtaining temperature distribution in two-dimensional geometries.

CHE 4252.4: Perform basic simulations of mixing processes, plug flow reactor and distillation process using DWSIM.

Programmes to be performed:

1. Basics of MATLAB Simulink tool application for performing dynamic simulation of a chemical process.
2. Dynamic simulation of a continuous stirred tank reactor for van de Vusse reaction.
3. Introduction to COMSOL, Solve for temperature distribution in a rectangular plate using CFD simulation software (COMSOL)
4. Introduction to DWSIM, utility of physical property and thermodynamic packages, simulation of a simple mixing process involving two components, simulation of major and minor losses for fluid flow through pipelines, simulation of process equipment like Plug flow reactor and Binary distillation columns.

Text Books:

1. Jain S. Modeling and Simulation using MATLAB – Simulink, Wiley, 2013.
2. Ferziger J. H. and Peric M. Computational Methods for Fluid Dynamics, 3rd Edition, Springer, 2001.
3. Stolarski T., Nakasone Y., Yoshimoto S., Engineering Analysis with ANSYS software, Butterworth-Heineman, 2018.

Books of reference:

1. Chidambaram M. Mathematical Modelling and Simulation in Chemical Engineering, Cambridge University Press, 2018.
2. Computational flow modelling for Chemical Reactor Engineering, Vivek V. Ranade, Academic Press, 2002.
3. Anderson J.D. Computational Fluid Dynamics, the basics with Applications, McGraw-Hill, Inc., 1995.
4. Incropera F.P., DeWitt D.P., Fundamentals of Heat and Mass Transfer, Wiley 2006.
5. Finlayson B.A., Introduction to Chemical Engineering Computing, Wiley, 2012.

Course Name: Industrial Training					
Course Code: CHE4191					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**0**	**0**	**2**

Course Outcomes:

After completion of this training Course, the students will be able to:

1. develop a concrete idea of industrial set up and its associated complexity.
2. evaluate the classroom knowledge against the real life application.
3. learn the sequence of activities that lead to a finished product from the raw material.
4. learn about activities other than design and manufacturing that are necessary for producing the goods and services.
5. develop the ability to identify problems when a process does not deliver the planned output.
6. develop ability to write report on an observed process.

Students sent for Industrial Training during Summer Recess after 6th Semester for a duration of four weeks will submit two copies of Training Report (only Hard/Spiral bound is allowed) on or before a notified date, to the Faculty In-charge, In-plant Training. The Viva voce would be held before commencement of Practical Examination.

Report should consist of:

1. Copy of Training Certificate & allotment order (if any).
2. A general overview of the Plant.
3. The products and raw material sources of the Plant.
4. Process description/flow diagram of individual units.
5. Environment & Safety Aspects, Techno-economics /Corporate Social responsibility work of the organization if any.
6. For Training in R & D organizations/project Work, overview of work with sketches, Objectives, Materials & Methods, Result & Discussions are to be included instead of items mentioned in points 2-5.

Course Name: Project II					
Course Code: CHE4195					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**8**	**8**	**4**

Course Outcomes:

After completion of this training Course, the students will be able to:

1. identify a real-life industrial and engineering problem.
2. plan and organize experiments for obtaining necessary data for solving the problem.
3. analyze and interpret the data obtained from the appropriate experiments.
4. work as part of a team which may be multidisciplinary in some cases.
5. present the results by **oral(viva-voce, presentation)** communication.
6. understand the impact of various socio-economic, environmental and political factors on the design and implementation of a solution to a real-life engineering problem.

Each student shall be required under the supervision of a faculty to carry out project work or investigation on an industrial/academic research problem. The project/research work assigned in Project I has to be carried out by the student himself occasionally consulting his supervisor.

An internal committee, chaired by the departmental head, will perform **one final** assessment at the end of semester in presence of student supervisor. Evaluation by the committee will be based on **regularity of attendance, incremental progress from work done in Project I and quality** of work done during the semester. The committee will comprise of the student supervisor and at least two members of faculty as appointed by the Department Head.

For the final assessment, a presentation must be prepared according to the template given for PROJECT II (CHE 4195). The examination shall include oral presentation of the research work with a Q&A session. Equal weightage shall be given on oral presentation and Q&A.

4th Year 2nd Semester (Semester 8)
LABORATORY/SESSIONAL

Course Name: Term Paper & Technical Seminar					
Course Code: CHE4291					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**3**	**3**	**1.5**

A seminar topic will be allotted to individual student according to his/her subject of interest. A thorough report should be prepared based on which seminar presentation and question–answer session will be conducted. Assessment of the student would be done by the faculty members on the basis of presentation, performance in the question-answer session and the report submitted, giving equal weightage on each component.

Course Name: Project III					
Course Code: CHE4295					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**8**	**8**	**4**

Course Outcomes:

After completion of this training Course, the students will be able to:

1. identify a real-life industrial and engineering problem.
2. plan and organize experiments for obtaining necessary data for solving the problem.
3. analyze and interpret the data obtained from the appropriate experiments.
4. work as part of a team which may be multidisciplinary in some cases.
5. present the results by the way of **written (Publications, Project report)** and/or **oral (viva-voce, presentation)** communication.
6. understand the impact of various socio-economic, environmental and political factors on the design and implementation of a solution to a real-life engineering problem.

Each student shall continue to work on the project work/research problem allotted to him at the beginning of the 6^{th} semester under supervision of a faculty member.

After project is completed as per the requirements of the surpervisor, a report must be prepared according to the template given for Project III (CHE 4295). The report prepared in **duplicate in typed and hard-bound form** has to be submitted by the student as per the deadline assigned by the Department Head. The examination shall be conducted in presence of external expert and the student's supervisor. The evaluation will be based on the Project Report and Viva voce.

Course Name: Grand Viva					
Course Code: CHE4297					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT**
	0	**0**	**0**	**0**	**2**

Viva – Voce examination shall be conducted to ascertain the students' overall grasp of the principles of Chemical Engineering and allied subjects. Evaluation of students would be conducted by a panel consisting of at least four Faculty members.

APPENDIX – A

UPDATED GUIDELINES OF MASSIVE OPEN ONLINE COURSES(MOOCS) SCHEME

(WITH EFFECT FROM2023-2024 ACADEMIC SESSION)

MOOCsforB.Tech.HonoursDegree

For B.Tech. honours degree, a 4 - year B.Tech. student will have to earn 20 credits from MOOCs from any established MOOCs platform in addition to 160 credits for B.Tech. degree.B.Tech. lateral entry students should earn 16 CREDIT s from MOOCs in addition to the required credit for B.Tech.degree. Student should submit all the certificates before the last date of submission of MOOCs for the B.Tech. Honours degree, through the department declared by office of the Controller of the Examinations.

CREDIT s from MOOCs Courses

All of the MOOCs courses are to be taken any MOOCs platform as per following scheme of CREDIT s. Students should be advised to avoid the courses taught/offered through the curriculum in the offline/ class room mode.

1.**For NPTEL/Swayam platform: Credit points as specified in the platform**

2.**For other MOOCs platforms like Coursera, edX, Udemy, Simpilearn etc**

i) Courses of 4 weeksto 7weeks:1 credit point
ii) Courses of 8 weeksto11weeks:2credit point
iii) Courses of 12 weeksto15weeks:3credit point
iv) Courses of 16 weeksor more:4 credit point

3.**For duration of MOOCs courses are available in hours**

i) Forevery8 –15 hoursof course:1 credit point**.**
ii) For the courses with duration less than 8 hours, multiple courses could be taken together (preferably in the same area) to consider 1 credit point. But where duration is available in weeks,count of hours will not be applicable.

The above structure is indicative only. Departmental Committee concerned may propose CREDIT s of the courses offered through MOOCs platform based on the content and level beginner/intermediate/advanced) of the courses. However, for any critical judgment the matter will be referred to the Departmental Committee.

Department will submit the list of the students who have successfully completed the MOOCs course along with the details in the prescribed format to the Controller of Examinations as and when notified.

APPENDIX – B

Sl. No.	Name of the Activity	Points	Maximum Points allowed
1	MOOCS (SWAYAM/NPTEL/Spoken Tutorial) (per course)	20	40
2	Tech Fest / Teachers Day / Freshers Welcome		
	(i) Organizer	05	10
	(ii) Participants	03	06
3	Rural Reporting	05	10
4	Tree Plantation (per tree)	01	10
5	Participation in Relief Camps	20	40
6	Participation in Debate/Group Discussion/ Tech quiz	10	20
7	Publication of Wall magazine at Institutional level (magazine/article/internet)	10	20
8	Publication in News paper, Magazine & Blogs	10	20
9	Research Publication (per publication)	15	30
10	Innovative Projects (other than course curriculum)	30	60
11	Blood donation camp		
	(i) Donor	08	16
	(ii) Camp Organizer	10	20
12	Participation in Sports/Games		
	(i) College Level	05	10
	(ii) University Level	10	20
	(iii) District Level	12	24
	(iv) State Level	15	30
	(v) National / International Level	20	40
13	Cultural programme (Dance, Drama, Elocution, Music etc.)	10	20
14	Member of Professional Society	10	20
15	Student Chapter Activities / Seminars		
	(i) Participant	05	20
	(ii) Presentation	10	20
	(iii) Organizer	10	20
16	Relevant industry visit & report	10	20
17	Activities in different clubs at HIT (Photography Club, Cine Club etc.)	05	10
18	Participation in Yoga Camp	05	10
19	Self-Entrepreneurship programme	20	20
20	Adventure sports	10	20
21	Training to under privileged / Physically challenged	15	30
22	Community Service & Allied Activities	10	20
23	Hackathon (State / National Level)		
	(i) Participation in Hackathon	10	20
	(ii) Qualifier for final round (not prize winner) in Hackathon	20	40
	(iii) Prize Winners of Hackathon	30	60

Format for Report Submission

Name :

Department :

Year/Semester :

Title of the Activity :

Date :

Name of the organization :

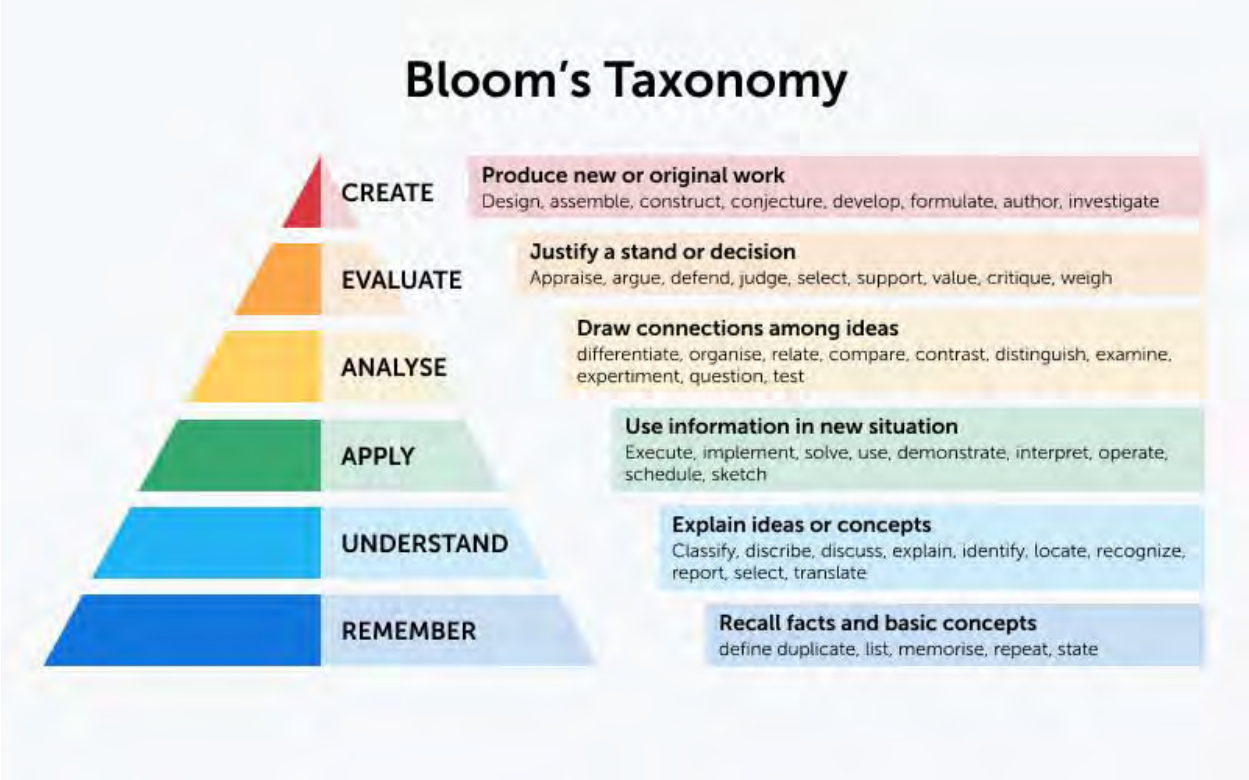
Report :

Signature
(Coordinator / Competent Authority)

Points earned:

Signature of the Mentor

APPENDIX – C


Bloom's Taxonomy
CREATE
Produce new or original work
Design, assemble, construct, conjecture, develop, formulate, author, investigate
EVALUATE
Justify a stand or decision
Appraise, argue, defend, judge, select, support, value, critique, weigh
ANALYSE
Draw connections among ideas
differentiate, organise, relate, compare, contrast, distinguish, examine, expertiment, question, test
APPLY
Use information in new situation
Execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch
UNDERSTAND
Explain ideas or concepts
Classify, discribe, discuss, explain, identify, locate, recognize, report, select, translate
REMEMBER
Recall facts and basic concepts
define duplicate, list, memorise, repeat, state