Syllabus for
Bachelor of Chemical Engineering
(B. Chem. Engg.)

(Under the National Education Policy, NEP 2020)
(2023-2024)

Department of Chemical Engineering
INSTITUTE OF CHEMICAL TECHNOLOGY
(University Under Section-3 of UGC Act, 1956)
Elite Status and Centre for Excellence
Government of Maharashtra

Nathalal Parekh Marg, Matunga, Mumbai 400 019 (INDIA)
www.ictmumbai.edu.in, Tel: (91-22) 3361 1111, Fax: 2414 5614

Preamble:

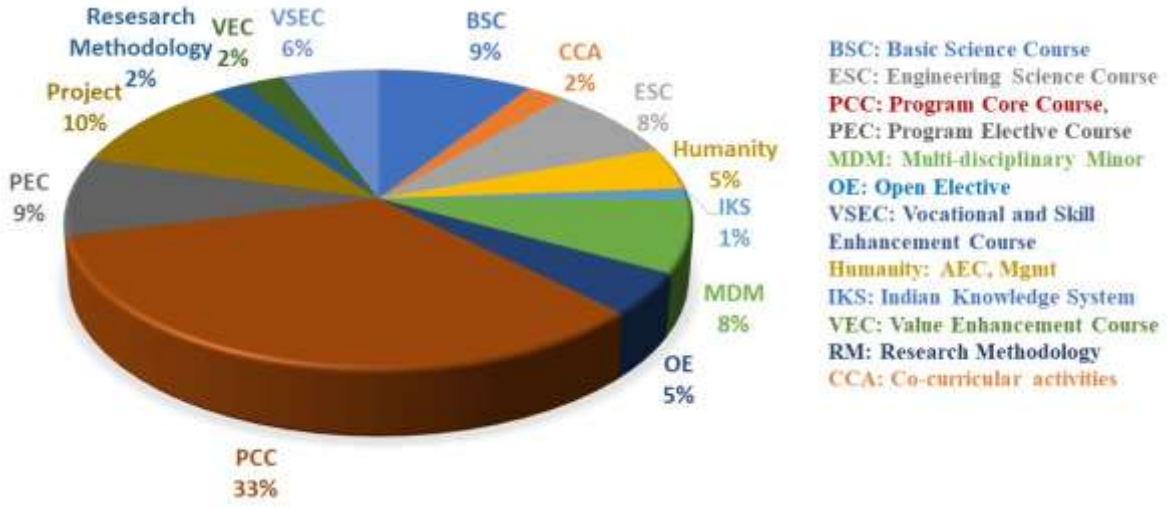
Chemical engineering is the engineering of systems—at scales ranging from the molecular to the macroscopic—that integrate chemical, physical, and biological elements to design processes and produce materials and products for the benefit of society. Chemical Engineering is the only engineering field with molecules and molecular transformations at its core. These transformations are at the heart of the technologies that enable modern society, and the work of chemical engineers has affected societies and individual lives around the world. It represents a discipline of intellectual inquiry and applications that is profoundly important for society's current and future needs in such vital areas as energy, food, water, medicine, and manufacturing.

Chemical engineering processes, with synthetic fertilizers, made Green Revolution possible to feed the world. With With the invention of a variety of catalysts, the benefits of plastics have reached to masses at affordable cost. Without the invention of tough, stable polymers such as Teflon® and Kevlar®, the commercial and medical devices made from those polymers would not have emerged. The contributions of chemical engineering to the silicon chips, glass materials, and plastics that make up today's ubiquitous electronic devices are undeniable. And without chemical engineering, there would be no oil and gas industry to power the world. Pharmaceutical industry's advances have been supplemented by Chemical Engineering to produce the medicines, therapeutics, and vaccines at scales for global supply needed. In recent years, chemical engineers have contributed to engineering of improved functions in proteins, metabolic pathways, and genomes.

The Chemical Engineering Course has been thus designed to provide best of the characteristics that a graduate of Chemical Engineering would demonstrate in his profession.

The Department of Chemical Engineering of ICT is one of the leading Chemical Engineering Departments in the Country maintaining high standards in teaching, research and industrial association. The Department offers Bachelor of Chemical Engineering, Master of Chemical Engineering and Ph.D.(Tech.) in Chemical Engineering programs. The program syllabus has always been based on strong theoretical background and modern trends in Industrial practice. The Department has thoroughly revised the syllabi of B. Chem. Engg. program in 2023 as per National Education Policy 2020. The NEP-2020 aims at making the education system holistic, flexible, multidisciplinary, and aligned to the needs of the 21st century and the 2030 Sustainable Development Goals. The revised syllabus has come into effect for first year undergraduate Chemical Engineering students from the academic year 2023-24. The revision is compliant with the NEP guidelines and perfect blend of basic sciences, engineering sciences, program electives, Indian knowledge system, co-curricular activities, vocational and skill development courses, ability

enhancement courses, multi-disciplinary minors, honours and research, etc. Students can also opt for courses from digital platforms such as MOOCs, NPTEL etc. The following figure shows the distribution of the courses in the B. Chem. Engg. program. The revised curriculum has significant weightage to hands-on training and also offers flexibility of exit option at regular intervals.



Programme Outcomes (POs) for B. Chem. Engg. Degree Programme

PO1	**Engineering knowledge**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems**	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
PO10	**Communication**	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Education Objectives (PEOs) of B. Chem. Engg. Program

PEO1	Create awareness amongst students about the social/industrial demands and role of chemical engineer in the society.
PEO2	Incorporate a culture of research and Innovation by providing students with latest facilities
PEO3	Provide a platform to the students to interact with leading teachers, scientists and industry practitioners
PEO4	Multi-faceted development of students through co-curricular and extra-curricular activities, participation in various events
PEO5	Build technical and managerial capabilities amongst students to meet the needs of society and industry.

Programme Specific Outcome (PSOs) of B. Chem. Engg. Program

The graduates will be able to:

PSO1	Understand terminology, basic concepts of science, mathematics, and fundamentals of engineering particularly in Chemical Engineering (Factual Knowledge).
PSO2	Comprehend theories or models, choose appropriate model, equipment, or process to meet the specified needs considering feasibility, safety, health hazards, societal, economic, environmental or sustainability factors as well as critically analyse relationships between these factors (Conceptual Knowledge).
PSO3	Investigate, conduct experiments, research, or model as per standards, collect and analyse information based on field visits, analysis, and interpretation of data to prepare the valid technical reports (Procedural knowledge).
PSO4	Apply Chemical Engineering knowledge in various sectors of industry, environment, life, and society, as well as develop solutions to complex problems applying principles and knowledge gained throughout the program or to develop new knowledge or methodologies through research (Metacognitive Knowledge).
PSO5	Cater to the needs of chemical industry, research organizations and academic institutes. set-up their own ventures and generate employment, promote awareness in society about Chemical Engineering profession

Exit Policy

As under the NEP –2020 guidelines, the following rules and regulations shall be applicable for the exit from the Degree program where the candidate is currently registered, after the First year, Second Year, and Third Year of the B. Chem. Engg. Degree programs:

a) A candidate who has earned a total of 44 credits after the First year of the Degree Course AND completed eight weeks of practical training can exit the degree course with a Certificate in a relevant degree program.

b) A candidate who has earned a total of 88 credits after the Second year of the Degree Course AND has completed eight weeks of practical training/Internship can exit the degree course with a Diploma in a relevant degree program.

c) A candidate who has earned a total of 132 credits after the Third year of the Degree course AND has completed eight weeks of practical training/ Internship can exit the degree with a B. Sc. degree in a relevant degree program.

d) The candidate shall apply for the exit from the program by this exit policy in a standard format. The letter will be addressed to The Dean, Academic Program. The exit will be permitted only on completion of the training program as prescribed by the Regulations.

Sr. No.	Exit Year	Mandatory Activity	Credits	Duration (No of Weeks)
1	1st Year (After Semester II)	8 credit course workshop/chemistry lab (after semester 2)	8	8 weeks
2	2nd Year (After Semester IV)	Certificate Course in Practice of Chemical Technology of ICT (CCPCT)	8	8 weeks
3	3rd Year (After Semester VI)	In-plant training for 3 months	8	8 weeks

Syllabus Structure for B. Chemical Engineering Course

SEMESTER – I										
Course Code	**Subjects**	**Course Type**	**Credits**	**Hrs/Week**			**Marks for various Exams**			
				L	**T**	**P**	**C. A.**	**M.S.**	**E. S.**	**Total**
CHT1251	Applied Chemistry	BSC	2	2	0	0	20	30	50	100
MAT1101	Applied Mathematics - I	BSC	4	3	1	0	20	30	50	100
GET1123	Structural Mechanics	ESC	3	2	1	0	20	30	50	100
GET1125	Electrical Engineering and Electronics	ESC	2	1	1	0	20	30	50	100
CHP1252	Applied Chemistry Laboratory	BSC	2	0	0	4	50	0	50	100
GEP1124	Structural Mechanics Laboratory	ESC	1	0	0	2	50	0	50	100
GEP1126	Electrical Engineering and Electronics Laboratory	ESC	2	0	0	4	50	0	50	100
GEP1127	Engineering Graphics and Computer Aided Drafting (CAD)	VSEC	2	0	0	4	50	0	50	100
HUP1110A	Communication Skills	AEC	2	0	0	4	50	0	50	100
HUPXXXX	OPEN Activity - Sports/ Fine arts/Yoga/ Music/NSS**	CCA	2	0	0	4	50	0	50	100
	Total		**22**	**8**	**3**	**22**				

SEMESTER – II										
Course Code	**Subjects**	**Course Type**	**Credits**	**Hrs/week**			**Marks for various Exams**			
				L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
PYT1251	Applied Physics	BSC	2	2	0	0	20	30	50	100
MAT1102	Applied Mathematics - II	BSC	4	3	1	0	20	30	50	100
GET1128	Elements of Mechanical Engineering	ESC	4	3	1	0	20	30	50	100
CET1151	Introduction to Chemical Engineering	ESC	2	2	0	0	20	30	50	100
PYP1252	Applied Physics Laboratory	BSC	2	0	0	4	50	0	50	100
CEP1152	Material Balance and Energy Balance Calculations	PCC	2	0	0	4	50	0	50	100
CEP1153	Engineering Applications of Digital Computers	VSEC	2	0	0	4	50	0	50	100
HUTXXXY	MOOC- Indian Knowledge System (NPTEL/SWAYAM - Introduction to Ancient Indian Technology)	IKS	2	2	0	0	20	30	50	100
HUTXXXZ	OPEN Activity- Sports/ Fine Arts/Yoga/ Music/NSS**	CCA	2	0	0	4	50	0	50	100
	Total		22	12	2	16				

Note: Universal Human Values (UHV) an audit course to be taken in inter-semester break after Semester-II to be taken as MOOC course.

** Students will undertake these co-curricular activities such as sports / Fine Arts / Yoga / Music / Literature etc administered through various clubs under Technological Association approved by Dean, Students Affairs.

SEMESTER – III										
Course Code	**Subjects**	**Course Type**	**Credits**	**Hrs /week**			**Marks for various Exams**			
				L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET1154	Fluid Flow	PCC	2	1	1	0	20	30	50	100
CET1155	Heat Transfer	PCC	2	1	1	0	20	30	50	100
CET1156	Engineering Thermodynamics	PCC	2	1	1	0	20	30	50	100
CET1157	Process Safety	PCC	2	1	1	0	20	30	50	100
HUT1252	Basic Principles of Finance & Economics	EEM	2	2	0	0	20	30	50	100
CET1159	Environmental Sciences	VEC	2	2	0	0	20	30	50	100
XXXXXXX	MDM-I: From Sciences and/or any other Engineering / Humanities Discipline	MDM	2	2*	0*	0*	20	30	50	100
CEP1158	Chemical Engineering Laboratory - I	PCC	2	0	0	4	50	0	50	100
XXXXXXX	From Basic Sciences (Chemistry/ Physics/Biology / Maths / Humanities)	OE	4	3	1	0	20	30	50	100
HUPXXXX	Modern Indian Language (Marathi / Hindi or Any other language will be chosen)	AEC	2	0	0	4	50	0	50	100
	Total		22	13	5	8				

*The number of hours/week may change based on the respective MDM

SEMESTER – IV										
Course Code	**Subjects**	**Course Type**	**Credits**	**Hrs/week**			**Marks for various Exams**			
				L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET1160	Chemical Engineering Operations	PCC	4	2	2	0	20	30	50	100
CET1161	Industrial Chemistry and Reaction Engineering	PCC	4	2	2	0	20	30	50	100
CET1162	Instrumentation and Process Dynamics	PCC	2	1	1	0	20	30	50	100
XXXXXXX	MDM II: From Sciences and/or any other Engineering /Humanities Discipline	MDM	2	2*	0*	0*	20	30	50	100
XXXXXXX	From Basic Sciences (Chemistry/ Physics/ Biology / Maths) or Humanities	OE	2	2	0	0	20	30	50	100
HUT1253	Production Management	EEM	2	2	0	0	20	30	50	100
CEP1163	Chemical Engineering Laboratory - II	VSEC	2	0	0	4	50	0	50	100
XXXXXXX	Course in Emerging Areas	VEC	2	0	0	4	50	0	50	100
XXXXXXX	Community Engagement Projects#	CEP/ FP	2	0	0	4	50	0	50	100
	Total		22	11	5	12				

*The number of hours/week may change based on the respective MDM

Students will undertake community projects, as individual or a group, related to study of societal technological activities through various organization such as Lions club, Teach India, Marathi Vidnyan Parishad, CSR projects outsourced by various industries, ISR activities administered through Technological Association approved by the Dean, Student Affairs.

SEMESTER – V										
Course Code	**Subjects**	**Course Type**	**Credits**	**Hrs /week**			**Marks for various Exams**			
				L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET1165	Chemical Reaction Engineering	PCC	2	1	1	0	20	30	50	100
CET1166	Momentum Transfer	PCC	2	1	1	0	20	30	50	100
CET1167	Chemical Engineering Thermodynamics	PCC	4	3	1	0	20	30	50	100
XXXXXXX	Chemical Engineering Elective - I Offered by Dept / NPTEL / MOOCS	PEC	4	3	1	0	20	30	50	100
XXXXXXX	MDM III: From Sciences and/or any other Engineering / Humanities Discipline	MDM	4	3*	1*	0*	20	30	50	100
XXXXXXX	MOOCs- From Other Science Disciplines and Humanities	OE	2	2	0	0	20	30	50	100
CEP1168	Chemical Engineering Laboratory - III	PCC	2	0	0	4	50	0	50	100
CEP1169	Process Simulation Laboratory - I	PCC	2	0	0	4	50	0	50	100
CET1170	Honors Course – I (Biochemical Engineering)	PCC	4	3	1	0	20	30	50	100
	Total		26	16	6	8				

*The number of hours/week may change based on the respective MDM

SEMESTER – VI										
Course Code	**Subjects**	**Course Type**	**Credits**	**Hrs/week**			**Marks for various Exams**			
				L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET1171	Multiphase Reaction Engineering	PCC	3	2	1	0	20	30	50	100
CET1172	Chemical Process Control	PCC	2	1	1	0	20	30	50	100
CET1173	Material Technology	PCC	2	2	0	0	20	30	50	100
CET1174	Separation Processes	PCC	3	2	1	0	20	30	50	100
CET1175	Heat Transfer Equipment Design	PCC	2	1	1	0	20	30	50	100
XXXXXXX	Chemical Engineering Elective – II Offered by Dept / MOOCS	PEC	4	3	1	0	20	30	50	100
XXXXXXX	MDM IV: From Sciences and/or any other Engineering / Humanities Discipline	MDM	2	2*	0*	0*	20	30	50	100
CET1176	Honours Course - II (Mathematical Methods and Optimization in Chemical Engineering)	PCC	4	2	0	4	20	30	50	100
CEP1177	Process Simulation Laboratory - II	VSEC	2	0	0	4	50	0	50	100
CEP1178	Chemical Engineering Laboratory - IV	VSEC	2	0	0	4	50	0	50	100
	Total		26	15	5	12				

*The number of hours/week may change based on the respective MDM

SEMESTER – VII										
Course Code	**Subjects**	**Course Type**	**Credits**	**Hrs/week**			**Marks for various Exams**			
				L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET1179	Chemical Process Development and Engineering	PCC	3	2	1	0	20	30	50	100
CET1180	Chemical Project Economics	PCC	2	2	0	0	20	30	50	100
XXXXXXX	Chemical Engineering Elective – III (offered by Dept / MOOCS)	PEC	3	2	1	0	20	30	50	100
XXXXXXX	Chemical Engineering Elective - IV Offered by Dept / MOOCS	PEC	2	2	0	0	20	30	50	100
XXXXXXX	MDM V: From Sciences and/or any other Engineering /Humanities Discipline	MDM	2	2*	0*	0*	20	30	50	100
GEP1138	Chemical Process Equipment Design and drawing	PCC	2	0	0	4	50	0	50	100
CEP1183	Research Methodology–I (Literature Review and Critical Analysis)	RM-I	2	0	0	4	50	0	50	100
CET1184	Research Methodology - II (Design and Analysis of Experiments)	RM-II	2	2	1	0	20	30	50	100
CEP1185	Design Project – I	Project	4	0	0	8	50	0	50	100
CET1182	Honours Course – III (Refinery Science and Engineering)	PCC	3	2	1	0	20	30	50	100
	Total		25	14	3	16				

*The number of hours/week may change based on the respective MDM

SEMESTER – VIII (10 Weeks)										
Course Code	**Subjects**	**Course Type**	**Credits**	**Hrs /week**			**Marks for various Exams**			
				L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
HUT1254	Industrial and Organizational Psychology	EEM	2	3	0	0	20	30	50	100
XXXXXXX	Chemical Engineering Elective - V Offered by Dept / MOOCS	PEC	2	3	0	0	20	30	50	100
XXXXXXX	MDM VI: From Sciences and/or any other Engineering /Humanities Discipline	MDM	2	3*	0*	0*	20	30	50	100
CET1187	Honours Course – IV (Catalytic Science and Engineering)	PCC	4	4	2	0	20	30	50	100
CEP1186	Design Project – II	PCC	4	0	0	12	**50**	**0**	**50**	**100**
CET1188	Honours Course – V (Statistical Thermodynamics)	PCC	3	3	2	0	20	30	50	100
	SEMESTER – VIII (12-16 Weeks)									
CEP1189		Internship/ On Job Training	12	0	0	0	**50**	**0**	**50**	**100**
	Total		29	16	4	12				

*The number of hours/week may change based on the respective MDM

Abbreviations:

BSC: Basic Science Course	**OE**: Open Elective: To be chosen compulsorily from faculty other than major discipline
PCC: Program Core Course	**MDM**: Multi-disciplinary Minor: Different discipline of engineering or different faculty altogether
RM: Research Methodology	**VSEC**: Vocational and Skill Enhancement Course: Hands on training corresponding to major/minor
ESC: Engineering Science Course	**AEC**: Ability Enhancement Course: English 2 credit, Modern Indian Language 2 credit
PEC: Program Elective Course	**IKS**: Indian Knowledge System: Indian Architecture/Maths/Medicine
CCA: Co-curricular activities: Health and wellness / Yoga / Sports / Cultural activities / NSS/NCC/Applied visual performing arts.	**VEC**: Value Enhancement Courses, Environmental Science / Education / Digital and Tech solutions
EEM: Entrepreneurship / Economics / Management	

First Year (Semester-I)

BSC	Course Code: CHT1251	Course Title: Applied Chemistry	Credits = 2		
			L	T	P
	Semester: I	Total contact hours: 30	2	0	0

List of Prerequisite Courses

HSC-level Chemistry or equivalent

List of Courses where this course will be prerequisite

Introduction to Chemical Engineering (CET1151), Material Technology (CET1173), Material Balance and Energy Balance Calculations (CEP1152), Process Safety (CET1157), Instrumentation and Process Dynamics (CET1162), Chemical Reaction Engineering (CET1165), Industrial Chemistry and Reaction Engineering (CET1161), Chemical Process Control (CET1172), Catalytic Science and Engineering (CET1187)

Description of relevance of this course in the B. Chem. Engg. Program

This is an introductory Chemistry course which addresses the scope and various applications of Chemistry. The topics discussed in the course will introduce the students to different aspects of Chemistry across various sub-disciplines.

	Course Contents (Topics and subtopics)	Reqd. hours
1	**Structure activity relationship in organic molecules**: Use of bond length and bond energies to explain the reactivity of functional groups. Acidity & basicity values for organic molecules such as alkynes, alcohols, acids, ketones, amines	**4**
2	**Aromatic electrophilic substitution**: Activating and deactivating functional groups on aromatic compounds, resonating structures, reactions such as Halogenation, Nitration, Friedel Crafts alkylation and acylation, sulfonation, Diazotization and important reacts of arene diazonium salts. Dyes – Chromophore and auxochrome concept, Azo dyes	**12**
3	**Aromatic compounds:** Problems associated with SNAr reactions and how to overcome them, Mechanism for aromatic nucleophilic substitutions.	**4**
4	**Spectroscopic methods:** General principles, UV-visible spectroscopy, fluorescence spectroscopy and their applications	**4**
5	**Chromatographic methods:** General principles, Basic instrumentation, and typical applications of GC, HPLC	**6**
		30

List of Text Books

1	L.G Wade- Organic Chemistry, Pearson Education, 2017, 9th Edition
2	Paula Y. Bruice – Organic Chemistry, Pearson Education, 2020, 8th Edition
3	D. A. Skoog, D. M. West, F. James Holler and S. R. Crouch - Fundamentals of Analytical Chemistry, Cengage Learning, 2022, 10th Edition
4	D. A. Skoog, F. James Holler and S. R. Crouch - Principles of Instrumental Analysis, Brooks/Cole, 2017,7th Edition

Course Outcomes (students will be able to…..)

CO1	Understand reactions and chemistry of various aromatic compounds.	K2
CO2	Write simple mechanisms of aromatic reactions	K3
CO3	Describe the fundamental concepts related to spectroscopic, electrochemical and chromatographic analysis	K4
CO4	Differentiate different spectroscopic techniques based on advantages and limitations	K4
CO5	Understand the concept of chromatograohic separations	K2
CO6	Differentiate between GC and HPCL and describe wokring principle of each	K2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Applied Chemistry (CHT1251) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	1	1	1	3
CO2	3	3	2	3	2	1	1	1	2	3	1	3
CO3	3	2	3	2	1	1	1	1	2	3	1	3
CO4	3	2	2	3	1	1	2	1	2	3	1	3
CO5	3	2	2	1	1	1	1	1	1	1	1	3
CO6	3	3	2	3	1	1	2	1	2	3	1	3

Course Title: Applied Chemistry (CHT1251) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	1	1
CO2	2	1	1	1	1
CO3	3	1	3	1	2
CO4	3	1	3	2	2
CO5	3	1	2	1	1
CO6	3	1	2	1	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

BSC	Course Code: MAT 1101	Course Title: Applied Mathematics – I	Credits = 4		
			L	T	P
	Semester: I	Total contact hours: 60	4	0	0

List of Prerequisite Courses

HSC Standard Mathematics

List of Courses where this course will be prerequisite

Fluid Flow (CET1154), Instrumentation and Process Dynamics (CET1162), Structural Mechanics (GET1123), Structural Mechanics Laboratory (GEP1124), Applied Mathematics - II (MAT1102), Elements of Mechanical Engineering (GET1128), Engineering Applications of Digital Computers (CEP1153), Heat Transfer (CET1155), Basic Principles of Finance & Economics (HUT1252), Momentum Transfer (CET1166), Process Simulation Laboratory - I (CEP1169), Honours Course - II (Mathematical Methods and Optimization in Chemical Engineering), (CET1176), Design and Analysis of Experiments (Research Methodology - II), (CET1184), Honours Course – V (Statistical Thermodynamics), (CET1188), Material Balance and Energy Balance Calculations (CEP1152), Chemical Process Control (CET1172), Chemical Engineering Laboratory - I (CEP1158), Chemical Engineering Laboratory - II (CEP1163), Chemical Engineering Laboratory - III (CEP1168), Chemical Engineering Laboratory - IV (CEP1178), Process Simulation Laboratory - II (CEP1177)

Description of relevance of this course in the B. Chem. Engg. Program

This is a basic Mathematics course. This knowledge will be required in almost all subjects later on. This knowledge is also required for solving various mathematical equations that need to be solved in several chemical engineering courses such as MEBC, momentum transfer, reaction engineering, separation processes, thermodynamics, etc.

	Course Contents (Topics and subtopics)	Reqd Hours
1	**Calculus of one variable:** Review of Mean Value theorems, Higher order differentiation and Leibnitz Rule for the derivative, Taylor's and Maclaurin's theorems and applications to error estimates, convexity of functions, Local Maxima/Minima.	8
2	**Multivariable calculus:** Functions of two or more variables, Limit and continuity, Partial differentiation, Directional derivatives, Total derivatives, Chain Rules of partial derivatives, Taylor's theorem for multivariable functions and its application to error calculations, Local and absolute Maxima/Minima	10
3	**Integral Calculus:** Beta and Gamma functions, Differentiation under the integral sign, Multiple Integrals, Line and surface integrals and applications to Greens, Gauss-Divergence and Stokes theorem	12
4	**Linear Algebra-I:** Systems of linear equations, matrices and Gauss elimination, Vectors in $\mathbb{R}^n$, notion of linear independence and dependence. Vector subspaces of $\mathbb{R}^n$, basis of a vector subspace., row space, null space, and column space, rank of a matrix. Determinants and rank of matrices. Abstract vector spaces, linear transformations, matrix of a linear transformation, change of basis and similarity, rank-nullity theorem and its applications	8
5	**Linear Algebra-II:** Inner product spaces, orthonormal bases, Gram-Schmidt orthogonalization process, Eigenvalues and eigenvectors, characteristic polynomials, eigenvalues of special matrices (orthogonal, unitary, Hermitian, symmetric, skew- symmetric, normal), Orthogonal projection and its application to	8

	least methods Diagonalization of matrices and its applications stochastic matrices, Matrix Factorization, Applications such as SVD, PCA etc.	
6	**Ordinary Differential Equations:** Review of first and second order ODEs (constant coefficient), Existence and Uniqueness theorems for first order ODEs. Higher order Linear ODE with constant and variable coefficient, Solutions of Initial and Boundary value problems, Solving initial value system of linear ordinary differential equations.	8
7	**Ordinary Differential Equations -II:** Power series method of solving ODE's and special functions, Legendre Polynomials Bessel functions and applications.	6
	Total	**60**
List of Textbooks / Reference Books		
1	G. Strang - Linear Algebra and its Applications, Cengage India Pvt Ltd, 2005, 4th Edition	
2	W. Keith Nicholson - Linear Algebra with Applications, Lyryx Learning Inc, 2018, Open Edition	
3	Howard Anton - Elementary Linear Algebra, John Wiley & sons, 2016, 11th Edition	
4	Arnold J. Insel, Lawrence E. Spence, and Stephen H. Friedberg - Linear Algebra, Pearson Education, 2022, 5th Edition	
5	E. Kreyszig - Advanced Engineering Mathematics, John Wiley & sons, 1998, 8th Edition (Officially prescribed)	
6	S. R. K. Iyengar, R. K. Jain - Advanced Engineering Mathematics, Narosa., 2019, 5th Edition	
7	Marsden, J.E., Tromba, Anthony, Weinstein Alan - Basic Multivariable Calculus, W.H Freeman and Co Ltd, 1993, 3rd Edition	
Course Outcomes (students will be able to….)		
CO1	Understand the notion of differentiability and apply these concepts to find maxima and minima of functions of one and several variables	K4
CO2	Understand different techniques for evaluating single and multiple integrals and apply them compute surface and volume integrals.	K4
CO3	Demonstrate their understanding on different concepts in vector spaces in solving computational problems related to matrices and determinants, such as solving systems of linear equations, etc.	K3
CO4	Understand the computational and geometrical concepts related to eigenvalues and eigenvectors and apply them to solve computational problems arising from chemical engineering	K3
CO5	Build mathematical models governed by differential equations to formulate chemical engineering problems and solve the equation using appropriate analytical techniques	K6
CO6	Solve ordinary differential equations using power series method and understand the utility and applications of various orthogonal functions in different chemical engineering problems	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Applied Mathematics – I (MAT1101) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	0	0	0	0	0	0	3
CO2	2	2	1	1	1	0	0	0	0	0	0	3
CO3	2	2	1	1	2	0	0	0	0	0	0	3
CO4	2	2	1	1	1	0	0	0	0	1	0	3
CO5	2	3	3	1	2	0	0	0	2	2	0	3
CO6	2	3	3	1	2	1	0	0	3	1	0	3

Course Title: Applied Mathematics – I (MAT1101) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1
CO2	3	1	1	2	1
CO3	3	1	1	1	1
CO4	3	1	1	1	1
CO5	3	3	2	3	1
CO6	3	3	2	3	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

ESC	Course Code: GET 1123	Course Title: Structural Mechanics	Credits = 2		
			L	T	P
	Semester: I	Total contact hours: 30	2	1	0

List of Prerequisite Courses
XIIth Standard Physics and Mathematics courses, Applied Physics - II
List of Courses where this course will be prerequisite
Structural Mechanics Laboratory (GEP1124), Material Technology (CET1173)
Description of relevance of this course in the B. Chem. Engg. Program
This subject will help students to understand basic steps in any engineering design. Different types of process considered in design of process equipment, supporting structures. Selection of materials and different rolled steel sections used for fabrication, their geometric properties, strength parameters. Design philosophies and calculation of stresses and deformations. This subject is introduced to improve the thinking. Advantages and disadvantages of various geometric sections available for engineering design.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Concepts of forces, their types, Resolution of forces, Composition of forces, Steps in Engineering Design, Different types supports and free body diagram.	4
2	Equilibrium of rigid bodies - Conditions of equilibrium. Determinant and indeterminate structures. Equilibrium of beams, trusses and frames problems on analysis of beams and truss.	5
3	Concept Centroid and Moment of Inertia (Second moment of area) its use. Parallel axis theorem. Problems of finding centroid and moment of Inertia of single figures, composite figures. Perpendicular axis theorem, Polar M.I., Radius of gyration.	4
4	Shear Force and Bending Moment - Basic concept, S.F. and B.M. diagram for cantilever, simply supported beams (with or without overhang). Problems with concentrated and U.D. loads.	5
5	Stresses and Strains - Tensile and compressive stresses, strains, modulus of elasticity, modulus of rigidity, bulk modulus. Relation between elastic constants. Lateral strain, Poisson's ratio, volumetric strain. Thermal stresses and strains. Problems based on stresses and strains. Stresses and Strains Relationship and Strain Deformation relationship.	4
6	Theory of Bending - Assumptions in derivation of basic equation, Derivation of Basic equation, section modulus, bending stress distribution. Advantages of various geometric sections from bending consideration.	3
7	Concept of Shear Stress, Derivation of basic formula, Problems on shear stress - Shear stress distribution for standard shapes. Problems of Shear stress distribution. Conditions under which shear stress is the governing criteria of design.	3
8	Slope and Deflection of beams - Basic concept, Slope and Deflection of cantilever and simply supported beams under standard loading. Macaulay's method. Simple problems of finding slopes and deflections.	4

List of Textbooks/ Reference Books	
1	B. N. Thadani, - Engineering Mechanics Vol I Statics, Wenall Book Corporation
2	Egor Popov - Introduction to Mechanics of Solids, Prentice Hall of India Pvt Ltd, 1968
3	Ferdinand Beer and E. Russel Johnston - Mechanics of Materials, Tata McGraw Hill Publishing Co. Ltd, 2009, 5th Edition
4	Dadhe, Jamdar and Walavalkar - Fundamentals of applied Mechanics, Sarita Prakashan Pune, 2006
5	S. Timoshenko and D. H. Young - Engineering Mechanics, McGraw Hill Publications, 2017, 5th Edition
6	Ferdinand Singer and Andrew Pytel - Strength of Materials, Harper Colins Publishers, 1997, 4th Edition

Course Outcomes (students will be able to….)		
CO1	Understand the use of basic concepts of Resolution and composition of forces.	K2
CO2	Analysis of the beams, truss or any engineering component by applying conditions of equilibrium. Shear Force and Bending moment for beams	K4
CO3	Understand the advantages and disadvantages of materials and various geometric sections used in engineering design.	K2
CO4	Understand the different stresses and strains occurring in components of structure various standard loadings and in case of any complicated loading.	K4
CO5	Determination of shear stress, bending stresses in the beams with simple and complex loading.	K4
CO6	Understand how to calculate the deformations such as axial, normal slope and deflections under different loading conditions.	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Structural Mechanics (GET1123)

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	0	0	0	0	0	2
CO2	3	3	3	3	2	0	1	0	0	0	0	0
CO3	3	3	3	2	0	0	1	0	0	0	1	0
CO4	3	3	3	3	2	0	0	0	0	0	0	0
CO5	3	3	3	2	2	0	1	0	0	0	1	0
CO6	3	3	3	3	1	0	0	0	0	0	0	0

Course Title: Structural Mechanics (GET1123)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	3	1	1
CO2	3	1	2	1	1
CO3	3	1	2	2	2
CO4	3	1	2	3	2
CO5	3	1	2	3	2
CO6	3	1	2	3	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

ESC	Course Code: GET 1125	Course Title: Electrical Engineering and Electronics	Credits = 2		
			L	T	P
	Semester: I	Total contact hours: 30	2	0	0

List of Prerequisite Courses
XIIth Standard Physics and Mathematics courses, Applied Physics - II
List of Courses where this course will be prerequisite
Process Safety (CET1157), Instrumentation and Process Dynamics (CET1162), Chemical Process Control (CET1172)
Description of relevance of this course in the B. Chem. Engg. Program
Students will get an insight to the importance of Electrical Energy in Chemical Plants . The students will understand the basics of electricity, selection of different types of drives for a given application process. They will get basic knowledge as regards to Power supplies, instrumentation amplifiers and thyristor application in industries.

	Course Contents (Topics and subtopics)	Reqd. hours
1	**Fundamentals of DC Circuits** Voltage and Current Sources, Basic Laws, Network Theorems, Superposition Theorem and Thevenin's Theorem,	4
2	**AC Fundamentals:** A.C. through resistance, inductance and capacitance, simple RL, RC and RLC circuits. Power, power factor	4
3	**Three Phase Systems**: Three phase system of emfs and currents, Star and Delta connections, Three phase power	3
4	**Single phase transformers**: Principle of working, Efficiency, regulation.	3
5	**Electrical drives**: Basic concepts of different types of Electrical motors as drives, Their suitability for various applications.	2
6	**Regulated power supplies**, Diodes as rectifiers, Half wave and Full wave rectifier, Filters and Regulators	3
7	**Bipolar junction transistors**: Different configurations, Characteristics, Concept of basic amplifier circuits, Amplifier gain, Transistor as switch	3
8	**Introduction to Integrated circuits:** Basic concepts of ICs	2
9	**Introduction to data acquisition and signal conditioning,** Basic concept and Block diagram, Concept of conversion of physical quantity to electrical signal, signal conditioning, Introduction to A/D and D/A converters	3
10	**Introduction to instrumentation amplifiers and their applications** Operational Amplifier – Notation, Pin diagram, Differential and common mode gain, CMRR, Applications as non-inverting, inverting, summing, differential amplifiers, integrator, differentiator,	3

List of Textbooks/ Reference Books		
1	Vincent Del toro - Electrical Engineering Fundamentals, Pearson Education, 2015, 2nd Edition	
2	Boylstead, Nashelsky - Electronic devices and circuits, Prentice Hall, 11th Edition	
3	Nagrath, D P Kothari - Electrical Machines, McGraw Hill Education, 2017, 5th Edition	
4	B.L.Theraja, A.K.Theraja - Electrical Technology vol I,II,IV, S Chand Publication	

Course Outcomes (students will be able to….)		
1	Understand the basic concepts of D.C. supply and circuits, Solve basic electrical circuit problems	K3
2	Understand the basic concepts single phase and three phase AC supply and circuits, Solve basic electrical circuit problems	K3
3	Understand the basic concepts of transformers, evaluate, and calculate efficiency at various load condition.	K5
4	Understand the concept of motors and their uses as various industrial drives.	K5
5	Understand the basic concepts of electronic devices and their applications in power supplies, amplification and instrumentation	K4
6	Understand the basic concepts of operational amplifiers and their applications, Understand the concept of Data acquisition, signal conditioning	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Electrical Engineering and Electronics (GET1125)

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	0	0	0	0	0	2	3	2	0	0
CO2	3	3	0	0	0	0	0	2	3	2	0	0
CO3	3	3	0	0	0	0	0	2	3	2	0	0
CO4	3	3	0	0	0	0	0	2	3	2	0	0
CO5	3	3	0	0	0	0	0	2	3	2	0	0
CO6	3	3	0	0	0	0	0	2	3	2	0	0

Course Title: Electrical Engineering and Electronics (GET1125)

Mapping of Course Outcomes (COs) with Programme Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1
CO2	3	2	3	2	3
CO3	3	2	3	2	3
CO4	3	2	3	2	3
CO5	2	2	3	3	3
CO6	2	2	3	2	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

BSC	Course Code: CHP1252	Course Title: Applied Chemistry Laboratory	Credits = 2		
			L	T	P
	Semester: I	Total contact hours: 60	0	0	4

List of Prerequisite Courses

HSC-level Chemistry or equivalent

List of Courses where this course will be prerequisite

Process Safety (CET1157), Chemical Reaction Engineering (CET1165), Material Balance and Energy Balance Calculations (CEP1152), Industrial Chemistry and Reaction Engineering (CET1161), Chemical Process Control (CET1172), Catalytic Science and Engineering (CET1187)

Description of relevance of this course in the B. Chem. Engg. Program

This is an introductory laboratory course in Chemistry designed to train students in the basic chemical analysis and chemical synthesis techniques. The techniques include identification, isolation, extraction, estimation and instrumentation.

	Course Contents (Topics and subtopics)	Reqd. hours
1	**ORGANIC CHEMISTRY:** a) Identification of an organic compound through elemental analysis, group detection, physical constants (m.p and b.p) and derivatisation. b) Separation and purification of binary mixtures of the type (1): water soluble-water insoluble, both water soluble. c) Separation and purification of binary mixtures of the type (2): liquid-liquid by distillation, dissociation –extraction, crystallization, etc	20
2	**PHYSICAL CHEMISTRY** a) Determination of the dissociation constant of the weak electrolyte using conductometry. b) Determination of the redox potential of $Fe^{3+}(aq)/Fe^{2+}(aq)$ system by potentiometric method. c) Determination of energy of activation of the reaction	20
3	**INORGANIC / ANALYTICAL CHEMSITRY:** a) Determination of Fe(III) with EDTA by photometric titration b) Determination of the dissociation constant of the given weak polybasic acid by pH-metry. c) Detection / quantitative determination of cations / anions in salts.	20
		60

List of Text Books

1	I.L. Finar - Practical Organic Chemistry, Pearson Education, 1973
2	B.Viswanthan and P.S. Raghavan - Practical Physical Chemistry Viva Book, 2005,
3	Alexander Findlay - Practical Physical Chemistry, Prentice Hall Press,1954, 8th Edition

Course Outcomes (students will be able to…..)

CO1	List steps for identifying simple organic compounds	K2
CO2	List some methods of separation of organic compounds	K3
CO3	List simple methods of chemical analysis	K2
CO4	Determine physicochemical parameters using simple laboratory tools	K5

CO5	Identify organic compound through various tests	K5
CO6	Determine activation energy of any reaction	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Applied Chemistry Laboratory (CHP1252)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	2	1	2	0	1	1	2	3
CO2	3	2	2	1	2	1	2	0	2	2	2	3
CO3	3	2	2	2	2	2	3	0	3	2	2	3
CO4	3	3	3	2	2	2	3	1	3	2	2	3
CO5	3	3	3	3	2	1	2	1	3	1	1	3
CO6	3	3	2	3	2	1	2	1	3	1	1	3

Course Title: Applied Chemistry Laboratory (CHP1252)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	1	1
CO2	2	3	3	2	2
CO3	2	1	3	1	2
CO4	3	3	3	2	2
CO5	3	3	3	2	1
CO6	3	3	3	2	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

ESC	Course Code: GEP 1124	Course Title: Structural Mechanics Laboratory	Credits = 1		
			L	T	P
	Semester: I	Total contact hours: 30 hrs	0	0	2

List of Prerequisite Courses
XIIth Standard Physics, Mathematics, Applied Mathematics I and II, Structural Mechanics
List of Courses where this course will be prerequisite
Equipment design and Drawing I and II, Home Paper I and II
Description of relevance of this course in the B. Chem. Engg. Program
This subject will help students to understand basics of Applied Mechanics and Strength of Materials. In industry different equipment are used to lift load, many non-destructive testings are done, Testing of materials is done to know the strength parameters. This course will help the students to understand these practical aspects of these. Also, different materials used in Fibre Reinforced Polymer composites, different cement composites and materials used for flooring as well as pipes will be introduced to students. Knowledge will be useful for courses in Equipment design and home papers where student design different processes for manufacturing. Advantages and disadvantages of various geometric sections and materials will be introduced to students. This is the foundation course for a good Design Engineer.

	Course Contents (Topics and subtopics)	Reqd. hours
	Suitable number of experiments from the above list will be performed (Minimum 5): 1. To study simple lifting machine and determine Law of Machine for (Screw Jack and Differential wheel and axle). 2. To study graphical methods of analysis. 3. To study the Universal testing machine and tests. (Demonstration) 4. To study Non-destructive testing methods in Engineering 5. Demonstration of Smith Hammer test, Ultrasonic pulse velocity test 6. To study corrosion of reinforcement. (Demonstration) 7. To study properties of cement composites and its applications. 8. To study effect of performance enhancing admixtures and additives for cement composites. 9. To study methods of manufacturing for Fibre Reinforced Polymer Composites 10. To study various materials used for flooring. 11. To study various materials used for Pipes for different engineering applications. In addition to above experiments, students will do a group project to understand different materials, manufacturing and testing. Learn modern materials used in engineering materials.	2 hours for each experiment including calculations and analysis

List of Textbooks/ Reference Books		
1	S C Rangwala, Charotar - Engineering Materials, Charotar publishing house Pvt Ltd, 2017, 43rd Edition	
2	R K Rajput - Engineering Materials, S Chand Publications, 2000, Revised Edition	
3	Dadhe, Jamdar and Walavalkar - Fundamentals of applied Mechanics, Sarita Prakashan Pune	
4	Niranjan Karak - Fundamentals of Polymers, Prentice Hall, 2009	
5	Peter Hewlett - Lea's Chemistry of Cement and Concrete, Elsevier publisher, 2019, 5th Edition	
Course Outcomes (students will be able to…..)		
CO1	Understand the working of simple lifting machine	K2
CO2	Understand destructive and non-destructive testing methods	K2
CO3	Understand the cement and its composites, performance enhancing construction chemicals.	K3

CO4	Select various materials, their suitability used for flooring, pipes, and various engineering applications	K4
CO5	Understand the applicability of universal testing machine for various tests	K3
CO6	Differentiate between different manufacturing methods and select appropriate method for Fibre Reinforced Polymer composite based on application	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Structural Mechanics Laboratory (GEP1124)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	0	1	2	0	0	0	0	0	0	1
CO2	3	2	0	2	2	0	0	0	1	0	0	2
CO3	3	2	2	2	2	0	1	0	2	1	0	1
CO4	3	3	2	1	1	1	1	0	1	0	0	2
CO5	3	2	2	1	2	1	1	1	2	1	0	2
CO6	3	3	3	3	1	1	1	1	2	1	0	2

Course Title: Structural Mechanics Laboratory (GEP1124)
Mapping of Course Outcomes (COs) with Programme Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	3	1	1
CO2	3	1	2	1	1
CO3	3	1	2	2	2
CO4	3	1	2	3	2
CO5	3	2	2	2	1
CO6	3	2	2	2	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

ESC	**Course Code:** **GEP 1126**	**Course Title: Electrical Engineering and Electronics Laboratory**	**Credits = 2**		
			L	**T**	**P**
	Semester: I	**Total contact hours: 60**	**0**	**0**	**4**

List of Prerequisite Courses		
XIIth Standard Mathematics and Physics courses, Applied Physics I, Electrical Engg and Elctronics		
List of Courses where this course will be prerequisite		
Process Safety (CET1157), Instrumentation and Process Dynamics (CET1162), Chemical Process Control (CET1172)		
Description of relevance of this course in the B. Chem. Engg. Program		
Students will get an insight to the importance of Electrical Energy in Chemical Plants. The students will understand the basics of electricity, selection of different types of drives for a given application process. They will get basic knowledge as regards to Power supplies, instrumentation amplifiers and thyristor application in industries.		
	Course Contents (Topics and subtopics)	**Reqd. hours**
	Suitable no. of experiments related the following concepts will be conducted: **Introduction to various Instruments and components in Electrical Engineering and Electronics** **Electrical Engineering**: Verification of Network Theorems Study of RLC circuits Load test on transformer Load test on induction motor Study of 3 phase circuits **Electronics:** Study of half wave, full wave rectifier circuits Study of input and output characteristics of a transistor. Study of operational amplifier circuits Study of sensors and transducers	4 hours for each experiment including calculations and analysis
List of Textbooks/ Reference Books		
1	Vincent Del toro - Electrical Engineering Fundamentals, Pearson Education, 2015, 2nd Edition	
2	Boylstead, Nashelsky - Electronic devices and circuits, Prentice Hall, 11th Edition	
3	Nagrath, D P Kothari - Electrical Machines, McGraw Hill Education, 2017, 5th Edition	
Course Outcomes (students will be able to…..)		
1	Understand the basic concepts of D.C. supply and circuits. Connect and analyse basic DC electrical circuits with suitable measuring equipment	K3
2	Understand the basic concepts of single phase and three phase AC supply and circuits. Connect and analyse basic DC electrical circuits with suitable measuring equipment	K3
3	Understand the basic concepts of single-phase transformer, its connections for different levels of loading and calculation of efficiency, losses, regulation using different measuring equipment	K5
4	Understand the basic concepts of electric motors and generators, their connections for different levels of loading and calculation of efficiency, Understanding speed control and electro mechanical power conversion concepts	K5
5	Understand the working and connections of electronic devices, their usage and applications, analysing electronic circuits and their applications	K4
6	Understand the working and connections of sensors and signal conditioning concepts, their usage and applications,	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Electrical Engineering and Electronics Laboratory (GEP1126) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	0	0	0	0	0	2	3	3	0	0
CO2	3	3	0	0	2	0	0	2	3	3	0	0
CO3	3	3	0	0	2	0	0	2	3	3	0	0
CO4	3	3	0	0	2	0	0	2	3	3	0	0
CO5	3	3	0	0	2	0	0	2	3	3	0	0
CO6	3	3	0	0	2	0	0	2	3	3	0	0

Course Title: Electrical Engineering and Electronics Laboratory (GEP1126) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1
CO2	3	2	2	1	1
CO3	3	3	2	2	2
CO4	3	3	3	2	2
CO5	3	3	3	2	2
CO6	3	2	2	1	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

VSEC	Course Code: GEP1127	Course Title: Engineering Graphics and CAD	Credits = 2		
			L	T	P
	Semester: I	Total contact hours: 60	0	0	4

List of Prerequisite Courses

Basic Geometry

List of Courses where this course will be prerequisite

Chemical Process Equipment Design and drawing (GEP1138), Structural Mechanics (GET1123)

Description of relevance of this course in the B. Chem.Engg. Program

A student of Chemical Engineering is required to know about various processes and equipment used in the industry. Some of the elementary processes like filtration, size reduction, evaporation, condensation, crystallization etc., are very commonly used in industries. These processes require identification, manufacturing, selection of machines and equipment. One should be familiar with the design, manufacturing, working, and maintenance of such machines and equipment. The current is a medium through which one can learn all such processes. These "drawings" are used to represent objects and processes on paper. An accurate communication of engineering knowledge is possible through drawings which is impracticable to transfer through a spoken word or a written text. Drawing is a language used by engineers and technologists. This course is a precursor for many subjects. Also a knowledge of this subject is useful for further pursuing a career.

	Course Contents (Topics and subtopics)	Required Hours
1	**Orthographic projections:** Basics of Engineering drawing, Different lines in the drawing and their applications, Methods of projection, Different planes of projection, first and third angle of projections of drawing, four quadrants and concept of orthographic projections.	12
2	**Sectional views and Missing views:** Need for the drawing sectional views, concept of sectioning and section lines, sectional drawings of different solids and machine components, auxiliary planes and views. Concept of recognizing missing views and their interpretation, drawing of missing views from given orthographic drawings.	08
3	**Projections, Sections, Development of surfaces and Interpenetration of solids:** Introduction to basic shapes of Solids, Projections of Solids in different planes as per the given conditions, Sectional planes for cutting solids and respective drawings, Concept of surface development of respective solids, Development of surfaces of cylinders, prisms, pyramids, cones etc. Interpenetration of two or more solids and their respective drawings	12
4	**Introduction to Computer Aided Drafting (CAD):** Basic introduction to CAD software, 2D and 3D drawings, drawing modification and dimensioning, different components of an engineering drawing in the industry.	08
5	**Isometric projections using CAD:** Concept of isometric views, isometric projections and isometric scale, Iso metric projections of different solids and machine components using CAD software.	08
6	**Assembly drawing using CAD:**	12

	Basics of Assembly drawing, preparation of 3d components and assembling on CAD software, labelling and table creation for bill of materials.	
	Total	**60**
List of Textbooks/ Reference Books		
1	N.D. Bhat - Engineering Drawing, Charotar Publication House, 2023, 54th Edition	
2	N.H. Dubey - Engineering Drawing, Nandu Printers and Publishers, 2015, 15th Edition	
3	Ibrahim Zeid and R Sivasubramanian - CAD/CAM: Theory and Practice, McGraw Hill Education, 2009, 2nd Edition	
Course Outcomes (students will be able to….)		
CO1	Understand the engineering drawing concepts and apply further in the engineering practice	K3
CO2	Remember the machine component assembly and apply its knowledge while doing machine assembly	K3
CO3	Understand the use of computers and software in drawing applications	K2
CO4	Understand the different solids and their orientation and apply its concepts to generate new machine components	K3
CO5	Apply a knowledge of sectional views and missing views while creating a new parts based on model imagination and thinking	K3
CO6	Apply the knowledge of engineering drawing preparation in the industrial production drawing and analysis.	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Engineering Graphics and CAD (GEP1127)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	3	2	0	2	2	1	2	3	1	2
CO2	3	0	3	0	0	0	0	0	0	0	1	0
CO3	3	1	3	0	2	0	3	0	0	3	0	1
CO4	3	0	3	2	0	0	2	0	0	0	0	2
CO5	3	2	3	2	0	2	3	0	0	0	1	0
CO6	3	3	3	3	3	0	0	0	3	0	0	3

Course Title: Engineering Graphics and CAD (GEP1127)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	3	3	3
CO2	2	2	2	1	1
CO3	1	2	3	2	2
CO4	1	2	2	3	2
CO5	2	1	3	2	2
CO6	1	3	3	1	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

AEC	**Course Code:**	**Course Title:**	**Credits = 2**

	HUT1110A	Communication Skills	L	T	P
	Semester: I	**Total contact hours:30**	**0**	**0**	**4**

	List of Prerequisite Courses	
Basic English language of the XII Grade level		
	List of Courses where this course will be prerequisite	
All subsequent courses of the University		
	Description of relevance of this course in the B. Chem. Engg. Program	
Communication skills are crucial for chemical engineers to facilitate clear and effective collaboration with multidisciplinary teams, ensuring that complex technical information is accurately conveyed. Strong communication enhances project management, safety protocols, and client interactions, driving successful project outcomes and innovation. Additionally, it helps in writing detailed reports, presenting findings, and obtaining necessary approvals, all essential for a thriving career in chemical engineering.		
	Course Contents (Topics and subtopics)	**Reqd. hours**
1	Communication as a way of life Process of communication and its elements Functions of communication and importance in future careers Essentials of good communication	6
2	The communication cycle 5 Steps of communication cycle: Idea formation, Message encoding, Message transmission, Decoding, Feedback	4
3	Factors affecting effective communication Planning for effective communication Modes of communication	3
4	Non verbal communication- Gestures, Facial expressions, Posture and movement, Paralinguistics, Eye contact, Image management	4
5	Presentation skills- What makes good presentation, Presenting the message, Presenting oneself, Visual Communication	8
6	Introduction to research study-Introduction to databases, Introduction to citation and referencing styles, How to conduct literature review, Preparation of a report based on literature review	5
	List of Textbooks/ Reference Books	
	The science of effective communication: Improve Your Social Skills and Small Talk, Develop Charisma and Learn How to Talk to Anyone- Ian Tuhovsky,	
	The Quick and Easy Way to Effective Speaking- Dale Carnegie	
	List of Additional Reading Material / Reference Books	
	The Hindu Businessline	
	National Newspapers' editorials	
Course Outcomes (students will be able to….)		
CO1	illustrate the 5 step communication process	K2
CO2	explain the end goal of communication	K2
CO3	explain barriers to clear communication	K2
CO4	articulate the role of visual communication within society, and implement the creative process to express himself/herself.	K2
CO5	identify the most relevant textbooks, reviews, papers and journals	K2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Communication Skills (HUT1110A)

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	0	0	0	0	0	1	1	3	3	2	3
CO2	0	0	0	0	0	0	1	1	3	3	2	3
CO3	0	0	0	0	0	0	1	1	3	3	2	3
CO4	0	0	0	0	0	0	1	1	3	3	2	3
CO5	0	0	0	0	0	0	1	1	3	3	2	3

Course Title: Communication Skills – English (HUT1110A) **Mapping of Course Outcomes (COs) with Programme Outcomes (PSOs)**						
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	0	0	0	0	0	2
CO2	0	0	0	0	0	2
CO3	0	0	0	0	0	2
CO4	0	0	0	0	0	2
CO5	0	0	0	0	0	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

CCA	Course Code: XXXX	Course Title: Yoga and Self Development	Credits= 2		
			L	T	P
	Semester: I	Total contact hours: 60	0	0	4

List of Prerequisite Courses

It may be necessary to gather some basic information about the students, such as their age, marital status, academic schedules, and recreational activities, whether they have any sleep issues and stress because of any situation. It shall be better to know how the students deal with stress, and whether they have proper nutrition. We also might need information about any injuries past or current and any other medical condition that may interfere in the program.

List of Courses where this course will be prerequisite

Applicable throughout professional and personal lives

Description of relevance of this course in the B. Chem.Engg. Program

Yoga is not course but a journey. The benefits of Yoga are many. It brings in calmness of mind besides the physical fitness by doing Yoga Aasanas. Apart from flexibility developed by regular physical activities, it makes one aware of his own potential. Professional and personal lives are full of situations that can be stressful. Yoga helps the students to withstand the stress coming from the expectations and demands of their own lives.

Sr. No	Course Contents (Topics and subtopics)	Reqd. hours
1	**Yoga** The principles and foundations of yoga. Both concentrative and insight meditation techniques may be practiced for each session. Behavioural techniques of self-monitoring should also be practiced observing the stream of consciousness from the perspective of a vigilant but detached observer. The students shall be trained to practice different models of mindfulness and meditation so as to elicit a state of deep physical and behavioural relaxation. They may work on selectively influencing or changing the symmetry in hemispheric brain activity. Positive addiction, meta-cognitive practices etc. are exercised to make the students experience the universal human capacity through spiritual experiences. The students may learn to turn-off or bypass the cognitive processing of usual daily preoccupations and concerns, allowing access to mindful, spiritual and meditative state of self-realization The students shall keep a small journal to write down their own journey/progress on physical flexibility, strength building and most importantly, how they deal with stressful conditions. This record will form the paper assessment of the student. Yoga helps to develop many mental skills like mindfulness, self-control, focus, and even self-compassion. It's mainly a physical practice. The students are taken through different movements and poses during the yoga sessions.	40
2	**Assessment: The** following assessments are recommended: Regular attendance **Paper Assessment**: A paper assessment may include assessing student's understanding of the basic philosophy of yoga Verbal Assessment on the basis of his/her ability to assimilate the philosophy of yoga and practicing in daily life. Mobility & Flexibility assessment is to assess the strength and flexibility, like twist.	20
	List of Books	
1	Yoga Sutra of Patanjali, Ramakrishna Mission, Kolkata	
2	RN Jha, Science of Consciousness Psychotherapy and Yoga Practices, Vidyanidhi Prakashan, Delhi 2016	

Course Outcomes (students will be able to…..)		
CO1	Keep physically fit and mentally agile	K2
CO2	Manage stress in studies and later in life	K2
CO3	Coordinate body and mind together	K2
CO4	Understand own emotions and maintain healthy daily routine	K2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Yoga and Self Development
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	1	2	0	1	0	1	2	2	1	0	2
CO2	0	1	2	0	1	0	1	2	2	1	0	2
CO3	0	1	2	0	1	0	1	2	2	1	0	2
CO4	0	1	2	0	1	0	1	2	2	1	0	2

Course Title: Yoga and Self Development
Mapping of Course Outcomes (COs) with Programme Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	0	0	0	0	0	1
CO2	0	0	0	0	0	1
CO3	0	0	0	0	0	1
CO4	0	0	0	0	0	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

CCA	Course Code: XXXX	Course Title: Fine Arts and Performing Arts	Credits = 2		
			L	T	P
Semester: I		Total contact hours: 30	2	0	0

List of Prerequisite Courses

No

List of Courses where this course will be prerequisite

NA

Description of relevance of this course in the B. Chem.Engg. Program

Cultivation of arts is an integral part of the development of human beings since the arts are what make us most human, most complete as people. They offer us the experience of wholeness because they touch us at the deepest levels of mind and personality. They come into being not when we move beyond necessity but when we move to a deeper necessity, to the deeper human need to create order, beauty and meaning out of chaos. They are the expressions of deepest human urges, imperatives and aspirations

	Course Contents (Topics and subtopics)	Reqd. hours
1	The Institute offers a range of courses in different art forms: music, dance, theatre, painting, and other art forms. Students will be given an option to choose a particular art form, and learn and practice it under an artist-instructor. At the end of the course, a student should be able to demonstrate basic proficiency in that particular art form.	30
	Total	**30**

Course Outcomes (students will be able to…..)

CO1	Enhance perceptual and cognitive skills	K3
CO2	Develop self-esteem, motivation, aesthetic awareness, cultural exposure	K3
CO3	Be creative with improved emotional expression	K3
CO4	Develop social harmony and appreciation of diversity.	K3
CO5	Develop an understanding and sharing of culture, with social skills that enhance the awareness and respect of others	K3

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Fine Arts and Performing Arts
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	0	1	0	2	1	1	2	2	2	1	2
CO2	0	0	1	0	2	1	1	2	2	2	1	2
CO3	0	0	1	0	2	1	1	2	2	2	1	2
CO4	0	0	2	0	1	1	1	2	2	1	1	2
CO5	0	0	2	0	1	1	1	2	2	1	1	2

Course Title: Fine Arts and Performing Arts **Mapping of Course Outcomes (COs) with Programme Outcomes (PSOs)**						
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	0	0	0	0	0	1
CO2	0	0	0	0	0	1
CO3	0	0	0	0	0	1
CO4	0	0	0	0	0	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

BSC	Course Code: PYT 1251	Course Title: Applied Physics	Credits = 2		
			L	T	P
	Semester: II	Total contact hours: 30	2	0	0

List of Prerequisite Courses

Standard XI and XII Physics course, Standard XII Chemistry course

List of Courses where this course will be a prerequisite

Instrumentation and Process Dynamics (CET1162), Applied Physics Laboratory (PYP1252), Fluid Flow (CET1154), Material Technology (CET1173), Momentum Transfer (CET1166)

Description of relevance of this course in the B. Chem. Engg. Program

Materials and their properties play a key role in chemical engineering and technology. The Applied Physics course will provide the students with the necessary fundamentals to develop a broad understanding of various aspects of materials, thereby equipping them with the ability to apply it wherever required in their course of study.

	Course Contents (Topics and subtopics)	Hours
1	Crystal Structure of Solids: A revision of concepts of a lattice, a basis, unit cell, different crystal systems (SC, BCC, FCC, HCP), co-ordination numbers and packing fractions. Single crystalline, Polycrystalline, and Amorphous materials.	3
2	Crystallographic planes and directions: concept of Miller indices and its determination, examples; calculation of inter-planar spacing in terms of Miller indices.	3
3	Determination of crystal structure using X-rays: Bragg's law of X-ray diffraction, types of diffractometers, Indexing diffraction peaks, and calculation of various lattice parameters and crystallite size	4
4	Energy band in solids and classification of solids, the concept of Fermi level and Fermi distribution function, Intrinsic and extrinsic semiconductors, Transport properties of semiconductors: Conductivity in semiconductors and its dependence of carrier concentration and mobility	5
	Electric and Magnetic properties of materials	
5	Revision of the laws of electrostatics and magnetostatics with illustrative examples. Introduction to the gradient, divergence, and curl operators. The current density vector and the continuity equation	4
6	Dielectrics: the concept of free and bound charges, polarization, introduction to the electric displacement and polarization vectors, dielectric constant, and electric susceptibility. Gauss's law in the presence of dielectrics, Claussius-Mossotti equation	6
7	Magnetism: The Langevin theory of Diamagnetism and Paramagnetism: deriving the magnetic susceptibility and Curie's law. An introduction to the Weiss theory of paramagnetism and ferromagnetism.	5
	Total	**30**

List of Textbooks / Reference Books

1	Halliday, Resnick, Walker - Fundamentals of Physics, John Wiley, 2018, 6th Edition
2	Young and Freedman - Sears and Zeemansky's University Physics, Pearson Education, 12th Edition

3	M N Avadhanulu, P G Kshirsagar, TVS Arun Murthy - A Textbook of Engineering Physics, S. Chand Publishers, 2018, 11th Edition	
4	S. O. Pillai - Solid State Physics, New Age Publishers,2022, 10th Edition	
5	A. J. Dekker - Solid State Physics, MacMillan India,2000	
6	V Rajendran - Engineering Physics, McGraw Hill Publishers, 2017, 6th Edition	
7	Edward Purcell and David Morin - Electricity and Magnetism, Cambridge University Press,2013, 3rd Edition	
Course Outcomes (students will be able to….)		
CO1	Assign Miller indices to various crystallographic planes and directions in a crystal lattice, thereby understand periodicity in the crystal lattice.	K3
CO2	Analyze a given x-ray diffraction pattern to deduce the crystal structure of the material and calculate the values of the basic structural parameters.	K3
CO3	Classify solids, and in turn semiconductors, based on electron occupancy and calculate basic quantities related to charge transport in them.	K3
CO4	Use basic vector calculus to describe the laws of electrostatics and magnetostatics.	K3
CO5	Apply the laws of electrostatics to dielectric materials.	K3
CO6	Understand the microscopic origins of magnetism in materials through semi-classical theories.	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Applied Physics (PYT1251)

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	1	1	1	1	1	1	3
CO2	3	3	2	1	2	1	1	1	1	1	1	3
CO3	3	3	2	1	1	1	1	1	1	1	1	3
CO4	3	3	1	1	2	1	1	1	1	1	1	3
CO5	3	3	2	1	1	1	2	1	1	1	1	3
CO6	3	3	2	1	1	1	2	1	1	1	1	3

Course Title: Applied Physics (PYT1251)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	1
CO2	3	3	3	2	1
CO3	3	3	2	2	1
CO4	3	2	2	2	1
CO5	3	2	2	2	1
CO6	3	2	2	2	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

BSC	Course Code: MAT 1102	Course Title: Applied Mathematics – II	Credits = 4		
			L	T	P
	Semester: II	Total contact hours: 60	4	0	0

List of Prerequisite Courses

HSC Standard Mathematics, Applied Mathematics – I (MAT 1101)

List of Courses where this course will be prerequisite

Momentum Transfer (CET1166), Process Simulation Laboratory - I (CEP1169), Honours Course - II (Mathematical Methods and Optimization in Chemical Engineering), (CET1176), Design and Analysis of Experiments (Research Methodology - II), (CET1184), Honours Course – V (Statistical Thermodynamics), (CET1188), Heat Transfer (CET1155), Chemical Engineering Laboratory - II (CEP1163), Chemical Engineering Laboratory - III (CEP1168), Chemical Engineering Laboratory - IV (CEP1178), Structural Mechanics (GET1123), Structural Mechanics Laboratory (GEP1124), Basic Principles of Finance & Economics (HUT1252), Fluid Flow (CET1154), Instrumentation and Process Dynamics (CET1162), Chemical Engineering Laboratory - I (CEP1158), Process Simulation Laboratory - II (CEP1177), Chemical Process Control (CET1172)

Description of relevance of this course in the B. Chem. Engg. Program

This is a basic Mathematics course. This knowledge will be required in almost all subjects later on. This knowledge is also required for solving various mathematical equations that need to be solved in several chemical engineering courses such as MEBC, momentum transfer, reaction engineering, separation processes, thermodynamics, etc.

	Course Contents (Topics and subtopics)	Hours
1	**Probability Theory and Sampling Distribution:** Review of probability, Random variables and cumulative distribution function; probability mass function and probability density function; Some common univariate distributions: Binomial, Poisson, Geometric and Uniform, exponential, Normal, Gamma, beta etc; Expectation and Moments (central and raw moments); Generating functions: moment generating function and characteristic function; Multiple random variables and Joint distribution; marginal distributions, independence; Covariance and Correlation; method of least squares and simple linear regression; nonlinear regression	15
2	**Partial Differential Equations**: Introduction to Partial Differential Equations (PDE), Classification of higher order PDEs, Solution of PDEs using separation of variable techniques	10
3	**Numerical Solution of System of Linear Equations:** Solutions of system of linear equations (Gauss-elimination, LU-decomposition etc.), Numerical solution set of linear algebraic equations: Jacobi, Gauss Siedel, and under/over relaxation method	5
4	**Numerical Roots:** Numerical methods for solving non-linear algebraic / transcendental etc.: Newton's method, Secant and Regula Falsi	6
5	**Interpolations:** Interpolation and extrapolation for equal and non-equal spaced data (Newtons Forward, Newtons backward and Lagrange), Numerical integration (trapezoidal rule, Simpson's Rule)	6
6	**Numerical Solution IVP:** Numerical methods for solution of first and higher order ODEs (initial values and boundary value problems) using single step methods (RK, Euler's explicit and implicit methods), multi-step methods (predictor – corrector methods etc.)	8

7	**Numerical Solutions of BVP and PDE:** Finite difference methods: Forward difference, Backward difference, and Central differences application of finite difference methods to Boundary value problem in ODE and PDE (parabolic, elliptic and hyperbolic)	10
	Total	**60**
List of Textbooks / Reference Books		
1	Sheldon Ross - A First Course in Probability, Pearson Prentice Hall, 2018, 9th Edition	
2	W.W. Hines, D. C. Montgomery, D.M. Goldsman, John-Wiley, Probability and Statistics in Engineering, John Wiley & Sons, 2008, 4th Edition	
3	Alexander M. Mood, Duane C. Boes, and Franklin A. Graybill - Introduction to the Theory of Statistics, McGraw Hill, 1974, 3rd Edition	
4	Thomas Haslwanter - An Introduction to Statistics with Python with Applications in the Life Sciences, Springer, 2016	
5	E. Kreyszig - Advanced Engineering Mathematics, John Wiley, 1999, 8th Edition	
6	S. R. K. Iyengar, R. K. Jain - Advanced Engineering Mathematics, Narosa, 2019, 5th Edition	
7	Daniel Joseph Navarro - Learning Statistics with R, 2015	
8	Sastry S. S - Introductory Methods of Numerical Analysis, PHI, 2012, 5th Edition	
9	M. K. Jain, S R K Iyengar and R K Jain - Numerical Methods: For Scientific and Engineering Computation, New Age International Publication, 2003,	
10	Kenneth J Beers - Numerical Methods for Chemical Engineering Application Using MATLAB, Cambridge University Press, 2007	
11	Mark E. Davis - Numerical Methods and Modelling for Chemical Engineers, Dover Publications, 2014	
12	Sandip Mazumder - Numerical Methods for Partial Differential Equations, Elsevier, 2015	
Course Outcomes (students will be able to….)		
CO1	Understand the concepts of various probability distributions and apply them to analyze various engineering problems and make inference about the system	K3
CO2	Understand the method of linear and nonlinear least squares method and apply it to choose appropriate mathematical functions for modelling real data sets, arising from chemical engineering applications	K3
CO3	classify higher order partial differential equation and solve parabolic equation using separation of variables.	K3
CO4	Understand the principles of various numerical approximation techniques and apply them to solve system of linear equations and nonlinear algebraic equations	K3
CO5	Approximate appropriate mathematical functions from equal an unequally spaced data and perform integration using various numerical methods	K3
CO6	Choose appropriate numerical techniques to solve initial and boundary value problems on ordinary and partial differential equations arising from various chemical engineering applications	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Applied Mathematics – II (MAT 1102) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	0	0	0	0	0	0	3
CO2	2	2	1	1	1	0	0	0	0	0	0	3
CO3	2	2	1	1	1	0	0	0	0	0	0	3
CO4	2	2	1	1	1	0	0	0	0	0	0	3
CO5	2	3	3	1	1	0	0	0	2	2	0	3
CO6	2	3	3	1	2	1	0	0	3	1	0	3

Course Title: Applied Mathematics – II (MAT 1102) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	2	2	3	2
CO3	3	2	2	1	1
CO4	3	1	1	2	1
CO5	3	1	3	3	1
CO6	3	2	2	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

ESC	Course Code: GET1128	Course Title: Elements of Mechanical Engineering	Credits = 4		
			L	T	P
	Semester: II	Total contact hours: 60	3	1	0

List of Prerequisite Courses

HSC standard Physics, HSC standard Mathematics, Applied Mathematics - I (MAT1101)

List of Courses where this course will be prerequisite

Chemical Process Equipment Design and drawing (GEP1138), Engineering Thermodynamics (CET1156), Chemical Engineering Thermodynamics (CET1167)

Description of relevance of this course in the B. Chem. Engg. Program

Students will be able to understand function , principle of operation and application of various power producing and absorbing devices such as steam turbine, gas turbine, pumps, compressors, refrigerators and power transmission system.

	Course Contents (Topics and subtopics)	Required Hours
1	Introduction to Thermodynamics, First and Second law of thermodynamics.	6
2	Properties of steam, T-S Diagram, Calculation of entropy, enthalpy, specific volume of steam, steam table, Dryness fraction. Ideal Rankine cycle, Regenerative Rankine cycle.	8
3	**Basics of Power Station** **(i) Steam Generators** Fire tube and Water tube boiler, Low pressure, and high-pressure boilers, Boiler Mountings and accessories, Boiler efficiency and equivalent evaporation. **(ii)Steam Turbines** Working principle of steam turbine, Concept of impulse and reaction steam turbines. Steam Nozzles and condensers, Vacuum efficiency of condensers. **(iii)Compressors/Pumps** Different Types of Compressors and their applications, Different Types of Pumps, and their applications	18
4	**Refrigeration:** COP of refrigerator and heat pumps, classification of refrigerants, Nomenclature, properties desired by refrigerants. Vapor compression refrigeration cycle. Methods of increasing COP of VCRS. Vapor absorption refrigeration systems.	6
5	**Internal combustion engines**: Thermodynamic cycles such as otto, diesel and dual cycles. Methods of increasing thermal efficiency and performance of internal combustion engines	6
6	**Gas turbines**: Constant pressure and constant volume gas turbines, open and closed cycle gas turbines. Methods of increasing thermal efficiency and specific work output of gas turbines.	6
7	Transmission of power: Introduction to various drives such as belt, rope, chain, and gear drives. Introduction to mechanical elements such as keys, couplings, and bearings in power transmission.	10
	Total	**60**

List of Textbooks/ Reference Books

1. Frederick T. Morse - Power plant Engineering, Van Nostrand, 1953, 3rd Edition
2. P.L. Balani – Thermal Engineering, Khanna Publication, 1978, 9th Edition

3	P.K. Nag – Engineering Thermodynamics, McGraw Hill Education, 2017, 6th Edition
4	Jagdish Lal - Hydraulic Machines, 1994
5	C.P. Arora - Refrigeration and air conditioning, McGraw Hill Education, 2017, 3rd Edition
6	Rattan. S.S - Theory of Machines, McGraw Hill Education, 2017, 4th Edition
7	HiH Saravanamutoo, G.F.C Rogers - Gas turbine theory, Pearson Education, 2017, 7th Edition

Course Outcomes (students will be able to….)		
CO1	Explain basic thermodynamic concepts and laws	K2
CO2	Describe the steam properties, boiler types and its construction	K2
CO3	Analyze steam power plant and refrigeration plants	K4
CO4	Evaluate means for increasing thermal efficiency of internal combustion engines, gas turbines.	K5
CO5	Recommend a suitable mechanical element /drive for different applications.	K4
CO6	Understand concept of Renewable Energy Sources	K2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Elements of Mechanical Engineering (GET1128)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	0	0	0	0	0	0	0	0	0	0	0
CO2	3	0	0	0	0	0	0	0	0	0	0	0
CO3	3	0	3	0	0	0	0	0	0	0	0	0
CO4	3	0	1	0	0	0	2	0	0	0	0	0
CO5	3	0	0	0	0	0	0	0	0	0	0	0
CO6	3	0	0	0	0	0	3	0	0	0	0	0

Course Title: Elements of Mechanical Engineering (GET1128)
Mapping of Course Outcomes (COs) with Programme Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	2
CO2	2	2	3	2	2
CO3	3	2	3	2	3
CO4	2	2	3	3	3
CO5	2	1	3	3	1
CO6	2	2	3	2	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

ESC	Course Code: CET 1151	Course Title: Introduction to Chemical Engineering	Credits= 2		
			L	T	P
	Semester: II	Total contact hours: 30	2	0	0

List of Prerequisite Courses

12th Standard Chemistry, Applied Chemistry (CHT1251), Applied Chemistry Laboratory (CHP1252)

List of Courses where this course will be prerequisite

Chemical Engineering Laboratory - I (CEP1158), Chemical Engineering Operations (CET1160), Chemical Engineering Laboratory - II (CEP1163), Chemical Engineering Laboratory - III (CEP1168), Honors Course – I (Biochemical Engineering), (CET1170), Multiphase Reaction Engineering (CET1171), Heat Transfer Equipment Design (CET1175), Chemical Engineering Laboratory - IV (CEP1178), Chemical Process Development and Engineering (CET1179), Honours Course – III (Refinery Science and Engineering), (CET1182), Separation Processes (CET1174), Environmental Sciences (CET1159), Chemical Project Economics (CET1180), Chemical Reaction Engineering (CET1165), Industrial Chemistry and Reaction Engineering (CET1161), Mathematical Methods and Optimization in Chemical Engineering (CET1176)

Description of relevance of this course in the B. Chem. Engg. Program

This course will help students to understand the status of chemical industry from Global and Indian perspectives. It also gives a flavor of role of Chemical Engineer in Chemical and Allied industries. Students will learn about the life cycle of chemical products/processes and their impact on Environment. It also touches upon the recent manufacturing trends.

	Course Contents (Topics and subtopics)	Hours
1	Chemical Engineer and Chemical Engineering Profession	4
2	Indian Chemical Industry: (a) Petroleum and petrochemical industry (b) Pharmaceutical industry (c) Agrochemicals and Pesticides industry (d) Speciality Chemicals industry (e) Inorganic Chemicals … etc	8
3	Chemical Engineering Principles: Chemical reaction engineering, separation processes, automation and process control	4
4	Overview of chemical process equipment: Reactors, Distillation, Absorption, Filters, Dryer and solid handling	4
5	Global trends of chemicals	4
6	Life cycle assessment and environmental impact	4
7	Modern Chemical Engineering Plants: Batch to Continuous processing	2

	List of Textbooks/ Reference books
1	Kenneth A. Solen, John N. Harb - Introduction to Chemical Engineering: Tools for Today and Tomorrow A First-Year Integrated Course, Wiley, 2014, 5th Edition
2	S. Pushpavanam - Introduction To Chemical Engineering, PHI Pvt Ltd, 2012
3	Morton Denn - Chemical Engineering: An Introduction, Cambridge University Press, 2011

	Course Outcomes (students will be able to….)	K Level
CO1	Understand the chemical sector	K2
CO2	Understand the role of chemical engineers	K2
CO3	Understand and predict the growth of various chemical sectors	K4
CO4	Understand the sequence of processing steps in chemical industry	K3
CO5	Understand the environmental impact of chemical industries	K2

CO6	Understand the recent trends related to process intensification using batch to continuous manufacturing	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Introduction to Chemical Engineering (CET1151) **Mapping of Course Outcomes (COs) with Programme Outcomes (POs)**												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	2	2	1	1	0	2	3
CO2	3	3	1	1	1	3	2	1	1	0	2	3
CO3	3	3	1	1	1	3	3	1	1	1	2	3
CO4	3	3	1	1	1	2	3	1	1	0	3	3
CO5	3	2	1	1	1	3	3	1	1	0	1	3
CO6	3	2	1	1	1	1	3	1	1	0	1	3

Course Title: Introduction to Chemical Engineering (CET1151) **Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)**					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	1	3	3
CO2	1	1	1	3	3
CO3	1	3	1	3	3
CO4	1	3	2	3	3
CO5	1	1	2	3	3
CO6	1	3	1	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

BSC	Course Code: PYP 1252	Course Title: Applied Physics Laboratory	Credits = 2		
			L	T	P
	Semester: II	Total contact hours: 60	0	0	4

List of Prerequisite Courses
Standard XI and XII Physics course, Applied Physics (theory)
List of Courses where this course will be a prerequisite
Fluid Flow (CET1154), Instrumentation and Process Dynamics (CET1162)
Description of relevance of this course in the B. Chem. Engg. Program
The hands-on experience gained by the students in the Applied Physics laboratory course will equip them with basic experimental skills related to the measurement of various important physical quantities. These skills will be a useful foundation for other laboratory and theory courses in their specializations.

	Course Contents (List of Experiments)	Hours
1	Determination of Co-efficient of Viscosity by Poiseuille's method	04
2	Thermistor characteristics: Determination of the Bandgap of a semiconductor	04
3	Determination of compressibility of liquids using an Ultrasonic Interferometer	04
4	Measurement of thermal conductivity of a solid: Lee's disc method	04
5	Photoelectric effect: Determination of h/e	04
6	Hall effect-I (sample current variation) Determination of carrier type and concentration in a semiconductor	04
7	Hall effect-II (magnetic field variation) Determination of carrier type and concentration in a semiconductor	04
8	Newton's rings: Determination of wavelength of light	04
9	Laser Diffraction: Determination of particle size	04
10	Studying variation of compressibility of liquid as a function of temperature	04
11	Estimating resistivity of semiconductor using four probe method	04
12	Determination of magnetic susceptibility of paramagnetic liquid using Quincke's method	04
	Total	60

	List of Textbooks / Reference Books	
1	Halliday, Resnick, Walker - Fundamentals of Physics, John Wiley, 2018, 6th Edition	
2	Young and Freedman - Sears and Zeemansky's University Physics, Pearson Education, 12th Edition	
3	V Rajendran - Engineering Physics, McGraw Hill Publishers, 2017, 6th Edition	
4	F. Jenkins and H. White - Fundamentals of Optics, McGraw Hill, 2017, 4th Edition	
5	ICT Physics Laboratory Manual (supplied to students)	
	Course Outcomes (students will be able to….)	
CO1	Independently set up, handle, and use basic setups to measure and obtain various physical quantities.	K2

CO2	Use basic instruments like vernier-caliper, screw-gauge, traveling microscope, thermometer, etc. to make accurate measurements.	K2
CO3	Correlate and use directly measured quantities to obtain the relevant parameters through appropriate formulae, calculations, and/or graphical plotting, thereby understanding the measurement principle involved in the experimental setups.	K3
CO4	Preliminarily treat the obtained datasets statistically to obtain errors in the experiments.	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Applied Physics Laboratory (PYP1252)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	3	1	1	1	3	1	1	3
CO2	3	2	1	2	3	1	1	1	3	1	1	3
CO3	3	3	2	2	3	1	1	1	3	2	1	3
CO4	3	2	1	2	3	1	1	1	3	1	1	3

Course Title: Applied Physics Laboratory (PYP1252)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	2
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	3	3	3	2	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CEP 1152	Course Title: Material Balance and Energy Balance Calculations	Credits= 2		
			L	T	P
	Semester: II	Total contact hours: 60	0	0	4

List of Prerequisite Courses

XIIth Standard Mathematics, Chemistry, Physics, Applied Chemistry (CHT1251), Applied Chemistry Laboratory (CHP1252), Applied Mathematics - I (MAT1101)

List of Courses where this course will be prerequisite

Chemical Engineering Laboratory - I (CEP1158), Chemical Engineering Operations (CET1160), Chemical Engineering Laboratory - II (CEP1163), Chemical Engineering Laboratory - III (CEP1168), Honors Course – I (Biochemical Engineering), (CET1170), Multiphase Reaction Engineering (CET1171), Separation Processes (CET1174), Heat Transfer Equipment Design (CET1175), Chemical Engineering Laboratory - IV (CEP1178), Chemical Process Development and Engineering (CET1179), Refinery Science and Engineering (CET1182), Heat Transfer (CET1155), Chemical Reaction Engineering (CET1165), Industrial Chemistry and Reaction Engineering (CET1161), Environmental Sciences (CET1159), Chemical Project Economics (CET1180), Mathematical Methods and Optimization in Chemical Engineering (CET1176), Chemical Process Control (CET1172)

Description of relevance of this course in the B. Chem. Engg. Program

This course is a foundation of Chemical Engineering. Almost all the chemical engineering calculations involve overall material balance and energy balance as starting step to design the equipment as well as to carry out the technoeconomic evaluation of the processes.

	Course Contents (Topics and subtopics)	Hours
1	Introduction to Chemical Engineering: Chemical Process Industries, Chemistry to Chemical Engineering, Revision of Units and Dimensions	4
2	Mole concept, composition relationship and Stoichiometry, Behaviour of gases and vapors	6
3	Material balances for reacting and non-reacting chemical and biochemical systems including recycle, bypass and purge	20
4	Introduction to psychrometry humidity and air-conditioning calculations.	10
5	Introduction to Energy Balances, Energy Balances in systems with and without reactions	10
6	Unsteady State Material and Energy Balances	6
7	Material and Energy Balances for multistage processes and complete plants	4
	List of Textbooks/ Reference books	
1	Hougen O.A, Watson K. M - Chemical Process Principles, CBS,2004, 2nd Edition	
2	Himmelblau - Basic Principles and Calculations in Chemical Engineering, Pearson Education, 2012, 8th Edition	
3	Bhatt B.I. and Vora S.M. – Stoichiometry, McGraw Hill, 2021, 6th Edition	

Course Outcomes (students will be able to….)		K Level
CO1	Convert units of simple quantities from one set of units to another set of units	K2
CO2	Calculate quantities and /or compositions in various processes and process equipment such as reactors, filters, dryers, etc.	K3
CO3	Select appropriate basis and conduct degree of freedom analysis before solving material and energy balance problems	K3
CO4	Quantify material input and output as well as energy requirement in various processing stages in chemical and allied industries	K4
CO5	Calculate conversion, selectivity etc for various reactions with and without recycle	K5
CO6	Calculate combustion efficiency and emissions as well as characterize various fuels	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Material Balance and Energy Balance Calculations (CEP1152)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	1	2	1	1	3
CO2	3	3	3	3	3	1	1	1	2	1	1	3
CO3	3	3	1	2	3	1	1	1	2	1	1	3
CO4	3	3	3	2	3	1	1	1	2	1	1	3
CO5	3	3	3	2	3	1	1	1	2	1	1	3
CO6	3	3	3	2	3	1	1	1	2	1	1	3

Course Title: Material Balance and Energy Balance Calculations (CEP1152)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	1	3
CO2	3	2	3	3	3
CO3	3	3	3	2	3
CO4	2	3	3	3	3
CO5	3	3	3	3	3
CO6	2	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

VSEC	Course Code: CEP 1153	Course Title: Engineering Applications of Digital Computers	Credits= 2		
			L	T	P
	Semester: II	Total contact hours: 60	0	0	4

List of Prerequisite Courses

XIIth Standard Mathematics and Physics Courses, Applied Mathematics - I (MAT1101)

List of Courses where this course will be prerequisite

Process Simulation Laboratory - I (CEP1169), Process Simulation Laboratory - II (CEP1177), Chemical Engineering Laboratory - I (CEP1158), Chemical Engineering Laboratory - II (CEP1163), Chemical Engineering Laboratory - III (CEP1168), Chemical Engineering Laboratory - IV (CEP1178)

Description of relevance of this course in the B. Chem. Engg. Program

The students opting for engineering education have different primary and secondary education based on the curriculum pattern as well as region (Metro, urban, rural etc). The basic knowledge of computers and programming depends on these aspects. This course helps students to understand applications of computers and programming tools for data analysis, simple engineering calculations. This is a foundation course essential for the process modeling and simulation courses covered later in the B. Chem. Engg. program.

	Course Contents (Topics and subtopics)	Hours
1	Spreadsheet calculations: Use of cells, formulas, table calculations, graphs, matrix operations, goal seek, solver, curve fitting, regression, statistical analysis, excel important formulas, visual basic programming	20
2	Any programming language (preferably python): Basics, array types, conditional statements, iterative loops, functions	20
3	Programming case studies involving solution of single non-linear equation (Equation of state such as Van der Waal, Peng Robinson, RKS, friction factor equation, Ergun equation, Estimation of Drag Coefficient etc)	6
4	Solution of ordinary differential equations (IVP and BVP)	8
5	Data visualization (2D plots, 3D plots, contours, surface plots)	6
	List of Textbooks/ Reference books	
1	Microsoft Office help	
2	Martin Brown - Python: The Complete Reference, McGraw Hill, 2018, 4th Edition	
3	McCabe, Smith, and Harriott - Unit Operations of Chemical Engineering (for case studies), McGraw Hill, 2017, 7th Edition	

Course Outcomes (students will be able to….)		K Level
CO1	Carry out Spreadsheet calculations for chemical engineering problems	K3
CO2	Develop programming logic and code it in software	K2
CO3	Use functions as good programming practice	K3
CO4	Fit the model parameters based on the experimental data	K4
CO5	Solve ordinary differential equations of engineering importance	K5
CO6	Construct tables and graphs to give meaningful outcomes for the physical problem under consideration	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Engineering Applications of Digital Computers (CEP1153) **Mapping of Course Outcomes (COs) with Programme Outcomes (POs)**												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	1	1	1	2	0	1	3
CO2	3	3	3	3	3	1	1	1	2	0	0	3
CO3	3	3	2	2	3	1	1	1	2	0	0	3
CO4	3	3	2	3	3	1	1	1	2	0	0	3
CO5	3	3	3	3	3	1	1	1	2	0	0	3
CO6	3	3	3	2	3	1	1	1	2	0	0	3

Course Title: Engineering Applications of Digital Computers (CEP1153) **Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)**					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	1	1
CO2	1	2	2	1	1
CO3	3	2	3	1	1
CO4	2	3	3	1	2
CO5	1	3	3	2	1
CO6	2	3	3	3	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

IKS	Course Code: HUT1117	Course Title: Traditional Indian Chemical Technology	Credits = 2		
			L	T	P
	Semester: II	Total Contact Hours: 30	1	1	0

List of Prerequisite Courses

NIL

List of Courses where this course will be prerequisite

NIL

Description of relevance of this course in the B. Chem. Engg. Program

To acquaint the students with major chronological developments in Indian science and technology.· To review the ancient discoveries and research related to chemicals in Pharmaceuticals, flavours and fragrances, metallurgy, architecture, textile, agriculture and Ayurveda etc. To know the fundamental principles of Indian health systems such as Ayurveda, which is useful in
maintaining well-being. To facilitate the students to identify and develop interest in the ancient knowledge systems to make meaningful contributions to the development of science today. To develop respect and pride about Indigenous Knowledge thereby to assist the learners' understanding about conclusions/products from ancient Indian knowledge system for verifying them on modern scientific and technological footings.

	Course Contents (Topics and subtopics)	Required Hours
1	**Introduction to Indian Knowledge System (IKS):** – Introduction, Definition and History – Need to study it in current times Chemists and texts of the ancient era	2
2	**Traditional Indian Pharmaceutical Sciences and Technology:** - Alternative systems of Medicine/ Welfare of the society: Principles of Ayurveda – Medicinal plants and crude drugs – Reappraisal of Ayurvedic Phytochemistry – Ayurvedic Dosage forms and similarity to that of modern dosage forms – Extraction of herbs in Ayurvedic System and comparison to that of modern extraction process – Detoxification of poisonous plants (*Shodhan Prakriya*) - Ancient perspective of Adulterants and Substitutes	6
3	**Traditional Indian Knowledge on Oils, Perfumery and Flavoring agents** – Essential oils and fixed oils - Applications in perfumery and flavoring-fragrance industry	3
4	**Traditional Indian Knowledge on Textile and Fibres** – Types of fibers – Textile patterns across the country - Methods and Techniques	2
5	**Traditional Indian Knowledge on Dyes, Pigments, mordents and specialty chemicals** – Natural dyes and pigments - Sources, Methods of dying	2
6	**Traditional Indian Knowledge on Polymers and surface coatings** Waxes, Gums, Carbohydrates	2
7	**Traditional Indian Food Technology**	2
8	Traditional Indian Knowledge about Metallurgy and Materials Science	3
9	**Traditional Indian Preservation Technology**	3

	– Methods of preservation: Food, monuments and artifacts - Materials used in Preservation	
10	Science associated with traditional Indian practices during festivals	2
11	Connecting The traditional Indian Knowledge with Modern Science	3
	Total	**60**
List of Textbooks/ Reference Books		
1	Acharya Prafulla Chandra Ray, A History of Hindu Chemistry, 1902, republ., Shaibya Prakashan Bibhag, centenary edition, Kolkata, 2002	
2	B. Mahadevan and Vinayak Rajat Bhat, Introduction To Indian Knowledge System: Concepts And Applications, PHI Learning publication, 2022	
3	The Positive Sciences of the Ancient Hindus; Brijendra Nath Seal; 4th Edition; 2016	
4	Fine Arts & Technical Sciences in Ancient India with special reference to Someśvara's Mānasollāsa; Dr. Shiv Shekhar Mishra, Krishnadas Academy, Varanasi 1982	
5	A Concise History of Science in India, ed. D M Bose, S N Sen and B V Subbarayappa; INSA; 2009	
6	Science and Technology in Medieval India - A Bibliography of Source Materials in Sanskrit, Arabic and Persian by A Rahman, M A Alvi, S A Khan Ghori and K V Samba Murthy; 1982.	
7	Vaidya Navnitlal B. Pandya, Fundamental principles of ayurveda part – 1. October 1982 Ancient Science of Life.	
8	Vasant Lad, Textbook of Ayurveda: Fundamental Principle, reprint 2010	
9	Lakshmi chandra Mishra (Editor), Scientific Basis for Ayurvedic Therapies, CRC Press LLC 2003	
10	H.Panda, Handbook on Speciality Gums, Adhesives , Oils, Rosin & Derivatives, Resins, Oleoresins, Katha, Chemicals with other Natural Products, Asia Pacific Business Press Inc., 2022	
11	Achyut Godbole, Anna, Madhushree Publication, 2022, Marathi edition	
12	Bhojanakutuhalam, Raghunatha Suri (author), frlht (contributor), M.A.Alwar (editor), Padma Venkat, The Medplan Conservatory Society 2019	
13	R.M. Pujari, Pradeep Kolhe, N. R. Kumar, 'Pride of India: A Glimpse into India's Scientific Heritage', Samskrita Bharati Publication.	
14	'Indian Contribution to science', compiled by Vijnana Bharati.	
15	'Knowledge traditions and practices of India',Kapil Kapoor, Michel Danino, CBSE, India	
Course Outcomes (students will be able to….)		
CO1	List the key achievements of Ancient India in different areas of Chemical Technology	K3
CO2	Describe the various features of traditional Indian knowledge in different areas of Chemical Technology	K2
CO3	Describe Key Principles of Traditional Indian Health Systems	K2
CO4	Describe the various products and key technology aspects based on traditional Indian Knowledge in context of Modern science	K2
CO5	Understanding the applications of IKS in current practices.	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Traditional Indian Chemical Technology (HUT1117) **Mapping of Course Outcomes (COs) with Programme Outcomes (POs)**												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	3	0	1	3	3	1	0
CO2	3	2	2	1	1	3	0	1	3	3	1	0
CO3	3	2	2	1	1	3	0	1	3	3	1	0
CO4	3	2	2	1	1	3	0	1	3	3	1	0
CO5	2	1	1	3	1	1	0	1	1	3	1	1

Course Title: Traditional Indian Chemical Technology (HUT1117) **Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)**					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	3	2
CO2	2	2	1	1	1
CO3	2	1	1	3	2
CO4	2	1	1	1	2
CO5	2	2	1	1	2

CCA	Course Code:	Course Title: Physical Activities (Sports & games)	Credits = 2		
			L	T	P
	Semester: II	Total contact hours: 60	0	0	4

List of Prerequisite Courses

None

List of Courses where this course will be prerequisite

Not Applicable

Description of relevance of this course in the B. Chem. Engg. Program

Games and sports are necessary and useful for all. Games play an important part in life. Education is incomplete without games. Games are necessary to keep the body fit and trim. Moreover, they provide recreation. As a result, one feels smart and cheerful throughout the day. If one is cheerful and healthy, he or she is able to get the best out of life. A player really enjoys life. For him, life is a song and a beauty. Games teach us the lesson of discipline, team-work, patience and punctuality. In the playground, the players obey the captain and abide by the rules of the games. Games also teach us that we should play a game for game's sake, not for victory or defeat. A healthy man is always hopeful and cheerful.

	Course Contents (Topics and subtopics)	Reqd. hours
1	The students shall select participating a specific sports/game/physical activity of their choice in morning/evening or at other suitable times according to the local climate. This would involve a routine of physical activity with games and sports. Physical activity means any bodily movement produced by skeletal muscles requiring energy expenditure, for example, Walking, gardening, climbing the stairs, playing soccer. Activities can be considered vigorous, moderate, or light in intensity. Activity makes one breathe harder and one's heart beat faster. **Moderate physical activities** include: □ Walking briskly (about 3½ miles per hour) □ Bicycling (less than 10 miles per hour) □ General gardening (raking, trimming shrubs) □ Dancing □ Golf (walking and carrying clubs) □ Water aerobics □ Canoeing □ Tennis (doubles) **Vigorous physical activities** include: □ Running/jogging (5 miles per hour) □ Walking very fast (4½ miles per hour) □ Bicycling (more than 10 miles per hour) □ Heavy yard work, such as chopping wood □ Swimming (freestyle laps) □ Aerobics □ Basketball (competitive) □ Tennis (singles)	60

Course Outcomes (students will be able to…..)

CO1	Keep physically fit and mentally agile	K2
CO2	Manage stress in studies and later in life	K2
CO3	Coordinate body and mind together	K2
CO4	Understand own emotions and maintain healthy daily routine	K2

CO5	Develop team work and an ability to work with others for a common goal	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Physical Activities (Sports & games)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	1	0	0	0	1	1	1	1	1	0	1
CO2	0	1	0	0	0	1	1	1	1	1	0	1
CO3	0	1	0	0	0	1	1	1	1	1	0	1
CO4	0	1	0	0	0	1	1	1	1	1	0	1
CO5	0	1	0	0	0	1	1	1	1	1	0	1

Course Title: Physical Activities (Sports & games)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	0	0	0	1
CO2	0	0	0	0	1
CO3	0	0	0	0	1
CO4	0	0	0	0	1
CO5	0	0	0	0	1

PCC	Course Code: CET 1154	Course Title: Fluid Flow	Credits= 2		
			L	T	P
	Semester: III	Total contact hours: 30	1	1	0

List of Prerequisite Courses

XIIth Standard Physics and Mathematics, Applied Physics (PYT1251), Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102)

List of Courses where this course will be prerequisite

Multiphase Reaction Engineering (CET1171), Heat Transfer Equipment Design (CET1175), Momentum Transfer (CET1166), Instrumentation and Process Dynamics (CET1162), Chemical Process Control (CET1172), Chemical Engineering Operations (CET1160)

Description of relevance of this course in the B. Chem. Engg. Program

This course is an industrially relevant course which help students to understand various components of fluid transport systems used in industry such as pipes, fittings, valves, pumps, blowers, compressors, vacuum pumps etc. The industrial operations involve heating, cooling of the reactors and other mixing/separation equipment which is provided by steam boilers, thermic fluid heaters, chillers, cooling towers etc. Many reactions and separation equipment also require understanding of fluid flow at design, operation and troubleshooting stage.

	Course Contents (Topics and subtopics)	Hours
1	Fluid Statics and applications to engineering importance.	4
2	Bernoulli's Equation and engineering applications, Pressure drop in pipes and Fittings, Piping systems	6
3	Utility network in chemical process industries: Cooling water, Steam, Chilled water, Thermic fluid system	8
4	Fluid moving machinery such as pumps, blowers, compressors, vacuum systems, etc.	6
5	Particle Dynamics, Boundary layer separation: skin and form drag, Flow through Fixed and Fluidised Beds, Flow through porous media	6

List of Textbooks/ Reference books

1. Bird R.B., Stewart W.E., Lightfoot E.N. - Transport Phenomena, Wiley, 2007, 3rd Edition
2. Kundu Pijush K. - Fluid Mechanics, Academic Press, 2015, 6th Edition
3. F. W. White - Fluid Mechanics, McGraw Hill, 2022, 9th Edition
4. McCabe, Smith and Harriott - Unit Operations of Chemical Engineering, McGraw Hill, 2017, 7th Edition

	Course Outcomes (students will be able to….)	K Level
CO1	Calculate pressure drop in pipelines and different pipe fittings	K3
CO2	Understand the applications of Bernoulli's equation	K2
CO3	Make appropriate selection of different pipe fittings based on the process requirement	K4
CO4	Calculate forces on particles and terminal velocities of particles	K3
CO5	Design or select pumps and piping systems for simple situations	K3
CO6	Calculate flow regimes and pressure drop different situations in multiphase systems such as two-phase pipe flow, fixed and fluidized beds etc	K4

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Fluid Flow (CET1154) **Mapping of Course Outcomes (COs) with Programme Outcomes (POs)**												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	2	1	1	0	2	0	1	3
CO2	3	2	2	1	1	1	0	0	1	0	0	3
CO3	3	2	2	2	1	1	1	0	2	0	0	3
CO4	3	3	2	2	2	1	0	0	1	0	0	3
CO5	3	3	3	2	2	1	1	0	2	0	1	3
CO6	3	3	2	3	2	1	0	0	2	0	0	3

Course Title: Fluid Flow (CET1154) **Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)**					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	3	2
CO2	2	3	3	3	2
CO3	1	2	3	3	2
CO4	3	3	2	3	2
CO5	2	2	3	3	3
CO6	2	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1155	Course Title: Heat Transfer	Credits= 2		
			L	T	P
	Semester: III	Total contact hours: 30	1	1	0

List of Prerequisite Courses

Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102), Material Balance and Energy Balance Calculations (CEP1152)

List of Courses where this course will be prerequisite

Chemical Engineering Operations (CET1160), Heat Transfer Equipment Design (CET1175), Chemical Process Control (CET1172), Instrumentation and Process Dynamics (CET1162), Multiphase Reaction Engineering (CET1171)

Description of relevance of this course in the B. Chem. Engg. Program

This is a basic course that deals with heat transfer, overview of heat exchangers Heat transfer forms one of the basic pillars of Chemical Engineering Education and is required in all future activities.

	Course Contents (Topics and subtopics)	Hours
1	Revision of Basics of Heat transfer: Steady state and unsteady state conduction, Fourier's law, Concepts of resistance to heat transfer and the heat transfer coefficient. Heat transfer in Cartesian, cylindrical and spherical coordinate systems, Insulation, critical radius.	6
2	Convective heat transfer in laminar and turbulent boundary layers. Theories of heat transfer and analogy between momentum and heat transfer.	4
3	Heat transfer by natural convection.	4
4	Heat transfer in laminar and turbulent flow in circular pipes: Double pipe heat exchangers: Concurrent, counter-current and cross flows, mean temperature difference, NTU – epsilon method for exchanger evaluation. Heat transfer outside various geometries in forced convection, such as, single spheres, banks of tubes or cylinders, packed beds and fluidised beds	8
5	Heat transfer in agitated vessels: coils, jackets, limpet coils, calculation of heat transfer coefficients, heating and cooling times, applications to batch reactors and batch processes	4
6	Basics of Radiative heat transfer and application to Furnace Design	4
	List of Textbooks/ Reference books	
1	Kern D.Q. - Process Heat Transfer, Wiley, 2019, 2nd Edition	
2	Kakac S., Bergles A.E., Mayinger F - Heat Exchangers, Springer, 2012,	
3	G. Hewitt - Process Heat Transfer, Begell House, 1994	

Course Outcomes (students will be able to….)		K Level
CO1	Calculate temperature profiles in a slab at steady state	K3
CO2	Calculate heat transfer coefficients for free and forced convection in different heat transfer equipment	K3
CO3	Rate performance of heat exchanger using NTU-epsilon method	K4
CO4	Design agitated vessel for heat transfer controlled process	K3
CO5	Understand the importance of Radiative heat transfer in furnace operation	K2
CO6	Estimate the approximate value of heat transfer coefficient using theories of heat transfer	K3

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Heat Transfer (CET1155) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	0	0	0	1	0	0	3
CO2	3	3	2	1	2	0	1	1	1	0	0	3
CO3	3	2	3	2	2	1	1	2	1	1	0	3
CO4	3	3	3	3	3	1	1	1	1	0	0	3
CO5	3	1	1	1	1	1	1	1	1	0	0	3
CO6	3	3	2	2	3	1	0	1	1	0	0	3

Course Title: Heat Transfer (CET1155) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1
CO2	2	3	2	2	1
CO3	3	3	3	2	1
CO4	3	3	2	3	3
CO5	2	2	1	3	3
CO6	2	3	2	2	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1156	Course Title: Engineering Thermodynamics	Credits= 2		
			L	T	P
	Semester: III	Total contact hours: 30	1	1	0

List of Prerequisite Courses

Elements of Mechanical Engineering (GET1128)

List of Courses where this course will be prerequisite

Statistical Thermodynamics (CET1188), Chemical Engineering Laboratory - II (CEP1163), Chemical Engineering Laboratory - III (CEP1168), Chemical Engineering Laboratory - IV (CEP1178), Multiphase Reaction Engineering (CET1171), Chemical Engineering Thermodynamics (CET1167), Environmental Sciences (CET1159), Honors Course – I (Biochemical Engineering) (CET1170), Chemical Engineering Operations (CET1160)

Description of relevance of this course in the B. Chem. Engg. Program

Thermodynamics sets hard limits on performance of processes and equipment. This course gives students the formalism and insights necessary to do a preliminary thermodynamic analysis of a process for the purpose of establishing feasibility assuming ideal mixing.

	Course Contents (Topics and subtopics)	Hours
1	Revision of basic Concepts of thermodynamics and 1st Law of Thermodynamics to open processes Concept of Equilibrium: Entropy and Gibbs-Free Energy	2
2	Need for Entropy and Gibbs Energy, Exergy, Industrial Applications of Second Law of Thermodynamics using Ideal Gas Law and Thermodynamic Property Charts and Tables	4
3	Equations for Property Changes, Maxwell Relations and the need for Equations of State. Residual Properties, Industrial Applications using Equations of State	4
4	Phase Equilibria for Pure Fluids, Fugacity and Fugacity Coefficient	4
5	Thermodynamic Properties of Mixtures, Gibbs Duhem Equation	4
6	Phase Equilibrium in Mixtures, Fugacity and Fugacity Coefficient in Mixtures	4
7	Vapor – Liquid Equilibria in Ideal Mixtures, T-x-y and P-x-y diagrams, Bubble point and Dew point calculations for Ideal mixtures	4
8	Non-Ideal Mixtures, Excess Properties and activity coefficients	4

List of Textbooks/ Reference books

1. Smith, van Ness, Abbott - Introduction to Chemical Engineering Thermodynamics, McGraw Hill, 2012, 7th Edition
2. S. I. Sandler - Chemical, Biochemical and Engineering Thermodynamics, Wiley, 2020, 5th Edition
3. Reid, Prausnitz, Pauling - Properties of Gases and Liquids, McGraw Hill, 2001, 5th Edition

	Course Outcomes (students will be able to….)	K Level
CO1	Calculate Enthalpy, Entropy and Gibbs energy changes in fluids with changes in temperature and pressure	K3
CO2	Analyse process efficiencies using entropy or exergy concepts	K4
CO3	Calculate saturation temperature and pressure relationship for pure fluids from equations of state	K3
CO4	Design experiments to measure the vapor-liquid equilibrium for ideal mixtures	K4
CO5	Fit thermodynamic model parameters based on experimental data	K5

CO6	Understand the effect of non-ideality of multicomponent mixtures on the design of separation equipment	K2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Engineering Thermodynamics (CET1156)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	2	0	0	0	2	0	0	3
CO2	3	3	2	2	2	0	2	0	2	0	0	3
CO3	3	3	1	1	2	0	0	0	2	0	0	3
CO4	3	3	3	3	3	0	1	1	2	0	1	3
CO5	3	2	2	2	3	0	0	0	2	0	0	3
CO6	3	1	1	1	1	0	1	0	2	0	0	3

Course Title: Engineering Thermodynamics (CET1156)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	2
CO2	2	3	3	3	3
CO3	2	3	3	3	2
CO4	2	3	3	3	2
CO5	2	3	3	3	2
CO6	2	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1157	Course Title: Process Safety	Credits= 2		
			L	T	P
	Semester: III	Total contact hours: 30	1	1	0

List of Prerequisite Courses

Applied Chemistry (CHT1251), Applied Chemistry Laboratory (CHP1252), Electrical Engineering and Electronics (GET1125)

List of Courses where this course will be prerequisite

Refinery Science and Engineering (CET1182), Chemical Process Development and Engineering (CET1179), Chemical Engineering Laboratory - II (CEP1163), Chemical Engineering Laboratory - III (CEP1168), Chemical Engineering Laboratory - IV (CEP1178)

Description of relevance of this course in the B. Chem. Engg. Program

This course is related to creating awareness in students about safety protocols to be followed in laboratory as well as industrial operations. The course helps students to understand the consequences of unsafe operations based on case studies, introduces the scientific approach towards process safety at every stage of chemical engineering operations such as storage, transportation, reactions, separations and subsequently disposals.

	Course Contents (Topics and subtopics)	Hours
1	Safety management in chemical industry (a) Regulations in chemicals manufacturing units (b) Overview of hazards, contributors to chemical process accidents, importance of safety culture (c) Causes of fires and explosion, , accident prevention, work permits	10
2	Transport, storage and safe handling of hazardous chemicals (a) Flammable and combustible liquids (b) Storage and handling of hazardous chemicals (c) Norms for safe handling of chemicals at workplace (d) Safety during transportation of hazardous substances	10
3	Basics of laboratory safety (a) MSDS and personal protective equipment (b) Electrical safety (c) Fire safety (d) Machine safety (e) Cylinder safety (f) Bio safety	10
	List of Textbooks/ Reference books	
1	Daniel A. CROWL and Joseph F. LOUVAR - Chemical Process Safety: Fundamentals with Applications, Pearson, 2020, 4th Edition	
2	Guidelines for Process Safety Management, Environment, Safety, Health, and Quality – Center for the Chemical Process Safety of the American Institute of Chemical Engineers (AIChE)	
3	Roy E. SANDERS - Chemical Process Safety Learning from Case Histories, Butterworth-Heinemann Inc, 2015, 4th Edition	
4	Guidelines for Process Safety Documentation – Center for the Chemical Process Safety of the American Institute of Chemical Engineers (AIChE)	

	Course Outcomes (students will be able to….)	K Level
CO1	Identify hazards in a given process and assess the same and provide solutions for operating safely.	K3
CO2	Specify safety requirements for storage and handling of a given chemical.	K4
CO3	Develop experimental plan for conducting reactions based on the MSDS	K5

CO4	Understand safe storage conditions based on the properties of the chemicals	K2
CO5	Develop standard operating procedure based on the activity considering all the elements of safety	K5
CO6	Understand the causes of fire and explosion and use the knowledge to develop inherently safer processes	K2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Process Safety (CET1157)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	0	2	2	0	1	0	0	3
CO2	3	1	1	1	0	1	2	1	1	3	0	3
CO3	3	2	2	2	1	1	1	0	1	2	1	3
CO4	3	1	1	1	0	2	2	1	1	1	0	3
CO5	3	3	3	2	2	3	2	2	1	2	1	3
CO6	3	2	1	1	0	3	2	0	1	1	0	3

Course Title: Process Safety (CET1157)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	3	3
CO2	2	2	3	3	3
CO3	2	3	3	2	3
CO4	2	3	3	3	3
CO5	2	3	3	3	3
CO6	3	2	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	**Course Code:** **HUT1252**	**Course Title:** **Basic Principles of Finance and Economics**	**Credits = 2**		
			L	**T**	**P**
	Semester: III	**Total contact hours: 30**	**2**	**0**	**0**

List of Prerequisite Courses

Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102)

List of Courses where this course will be prerequisite

Chemical Project Economics (CET1180)

Description of relevance of this course in the B. Chem. Engg.'S Program

The engineering requires application of scientific principles with an objective of making economical gains by services and production. The knowledge of economics and financial management becomes important in industry.

	Course Contents (Topics and subtopics)	**Reqd. hours**
1	Introduction- Explaining the Economy, The Supply and Demand Model, Using the Supply and Demand Model	3
2	THe Competitive Equilibrium Model- Deriving Demand, Deriving Supply, Market Equilibrium and Efficiency	4
3	Deviations From Competition- Monopoly and Market Power, Between Monopoly and Competition, Antitrust Policy and Regulation	4
4	Macro Facts And Measures- Getting Started with Macroeconomic Ideas, Measuring Production, Income and Spending of Nations	4
5	Accounting Transactions Journal entries, Debit credit rules, Compound journal entry, Journal and ledger, Rules of posting entries, Trial balance	6
6	CApital And Revenue Income and expenditure, Expired costs and income, Final accounts, Manufacturing accounts, Trading accounts, Profit and Loss account, Suspense account, Balance sheet	6
7	Concept Of Depreciation	3

List of Textbooks

	William G. Droms and Jay O. Wright - Finance and Accounting for Nonfinancial Managers: All the Basics You Need to Know, Basic book, 2010, 6th Edition A A Temu, D W Ndyetabula - Microeconomics: Basic Principles and Applications E. Case Karl, C. Fair Ray, et al - Principles Of Economics(12e)

List of Additional Reading Material / Reference Books

	Basic Finance for Nonfinancial Managers: A Guide to Finance and Accounting Principles for Nonfinancial Managers- Kendrick Fernandez Microeconomic Theory: Basic Principles and Extensions- Walter Nicholson and Christopher Snyder Macroeconomics(10e) Part of: Pearson Series in Economics (23 books) - by Froyen

Course Outcomes (students will be able to…..)

CO1	Students will be able to know and understand accounting and finance theory.	K2
CO2	Students will be able to understand the mechanics of preparation of financial statements, their analysis and interpretation	K2
CO3	Students will understand and explain the balance sheet of a company	K2
CO4	Students will be able to explain basic economic terms, concepts, and theories	K2
CO5	Students will be able to identify key macroeconomic indicators	K2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Basic Principles of Finance and Economics (HUT1252) **Mapping of Course Outcomes (COs) with Programme Outcomes (POs)**												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	0	0	0	0	0	0	0	0	0	3	0
CO2	0	0	0	0	0	0	0	0	0	0	3	0
CO3	0	0	0	0	0	0	0	0	0	0	3	0
CO4	0	0	0	0	0	0	0	0	0	0	3	0
CO5	0	0	0	0	0	0	0	0	0	0	3	0

Course Title: Basic Principles of Finance and Economics (HUT1252) **Mapping of Course Outcomes (COs) with Programme Outcomes (PSOs)**						
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	0	0	0	0	0	0
CO2	0	0	0	0	0	0
CO3	0	0	0	0	0	0
CO4	0	0	0	0	0	0
CO5	0	0	0	0	0	0

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

VEC	Course Code: CET 1159	Course Title: Environmental Sciences	Credits= 2		
			L	T	P
	Semester: III	Total contact hours: 30	2	0	0

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Engineering Thermodynamics (CET1156), Process Safety (CET1157)

List of Courses where this course will be prerequisite

Chemical Process Development and Engineering (CET1179)

Description of relevance of this course in the B. Chem. Engg. Program

This course provides the basic guidelines of environment, heath and safety (EHS) management. It also introduces regulatory aspects of handling liquid and gaseous effluents in terms of monitoring, analysis, safe limits during disposal, methods of waste treatment as well as overall life cycle assessment including environmental impact.

	Course Contents (Topics and subtopics)	Hours
1	(a) Concept of circular economy, EHS management (b) Environment management systems in the chemical industry (c) Legal provisions for environmental management: EP Act 1986; Air Act, 1981; Water Act, 1974; Hazardous waste management Rules, 2019	6
2	Importance of ecology, effluent treatment and discharging norms for treated water	6
3	SPCB consent parameters, monitoring and analysis	4
4	External monitoring of ambient air, noise, stacks, etc	4
5	Air pollutants, sources and effects on human health and environment, monitoring and analysis	6
6	Life cycle analysis, environmental impact assessment	4
	List of Textbooks/ Reference books	
1	Gilbert M Masters and Wendell P Ela - Introduction to Environmental Engineering and Science, Pearson Education, 2006, 3rd Edition	
2	C. S. Rao - Environmental Pollution Control Engineering, New age international publishers, 2018, 3rd Edition	
3	D. A. Skoog, F. James Holler and S. R. Crouch - Principles of Instrumental Analysis, Brooks/Cole, 2007, 6th Edition	

	Course Outcomes (students will be able to….)	K Level
CO1	Describe the methods of industrial effluent treatment	K2
CO2	Select method for treatment of liquid water based on the source and composition	K3
CO3	Select method for treatment of contaminated air based on the source and composition	K3
CO4	Apply the learning for selection and implementation of appropriate waste management technique for sustainable development	K4
CO5	Select appropriate monitoring and analysis method based on the type of pollutant	K3
CO6	Evaluate the environmental burdens associated with a process through LCA	K4

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Environmental Sciences (CET1159) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	0	0	0	0	1	2	0	3
CO2	3	2	1	2	1	1	2	0	1	0	0	3
CO3	3	2	1	2	1	1	2	0	1	0	0	3
CO4	3	3	2	2	0	3	3	2	2	2	1	3
CO5	3	2	1	2	1	3	3	1	1	0	0	3
CO6	3	2	1	3	2	3	3	2	1	2	1	3

Course Title: Environmental Sciences (CET1159) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	3	3
CO2	2	3	3	3	3
CO3	2	3	3	3	3
CO4	2	3	2	3	3
CO5	2	3	3	3	3
CO6	2	3	2	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CEP 1158	Course Title: Chemical Engineering Laboratory - I	Credits= 2		
			L	T	P
	Semester: III	Total contact hours: 60	0	0	4

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Engineering Applications of Digital Computers (CEP1153), Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102)

List of Courses where this course will be prerequisite

Chemical Engineering Laboratory - II (CEP1163), Chemical Engineering Laboratory - III (CEP1168), Chemical Engineering Laboratory - IV (CEP1178)

Description of relevance of this course in the B. Chem. Engg. Program

Chemical Engineering laboratory provides students the firsthand experience of verifying various concepts learnt in theory courses. It also exposes them to actual set-ups of typical chemical engineering equipment and servers as a bridge between theory and practice. This lab focuses on fluid mechanics, reaction engineering, thermodynamics, heat & mass transfer and process automation.

	Course Contents (Topics and subtopics)	Hours
1	8-10 Experiments on Fluid Flow	40
2	2-3 Experiments on Heat Transfer	10
3	2-3 Experiments on Thermodynamics	10
	List of Textbooks/ Reference books	
1	McCabe W.L., Smith J.C., and Harriott P - Unit Operations in Chemical Engineering, 2014	
2	Bird R.B., Stewart W.E., Lightfoot E.N. - Transport Phenomena, Wiley, 2007, 3rd Edition	
3	Coulson J.M., Richardson J.F., and Sinnott - R.K. Coulson & Richardson's Chemical Engineering: Chemical engineering design, Butterworth-Heinemann Inc, 1999, 3rd Edition	
4	Green D. and Perry R. Perry's Chemical Engineers' Handbook, McGraw Hill, 2007, 8th Edition	

Course Outcomes (students will be able to….)		K and P Level
CO1	Learn how to experimentally verify various theoretical principles of heat transfer	K3, P2
CO2	Visualize practical implementation of chemical engineering equipment	K4, P2
CO3	Perform statistical analysis of experimental data	K4, P2
CO4	Get hands on experience with various flow measurement devices such as rotameter, venturi meter, anemometer etc.	K2,P2
CO5	Develop empirical correlations based on the experimental data generated	K5, P3
CO6	Generate meaningful tables and graphs	K3, P3

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody, P6 – Creating

Course Title: Chemical Engineering Laboratory – I (CEP1158) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	3	3	2	1	3
CO2	3	3	3	2	1	1	1	2	3	1	1	3
CO3	3	3	2	3	3	1	1	3	3	1	1	3
CO4	3	3	2	2	3	1	1	2	3	1	1	3
CO5	3	3	3	3	3	1	1	1	3	1	1	3
CO6	3	3	3	2	3	1	1	2	3	1	1	3

Course Title: Chemical Engineering Laboratory – I (CEP1158) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
CO6	3	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1160	Course Title: Chemical Engineering Operations	Credits= 4		
			L	T	P
	Semester: IV	Total contact hours: 60	2	2	0

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Fluid Flow (CET1154), Heat Transfer (CET1155), Engineering Thermodynamics (CET1156)

List of Courses where this course will be prerequisite

Refinery Science and Engineering) (CET1182), Separation Processes (CET1174), Honors Course – I (Biochemical Engineering), (CET1170), Chemical Engineering Laboratory - III (CEP1168), Chemical Engineering Laboratory - IV (CEP1178), Instrumentation and Process Dynamics (CET1162), Chemical Process Development and Engineering (CET1179), Chemical Process Control (CET1172), Separation Processes (CET1174), Chemical Process Equipment Design and drawing (GEP1138)

Description of relevance of this course in the B. Chem. Engg. Program

The principles learnt in this course are required in almost all the courses and throughout the professional career of Chemical Engineer. Most of the chemical processes involve handling of multicomponent mixtures which may be homogenous or heterogenous phases. Separation is essential for material recovery and recycle as well as meeting the product specifications based on market requirements. Separation methods are selected based on the material properties, process scalability and economics. This course introduces most commonly used separation methods in industrial operations.

	Course Contents (Topics and subtopics)	Hours
1	Introduction to Unit Operations and Chemical Engineering Processes, Introduction to mass transfer: Concepts of Convective and diffusive transport	4
2	Distillation of binary mixtures: Differential distillation, Flash or equilibrium distillation, Fractionating column and multistage column, reflux, reflux ratio, need for reflux, McCabe-Thiele, Lewis-Sorel methods of estimation of number of equilibrium stages, Operating and feed lines, minimum and optimum reflux ratio, Tray and column efficiency, Packed column distillation: rate based methods: HETP, HTU, Ponchon Savarit method, Introduction to batch distillation and steam distillation. Methods for multicomponent separations: Fenske-Underwood-Gilliland Method	12
3	Absorption and Stripping of dilute mixtures: Fundamentals of absorption, equilibrium curves, Operating lines from material balances, Number of equilibrium stages, Kremser Equation, Stage efficiency and column performance, Absorption columns, Rate based methods for packed columns (HTU, NTU), Design considerations: loading and flooding zones, pressure drop and column diameter	12
4	Liquid Filtration: Filtration theory: constant pressure, constant rate, and variable pressure-variable rate filtration, Incompressible and compressible cake filtration, Continuous filtration, filter aids, Filtration equipment, Selection, Sizing and Scale-up	10
5	Sedimentation, Classification and Centrifugal Separations: Design and scale up equations, Performance evaluation, Sedimentation equipment, classifiers, centrifugal equipment, Sieving operations, types of sieving (dry, wet, vibro), magnetic separators, and froth flotation, Selection, sizing and scale-up	8

6	Drying of solids: Mechanism of drying, drying rate curves, Estimation of drying time , Drying Equipment, operation, Process design of dryers, material and energy balances in direct dryers, Drying of bioproducts	10
7	Particle Size Reduction: Energy requirements for size reduction and scale-up considerations, Operational considerations, Crushing and grinding equipment: impact and roller mills, fluid energy mills, wet/dry media mills, Selection of equipment	4
	List of Textbooks/ Reference books	
1	Richardson, J.F., Coulson, J.M., Harker, J.H., Backhurst, J.R. - Chemical engineering: Particle technology and separation processes, Butterworth-Heinemann, 2002, 5th Edition	
2	Seader, J.D., Henley, E.J. - Separation Process Principles, Wiley, 2006 2nd Edition	
3	Svarovsky, L - Solid-Liquid Separation. Butterworth-Heinemann, 2000, 4th Edition	
4	McCabe, W., Smith, J., Harriott, P - Unit Operations of Chemical Engineering, McGraw-Hill, 2017, 7th Edition	
5	Green, D., Perry, R. - Perry's Chemical Engineers' Handbook, McGraw-Hill Professional, 2007, 8th Edition	
6	Dutta, B.K. - Principles of Mass Transfer and Separation Process. Prentice-Hall of India Pvt. Ltd, New Delhi, 2007	

Course Outcomes (students will be able to….)		**K Level**
CO1	Know the significance and usage of different particulate characterization parameters, and equipment to estimate them	K2
CO2	Describe Size reduction energy requirements, estimate performance of equipment, selection and sizing of equipment	K2
CO3	Analyze filtration data and select systems based on requirements, estimate filtration area for given requirements, understand filter aids and their usage	K4
CO4	Draw T-y-x diagrams, and y-x diagrams, operating lines, feed line, bubble point, dew point calculations, ternary phase diagrams, partition coefficient	K3
CO5	Describe two common modes of drying, industrial drying equipment	K2
CO6	Calculate mass transfer coefficient in various equipment, Calculate height and diameter required, minimum solvent required in absorption, calculate height and diameter required, minimum reflux required in distillation	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Chemical Engineering Operations (CET1160) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	1	1	1	1	2	1	1	3
CO2	3	2	3	3	2	2	1	2	2	1	1	3
CO3	3	3	3	2	2	1	1	2	2	1	1	3
CO4	3	3	2	2	3	1	1	2	2	1	1	3
CO5	3	2	2	2	1	1	1	1	2	1	1	3
CO6	3	3	2	2	3	2	2	2	2	1	1	3

Course Title: Chemical Engineering Operations (CET1160) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	2
CO2	2	2	3	2	2
CO3	2	3	3	2	3
CO4	2	3	3	2	2
CO5	2	3	3	2	3
CO6	2	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1161	Course Title: Industrial Chemistry and Reaction Engineering	Credits= 4		
			L	T	P
	Semester: IV	Total contact hours: 60	2	2	0

List of Prerequisite Courses

Applied Chemistry (CHT1251), Applied Chemistry Laboratory (CHP1252), Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Engineering Thermodynamics (CET1156), Process Safety (CET1157)

List of Courses where this course will be prerequisite

Catalytic Science and Engineering (CET1187), Chemical Reaction Engineering (CET1165), Multiphase Reaction Engineering (CET1171), Chemical Process Development and Engineering (CET1179), Refinery Science and Engineering (CET1182), Chemical Engineering Laboratory - IV (CEP1178), Chemical Engineering Laboratory - III (CEP1168)

Description of relevance of this course in the B. Chem. Engg. Program

Students will be able to understand sources and processes of manufacture of various chemicals such as petroleum and petroleum products, petrochemicals, biochemicals, industrial chemicals, clean utilization of coal and advances in fuels. The course also introduces the rate based aspects of chemical transformations under isothermal, adiabatic and non-isothermal conditions. Different types of ideal reactor conditions and their design aspects are covered which form the basis for the selection of different single and multiphase reactors.

	Course Contents (Topics and subtopics)	Hours
1	Raw material and energy sources, Organic and inorganic intermediates and final products, Bulk and specialty chemicals	10
2	Production costs of fuels and chemicals	2
3	Industrial gases and inorganic products	4
4	Examples of major industrial processes	6
5	Types of chemical reactions: elementary/non-elementary, single/multiple, irreversible/reversible	8
6	Types of chemical reactors: batch and semi-batch reactors, continuous reactors (CSTR and PFR)	8
7	Reaction kinetics (homogeneous reactions)	8
8	Isothermal, adiabatic and non-isothermal operation modes	8
9	Different types of single phase and multiphase reactors	6
	List of Textbooks/ Reference books	
1	H. Scott Fogler - Elements of Chemical Reaction Engineering, Pearson Education, 2016, 5th Edition	
2	Octave LEVENSPIEL - Chemical Reaction Engineering, Wiley, 2006, 3rd Edition	
3	Lanny D. Schmidt - The Engineering of Chemical Reactions, Oxford university press, 2004, 2nd Edition	
4	Charles Hill - An introduction to Chemical Engineering Kinetics and Reactor Design, Wiley, 2014, 2nd Edition	
5	L. K. Doraiswamy, M. M. Sharma - Heterogeneous Reactions, Vol. I and II, Wiley-Blackwall, 1984	
6	Kirk-Othmer - Encyclopedia of Chemical Technology	
7	Ulmann's Encyclopedia of Industrial Chemistry	
8	Weissermel & Arpe - Industrial Organic Chemistry, John Wiley & sons, 2003	

9	Shreve B. Austin - Chemical Process Industries, McGraw Hill, 2017, 5th Edition
10	Moulijn, M. and van Dippen - Chemical Process Technology, John Wiley & sons, 2013, 2nd Edition
11	Dryden's Outlines of Chemical Technology, East-West press,1997, 3rd Edition
12	O.P. Gupta - Elements of Fuels, Furnaces and Refractories, Khanna, 1989,
13	Johnson – Fuels Handbook, McGraw Hill, 1951

Course Outcomes (students will be able to….)		**K Level**
CO1	Design chemical reactors optimally, using minimum amount of data	K4
CO2	design experiments in a judicious way to get the required data, if not available	K4
CO3	Increase capacity and/or selectivity and/or safety by improving/changing the reactor type/sequence and/or operating conditions	K3
CO4	Draw process flow diagrams/process block diagrams for the manufacture of various chemicals from process description	K4
CO5	List out various alternatives for carrying out a particular process and provide recommendations for the best choice	K3
CO6	List Principles of combustion systems for solid, liquid and gaseous fuel	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Industrial Chemistry and Reaction Engineering (CET1161)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	2	2	1	1	3
CO2	3	3	3	3	2	0	0	1	2	1	1	3
CO3	3	3	3	3	1	1	2	1	2	1	0	3
CO4	3	2	2	1	2	0	0	0	2	1	0	3
CO5	3	1	1	1	0	1	2	1	2	1	0	3
CO6	3	1	1	1	0	0	0	0	2	1	0	3

Course Title: Industrial Chemistry and Reaction Engineering (CET1161)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	3	2
CO2	2	3	3	3	2
CO3	2	3	3	3	3
CO4	2	2	3	3	3
CO5	2	2	3	3	2
CO6	2	2	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET1162	Course Title: Instrumentation and Process Dynamics	Credits = 2		
			L	T	P
	Semester: IV	Total contact hours:	1	1	0

List of Prerequisite Courses

Applied Chemistry (CHT1251), Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102), Applied Physics (PYT1251), Fluid Flow (CET1154), Heat Transfer (CET1155), Process Safety (CET1157), Chemical Engineering Operations (CET1160)

List of Courses where this course will be prerequisite

Refinery Science and Engineering (CET1182), Chemical Process Control (CET1172), Chemical Engineering Laboratory - IV (CEP1178), Chemical Engineering Laboratory - III (CEP1168), Environmental Sciences (CET1159), Industrial Chemistry and Reaction Engineering (CET1161), Chemical Process Control (CET1172), Instrumentation and Process Dynamics (CET1162)

Description of relevance of this course in the BChemEngg. Degree Program

This course lays the foundation for operating different units in Chemical industry. The process dynamics covers behaviour of chemical engineering systems. Instrumentation forms an integral part of operations to quantify the values of different variables in real time.

	Course Contents (Topics and subtopics)	Required Hours
1	Instrumentation for measurement of temperature, flow, pressure, level, concentration. Basic underlying principles and physical construction of instruments,	6
2	Precision, Sensitivity, accuracy and error analysis of measurements, Transduces, Transmission of signals, Drift	2
3	Unsteady mass and energy balances of system, dynamic equations	2
4	First and second order systems, Stimulus-Response Techniques, Response of First order systems to step, pulse, sinusoidal stimuli, characteristics of First and second order systems	6
5	Combination of systems and their response to input changes, Open Loop response	2
6	Overview of dynamic model equations of typical chemical engineering operations, such as level in a tank, temperature in a heated tank, CSTR, distillation column, Distributed parameter systems, packed column, Heat exchanger	6
7	To design a simple control system of first order and second order nature, e.g. P, PI and PID	4
8	Electronics for control systems: Distributed control system, Programmable Logic Controllers, SCADA, HMI	2
	Total	**30**

List of Textbooks/ Reference Books

1	Eckman - Industrial Instrumentation, CBS publishers, 2020
2	George Stephanopoulos - Chemical Process Control, Pearson Education, 2015
3	James B Riggs - Chemical Process Control, Prentice Hall, 2000, 3rd Edition
4	Coughnowr - Process Systems Analysis and Control, McGraw Hill,2017, 3rd Edition

Course Outcomes (students will be able to….)

CO1	To identify appropriate instrument for measurement of process variables	K2

CO2	To estimate time variant nature of process	K3
CO3	To classify nature of the system as first order, second order, etc,	K3
CO4	To estimate response of the system when subjected to change	K3
CO5	To analyze the behavior of combined systems	K4
CO6	To develop control strategy for different reactor types and unit operations	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Instrumentation and Process Dynamics (CET1162)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	2	1	1	2	1	1
CO2	3	3	3	3	2	1	1	1	1	2	1	1
CO3	3	3	3	3	2	1	1	1	1	2	1	1
CO4	3	3	3	3	2	1	1	1	1	2	1	1
CO5	3	3	3	3	2	1	1	1	1	2	1	1
CO6	3	3	3	3	2	1	1	1	1	2	1	1

Course Title: Instrumentation and Process Dynamics (CET1162)
Mapping of Course Outcomes (COs) with Programme Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	2
CO4	3	3	3	3	3
CO5	3	3	3	3	3
CO6	3	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: HUT1253	Course Title: Production Management	Credits = 2		
			L	T	P
	Semester: IV	Total contact hours: 30	2	0	0

	List of Prerequisite Courses	
	NONE	
	List of Courses where this course will be prerequisite	
	Chemical Project Economics (CET1180)	
	Description of relevance of this course in the B. Chem. Engg. Program	
A course in production management is essential for chemical engineers to enable them understand production functions, select appropriate manufacturing systems, and determine optimal plant locations. It equips them with productivity techniques like Kaizen and Six Sigma, ensuring efficient and high-quality operations. Additionally, tools like Gantt charts enhance their ability to plan and control production processes, fostering innovation and operational excellence in the chemical industry		
	Course Contents (Topics and subtopics)	**Reqd. hours**
1	The production function- Operation concept of production, Production as the conversion process, Productivity of conversion process, Components of production function-Planning, organising and controlling	6
2	Manufacturing systems- Factors influencing choice of manufacturing system, Classification of manufacturing systems, Jobbing production, Batch production, Mass or flow production	8
3	Facilities location- Factors governing plant location, Economic survey of site selection, Urban, sub-urban, rural site location	6
4	Productivity techniques-Kaizen, Kanban, JIT, 5S, Poka yoke, Six sigma	5
5	Gantt chart for production planning and control	5
	List of Text Books	
1	Buffa and Sarin - Modern Production / Operations Management, Wiley, 2007, 8th Edition	
2	Jay Heizer, Barry Render – Operation Management, Pearson, 2017, 12th Edition	
	List of Additional Reading Material / Reference Books	
	Operations management 13th edition, by William J. Stevenson Operations and Supply Chain Management (SIE) | 15th Edition, by Richard B. Chase, Ravi Shankar, et al.	
	Course Outcomes (students will be able to…..)	
1	Student would be able to understand the various production and operations processes	K2
2	Student would be able to explain the importance, functions and factors necessary for manufacturing processes	K2
3	Student would gain understanding of various productivity techniques	K2
4	Students would obtain an understanding of various productivity techniques and their relationship with organizational effectiveness	K2
5	Students would be able to think of the enterprise as a whole with a specific focus on the conversion processes	K2
6	Students would be able to develop Gantt chart for a given chemical manufacturing case study	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Production Management (HUT1253) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	0	0	0	0	1	0	2	2	2	2	1
CO2	0	0	0	0	0	1	0	2	2	2	2	1
CO3	0	0	0	0	0	1	0	2	2	2	2	1
CO4	0	0	0	0	0	1	0	2	2	2	2	1
CO5	0	0	0	0	0	1	0	2	2	2	2	1

Course Title: Production Management (HUT1253) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	1	0	0	2
CO2	0	1	0	0	2
CO3	0	1	0	0	2
CO4	0	1	0	0	2
CO5	0	1	0	0	2
CO6	0	1	0	0	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

VSEC	Course Code: CEP 1163	Course Title: Chemical Engineering Laboratory - II	Credits= 2		
			L	T	P
	Semester: IV	Total contact hours: 60	0	0	4

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152),Engineering Applications of Digital Computers (CEP1153), Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102), Chemical Engineering Laboratory - I (CEP1158), Engineering Thermodynamics (CET1156), Process Safety (CET1157)

List of Courses where this course will be prerequisite

Chemical Engineering Laboratory – III, Chemical Engineering Laboratory – IV

Description of relevance of this course in the B. Chem. Engg. Program

Chemical Engineering laboratory provides students the firsthand experience of verifying various concepts learnt in theory courses. It also exposes them to actual set-ups of typical chemical engineering equipment and servers as a bridge between theory and practice. This lab focuses on fluid mechanics, reaction engineering, thermodynamics, heat & mass transfer and process automation.

	Course Contents (Topics and subtopics)	Hours
1	1-2 Experiments on Fluid Dynamics	6
2	4-6 Experiments on Heat Transfer	18
3	1-2 Experiments on Reaction Engineering	6
4	6-8 Experiments on Chemical Engineering Operations	24
5	1-2 Experiments on Instrumentation	6
	List of Textbooks/ Reference books	
1	McCabe W.L., Smith J.C., and Harriott P. Unit Operations in Chemical Engineering, 2014	
2	Bird R.B., Stewart W.E., Lightfoot E.N. - Transport Phenomena, Wiley, 2007, 3rd Edition	
3	Coulson J.M., Richardson J.F., and Sinnott - R.K. Coulson & Richardson's Chemical Engineering: Chemical engineering design, Butterworth-Heinemann Inc, 1999, 3rd Edition	
4	Green D. and Perry R. Perry's Chemical Engineers' Handbook, McGraw Hill, 2007, 8th Edition	

Course Outcomes (students will be able to….)		K and P Level
CO1	Learn how to experimentally verify various theoretical principles	K3, P2
CO2	Visualize practical implementation of chemical engineering equipment	K4, P2
CO3	Perform statistical analysis of experimental data	K4, P2
CO4	Get hands on experience with various measurement devices	K2, P2
CO5	Develop empirical correlations based on the experimental data generated	K5, P3
CO6	Generate meaningful tables and graphs	K3, P3

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody, P6 – Creating

Course Title: Chemical Engineering Laboratory – II (CET1163) **Mapping of Course Outcomes (COs) with Programme Outcomes (POs)**												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	3	3	2	1	3
CO2	3	3	3	2	1	1	1	2	3	1	1	3
CO3	3	3	2	3	3	1	1	3	3	1	1	3
CO4	3	3	2	2	3	1	1	2	3	1	1	3
CO5	3	3	3	3	3	1	1	1	3	1	1	3
CO6	3	3	3	2	3	1	1	2	3	1	1	3

Course Title: Chemical Engineering Laboratory – II (CET1163) **Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)**					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
CO6	3	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

<table>
<tr><td rowspan="2">CEP/FP</td><td>Course Code:
XXXXXXX</td><td colspan="2" rowspan="2">Course Title: Community Engagement Projects</td><td colspan="3">Credits = 2</td></tr>
<tr><td></td><td></td><td>L</td><td>T</td><td>P</td></tr>
<tr><td></td><td>Semester: IV</td><td colspan="2">Total Contact Hours: 60</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7">NIL</td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7">NIL</td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="7">Students will explore the various community projects as individual or group related to study of societal technological activities through various organizations.</td></tr>
<tr><td colspan="5">Course Contents (Topics and subtopics)</td><td colspan="2">Required Hours</td></tr>
<tr><td>1</td><td colspan="4">Engineering sciences have the main objective of making the knowledge useful for the benefit of society.
In the first step, students, individually or in a group not more than 5, shall identify the problems faced by the society in their neighbourhood or city, or the state. They shall collect necessary data, collate relevant information and identify a problem that can be solved using the knowledge of own field or general sciences and propose an affordable solution.
The team shall then execute the project with support from Institute, Local Society groups, NGOs, Industry.
Some of the suggested projects are:
(i) Identification of water supply Pipeline network, estimation of water requirement, Pressure drop calculations and pumping requirements
(ii) Based on census data, identification of food supply, waster generation,
(iii) Survey of waste dump areas in local areas, treatment of malodour from dumped materials by biological means
(iv) Survey of local hospitals, waste generation, analysis of waste treatment
(v) Water and air pollution in the areas, identification and quantitative measurements and effect of the same on local population in the areas.
(vi) Identification of waste materials generated by local economic activities, development of recycle of waste, and/or building economic activities
(vii) Safety awareness among people in the vicinity of chemical plants, suggesting methods in the event of emergencies
(viii) Development of methods to contain fugitive emissions from vehicles, and transport of chemicals
(ix) Plastic collection drives and recycle methods
(x) Design of rain water harvesting methods in housing societies
(xi) Green building concept awareness
(xii) Any-other project of social relevance with prior approval of the HOD</td><td>60</td></tr>
<tr><td></td><td colspan="4">Total</td><td>60</td></tr>
<tr><td colspan="7">List of Textbooks/ Reference Books</td></tr>
</table>

1	General Books, News paper etc	
Course Outcomes (students will be able to….)		
CO1	This course will help students to contribute of social networking as a bridge between the various government schemes and the people of India. The course also outlines the benefits of community engagement through research and innovation.	K2
CO2	Sensitivity towards the environment and education, safety and energy, enthusiasm towards physical, mental and spiritual health along with simple living and high thinking have been explained for better understanding of the students.	K2
CO3	Students will be able to understand the various problems of any community and the possible ways to address the same.	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Community Engagement Projects

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	1	1	2	1	1	2	1	2	2
CO2	1	1	2	1	1	2	1	1	2	1	2	2
CO3	1	1	2	1	1	2	1	1	2	1	2	2

Course Title: Community Engagement Projects

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	0	0	1	3
CO2	0	0	0	1	3
CO3	0	0	0	1	3

PCC	Course Code: CET1165	Course Title: Chemical Reaction Engineering	Credits= 2		
			L	T	P
	Semester: V	Total contact hours: 30	1	1	0

List of Prerequisite Courses

Applied Chemistry (CHT1251), Applied Chemistry Laboratory (CHP1252), Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Industrial Chemistry and Reaction Engineering (CET1161)

List of Courses where this course will be prerequisite

Catalytic Science and Engineering (CET1187), Chemical Engineering Laboratory - IV (CEP1178), Multiphase Reaction Engineering (CET1171), Chemical Process Development and Engineering (CET1179)

Description of relevance of this course in the B. Chem. Engg. Program

Chemical Reaction Engineering is concerned with the utilisation of chemical reactions on a commercial scale. This course is very relevant but not limited to the following industries: Inorganic chemicals, organic chemicals, petroleum & petrochemicals, Pulp & paper, Pigments & paints, rubber, plastics, synthetic fibres, Foods, Dyes and intermediates, Oils, oleochemicals, and surfactants, Minerals, cleansing agents, Polymers and textiles, Biochemicals and biotechnology, pharmaceuticals and drugs, Microelectronics, energy from conventional and non-conventional resources, Metals etc

	Course Contents (Topics and subtopics)	Hours
1	Sizing and analysis of chemical Reactors (single and multiple reactions (series/parallel))	6
2	Series of reactors, Recycle reactors, Use of energy balance in reactor sizing and analysis, Non-Isothermal reactor design	6
3	Non-idealities in chemical reactors: RTD, Axial dispersion models	6
4	Gas-Solid reactions: Catalytic and Non-catalytic	4
5	Heterogeneous catalysis: internal and external transport, kinetics and mechanisms	4
6	Gas-solid reactions (non-catalytic), Kinetics of fluid-fluid reactions	4
	List of Textbooks/ Reference books	
1	H. Scott FOGLER - Elements of Chemical Reaction Engineering, Pearson Education, 2016, 5th Edition	
2	Octave LEVENSPIEL - Chemical Reaction Engineering, Wiley, 2006, 3rd Edition	
3	Lanny D. SCHMIDT - The Engineering of Chemical Reactions, Oxford university press, 2004, 2nd Edition	
4	Charles HILL - An introduction to Chemical Engineering Kinetics and Reactor Design, Wiley, 2014, 2nd Edition	
5	L. K. Doraiswamy, M. M. Sharma - Heterogeneous Reactions, Vol. I and II, Wiley-Blackwall, 1984	

	Course Outcomes (students will be able to….)	K Level
CO1	Estimate kinetics of chemical reaction based on laboratory data	K3
CO2	Derive design expressions for ideal reactor systems such as batch, plug flow and continuous stirred tank reactor	K3

CO3	Estimate conversion, yield and selectivity for different chemical reactions	K3
CO4	Compare various reactors and select an appropriate reactor for a given situation	K4
CO5	Select appropriate multiphase reactor based on reaction chemistry, heat and mass transfer aspects	K4
CO6	Identify rate controlling mechanism of a given reaction system involving mass transfer	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Chemical Reaction Engineering (CET1165)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	1	1	3
CO2	3	3	3	3	3	1	1	1	2	1	1	3
CO3	3	3	3	2	2	1	1	1	1	1	1	3
CO4	3	3	3	3	2	1	3	1	1	1	1	3
CO5	3	3	3	3	1	2	1	1	2	1	1	3
CO6	3	3	3	3	2	1	1	1	2	1	1	3

Course Title: Chemical Reaction Engineering (CET1165)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	2	3	3	3	2
CO3	2	3	3	3	2
CO4	2	3	3	3	3
CO5	2	3	3	3	3
CO6	3	3	3	3	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1166	Course Title: Momentum Transfer	Credits= 2		
			L	T	P
	Semester: V	Total contact hours: 30	1	1	0

List of Prerequisite Courses

HSC Standard Physics and Mathematics, Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102), Applied Physics (PYT1251), Fluid Flow (CET1154)

List of Courses where this course will be prerequisite

Multiphase Reaction Engineering (CET1171), Chemical Process Development and Engineering (CET1179), Chemical Process Control (CET1172), Separation Processes (CET1174), Heat Transfer Equipment Design (CET1175)

Description of relevance of this course in the B. Chem. Engg. Program

This basic course introduces concepts of momentum transfer to students. Various concepts such as pressure, momentum, energy are introduced. Laws related to conservation of momentum, energy are taught. Applications of these laws to various engineering situations and process equipment is explained with the help of several problems

	Course Contents (Topics and subtopics)	Hours
1	Equations of Continuity and Motion (Cartesian, cylindrical, and spherical coordinates) in laminar flows and its applications for the calculation of velocity profiles, shear stresses, power, etc. in various engineering applications.	8
2	Boundary Layer Flows: Blasius equations and solution, Von-Karman integral equations and solutions,	6
3	Introduction to turbulence: Turbulent pipe flow, basis of Universal velocity profile and its use	6
4	Similarities in Momentum, Heat and Mass Transfer	6
5	Introduction to experimental and computational fluid dynamics: HFA, LDA, PIV, UVP, tomography etc, Turbulence modeling, multiphase system modeling etc	4

List of Textbooks/ Reference books

1. Bird R.B., Stewart W.E., Lightfoot E.N. - Transport Phenomena, Wiley, 2007, 3rd Edition
2. Kundu Pijush K. - Fluid Mechanics, Academic Press, 2015, 6th Edition
3. F. W. White - Fluid Mechanics, McGraw Hill, 2022, 9th Edition
4. McCabe W.L., Smith J.C., and Harriott P. - Unit Operations in Chemical Engineering, 2014

	Course Outcomes (students will be able to….)	K Level
CO1	Calculate velocity profiles, forces, pressure drops for simple 1 –D laminar flow situations	K3
CO2	Calculate forces on particles and terminal velocities of particles	K3
CO3	Apply Momentum, Heat and mass transfer concepts to simple situations	K3
CO4	Select appropriate measurement technique for detailed characterization in chemical process equipment	K3
CO5	Describe applications of turbulent flow in chemical processes	K2
CO6	Estimate the transport rates (Heat and/or mass) based on velocity/pressure measurements using similarity in the transport processes	K4

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Momentum Transfer (CET1166) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	3	0	0	1	1	1	1	3
CO2	3	2	3	2	2	0	0	1	1	1	1	3
CO3	3	1	1	1	1	0	0	1	1	1	1	3
CO4	3	2	2	1	2	1	1	1	1	2	1	3
CO5	3	1	1	1	1	0	0	1	1	3	1	3
CO6	3	3	3	3	2	1	1	1	1	2	1	3

Course Title: Momentum Transfer (CET1166) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	3	2
CO2	3	3	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	3	3
CO5	3	3	3	3	2
CO6	2	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1167	Course Title: Chemical Engineering Thermodynamics	Credits= 4		
			L	T	P
	Semester: V	Total contact hours: 60	3	1	0

List of Prerequisite Courses

Elements of Mechanical Engineering (GET1128), Engineering Thermodynamics (CET1156)

List of Courses where this course will be prerequisite

Biochemical Engineering (CET1170), Chemical Process Development and Engineering (CET1179), Separation Processes (CET1174), Separation Processes (CET1174), Statistical Thermodynamics (CET1188)

Description of relevance of this course in the B. Chem. Engg. Program

This course builds on the preceding course by developing the concept of non-ideal mixing and provides students with the formalism and insights necessary to tackle real industrial problems like liquid-liquid phase splitting, azeotropy, non-zero heats of mixing, sparingly soluble gases and solids, electrolytes etc. Student who have taken this course may be expected to intelligently analyze practically the full spectrum of industrial chemical processes.

	Course Contents (Topics and subtopics)	Hours
1	Revision of Concepts of Ideal and non-ideal mixtures	4
2	Models of the Liquid Phase: Activity Coefficient Models (Redlich-Kister, Wilson et al, UNIQUAC and NRTL)	8
3	Vapor – liquid equilibria in non-ideal mixtures including azeotropes and high pressure vapor – liquid equilibria using gamma-phi and phi-phi approaches	8
4	Use of VLE data in design and analysis of distillation processes	4
5	Solubility of Gases in Liquids, concept of infinite dilution activity coefficient and Unsymmetric convention, Henry's law, Shair Prausnitz correlation	8
6	Liquid – Liquid Equilibria and Phase splitting, applications to extraction	8
7	Solubility of Solids in Liquids	4
8	Debye Huckel Theory, activity coefficients of electrolytes	4
9	Chemical Equilibrium in Ideal and non-ideal Mixtures in single phase reacting mixtures	6
10	Chemical Equilibrium in Ideal and non-ideal mixtures in Heterogenous reacting mixtures	6
	List of Textbooks/ Reference books	
1	S. I. Sandler - Chemical, Biochemical and Engineering Thermodynamics, Wiley, 2020, 5th Edition	
2	Smith, van Ness, Abbott - Introduction to Chemical Engineering Thermodynamics, McGraw Hill, 2012, 7th Edition	
3	Reid, Prausnitz, Pauling - Properties of Gases and Liquids, McGraw Hill, 2001, 5th Edition	

	Course Outcomes (students will be able to….)	K Level
CO1	Calculate Vapor – liquid equilibria in binary non-ideal mixtures using activity coefficient models	K2
CO2	Calculate solubility of solutes (gases and solids) in liquids	K2
CO3	Calculate liquid – liquid equilibria using activity coefficient models	K2
CO4	Analyze equilibria in reacting mixtures	K3
CO5	Predict the equilibrium conversion in single phase reacting systems	K4
CO6	Predict the equilibrium conversion in heterogeneous reacting systems	K4

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Chemical Engineering Thermodynamics (CET1167) **Mapping of Course Outcomes (COs) with Programme Outcomes (POs)**												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	3	2	0	0	0	1	0	0	3
CO2	3	2	1	3	2	0	0	0	1	0	0	3
CO3	3	2	1	3	2	0	0	0	1	0	0	3
CO4	3	3	2	3	3	1	1	1	1	0	0	3
CO5	3	2	2	2	1	1	0	1	1	1	0	3
CO6	3	3	2	2	1	1	0	1	1	1	0	3

Course Title: Chemical Engineering Thermodynamics (CET1167) **Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)**					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	1	1
CO2	2	3	3	1	1
CO3	2	3	3	1	1
CO4	2	3	3	1	1
CO5	2	3	3	2	2
CO6	2	3	3	2	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CEP 1168	Course Title: Chemical Engineering Laboratory - III	Credits= 2		
			L	T	P
	Semester: V	Total contact hours: 60	0	0	4

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152),Engineering Applications of Digital Computers (CEP1153), Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102), Chemical Engineering Laboratory - I (CEP1158), Engineering Thermodynamics (CET1156), Process Safety (CET1157), Chemical Engineering Operations (CET1160), Industrial Chemistry and Reaction Engineering (CET1161),Instrumentation and Process Dynamics (CET1162)

List of Courses where this course will be prerequisite

Chemical Engineering Laboratory - IV

Description of relevance of this course in the B. Chem. Engg. Program

Chemical Engineering laboratory provides students the firsthand experience of verifying various concepts learnt in theory courses. It also exposes them to actual set-ups of typical chemical engineering equipment and servers as a bridge between theory and practice. This lab focuses on fluid mechanics, reaction engineering, thermodynamics, heat & mass transfer and process automation.

	Course Contents (Topics and subtopics)	Hours
1	4-6 Experiments on Momentum Transfer	18
2	2-3 Experiments on Chemical Engineering Thermodynamics	10
3	4-6 Experiments on Reaction Engineering	16
4	2-4 Experiments on Chemical Engineering Operations	10
5	1-2 Experiments on Instrumentation	6

List of Textbooks/ Reference books

1	McCabe W.L., Smith J.C., and Harriott P. - Unit Operations in Chemical Engineering, 2014
2	Bird R.B., Stewart W.E., and Lightfoot, E.N. - Transport Phenomena, 2007
3	Coulson J.M., Richardson J.F., and Sinnott, R.K. - Coulson & Richardson's Chemical Engineering: Chemical engineering design, 1996.
4	Green D. and Perry R. - Perry's Chemical Engineers' Handbook, Eighth Edition, 2007.

Course Outcomes (students will be able to….)		K Level
CO1	Learn how to experimentally determine order of reaction	K3, P2
CO2	Visualize practical implementation of chemical engineering equipment such as distillation and ion exchange	K4, P2
CO3	Perform statistical analysis of experimental data	K4, P2
CO4	Get hands on experience with various measuring devices	K2, P2
CO5	Develop empirical correlations based on the experimental data generated	K5, P3
CO6	Generate meaningful tables and graphs	K3, P3

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody, P6 – Creating

Course Title: Chemical Engineering Laboratory – III (CEP1168) **Mapping of Course Outcomes (COs) with Programme Outcomes (POs)**												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	3	3	2	1	3
CO2	3	3	3	2	1	1	1	2	3	1	1	3
CO3	3	3	2	3	3	1	1	3	3	1	1	3
CO4	3	3	2	2	3	1	1	2	3	1	1	3
CO5	3	3	3	3	3	1	1	1	3	1	1	3
CO6	3	3	3	2	3	1	1	2	3	1	1	3

Course Title: Chemical Engineering Laboratory – III (CEP1168) **Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)**					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
CO6	3	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CEP 1169	Course Title: Process Simulation Laboratory - I	Credits= 2		
			L	T	P
	Semester: V	Total contact hours: 60	0	0	4

List of Prerequisite Courses

Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102), Engineering Applications of Digital Computers (CEP1153)

List of Courses where this course will be prerequisite

Mathematical Methods and Optimization in Chemical Engineering (CET1176), Process Simulation Laboratory - II (CEP1177)

Description of relevance of this course in the B. Chem. Engg. Program

Design and optimization various chemical engineering operations require tedious calculations and writing a computer program to solve these problems help to understand the concepts learned in theory class better. Such calculations are done on repetitive basis in industry and generalized computer programs are useful. The course will help to write programs for chemical engineering problems in various basic as well as advanced programming software . Students will solve problems using various numerical methods for chemical engineering subject which they have learnt so far. The course is designed in such a way that students will get an opportunity to revise chemical engineering basic along with developing software skills.

	Course Contents (Topics and subtopics)	Hours
1	Introduction to object-oriented programming in python	8
2	Mathematical methods in chemical engineering such as simultaneous linear and nonlinear equations, interpolation, optimization	8
3	Design of chemical reactors: CSTR, PFR, multiple reactions, adiabatic, non-isothermal systems etc	8
4	Flash vessel calculations	4
5	Design of chemical engineering equipment	12
6	Process flow sheeting	4
7	Chemical process simulators such as Aspen, Coco simulators etc (mixing blocks, reactors, short cut and detailed design of separation equipment such as distillation, sizing of heat exchangers)	16

List of Textbooks/ Reference books

1	Coker, A. Kayode. Ludwig - applied process design for chemical and petrochemical plants. gulf professional publishing, 2014.
2	Green D. and Perry R. - Perry's Chemical Engineers' Handbook, Eighth Edition, 2007.
3	Albright, Lyle. - Albright's chemical engineering handbook. CRC Press, 2008.
4	ASPEN manual

	Course Outcomes (students will be able to….)	K Level
CO1	Use advanced programming software with built in functions	K3, P2
CO2	Write own functions/macros	K3, P2
CO3	Solve chemical engineering problems using computers	K5, P3
CO4	Design a distillation column using short-cut and rigorous method	K4, P3
CO5	Compare simulation results from rigourous software based simulation with simplified first priciple based models	K5, P4

CO6	Develop process flow sheet including reactors, separation equipments and material/energy recycle	K4, P4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody, P6 – Creating		

Course Title: Process Simulation Laboratory – I (CEP1169)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	3	0	0	0	1	0	0	3
CO2	3	3	2	3	3	0	0	1	1	0	0	3
CO3	3	3	3	3	3	0	0	1	1	0	0	3
CO4	3	3	3	3	3	0	0	2	1	0	0	3
CO5	3	3	3	3	3	1	0	2	1	0	0	3
CO6	3	3	3	3	3	0	0	2	1	0	0	3

Course Title: Process Simulation Laboratory – I (CEP1169)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	2	2
CO2	2	3	3	2	2
CO3	2	3	3	3	2
CO4	2	3	3	3	2
CO5	2	3	3	3	2
CO6	2	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1171	Course Title: Multiphase Reaction Engineering	Credits= 3		
			L	T	P
	Semester: VI	Total contact hours: 45	2	1	0

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Fluid Flow (CET1154), Heat Transfer (CET1155), Engineering Thermodynamics (CET1156), Industrial Chemistry and Reaction Engineering (CET1161), Chemical Reaction Engineering (CET1165), Momentum Transfer (CET1166)

List of Courses where this course will be prerequisite

Refinery Science and Engineering (CET1182), Chemical Engineering Laboratory - IV (CEP1178), Chemical Process Equipment Design and drawing (GEP1138), Biochemical Engineering (CET1170)

Description of relevance of this course in the B. Chem. Engg. Program

Multiphase Reaction Engineering is concerned with the utilisation of chemical reactions on a commercial scale. This course helps in classifying the multiphase reactions based on the rate controlling step as well as estimation of intrinsic kinetics which is helpful in the reliable scale of multiphase reactions at industrial scale. The course helps students to select appropriate multiphase equipment, design (and/or troubleshoot) for different applications.

	Course Contents (Topics and subtopics)	Hours
1	Classification of multiphase reactors, qualitative description, examples of industrial importance	8
2	Hydrodynamics, scale-up, process design and performance of the following major classes of multiphase reactors, case studies and problems, w.r.t:	
2a	Stirred tank reactors,	10
2b	Bubble columns, packed bubble columns, sectionalised bubble columns,	8
2c	Internal loop and external loop air-lift reactors, jet loop reactors,	6
2d	Fluid-fluid reactors such as spray columns, packed columns, plate columns, static mixers, rotating disc contactors	5
2e	Fixed bed reactors, trickle bed reactors,	4
2f	Solid-liquid and gas-solid fluidised bed reactors, solid-gas transport reactors	4

List of Textbooks/ Reference books

1	L. K. Doraiswamy, M. M. Sharma - Heterogeneous Reactions, Vol. I and II, Wiley-Blackwall, 1984
2	Tatterson, Gary B. Fluid mixing and gas dispersion in agitated tanks, (1991).
3	Deckwer, Wolf-Dieter, Valerie H. Cottrell, and Robert W. Field. Bubble column reactors. Vol. 200. New York: Wiley, 1992.
4	ID Kuni and O. Levenspiel - Fluidization Engineering, Wiley, New York, 1969, pp. 65-77.
5	Danckwerts, Peter Victor. - Gas-liquid reactions, (1970): 96.
6	Lockett, M. J., J. F. Davidson, and David Harrison. - On the two-phase theory of fluidisation. Chemical Engineering Science 22.8 (1967): 1059-1066.
7	R. F. Strigel - Random Packings and Packed Tower Design, 1994

Course Outcomes (students will be able to….)		K Level
CO1	Calculate operating regime for a given reaction.	K4

CO2	Select appropriate model contactor based on the phases involved in heterogenous reactions	K3
CO3	Calculate intrinsic kinetics from the data on model contactors.	K4
CO4	Select appropriate multiphase reactor for a given process	K3
CO5	Calculate conversion / selectivity / size / temperature / pressure / power required for conducting a given multiphase reaction equipment	K4
CO6	Evaluate effect of different scale-up rules on the overall performance of multiphase reactors	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Multiphase Reaction Engineering (CET1171)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	0	0	0	1	0	0	3
CO2	3	2	3	2	1	1	0	1	1	0	0	3
CO3	3	3	3	2	3	0	0	1	1	0	0	3
CO4	3	3	3	2	2	2	0	2	1	0	0	3
CO5	3	3	3	3	2	3	0	2	1	0	0	3
CO6	3	3	3	3	3	2	0	2	1	0	0	3

Course Title: Multiphase Reaction Engineering (CET1171)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	2	2
CO2	2	3	3	2	2
CO3	2	3	3	2	2
CO4	2	3	3	3	3
CO5	2	3	3	3	3
CO6	2	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET1172	Course Title: Chemical Process Control	Credits = 2		
			L	T	P
	Semester: VI	Total contact hours:	1	1	0

List of Prerequisite Courses

Applied Chemistry (CHT1251), Applied Chemistry Laboratory (CHP1252), Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102), Material Balance and Energy Balance Calculations (CEP1152), Fluid Flow (CET1154), Heat Transfer (CET1155), Process Safety (CET1157), Chemical Engineering Operations (CET1160), Instrumentation and Process Dynamics (CET1162), Momentum Transfer (CET1166)

List of Courses where this course will be prerequisite

Biochemical Engineering (CET1170), Refinery Science and Engineering (CET1182), Chemical Engineering Laboratory - IV (CEP1178), Environmental Sciences & Process Safety

Description of relevance of this course in the B. Chem.Engg Program

Process control plays a very critical role in the context of actual operation of a chemical plant. Most of the core chemical engineering courses focus on the steady state operation. In the real-life environment, process is continuously subjected to various disturbances which deviates the operation from the designed steady state. This course specifically prepares students to assess the impact of such disturbances and equip them with the tools available with the chemical engineer to tackle these situations.

	Course Contents (Topics and subtopics)	Required Hours
1	Design of controllers using frequency response technique, Nyquist and Bode Stability criteria,	4
2	Control Strategies- Cascade control, Ratio Control, Feedforward control, Dead time compensation	4
3	Multivariable Systems, Identification of Interaction and selection of pairings, Design of controllers for multivariable systems, Decouplers,	4
4	Modern control strategies, Internal model control, Dynamic Matrix control	4
5	Design of control systems for CSTR, Distillation column, heat exchangers	6
6	Process Instrumentation diagrams, Safety alarms and interlocks	2
7	Control of batch processes, programmable logical controllers, Distributed control systems, supervisory Control systems	2
8	Digital control systems, Introduction to z-transforms	2
9	Flow-sheet modelling and Simulation of plant-wide control systems	2

List of Textbooks/ Reference Books

1	Eckman - Industrial Instrumentation, CBS publishers, 2020
2	George Stephanopoulos - Chemical Process Control, Pearson Education, 2015
3	James B Riggs - Chemical Process Control, Prentice Hall, 2000, 3rd Edition
4	Coughnowr - Process Systems Analysis and Control, McGraw Hill,2017, 3rd Edition
5	Shinskey, Francis G. - Process control: as taught vs as practiced. Industrial & engineering chemistry research 41.16 (2002): 3745-3750.

Course Outcomes (students will be able to….)

CO1	To design a controller and understand behavior of a close loop controlled system	K4
CO2	To evaluate performance of a close loop control system, stability and controllability, Robustness	K5
CO3	To select and Design control strategy	K5
CO4	To evaluate a multivariable system, design multivariable controllers	K4
CO5	To evaluate plant-wide control systems	K5
CO6	Develop P&ID diagram with bill of materials for a given process	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Chemical Process Control (CET1172)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	2	1	2	1	1	1
CO2	3	3	3	3	3	2	1	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	2	1
CO4	3	3	3	3	3	2	2	2	2	2	2	1
CO5	3	3	3	3	3	2	2	1	1	1	1	1
CO6	3	3	3	3	3	2	2	1	1	1	1	1

Course Title: Chemical Process Control (CET1172)
Mapping of Course Outcomes (COs) with Programme Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1173	Course Title: Materials Technology	Credits= 2		
			L	T	P
	Semester: VI	Total contact hours: 30	2	0	0

List of Prerequisite Courses
Structural Mechanics (GET1123), Applied Chemistry (CHT1251), Applied Physics (PYT1251)
List of Courses where this course will be prerequisite
Chemical Process Equipment Design and Drawing (GEP1138)
Description of relevance of this course in the B. Chem. Engg. Program
Selection of MOC for a given application, maintenance and corrective measures for various engineering materials

	Course Contents (Topics and subtopics)	Hours
1	Engineering Materials: Classification, study of ferrous and nonferrous materials	2
2	Phase diagrams of steel and the applications of phase diagrams	2
3	Effect of structure on properties: subatomic to macroscopic level	4
4	Modification and control of material properties	3
5	Polymeric materials, Ceramic materials, Composite materials and Smart materials	3
6	Corrosion Engineering: Electrochemical principles, different types of corrosion Polarisation, mechanisms of corrosion control and prevention, preventive coatings. Corrosion behavior of important alloys such as stainless steels, brass etc.	8
7	Theory of failure: Crystal defects, plastic deformation. Types of mechanical failure, fracture , fatigue and creep	6
8	Criteria for selection of materials in chemical process industry	2

	List of Textbooks/ Reference books
1	Messler, Robert W. - The essence of materials for engineers. Jones & Bartlett Publishers, 2011.
2	Raghavan, Viswanatha. - Materials science and engineering: a first course. PHI Learning Pvt. Ltd., 2015.
3	Van Vlack, Lawrance H. - Materials science and engineering. (1970).
4	Metals handbook
5	Flinn, Richard A., and Paul K. Trojan. - Engineering materials and their applications. 1994.

	Course Outcomes (students will be able to….)	K Level
CO1	Read and interpret the Phase Diagrams	K2
CO2	Understand the mechanism of corrosion for various processes	K2
CO3	Select a proper MOC for the desired process or operation	K3
CO4	Describe causes of mechanical failure and failure analysis	K3
CO5	Analyse the corrosion problems in process industry and ways to control the corrosion	K4
CO6	Understand structure-property relationship of advanced materials for corrosion control and prevention	K2

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Materials Technology (CET1173) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	0	1	1	0	0	0	1	0	0	3
CO2	3	1	1	1	0	0	0	0	1	0	0	3
CO3	3	1	2	2	1	0	0	1	1	0	0	3
CO4	3	2	2	3	0	0	1	0	1	2	0	3
CO5	3	2	2	3	1	0	2	1	1	1	0	3
CO6	3	1	1	2	0	0	2	0	1	1	0	3

Course Title: Materials Technology (CET1173) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	1	1
CO2	2	3	3	3	1
CO3	2	3	3	3	3
CO4	2	3	3	2	1
CO5	2	3	3	2	1
CO6	2	3	3	3	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1174	Course Title: Separation Processes	Credits= 3		
			L	T	P
	Semester: VI	Total contact hours: 45	2	1	0

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Chemical Engineering Operations (CET1160), Momentum Transfer (CET1166), Chemical Engineering Thermodynamics (CET1167), Chemical Engineering Operations (CET1160)

List of Courses where this course will be prerequisite

Biochemical Engineering (CET1170), Chemical Process Development and Engineering (CET1179), Refinery Science and Engineering (CET1182), Chemical Engineering Laboratory - IV (CEP1178), Chemical Process Equipment Design and drawing (GEP1138)

Description of relevance of this course in the B. Chem. Engg. Program

This is a course further built up on and in continuation with Chem. Engg. operations. It forms the basis of Chemical Engineering Principles and hence it is required in almost all the courses and throughout the professional career of a Chemical Engineer.

	Course Contents (Topics and subtopics)	Hours
1	Extraction and Leaching of ternary systems: Ternary diagrams, Hunter-Nash graphical method and Maloney–Schubert graphical equilibrium-stage method, Solvent Selection, Operating point, number of stages, maximum solvent to feed ratios, minimum reflux, minimum number of stages, Introduction to reactive extraction, aqueous two phase extraction, extraction of biomolecules, supercritical fluid extraction, Solid-liquid extraction: Solid - liquid equilibria, efficiency, performance evaluation, Equipment for extraction, leaching and their sizing, Design considerations	10
2	Adsorption and Ion exchange: Liquid Adsorption, Ion-Exchange Equilibria, Equilibria in Chromatography, Breakthrough Curves, Kinetic and transport considerations, Convection-Dispersion Model, Separation Efficiency (Plate Height or Bandwidth), Correlations for Transport-Rate Coefficients, Equipment for sorption operations, Scale-Up and Process Alternatives, Adsorptive Membranes, simulated-moving-bed operation, modes of operation	10
3	Crystallization: Theory of solubility and crystallization, phase diagram (temp/solubility relationship), Supersaturation, Nucleation, Crystal Growth, Population balance analysis, method of moments for rate expressions for, volume, area and length growth, CSD distribution, MSMPR operation, evaporative and cooling (rate expressions) , most dominant size, ideal classified bed, Precipitation, Melt crystallization, Process design of crystallizers and their operation	10
4	Humidification and Cooling Towers: Method of changing humidity and equipment, Cooling tower process design, counter-current, concurrent and cross current, mass and heat balances in bulk and interfaces, Estimation of air quality, performance evaluation of cooling towers.	5
5	Membrane Separations: Types of separations, reverse osmosis, ultrafiltration, gas separation, vapour permeation and pervaporation, dialysis, electrodialysis, nanofiltration, Transport Through Porous Membranes, Resistance Models, Liquid Diffusion Through Pores, Gas Diffusion Through Porous Membranes,	10

	Transport Through Nonporous Membranes, Solution-Diffusion for Liquid Mixtures, Gas Mixtures, Concentration Polarization and Fouling, Membrane modules, arrangement of modules in cascades, performance criteria and design considerations	

	List of Textbooks/ Reference books
1	Richardson, J.F., Coulson, J.M., Harker, J.H., Backhurst, J.R. - Chemical engineering: Particle technology and separation processes. Butterworth-Heinemann, Woburn, MA, 2002.
2	Seader, J.D., Henley, E.J. - Separation Process Principles, 2 ed. Wiley, Hoboken, N.J, 2005.
3	McCabe, W., Smith, J., Harriott, P. - Unit Operations of Chemical Engineering, 7 ed. McGraw-Hill Science/Engineering/Math, Boston, 2004.
4	Green, D., Perry, R. - Perry's Chemical Engineers' Handbook, Eighth Edition, 8 ed. McGraw-Hill Professional, Edinburgh, 2007.
5	Dutta, B.K. - Principles of Mass Transfer and Separation Process. Prentice-Hall of India Pvt. Ltd, New Delhi, 2007.

Course Outcomes (students will be able to….)		**K Level**
CO1	List situations where liquid–liquid extraction might be preferred to distillation, Make a preliminary selection of a solvent using group-interaction rules, Size simple extraction equipment	K2
CO2	Differentiate between chemisorption and physical adsorption, List steps involved in adsorption of a solute, and which steps may control the rate of adsorption, Explain the concept of breakthrough in fixed-bed adsorption	K2
CO3	Explain how crystals grow, Explain the importance of supersaturation in crystallization. Describe effects of mixing on supersaturation, mass transfer, growth, and scale-up of crystallization	K3
CO4	Explain membrane processes in terms of the membrane, feed, sweep, retentate, permeate, and solute-membrane interactions. Distinguish among microfiltration, ultrafiltration, nanofiltration, virus filtration, sterile filtration, filter-aid filtration, and reverse osmosis in terms of average pore size. Explain common idealized flow patterns in membrane modules.	K3
CO5	Understand and compare various separation processes used in the chemical and allied industries	K3
CO6	Select and carry out preliminary sizing of various industrial extraction, crystallization, filtration and drying equipment	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Separation Processes (CET1174)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	1	1	1	1	2	1	1	3
CO2	3	2	3	3	2	2	1	2	2	1	1	3
CO3	3	3	3	2	2	1	1	2	2	1	1	3
CO4	3	3	2	2	3	1	1	2	2	1	1	3
CO5	3	2	2	2	1	1	1	1	2	1	1	3
CO6	3	3	2	2	3	2	2	2	2	1	1	3

Course Title: Separation Processes (CET1174) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	2
CO2	3	3	3	2	2
CO3	3	3	3	2	2
CO4	3	3	3	3	2
CO5	3	3	3	3	3
CO6	3	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1175	Course Title: Heat Transfer Equipment Design	Credits= 2		
			L	T	P
	Semester: VI	Total contact hours: 30	1	1	0

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Fluid Flow (CET1154), Heat Transfer (CET1155), Momentum Transfer (CET1166)

List of Courses where this course will be prerequisite

Chemical Process Equipment Design and drawing (GEP1138), Refinery Science and Engineering (CET1182), Chemical Engineering Laboratory - IV (CEP1178)

Description of relevance of this course in the B. Chem. Engg. Program

This is a basic course that deals with heat transfer, heat exchangers and their design. Heat transfer forms one of the basic pillars of Chemical Engineering Education and is required in all future activities.

	Course Contents (Topics and subtopics)	Hours
1	Shell and tube heat exchangers: Basic construction and features, TEMA exchanger types, their nomenclature, choice of exchanger type, correction to mean temperature difference due to cross flow, multipass exchangers. Design methods for shell and tube heat exchangers such as Kern Method, Bell – Delaware method	8
2	Finned tube exchangers, air-cooled cross flow exchangers and their process design aspects	3
3	Compact Exchangers: Plate, Plate fin, Spiral, etc.: Construction, features, advantages, limitations and their process design aspects	3
4	Condensation of vapours: theoretical prediction of heat transfer coefficients, practical aspects, horizontal versus vertical condensation outside tubes, condensation inside tubes, Process Design aspects of total condensers, condensers with de-superheating and subcooling, condensers of multicomponent mixture, condensation of vapours in presence of non-condensables.	8
5	Heat transfer to boiling liquids: Process design aspects of evaporators, natural and forced circulation reboilers	8

	List of Textbooks/ Reference books
1	Kern D.Q. - Process Heat Transfer, Wiley, 2019, 2nd Edition
2	Kakac S., Bergles A.E., Mayinger F - Heat Exchangers, Springer, 2012,
3	G. Hewitt - Process Heat Transfer, Begell House, 1994

	Course Outcomes (students will be able to….)	K Level
CO1	Calculate heat duty/outlet temperatures/pressure drops/area required for various equipment like double pipe heat exchangers, shell and tube heat exchangers, plate heat exchangers, condensation, evaporation, agitated tanks.	K3
CO2	Identify and select type of shell and tube exchanger based on TEMA classification.	K2
CO3	Understand and compare various heat exchangers used in the chemical and allied industries	K3
CO4	Do the basic sizing of condensers based on mass and energy balance	K3
CO5	Carry out preliminary sizing of evaporators used in chemical and allied industries	K3
CO6	Differentiate between different types of reboilers and design a reboiler system for distillation	K3

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Heat Transfer Equipment Design (CET1175) **Mapping of Course Outcomes (COs) with Programme Outcomes (POs)**												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	1	1	1	1	2	1	1	3
CO2	3	2	3	3	2	2	1	2	2	1	1	3
CO3	3	3	3	2	2	1	1	2	2	1	1	3
CO4	3	3	2	2	3	1	1	2	2	1	1	3
CO5	3	2	2	2	1	1	1	1	2	1	1	3
CO6	3	3	2	2	3	2	2	2	2	1	1	3

Course Title: Heat Transfer Equipment Design (CET1175) **Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)**					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	2	1
CO2	2	3	3	2	1
CO3	2	3	3	2	1
CO4	2	3	3	3	1
CO5	2	3	3	3	2
CO6	2	3	3	3	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

VSEC	Course Code: CEP 1177	Course Title: Process Simulation Laboratory - II	Credits= 2		
			L	T	P
	Semester: VI	Total contact hours: 60	0	0	4

List of Prerequisite Courses

Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102), Engineering Applications of Digital Computers (CEP1153), Process Simulation Laboratory - I (CEP1169)

List of Courses where this course will be prerequisite

Design Project I and II

Description of relevance of this course in the B. Chem. Engg. Program

Design and optimization various chemical engineering operations require tedious calculations and writing a computer program to solve these problems help to understand the concepts learned in theory class better. Such calculations are done on repetitive basis in industry and generalized computer programs are useful. The course will help to write programs for chemical engineering problems in various basic as well as advanced programming software . Students will solve problems using various numerical methods for chemical engineering subject which they have learnt so far. The course is designed in such a way that students will get an opportunity to revise chemical engineering basic along with developing software skills.

	Course Contents (Topics and subtopics)	Hours
1	Detailed design of multicomponent distillation	8
2	Detailed design of shell and tube heat exchanger	8
3	Detailed design of multiphase reactor system such as hydrogenation etc	8
4	Detailed design of continuous crystallizer (MSMPR)	4
5	Modeling and simulation of transient systems (solution of partial differential equations)	8
6	Detailed design of batch crystallizer	4
7	Advanced process flow sheeting: mechanical vapor compression refrigeration, absorption refrigeration	8
8	Data analytics: feature importance, bagging and boosting, hyper parameter optimization	6
9	Uncertainty analysis	6
	List of Textbooks/ Reference books	
1	Coker, Ludwig - Applied Process Design for Chemical and Petrochemical Plants, 2007.	
2	Green D. and Perry R. - Perry's Chemical Engineers' Handbook, Eighth Edition, 2007.	
3	Albright, Lyle. - Albright's chemical engineering handbook. CRC Press, 2008.	
4	ASPEN manual	

	Course Outcomes (students will be able to….)	K Level
CO1	Solve chemical engineering design problems involving iterative calculations	K4, P2
CO2	Solve chemical engineering problems involving non-linear equations coupled with ODEs/PDEs	K4, P2
CO3	Develop and optimize a process flow sheet for chemical production	K5, P3
CO4	Carry out sensitivity analysis based on validated process models	K5, P3
CO5	Apply data analytics techniques on surrogate data related to chemical processes to develop predictive models and/or tune first principle-based process models	K5, P4

CO6	Perform uncertainty analysis of chemical processes	K5, P4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody, P6 – Creating		

Course Title: Process Simulation Laboratory – II (CEP1177)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	3	0	0	0	1	0	0	3
CO2	3	3	2	3	3	0	0	1	1	0	0	3
CO3	3	3	3	3	3	0	0	1	1	0	0	3
CO4	3	3	3	3	3	0	0	2	1	0	0	3
CO5	3	3	3	3	3	1	0	2	1	0	0	3
CO6	3	3	3	3	3	0	0	2	1	0	0	3

Course Title: Process Simulation Laboratory – II (CEP1177)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	2	1
CO2	2	3	3	2	1
CO3	2	3	3	2	1
CO4	2	3	3	2	1
CO5	2	3	3	3	3
CO6	2	3	3	2	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

VSEC	Course Code: CEP 1178	Course Title: Chemical Engineering Laboratory - IV	Credits= 2		
			L	T	P
	Semester: VI	Total contact hours: 60	0	0	4

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152),Engineering Applications of Digital Computers (CEP1153), Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102), Chemical Engineering Laboratory - I (CEP1158), Engineering Thermodynamics (CET1156), Process Safety (CET1157), Chemical Engineering Operations (CET1160), Industrial Chemistry and Reaction Engineering (CET1161),Instrumentation and Process Dynamics (CET1162), Chemical Reaction Engineering (CET1165), Multiphase Reaction Engineering (CET1171), Chemical Process Control (CET1172), Separation Processes (CET1174), Heat Transfer Equipment Design (CET1175)

List of Courses where this course will be prerequisite

Design Project I and II

Description of relevance of this course in the B. Chem. Engg. Program

Chemical Engineering laboratory provides students the firsthand experience of verifying various concepts learnt in theory courses. It also exposes them to actual set-ups of typical chemical engineering equipment and servers as a bridge between theory and practice. This lab focuses on fluid mechanics, reaction engineering, thermodynamics, heat & mass transfer and process automation.

	Course Contents (Topics and subtopics)	Hours
1	6-8 Experiments on Multiphase Reactors	22
2	2-3 Experiments on Heat transfer	8
3	4-6 Experiments on Chemical Process Control and Dynamics	18
4	2-4 Experiments on Mass Transfer and Separation Processes	12

List of Textbooks/ Reference books

1	McCabe W.L., Smith J.C., and Harriott P. - Unit Operations in Chemical Engineering, 2014
2	Bird R.B., Stewart W.E., and Lightfoot, E.N. - Transport Phenomena, 2007
3	Coulson J.M., Richardson J.F., and Sinnott, R.K. - Coulson & Richardson's Chemical Engineering: Chemical engineering design, 1996.
4	Green D. and Perry R. - Perry's Chemical Engineers' Handbook, Eighth Edition, 2007.

Course Outcomes (students will be able to….)		K and P Level
CO1	Learn how to experimentally verify various theoretical principles	K3, P2
CO2	Visualize practical implementation of heat and mass transfer equipment	K4, P2
CO3	Perform statistical analysis of experimental data	K4, P2
CO4	Get hands on experience with controllers used for chemical process control	K2, P2
CO5	Develop empirical correlations based on the experimental data generated for various multiphase systems	K5, P3
CO6	Generate meaningful tables and graphs	K3,

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody, P6 – Creating

Course Title: Chemical Engineering Laboratory – IV (CEP1178) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	3	3	2	1	3
CO2	3	3	3	2	1	1	1	2	3	1	1	3
CO3	3	3	2	3	3	1	1	3	3	1	1	3
CO4	3	3	2	2	3	1	1	2	3	1	1	3
CO5	3	3	3	3	3	1	1	1	3	1	1	3
CO6	3	3	3	2	3	1	1	2	3	1	1	3

Course Title: Chemical Engineering Laboratory – IV (CEP1178) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
CO6	3	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1179	Course Title: Chemical Process Development and Engineering	Credits= 3		
			L	T	P
	Semester: VII	Total contact hours: 45	2	1	0

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Process Safety (CET1157), Environmental Sciences (CET1159), Chemical Engineering Operations (CET1160), Industrial Chemistry and Reaction Engineering (CET1161), Chemical Reaction Engineering (CET1165), Momentum Transfer (CET1166), Chemical Engineering Thermodynamics (CET1167), Separation Processes (CET1174)

List of Courses where this course will be prerequisite

Design Project I and II

Description of relevance of this course in the B. Chem. Engg. Program

This course integrates all the chemical engineering and allied subjects for appropriate design of process plants, in selection of processes and evaluating alternatives

	Course Contents (Topics and subtopics)	Hours
1	Development of a preliminary Process System: Modular approach	2
2	Multiple process synthesis, selection of process, basic economic evaluation	2
3	Sequencing of operations and integration in processes	2
4	Batch vs continuous vs semi-batch processes- Scale up	3
5	Process Engineering aspects of low and medium volume chemicals including process development.	3
6	Concept of dedicated and multiproduct plant facilities, pilot plant, mini plants	3
7	Development and evaluation of alternative flow sheets	3
8	Scale up aspects; identification of controlling steps of process,	3
9	Green Engineering principles	6
10	Utilisation of energy; cost of utilities, heat exchange networks	3
11	Process intensification	3
12	Preparation of Conceptual process and instrumentation diagrams. .	3
13	Preparation of process specifications for typical equipment.	3
14	Safety and Risk of chemical processes	3
15	Learn from mistakes	3

List of Textbooks/ Reference books

1	Erwin, Douglas L.- Industrial Chemical Process Design. McGraw-Hill Education, New York, 2nd ed 2014
2	Anderson, Neal G. - Practical process research and development. Elsevier, 2000.
3	Groggins, Philip Herkimer - Unit processes in organic synthesis. (1958): 670-728.
4	Silla, Harry. - Chemical process engineering: design and economics. CRC Press, 2003.
5	S. B. Chandalia - Handbook of Chemical Process Development, Multi-tech Publishing Company, 2002
6	Douglas, James M., and Jeffrey J. Siirola. - Conceptual design and process synthesis. Comp. Chem. Eng. Educ (2001): 153-160.

Course Outcomes (students will be able to….)	K Level

CO1	To select a strategy for a process from amongst the alternatives	K2
CO2	Determine strategy for carrying out a particular process	K3
CO3	Prepare specifications for a particular equipment	K2
CO4	Calculate utility requirements	K3
CO5	Identify possible process intensification routes for a given chemical process	K3
CO6	Should be able to draw basic flowsheet of a chemical process	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Chemical Process Development and Engineering (CET1179)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	3	3	2	1	3
CO2	3	3	3	2	1	1	1	2	3	1	1	3
CO3	3	3	2	3	3	1	1	3	3	1	1	3
CO4	3	3	2	2	3	1	1	2	3	1	1	3
CO5	3	3	3	3	3	1	1	1	3	1	1	3
CO6	3	3	3	2	3	1	1	2	3	1	1	3

Course Title: Chemical Process Development and Engineering (CET1179)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	3	3	2	1
CO2	1	3	3	2	1
CO3	1	3	3	2	1
CO4	1	3	3	2	3
CO5	1	3	3	3	3
CO6	1	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1180	Course Title: Chemical Project Economics	Credits= 2		
			L	T	P
	Semester: VII	Total contact hours: 30	2	0	0

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Basic Principles of Finance & Economics (HUT1252), Production Management (HUT1253)

List of Courses where this course will be prerequisite

Design Project I and II

Description of relevance of this course in the B. Chem. Engg. Program

This course is as essential as other technical courses in chemical engineering. Any commercial project in chemical and allied industry will be driven by the profitability analysis considering the market scenario, fluctuations, availability of appropriate land, facilities provided by the local industrial development corporation, project financing, taxation, overall capital and working expenditure analysis. Any small change in manufacturing operation, upstream/downstream process integration and/or green field projects need a detailed project economics report in addition to technical feasibility of the project so that the management can take judicious decision about the implementation.

	Course Contents (Topics and subtopics)	Hours
1	Introduction to greenfield projects and global nature of projects; Impact of currency fluctuations on Project justification and cash flows and Concepts of "Quality by Design" including typical design deliverables and understanding constructability, operability and maintainability during all stages of project execution. Meaning of Project Engineering, various stages of project implementation	4
2	Relationship between price of a product and project cost and cost of production, EVA analysis. Elements of cost of production, monitoring of the same in a plant, Meaning of Administrative expenses, sales expenses etc. Introduction to various components of project cost and their estimation. Introduction to concept of Inflation, location index and their use in estimating plant and machinery cost. Various cost indices, Relationship between cost and capacity.	4
3	Project financing: debt: Equity ratio, Promoters' contribution, Shareholders' contribution, source of finance, time value of money. Concept of interest, time value of money, selection of various alternative equipment or system based on this concept. Indian norms, EMI calculations. Depreciation concept, Indian norms and their utility in estimate of working results of project. Working capital concept and its relevance to project.	4
4	Estimate of working results of proposed project. Capacity utilization, Gross profit, operating profit, profit before tax, Corporate tax, dividend, Net cash accruals. Project evaluation: Cumulative cash flow analysis Break-Even analysis, incremental analysis, various ratios analysis, Discounted cash flow analysis	4
5	Process Selection, Site Selection, Feasibility Report	4
6	Project: Conception to Commissioning: milestones, Project execution as conglomeration of technical and non technical activities, contractual details.	4

	Contract: Meaning, contents, Types of contract. Lump-sum Turnkey (LSTK), Eng, Procurement and Construction (EPC), Eng, Procurement and Construction Management (EPCM). Mergers and Acquisitions	
7	Reading of Balance Sheets and evaluation of Techno-commercial Project Reports.	2
8	PERT, CPM, bar charts and network diagrams	4
	List of Textbooks/ Reference books	
1	Mahajani, V. V., and S. M. Mokashi. - Chemical project economics. Macmillan, 2005.	
2	Peters, Max Stone, and Klaus D. Timmerhaus. - Plant design and economics for chemical engineers. (1968).	
3	Kharbanda, Om Prakash - Process Plant and Equipment Cost Estimation Craftsman Book Co., 1979.	

Course Outcomes (students will be able to….)		**K Level**
CO1	Calculate working capital requirement for a given project	K3
CO2	Calculate cost of equipment used in a plant total project cost	K3
CO3	Calculate cashflow from a given project	K3
CO4	Select a site for the project from given alternatives	K4
CO5	List out various milestones related to project concept to commissioning	K2
CO6	Calculate overall profitability and rate of return for a given project	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Chemical Project Economics (CET1180)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	2	2	1	2	2	3	1	3	3
CO2	3	3	1	2	2	1	2	1	3	1	3	3
CO3	3	3	2	3	2	1	2	2	1	1	3	3
CO4	3	3	3	2	2	2	3	1	1	1	3	3
CO5	3	3	2	2	1	1	1	2	3	1	3	3
CO6	3	3	2	3	3	2	2	1	3	1	3	3

Course Title: Chemical Project Economics (CET1180)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	0	1	3
CO2	0	0	0	1	3
CO3	0	0	0	1	3
CO4	0	0	0	1	3
CO5	0	0	0	2	3
CO6	0	0	0	2	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: GEP 1138	Course Title: Chemical Process Equipment Design and Drawing	Credits = 2		
			L	T	P
	Semester: VII	Total contact hours: 60	0	0	4

List of Prerequisite Courses

Engineering Graphics and Computer Aided Drafting (CAD) (GEP1127), Elements of Mechanical Engineering (GET1128), Chemical Engineering Operations (CET1160), Multiphase Reaction Engineering (CET1171), Separation Processes (CET1174), Heat Transfer Equipment Design (CET1175), Material Technology (CET1173)

List of Courses where this course will be prerequisite

Design Project I and II

Description of relevance of this course in the B. Chem. Engg. Program

This subject will help students to understand different codes and standards used in industries pertaining to chemical process equipment along with selection of suitable materials and fabrication process for various parts of different chemical process equipment's. This will help Chemical engineer to understand mechanical design of various chemical process equipment's and their drawing as per industry requirements.

	Course Contents (Topics and subtopics)	Required Hours
1	Design of pressure vessels: stresses acting on pressure vessels, operating conditions, selection of materials, pressure vessel codes, design stress and design criteria's, Design of Shell, Head, Nozzle, Flanged joints for heads and nozzles.	12
2	Design of Storage vessels: Storage of various types of fluids and liquids in tanks, Loss mechanism of storage of volatile and non-volatile liquids and gases, Types of storage vessels, Vessels for storing of gases, method of storage of gases, Design of rectangular and cylindrical tank with components such as shell, bottom plate, self-supporting roof design, types of roofs,	12
3	Mechanical Design of Reaction Vessels. a) Design of shells/heads subjected to internal and external pressures. Design of stiffening rings b) Types of Jackets /Coils used for heating and cooling in reaction vessels and their design. c) Design of agitator shaft for various impellers d) Design of leg and bracket supports	12
4	Mechanical Design of Heat Exchangers a) Components of shell and tube type heat exchangers. b) Design of various components of heat exchangers such as Fixed tube sheet type tube, Floating head etc. c) Various design codes d) Design of saddle supports.	12
5	Mechanical design of distillation columns a) Various components of columns such as trays, packings, downcomers, bubble cap etc b) Design of shell for various stress conditions. Design of skirt supports. Tray supports and their design	12
	Total	**60**

List of Textbooks/ Reference Books

1 Mahajani, V. V., and S. B. Umarji. - Joshi's Process Equipment Design. Laxmi Publications Pvt Ltd, 2016.

2	Dawande Dr. S.D. - Chemical Process Equipment Design, Denett & Company, 5th ed.	
3	Brownell, Lloyd E., and Edwin H. Young. - Process equipment design: vessel design. John Wiley & Sons, 1959.	
4	ASME SECTION VII DIV 1 and 2	
Course Outcomes (students will be able to….)		
CO1	Understand general design procedure for chemical process equipment's	K2
CO2	Design and draw reaction vessel and its parts subjected to internal and external pressure.	K6
CO3	Design and draw shell and tube type of heat exchangers	K6
CO4	Design and draw tray distillation columns and its parts.	K6
CO5	Understand different types of supports and their mechanical design for chemical process equipment's	K2
CO6	Understand and evaluate the effect of internal/external pressure/vacuum on the mechanical design of the equipment	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Chemical Process Equipment Design and Drawing (GEP1138)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	0	0	0	0	0	0	0	0	0
CO2	3	2	3	0	0	0	0	0	0	0	0	0
CO3	3	2	3	0	0	0	0	0	0	0	0	0
CO4	3	2	3	0	0	0	0	0	0	0	0	0
CO5	3	2	3	0	0	0	0	0	0	0	0	0
CO6	3	2	3	0	0	0	0	0	0	0	0	0

Course Title: Chemical Process Equipment Design and Drawing (GEP1138)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	3	1	2	2
CO2	1	3	1	3	3
CO3	1	2	2	3	3
CO4	1	2	2	3	3
CO5	1	2	2	3	3
CO6	1	2	2	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

RM	Course Code: CEP 1183	Course Title: Research Methodology – I (Literature Review and Critical Analysis)	Credits= 2		
			L	T	P
	Semester: VII	Total contact hours: 45	0	0	4

List of Prerequisite Courses		
All courses		
List of Courses where this course will be prerequisite		
Design Project I and II		
Description of relevance of this course in the B. Chem. Engg. Program		
This course enables students to gather scientific information on a particular topic, analyze the information from scientific principles, present a written and oral summary on that topic. This enables the students to function in a professional environment later on in their career.		
Course Contents (Topics and subtopics)		**Hours**
1	Students will be required to prepare a critical review of selected topics in Chemical Engineering and allied subjects and submit in the form of a standard typed report. Typically, the report should contain and will be evaluated based on the following points: (i) Introduction: 2 pages maximum, (ii) Exhaustive review of literature (including figures): 10 – 12 pages: 50% weightage (iii) Critical analysis of the literature and comments on the analysis (including figures): 10 – 12 pages: 50% weightage. The critical analysis of literature should include the following points: - Are the papers technically correct? are assumptions reasonable; is the reasoning logical? If you think it is not, specify what you think is incorrect and suggest the correct approach. - Are the methods used in the literature appropriate? - Are there any internal contradictions or computational errors and are there any loopholes in the observations? If so, please explain. Critical analysis of papers should also contain quantitative comparison of observations, results and conclusion amongst the various papers. Each student will also be required to make an oral presentation of the review. Weightage would be 40% for the presentation and 60% for the report. Additional details and requirements are given to the students every year by the coordinator of this activity.	45
	List of Textbooks/ Reference books	
1	Menzel, D. - Writing a Technical Paper; McGraw-Hill, United States (1961).	
2	Best, J. W., Kahn, J. V., Jha, A. K. - Research in Education; 10th ed.; Pearson, New Delhi, India (2005)	

Course Outcomes (students will be able to….)		K and P Level
CO1	Understand the basic concepts of research and the components therein, formally	K2
CO2	Understand and appreciate the significance of statistics in Chemical Technology, Pharmacy and Chemical Engineering	K2
CO3	Understand and apply importance of literature survey in research design	K3, P1

CO4	Understand an in-depth knowledge on the documentation in research	K2, P2
CO5	Evaluate importance of various parts of a research report/paper/thesis in presentation of research results	K4, P2
CO6	Prepare and Deliver a model research presentation	K5, P3
CO7	Understand the significance of various types of IPRs in research	K1
CO8	Create a model research project	K6, P3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody, P6 – Creating		

Course Title: Research Methodology – I (CEP1183)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	0	0	1	0	0	0	2	0	0	3
CO2	3	1	1	0	3	1	0	0	2	0	1	3
CO3	3	1	3	2	2	0	0	0	2	0	1	3
CO4	3	1	0	1	2	0	0	0	2	0	3	3
CO5	3	2	3	3	1	0	0	3	2	1	0	3
CO6	3	2	3	3	3	1	1	3	2	3	2	3

Course Title: Research Methodology – I (CEP1183)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	0	0	0	3
CO2	0	0	0	2	3
CO3	0	0	0	0	3
CO4	0	0	0	0	3
CO5	0	0	0	0	3
CO6	0	0	0	0	3
CO7	0	0	0	0	3
CO8	0	0	0	0	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

RM	Course Code: CEP 1184	Course Title: Research Methodology – II (Design and Analysis of Experiments)	Credits= 2		
			L	T	P
	Semester: VII	Total contact hours: 45	1	0	2

List of Prerequisite Courses

Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102)

List of Courses where this course will be prerequisite

This course is required for graduating engineers to function effectively in Industry, Academia and other professional spheres.

Description of relevance of this course in the B. Chem. Engg. Program

Modern day manufacturing activities and R&D activites need decisions taken with a scientific rigour and should be well-supported by 'statistics'. Chemical engineering graduates who will serve industry as well as postgraduate research students who will serve industry, R&D organisations, or academic research should have a reasonably good background of statistical decision making. This also involves extraction of meaningful data from well-designed minimal number of experiments at the lowest possible material costs. This course will also help the students in all domains of their life by imparting them a vision for critical appraisal and analysis of data.

	Course Contents (Topics and subtopics)	Hours
1	Fundamental principles of classical design of experiments Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments.	4
2	Review of Probability and basic statistical inference: Concepts of random variable, probability, density function cumulative distribution function. Sample and population, Measure of Central tendency; Mean median and mode, Measures of Variability, Concept of confidence level. Statistical Distributions: Normal, Log Normal & Weibull distributions, Hypothesis testing.	3
3	Experiments with a Single Factor: The Analysis of Variance Fixed effect model and Random effect model, Model adequacy checking, Contrasts, Orthogonal contrasts, Regression Models and ANOVA, Violation of Normality Assumption: Kruskal-Wallis test. Randomized block designs, Latin square designs, Balanced Incomplete Block Designs	6
4	Factorial designs: Definition, Estimating model parameters, Fitting response curves and surfaces.	3
5	The 2^k Factorial Design, Blocking and Confounding in the 2k Factorial Design; Focus of 2^2 and 2^3 designs, Blocking and Confounding in the 2^k Factorial Design.	6
6	Plackett Burman methods, Central Composite Design (CCD)	3
7	Descriptive Statistics, Probability Distribution and testing of Hypothesis using R	4
8	Regression techniques, diagnostic checks, ANOVA using R and implementation of contrasts.	4
9	Construction of Balanced Incomplete Block Designs and data analysis using R	4
10	Analysis of factorial designs using R, understanding output and interpretation.	4
11	Factorial designs, Data analysis and interpretation.	4

	List of Textbooks/ Reference books
1	Douglas C. Montgomery - Design and Analysis of Experiments, 8th Edition, John Wiley & Sons, Inc. 2013
2	Box, G. E., Hunter, W.G., Hunter, J.S., Hunter, W.G. - Statistics for Experimenters: Design, Innovation, and Discovery, 2nd Edition, Wiley, 2005.
3	John Lawson - Design and Analysis of Experiments with R, CRC Press, 2015
4	Dieter Rasch, Jürgen Pilz, Rob Verdooren, Albrecht GebhardtOptimal Experimental Designs with R. CRC Press, 2011.
5	José Unpingco, Python for Probability, Statistics, and Machine Learning, Springer, 2019
6	Response Surface Methodology: Process and Product Optimization using Designed Experiments: R. H. Myers, D. C. Montgomery.
7	Introduction to Statistical Quality Control: D. C. Montgomery.
8	Design of Experiments in Chemical Engineering: Živorad R. Lazić.

Course Outcomes (students will be able to….)		K Level
CO1	Understand basic principles of design of experiments.	K2
CO2	Perform statistical analysis of single experiments and do post hoc analysis.	K4
CO3	Conduct experiment and analyse the data using statistical methods.	K5
CO4	Choose an appropriate independent and dependent variables (with value range) for given research problem.	K3
CO5	Perform statistical analysis of different designs using R and interpret the results.	K4
CO6	Select appropriate DOE technique based on the process	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Research Methodology – II (Design and Analysis of Experiments) (CEP1184) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	2	0	1	1	1	0	0	3
CO2	3	2	1	3	3	0	1	2	1	0	1	3
CO3	3	3	1	3	3	0	0	2	1	0	1	3
CO4	3	3	1	3	3	0	0	0	1	0	0	3
CO5	3	3	3	3	3	0	0	0	1	0	0	3
CO6	3	3	2	3	3	0	0	0	1	0	0	3

Course Title: Research Methodology – II (Design and Analysis of Experiments) (CEP1184) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	0	3	0	3
CO2	0	0	3	0	3
CO3	0	0	3	0	3
CO4	0	0	3	0	3
CO5	0	0	3	0	3
CO6	0	0	3	0	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

<table>
<tr><td rowspan="2">Project</td><td rowspan="2"></td><td>Course Code:
CEP 1185</td><td colspan="2">Course Title: Design project – I</td><td>Credits= 4</td><td></td></tr>
<tr><td>Semester: VII</td><td colspan="2">Total contact hours: 120</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td></td><td></td><td colspan="3"></td><td>0</td><td>0</td><td>8</td></tr>
<tr><td colspan="8">List of Prerequisite Courses</td></tr>
<tr><td colspan="8">All</td></tr>
<tr><td colspan="8">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="8">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="8">This course enables students to integrate all the subjects that they have learnt and design plants / processes from Chemical Engineering Principles.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="6"></td><td colspan="2">Hours</td></tr>
<tr><td>1</td><td></td><td colspan="5">Every student will be required to solve a problem on design, which will set by one or more of the teachers in the institution. The design will have to be submitted in the form of a standard typed report. Every student will be orally examined. The student will be assessed based on the progress made during the semester. There would be two submissions: (i) Process selection and PFD, (ii) Material and Energy Balance. The submissions will be presented to a panel of faculty members / examiners There will be a weightage of 60% for the submissions and 40% for the presentation.
Additional details may be given to the students from time to time by the coordinator.</td><td colspan="2">120</td></tr>
<tr><td></td><td></td><td colspan="6">List of Textbooks/ Reference books</td></tr>
<tr><td></td><td></td><td colspan="6">1) Detailed Guidelines documents provided by the Department
2) Reference material will be specific to the design project as well as engineering components involved in the calculations</td></tr>
<tr><td colspan="6"></td><td colspan="2">K Level</td></tr>
<tr><td colspan="2"></td><td colspan="4">Identify market requirement related to a particular chemical</td><td colspan="2">K2, P2</td></tr>
<tr><td colspan="2"></td><td colspan="4">Draw a process block diagram from a given process description.</td><td colspan="2">K4, P2</td></tr>
<tr><td colspan="2"></td><td colspan="4">Select a site for the project</td><td colspan="2">K3, P3</td></tr>
<tr><td colspan="2"></td><td colspan="4">Develop a PFD based on block diagram</td><td colspan="2">K4, P3</td></tr>
<tr><td colspan="2"></td><td colspan="4">Perform material and energy balance computation for all the blocks in the process</td><td colspan="2">K4, P4</td></tr>
<tr><td colspan="2"></td><td colspan="4">Prepare the batch scheduling chart (Gantt Chart) for the process</td><td colspan="2">K4, P4</td></tr>
<tr><td colspan="8">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody</td></tr>
</table>

Course Title: Design project – I (CEP1185) **Mapping of Course Outcomes (COs) with Programme Outcomes (POs)**												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	0	1	1	0	1	0	1	0	2	3
CO2	3	2	2	1	2	0	0	0	1	0	0	3
CO3	3	2	2	1	1	2	1	2	1	0	0	3
CO4	3	2	2	1	3	0	0	0	1	0	0	3
CO5	3	2	3	1	2	0	0	0	1	0	0	3
CO6	3	2	3	1	2	0	0	1	2	0	2	3

Course Title: Design project – I (CEP1185) **Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)**					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	3	3	3	3
CO2	1	3	3	3	3
CO3	1	1	3	3	3
CO4	1	3	3	3	3
CO5	1	3	3	3	3
CO6	1	2	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

Project	Course Code: CEP 1186	Course Title: Design Project – II	Credits= 4		
			L	T	P
	Semester: VIII	Total contact hours: 120	0	0	12

List of Prerequisite Courses

All

List of Courses where this course will be prerequisite

Description of relevance of this course in the B. Chem. Engg. Program

This course enables students to integrate all the subjects that they have learnt and design plants / processes from Chemical Engineering Principles.

	Course Contents (Topics and subtopics)	Hours
1	There would be two submissions: (iii) Process Design, (iv) P&ID, Mechanical design, Costing, feasibility. The submissions will be presented to a panel of faculty members / examiners. The submissions would be given a weightage of 50 marks. There will be a weightage of 60% for the submissions and 40% for the presentation. Final report of the home paper would be given a weightage of 50 marks. There will be a viva-voce after the submission of the report. The weightage for the viva-voce would be 50 marks. Additional details may be given to the students from time to time by the Coordinator	120
	List of Textbooks/ Reference books	
	1) Detailed Guidelines documents provided by the Department 2) Reference material will be specific to the design project as well as engineering components involved in the calculations	

	Course Outcomes (students will be able to….)	K Level
CO1	Design, calculate size/power/internals, etc required for all the process equipment in the PFD together with necessary instrumentation, safety aspects.	K4, P3
CO2	Size the pumps/compressors/equipment	K4, P3
CO3	Estimate the cost of equipment based on cost index	K4, P4
CO4	Perform the HAZOP analysis of most critical equipment	K5, P4
CO5	Develop a floor-wise layout of equipment based on material flow	K5, P4
CO6	Perform a techno economic feasibility of the selected process.	K5, P5

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating
P1 – Imitate, P2 – Manipulate, P3 – Perfect, P4 – Articulate, P5 – Embody

Course Title: Design Project – II (CEP1186)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3	0	0	1	2	0	1	3
CO2	3	1	3	2	2	0	0	0	2	0	0	3
CO3	3	1	2	1	2	0	0	1	2	0	0	3
CO4	3	1	2	2	1	0	1	1	2	0	1	3
CO5	3	1	3	2	2	0	1	0	2	0	1	3
CO6	3	1	3	2	2	1	1	0	2	0	1	3

Course Title: Design Project – II (CEP1186) **Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)**					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	2	3	2
CO2	1	2	2	3	2
CO3	1	1	2	3	2
CO4	1	2	2	3	3
CO5	1	2	2	3	2
CO6	1	2	2	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: HUT1254	Course Title: Industrial and Organizational Psychology	Credits = 2		
			L	T	P
	Semester: VIII	Total contact hours:30	3	0	0

	List of Prerequisite Courses	
	NONE	
	Description of relevance of this course in the B. Chem. Engg. Program	
A course in management is vital for chemical engineers, providing insights into organizational behavior, effective employee recruitment and performance management, and motivational strategies. Understanding group dynamics and conflict resolution enhances teamwork and productivity. This knowledge equips chemical engineers to lead and manage teams efficiently, driving innovation and operational success in the chemical industry.		
	Course Contents (Topics and subtopics)	**Reqd. hours**
1	Basics of management, The eras of management, Mission and vision of organizations	3
2	Micro organizational behaviour, Psychoanalytical framework, Common personality traits Hofstede cultural dimensions	5
3	Employee Recruitment and Selection, Concept of Role, Job description and man specifications, Some methods of recruitment, Selection methods	6
4	Employee performance, MBO, Appraisal methods, Review meetings	5
5	Employee motivation, Employee predisposition to motivation, Goal setting, Recent motivation theories, How to motivate trouble spots	5
6	Group dynamics, Theories of group formation, Pitfalls of a group, Conflicts	6
	List of Text Books	
	Human Resource Management (15e) - Gary Dessler, Biju Varrkey Management(15e)-Robbins	
	List of Additional Reading Material / Reference Books	
	Select HBR articles	
	Industrial/Organizational Psychology: An Applied Approach- Michael Aamodt	
	Course Outcomes (students will be able to…..)	
1	Student would be able to understand the major management theories and concepts underlying organizational and corporate practices	K2
2	Student would be able to apply the above theories and concepts in their own organizations or ventures	K3
3	Student would be able to make rational decisions about work culture, teams and individuals	K4
4	Student would be able to understand the role of teams, group dynamics, and their application to collaborative work practices in any organization or their own ventures	K2
5	Students can effectively identify, apply and analyze various principles learnt to solve problems affecting their, their group or organization's performance	K3
6	Students should be able to face the interview process confidently based on the course learning	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Industrial and Organizational Psychology (HUT1254) Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	0	0	0	0	3	1	3	3	3	2	3
CO2	0	0	0	0	0	3	1	3	3	3	2	3
CO3	0	0	0	0	0	3	1	3	3	3	2	3
CO4	0	0	0	0	0	3	1	3	3	3	2	3
CO5	0	0	0	0	0	3	1	3	3	3	2	3
CO6	0	0	0	0	0	3	1	3	3	3	2	3

Course Title: Industrial and Organizational Psychology (HUT1254) Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	0	0	0	3
CO2	0	0	0	0	3
CO3	0	0	0	0	3
CO4	0	0	0	0	3
CO5	0	0	0	0	3
CO6	0	0	0	0	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

HONOURS Syllabus

PCC	Course Code: CET1170	Course Title: Biochemical Engineering	Total Credits=4		
			L	T	P
	Semester: V	Total contact hours:	3	1	0

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Engineering Thermodynamics (CET1156), Chemical Engineering Operations (CET1160), Multiphase Reaction Engineering (CET1171), Chemical Process Control (CET1172), Separation Processes (CET1174), Chemical Engineering Thermodynamics (CET1167)

List of Courses where this course will be prerequisite

Multiphase Reactor Engineering, Env. Engg and Proc Safety, Proc Dev and Engg., Home Paper- I and -II

Description of relevance of this course in the B. Chem. Engg. Program

This course integrates Biological sciences and chemical engineering and is a requisite for employment in Biobased Industry

	Course Contents (Topics and subtopics)	Required Hours
1	Introduction to Biotechnology: Role of chemical engineers in biotechnology	3
2	Mechanism of Enzyme action, Enzyme kinetics, inhibition and regulation	3
3	Enzyme purification and characterization, Coenzymes, cofactors	3
4	Enzyme reactors, thermostabilization, immobilization of enzymes	3
5	Kinetics of microbial growth, models and simulations, Batch and continuous culture, Mixed microbial culture	8
6	Biochemical process development and bioreactors using biological catalysts	8
7	Transport phenomena in bioreactions and bioreactors	4
8	Fundamentals of fermentation-submerged fermentation, Fermenter design and basic biochemical engineering aspects of fermentation	4
9	Reactor design for biochemical reactions and scale up, Process Design for bioproducts, Bioreactor design, Scale up of bioreactions/reactors,	8
	Total	

List of Textbooks/ Reference Books

1	Bailey, James E., and David F. Ollis. - Biochemical engineering fundamentals. McGraw-Hill, 2018.
2	Doble, Mukesh, Anil Kumar Kruthiventi, and Vilas Ganjanan Gaikar. - Biotransformations and bioprocesss. CRC Press, 2004.

Course Outcomes (students will be able to….)

CO1	Calculate microbial/enzymatic kinetics parameters	K3
CO2	Design enzyme reactors and scale up fermenters	K3
CO3	Calculate biomass production/substrate requirements	K3
CO4	Decide process parameters	K3
CO5	Estimate energy equipment/oxygen requirements	K3
CO6	Design bio-reactor size /time for a given microbial/enzymatic process.	K4

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	0	1	1	0	0
CO2	3	3	3	3	2	0	2	1	1	1	1	0
CO3	3	3	3	3	2	0	2	1	1	1	2	0
CO4	3	3	3	3	2	1	2	1	1	1	2	0
CO5	3	3	3	3	2	1	1	1	1	1	2	1
CO6	3	3	3	3	2	1	1	1	1	1	1	0

Mapping of Course Outcomes (COs) with Programme Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
CO6	3	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1176	Course Title: Mathematical Methods and Optimization in Chemical Engineering	Credits= 4		
			L	T	P
	Semester: VI	Total contact hours: 60	2	0	4

List of Prerequisite Courses
Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102), Introduction to Chemical Engineering (CET1151),Material Balance and Energy Balance Calculations (CEP1152), Process Simulation Laboratory - I (CEP1169)

List of Courses where this course will be prerequisite	
Transport Phenomena, Heat transfer, Chemical Reaction Engineering , Chemical Process Control, Optimization of Chemical Engineering Systems, Home Paper I and II, Seminar, etc.	

Description of relevance of this course in the B. Chem. Engg. Program
In this course advanced mathematical tools are covered which will help students to solve complex problems in Chemical Engineering. This course will serve as a bridge between the applied mathematics courses and their application to Chemical Engineering problems. Specifically, the techniques learnt in this course will help problem formulation and solution in Chemical Reaction Engineering, Chemical Process Control, Heat Transfer and Transport Phenomena. Many Chemical Engineering problems encounter trade-offs between two or more parameters and thus formulation and solution of an optimization problem helps a Chemical Engineer to obtain the best solution.

	Course Contents (Topics and subtopics)	Hours
1	Vector algebra: scalar & vector product (application to fluid flow problems) and Linear algebra	12
2	PDEs: Types, solution (penetration theory, 2D conduction, counter-current heat exchanger, reaction-diffusion, dispersion model, etc.)	8
3	Fourier series, transforms (diffusion equations), Laplace, Z transform	8
4	Equation scaling, normalization, convergence	4
5	Integer, linear and quadratic programming (simple scheduling, simple production planning, fuel blending, data fitting, optimal control)	10
6	Nonlinear programming (Reflux ratio optimization, consecutive reaction, reactor-separator recycle systems)	6
7	Mixed integer linear programming (flowsheet optimization, supply chain optimization)	6
8	Multi-objective optimization (design and operation of chemical processes)	6
	List of Textbooks/ Reference books	
1	Kreyszig, Erwin. - Advanced Engineering Mathematics 9th Edition with Wiley Plus Set. Vol. 334. US: John Wiley & Sons, 2007.	
2	Pushpavanam, S. - Mathematical methods in chemical engineering. PHI Learning Pvt. Ltd., 1998.	
3	Collette, Yann, and Patrick Siarry. - Multiobjective optimization: principles and case studies. Springer Science & Business Media, 2013.	

4	Vanderbei, Robert J. - Linear programming: foundations and extensions. Journal of the Operational Research Society 49.1 (1998).
5	Jensen, Victor George, and Godfrey Vaughan Jeffreys. - Mathematical methods in chemical engineering. Elsevier, 1977.

Course Outcomes (students will be able to….)		K Level
CO1	Formulate a Chemical Engineering problem into a mathematical problem	K5
CO2	Solve (analytically or numerically) ODE and PDE equations encountered in Chemical Engineering Applications	K4
CO3	Assess stability of Chemical Engineering systems	K4
CO4	Formulate a Chemical Engineering problem into an optimization problem	K5
CO5	Solve (analytically or numerically) optimization problems encountered in Chemical Engineering Applications	K5
CO6	Develop efficient and economical process based on the course learning	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Mathematical Methods and Optimization in Chemical Engineering (CET1176)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	0	0	1	2	0	0	3
CO2	3	1	3	2	3	0	0	1	2	0	0	3
CO3	3	2	2	2	1	0	0	0	2	0	0	3
CO4	3	2	3	3	1	0	0	0	2	0	0	3
CO5	3	2	3	3	3	0	0	1	2	0	0	3
CO6	3	2	2	3	1	1	0	1	2	0	0	3

Course Title: Mathematical Methods and Optimization in Chemical Engineering (CET1176)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	3	1
CO2	2	3	3	2	1
CO3	2	3	3	3	1
CO4	2	3	3	2	1
CO5	2	3	3	2	1
CO6	2	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET1182	Course Title: Refinery Science and Engineering	Credits = 3		
			L	T	P
	Semester: VII	Total contact hours: 45	2	1	0

List of Prerequisite Courses

Introduction to Chemical Engineering (CET1151), Material Balance and Energy Balance Calculations (CEP1152), Process Safety (CET1157), Chemical Engineering Operations (CET1160), Industrial Chemistry and Reaction Engineering (CET1161),Instrumentation and Process Dynamics (CET1162), Multiphase Reaction Engineering (CET1171), Chemical Process Control (CET1172), Separation Processes (CET1174), Heat Transfer Equipment Design (CET1175)

List of Courses where this course will be prerequisite

Design Project - I and II

Description of relevance of this course in the B. Chem. Engg. Program

This course provides the basis of major chemical engineering operations in large scale petroleum refineries

	Course Contents (Topics and subtopics)	Required Hours
1	World oil scenario and future of oil, Petroleum pricing and economics	4
2	Fundamentals of crude distillation	4
3	Refinery products and properties, refining chemistry, role of catalysis	4
4	Refinery processes - thermal cracking, fluid catalytic cracking, hydrotreating, catalytic reforming, refinery alkylation, isomerization	9
5	Integration of petrochemical processes with refinery	4
6	Material selection in refinery technology	4
7	Treatment processes, gas cleaning	3
8	Safety, health and environment issues	4
9	Renewable and alternative fuels	4
	Total	

List of Textbooks/ Reference Books

1	W. C. Edmister, - Applied Hydrocarbon Thermodynamics Vol I and Vol II Gulf Publishing Co.
2	Joseph Hilyard - International petroleum encyclopedia 2008 (3 Volume).
3	

Course Outcomes (students will be able to….)

CO1	To understand refining trends, challenges and key issues	K3
CO2	To analyze the role of refining processes in the world energy challenge	K3
CO3	To propose feasible solutions for energy security in India	K5
CO4	To understand reasons of operations in Refineries	K4
CO5	To understand safety aspects of handling large volumes of hazardous materials	K4
CO6	To understand the selection of treatment processes and cost implication based on the quality requirements imposed by various regulating bodies	K4

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Course Title: Refinery Science and Engineering (CET1182)

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	0	1	1	0	0
CO2	3	3	3	3	2	0	2	1	1	1	1	0
CO3	3	3	3	3	2	0	2	1	1	1	1	0
CO4	3	3	3	3	2	0	2	1	1	1	1	0
CO5	3	3	3	3	2	0	2	1	1	1	1	0
CO6	3	3	3	3	2	0	2	1	1	1	1	0

Course Title: Refinery Science and Engineering (CET1182) **Mapping of Course Outcomes (COs) with Programme Outcomes (PSOs)**					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
CO6	3	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1187	Course Title: Catalytic Science and Engineering	Credits= 4		
			L	T	P
	Semester: VIII	Total contact hours: 60	4	2	0

List of Prerequisite Courses

Applied Chemistry (CHT1251), Applied Chemistry Laboratory (CHP1252), Industrial Chemistry and Reaction Engineering (CET1161), Chemical Reaction Engineering (CET1165)

List of Courses where this course will be prerequisite

Description of relevance of this course in the B. Chem. Engg. Program

Catalysis plays an important role in chemical manufacturing. Understanding of the fundamentals of catalysis and catalyst selection and transport phenomena in heterogeneous catalysis helps in the development of efficient processes.

	Course Contents (Topics and subtopics)	Hours
1	Relevance and examples, Atom economy and green chemistry concepts, Homogenous and heterogeneous catalysis	10
2	Fundamentals of homogeneous catalysis and mechanisms and kinetics, Fundamentals of adsorption, isotherms, energetics, structural and dynamic considerations,	10
3	Mechanisms, models and kinetics of surface reactions, Fractal models, Determination of surface structure though modern methods, Significance of Pore structure and models	10
4	Catalysts Characterization methods: Surface area and pore volume determinations, XRD, various Spectroscopic techniques, Temperature programmed reduction & oxidation, Electron microscopy.	10
5	Solid and surface chemistry of catalysis, Quantum mechanical, molecular mechanical and hybrid models, Catalyst design through artificial intelligence and computer modelling	10
6	Poisoning, promotion, deactivation and selectivity , Catalytic process engineering , Measurement of catalytic rates and kinetic parameters, Types of reactors	10

List of Textbooks/ Reference books

1. G. Ertl, H. Knozinger and J. Weitkamp, "Handbook of Heterogeneous Catalysis" Vol 1-5, Wiley - VCH.
2. J.J. Carberry , "Chemical and catalytic reaction Engineering", Dover Publications.
3. C. H. Bartholomew and R. J. Farrauto "Fundamentals of Industrial catalytic Processes", Wiley-VCH.

Course Outcomes (students will be able to….)		K Level
CO1	Understand synthesis, characterization, activity and deactivation of heterogeneous catalyst	K2
CO2	Understand the mechanisms of homogeneous catalysis	K2
CO3	Understand the role of catalysis in industrial processes	K2
CO4	To plan, develop and test catalyst for given application	K3

CO5	Suggest strategies for catalyst development	K3
CO6	Select and design multiphase catalytic reactors	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Catalytic Science and Engineering (CET1187)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	3	3	2	1	3
CO2	3	3	3	2	1	1	1	2	3	1	1	3
CO3	3	3	2	3	3	1	1	3	3	1	1	3
CO4	3	3	2	2	3	1	1	2	3	1	1	3
CO5	3	3	3	3	3	1	1	1	3	1	1	3
CO6	3	3	3	2	3	1	1	2	3	1	1	3

Course Title: Catalytic Science and Engineering (CET1187)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	3	3	1
CO2	2	1	2	1	1
CO3	2	1	2	1	1
CO4	1	2	3	3	1
CO5	2	2	3	2	1
CO6	2	2	3	3	2

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

PCC	Course Code: CET 1188	Course Title: Statistical Thermodynamics	Credits= 3		
			L	T	P
	Semester: VIII	Total contact hours: 45	3	2	0

List of Prerequisite Courses

Applied Mathematics - I (MAT1101), Applied Mathematics - II (MAT1102), Engineering Thermodynamics (CET1156),Chemical Engineering Thermodynamics (CET1167)

List of Courses where this course will be prerequisite

Description of relevance of this course in the B. Chem. Engg. Program

Thermodynamics sets hard limits on performance of processes and equipment. This course gives students the formalism and insights into statistical thermodynamics.

	Course Contents (Topics and subtopics)	Hours
1	Introduction to statistical mechanics – a first look at the Canonical Ensemble. Introduction to the Boltzmann Distribution	3
2	Introduction to the microcanonical, PVT and Grand Canonical Ensembles	3
3	Macroscopic Thermodynamic Quantities as Functions of Ensembles with particular emphasis on the microscopic level difference between Heat Transfer and Work Transfer.	3
4	a) Derivation of the Ideal Gas Law using Schrodinger's Equation applied to Particle-in-a-box and extended to many particle systems using statistical mechanics b) Derivation of Pressure for an Ideal Gas and introduction to the Virial Theorem	8
5	Introduction to the pair interaction energy, pair correlation function (radial distribution function) and determination of macroscopic thermodynamic quantities including derivation of the van der Waals equation of state.	5
6	Introduction to Importance Sampling, detailed balance and the Metropolis Monte Carlo Algorithm	3
7	Writing a code for Monte Carlo simulations in 1D using periodic boundary conditions	3
8	Phase Space, the Liouville Theorem and Molecular Dynamics Simulations	3
9	Symplectic integrators and writing a code for molecular dynamics simulations in 1D using periodic boundary conditions	3
10	Fluctuation Dissipation theorem and the Green Kubo relations to determine transport properties from MD simulations Writing code to determine thermodynamic and transport properties of a system from fluctuations and autocorrelations thereof.	8
11	Introduction to Transition State Monte Carlo Simulations for Phase Equilibria	3
	List of Textbooks/ Reference books	
1	Hill, Terrell L. - An introduction to statistical thermodynamics. Courier Corporation, 1986.	
2	Frenkel, Daan, and Berend Smit. - Understanding molecular simulation: from algorithms to applications. Elsevier, 2023.	

3	Marion, Jerry B. - Classical dynamics of particles and systems. Academic Press, 2013.
4	Donald A. McQuarrie - Statistical Mechanics, University Science Books, 1984

Course Outcomes (students will be able to….)		K Level
CO1	Understand and use the concept of microcanonical, canonical, grand-canonical and PVT ensembles and the partition functions thereof	K3
CO2	Relate macroscopic thermodynamic quantities like entropy and free energy to the partition functions	K3
CO3	Understand the algorithms behind Monte Carlo simulations and write a simple Monte Carlo Simulation	K3
CO4	Understand the algorithms behind Molecular Dynamics Simulations and write a simple MD simulation	K3
CO5	Understand and use the fluctuation dissipation theorem in conjunction with Monte Carlo simulations to determine transport coefficients using the Green Kubo relations.	K4
CO6	Estimate thermodynamic and transport properties	K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Statistical Thermodynamics (CET1188)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	0	0	0	2	0	0	3
CO2	3	2	1	3	2	0	0	0	2	0	0	3
CO3	3	3	2	2	3	0	0	0	2	0	0	3
CO4	3	3	2	2	3	0	0	0	2	0	0	3
CO5	3	3	2	2	3	0	0	0	2	0	0	3
CO6	3	3	3	3	3	0	0	0	2	0	0	3

Course Title: Statistical Thermodynamics
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	1	0
CO2	3	1	2	1	0
CO3	3	1	2	1	0
CO4	3	2	2	1	0
CO5	3	2	2	1	0
CO6	3	2	2	2	1

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

CEP1189: Internship / On Job Training

CEP 1710 Internship
• In the Eighth semester, every student will have to undergo an internship and/or On Job Training. The Internship would be of 12 credits. • The internship would be assigned to the student by the Departmental Internship Coordinator, with the approval of Head, Chemical Engineering Department. • The total duration of the internship would be for a period equivalent to 12 Calendar weeks. The internship may be completed in one or more organizations as described below. • The internship could be of the following forms: Industrial internship in a company (within India or Abroad) involved in R&D / design / manufacturing (QA/QC/Plant Engineering/Stores and Purchase) / marketing / finance / consultancy / Technical services / Engineering / Projects, etc. • At the end of the internship, each student will submit a written report based on the work carried out during the Internship. The report will be countersigned by the Supervisor from Industry / Institute as the case may be. • Performance of the student will be assessed based on the written report and a presentation to a committee consisting of two faculty members from the Chemical Engineering Department. • Students will be assigned a grade based on the written report and a presentation; evaluated by a committee of faculty members. • Feedback will be taken from Industry mentors and this will used while assigning the grades.

LIST OF ELECTIVES

PCC	Course Code: CET 1181	Course Title: Environmental Engineering and Chemical Process Safety	Credits= 3		
			L	T	P
	Semester: VII	Total contact hours: 45	2	1	0

List of Prerequisite Courses

Process Safety (CET1157), Environmental Sciences (CET1159)

List of Courses where this course will be prerequisite

Design project I and II

Description of relevance of this course in the B. Chem. Engg. Program

A chemical engineer working in any function of process industry should have working knowledge of all the prevailing safety, environment, and health standards. The course is relevant for R&D roles, scale-up engineers and project engineering for development of safe protocols for various processes including the environmental assessment and pollution abatement.

	Course Contents (Topics and subtopics)	Hours
1	Industrial wastewater treatment: characterization of effluents (COD and BOD), treatment levels (primary, secondary and tertiary) and strategies (physical, chemical and biological), sludge treatment and valorization	8
2	Details of the effluent treatment plant and machines, chemical pipelines and storage condition, segregation of waste streams (high COD and low COD)	4
3	Current practices in wastewater treatment: examples and case studies	4
4	Management of municipal solid waste, waste-to-energy strategies, refuse-derived fuel, hazardous waste, E-waste, battery waste, plastic waste	3
5	Methods (absorption, adsorption, oxidation and reduction) and equipment (scrubbers, dust management systems) for the control of gaseous pollutants from the industry, Catalytic technologies for air pollution control	6
6	Prevention and control of accidental release of contaminants, plume behavior, dispersion modeling	4
7	Lessons learned from major industrial disasters and recent process safety incidents	2
8	Process safety management, Risk assessment and identification, HAZOP, LOPA and FMEA	4
9	Process hazards, design and control: safe design of process vessels, safety systems, color coding, earthing, safety-related equipment	7
10	Risk-based process safety, Inherently safer design	3

List of Textbooks/ Reference books

1. Daniel A. CROWL and Joseph F. LOUVAR - Chemical Process Safety: Fundamentals with Applications, Pearson, 2020, 4th Edition
2. Guidelines for Process Safety Management, Environment, Safety, Health, and Quality – Center for the Chemical Process Safety of the American Institute of Chemical Engineers (AIChE)
3. Roy E. SANDERS - Chemical Process Safety Learning from Case Histories, Butterworth-Heinemann Inc, 2015, 4th Edition
4. Guidelines for Process Safety Documentation – Center for the Chemical Process Safety of the American Institute of Chemical Engineers (AIChE)

Course Outcomes (students will be able to….)		K Level
CO1	Select appropriate pollution abatement technique for a given pollutant	K1

CO2	Carry out quantitative environmental impact assessment of a process	K4
CO3	Analyze the case scenarios of major industrial disasters	K3
CO4	Carry out HAZOP/LOPA analysis of various unit operations and process equipment	K3
CO5	Design pressure relief valve, flare and stacks based on the available process data	K3
CO6	Select method and equipment for control of gaseous pollutant from chemical industries	K5
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title: Environmental Engineering and Chemical Process Safety (CET1181)
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	0	0	3	1	2	2	1	3
CO2	3	3	3	3	1	0	1	0	2	1	1	3
CO3	3	3	3	3	0	0	2	0	2	1	1	3
CO4	3	3	3	3	2	0	2	0	2	1	1	3
CO5	3	3	3	3	2	0	1	0	2	1	1	3
CO6	3	3	2	2	1	0	1	1	2	1	1	3

Course Title: Environmental Engineering and Chemical Process Safety (CET1181)
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	1	1
CO2	2	3	3	1	1
CO3	2	2	3	1	3
CO4	2	3	3	3	3
CO5	2	3	3	1	1
CO6	2	3	3	3	3

3-Strong Contribution; 2-Moderate Contribution; 1-Low Contribution, 0 – No contribution

ELE	Course Code: HUT1102E	Course Title: Perspective of Society of Science and Technology	Credits =		
			L	T	P
	Semester:	Total contact hours:	2		

List of Prerequisite Courses

None

List of Courses where this course will be prerequisite

This course is important for all engineering sciences which have main objective of simplifying the lives of human beings. This course thus forms the basis of professional ethics

Description of relevance of this course in the B. Chem. Engg. Program

	Course Contents (Topics and subtopics)	Reqd Hours
1	**Globalization and its impact on the environment of science and technology** How science and technology affect and are affected by various aspects of social life, such as power, class, gender, race, culture, religion, education, health, environment, and politics. How lay people perceive and engage with science and technology in their everyday lives and how they participate in public debates and decision making on scientific and technological issues Impact of scientific advances on society (For example, Antibiotics, Vaccines, Hygiene practices, Longevity, Pollution and climate change) Discussion on the micro- and macro-environment affecting any organization The role of science and technology in the larger perspective of any organization and society Insights into the relationships between science, technology and society from practical experiences Case studies (For example, River Blindness and Merck, Story of Nirma, 3M Post It notes)	4
2	**Is Science Values-laden or Values-free?** The concept of values, The idea that science is value-free	2
3	**Ethics in scientific Research and technology** The human psyche in making choices, The ethical dilemma while making choices that impact society, Ethics in scientific publications, data handling and disseminating information to stakeholders, Ethics in Medical research: Informed consent, Cultural difference in ethics Case Studies (for example, A7D and Goodrich, Johnson and Johnson Tylenol, Exxon Valdez spill, Tuskegee syphilis study, Bidil racial medicine)	7
4	**Gender, Science and Technology** Gender disparity in STEM, The leaky pipeline, Gender diversity in tech companies and scientific research institutions, Implicit biases and stereotypes affecting women in STEM. Mentorship and support networks for women and underrepresented genders. The impact of work-life balance and family responsibilities on careers in science and technology, The Matilda and Mathew effect in science, Unique challenges faced by LGBTQ+ individuals in STEM. Strategies for fostering an inclusive environment for all underrepresented groups, Biases in scientific and technology works Case Studies (Example, Rosalind Franklin and the Double Helix DNA, The flying Jewess Lise Meitner, Joycelyn Bell Burnell and Pulsars)	7
5	**The macro environmental factors affecting science and technology** Scientific factors, technological factors, market factors, political factors, juridical factors, aesthetic factors, beliefs and perception Case Studies (Nigeria polio vaccine boycott, Human Embryonic stem cell Research, HELA cell, EVMs, atomic energy plants, Insulin from animal source, Patents, COVID vaccine	4
6	**Pseudoscience**	2

	What is pseudoscience? The problem with pseudoscience, Opinion leaders ad pseudoscience	
7	**Sustainable way of doing business** Concept of sustainable development, The pillars of sustainability, SDG 2030 Case studies: (Example, DuPont's sustainable business strategy, BP Reports, Corporate responsibility of organizations)	4
List of Textbooks / Reference Books		
1	Science, Technology, and Society: A Sociological Approach- by Wenda Bauchspies, Jennifer Croissant, and Sal Restivo	
2	Science, Technology, and Society: An Introduction-by Martin Bridgstock	
List of Additional Reading Material / Reference Books		
	The Hindu Businessline	
	National Newspapers' editorials	
	Harvard Business review cases and articles	
Course Outcomes (students will be able to….)		
CO1	Student would be able to understand the impact of globalization on science ,technology and society	K1,K2
CO2	Student would be able to examine the influence of science and technology on society and vice versa	K1,K2
CO3	Student would be able to understand the importance of acting ethically in scientific research	K1,K2
CO4	Students will display critical thinking about the role of gender in science, technology, and medicine.	K1,K2
CO5	Student would be able to explain the interplay between culture, politics, religion, science and technology	KI,K2
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Course Title:
Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	1	1	1	3
CO2	3	3	2	3	2	1	1	1	2	3	1	3
CO3	3	2	3	2	1	1	1	1	2	3	1	3
CO4	3	2	2	3	1	1	2	1	2	3	1	3
CO5	3	2	2	1	1	1	1	1	1	1	1	3
CO6	3	3	2	3	1	1	2	1	2	3	1	3

Course Title:
Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	1	1
CO2	2	1	1	1	1
CO3	3	1	3	1	2
CO4	3	1	3	2	2
CO5	3	1	2	1	1
CO6	3	1	2	1	1

	Course Code: MAT XXXXE	Course Title: Optimization Techniques	Credits =		
			L	T	P
	Semester:	Total contact hours:			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			Reqd Hours		
	Review of local maximum/minimum Method of Lagrange Multipliers and KKT methods One dimensional Optimization Techniques: Fibonacci search method, Golden section method and interpolation method. Direct Search unconstrained optimization: Powell's method, Nelder-Mead (simplex) method Gradient Search Optimization Methods: Steepest Descent Method, Newton's Method, Conjugate gradient methods Linear Programming: Simplex Method, Revised Simplex Method and other Advanced Methods, Integer Programming Modern Optimization Techniques; Genetic Algorithms, Simulated Annealing, Ant Colony Optimization					
List of Textbooks / Reference Books					
1	Engineering Optimization: theory and practices, S.S. Rao, New Age International Pvt. Ltd.				
2	An Introduction to Optimization, Edvin K. P. Chong & Stanislab H. Zak, Wiley Publication				
3	Optimization for Engineering Design, K. Deb, Prentice Hall, India				
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

<table>
<tr><td rowspan="2">ELE</td><td>Course Code:
MATXXXXE</td><td>Course Title: Machine Learning</td><td colspan="3">Credits =</td></tr>
<tr><td>Semester:</td><td>Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Prerequisite Courses</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="5">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="4">Machine Learning Concepts: Mean Square Error (MSE), Training Error, Test Error, Bias-variance trade-off, Measuring the quality of fit, Regression Diagnostics, Understanding the concept of model flexibility and prediction accuracy, Universal behaviour of Training and Test MSE. Case study of linear regression with K-nearest neighbour regression
Model Selection and Regularization: Validation set approach, Leave-One-Out-Cross-Validation, K-fold cross validation, Best subset selection, Forward Selection, Backward selection, Hybrid selection, shrinkage methods: Ridge regression, Lasso, Least angle regression.
Decision Trees, Bagging and Boosting, Random Forests, Gradient Boosting, Artificial Neural Network
Classification problem: Logistic Regression, Support Vector Machines, Receiver operating characteristic (ROC) curves, Area under the curve (AUC) and other related accuracy measures
Multivariate methods: Principal Component Analysis, Factor Analysis, Principal component regression, K-means clustering, Hierarchical Clustering, Multi-dimensional scaling</td><td></td></tr>
<tr><td colspan="5">List of Textbooks / Reference Books</td><td></td></tr>
<tr><td>1</td><td colspan="4">Review of local maximum/minimum</td><td></td></tr>
<tr><td>2</td><td colspan="4">Method of Lagrange Multipliers and KKT methods</td><td></td></tr>
<tr><td>3</td><td colspan="4">One dimensional Optimization Techniques: Fibonacci search method, Golden section method and interpolation method.</td><td></td></tr>
<tr><td>4</td><td colspan="4">Direct Search unconstrained optimization: Powell’s method, Nelder-Mead (simplex) method</td><td></td></tr>
<tr><td>5</td><td colspan="4">Gradient Search Optimization Methods: Steepest Descent Method, Newton’s Method, Conjugate gradient methods</td><td></td></tr>
<tr><td>6</td><td colspan="4">Linear Programming: Simplex Method, Revised Simplex Method and other Advanced Methods, Integer Programming</td><td></td></tr>
<tr><td>7</td><td colspan="4">Modern Optimization Techniques; Genetic Algorithms, Simulated Annealing, Ant Colony Optimization</td><td></td></tr>
<tr><td colspan="5">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Biomaterials: Biodegradable Materials for Biomedical Applications</td><td colspan="3">Credits =</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Introduction of Biomaterials
Biomaterials Surfaces: Structure and Properties, Surface Energy
Adsorption and Reconstruction at Surfaces,
Protein-Surface Interactions
Proteins: Structure, Properties, Functions, Protein Adsorption: Complex Phenomena, Measurement
Cell-Surface Interactions: Host Response to Biomaterials: Cell adhesion mechanism, coagulation cascade, immune response
Surface Characterization: AES, XPS, AFM, Contact Angle
Quantifying Cell Behavior: Cell Culture, Cellular Assays
Biosensors and Diagnostic devices
Drug Delivery: Controlled Release, Diffusion Controlled and Membrane based devices, Mechanical Pumps
Biomaterial for Organ Replacement
Mechanical Properties, Bone Substitutes
Introduction of Tissue Engineering: Cell, Scaffold design, Artificial liver, pancreas, cartilage
Regulatory overview</td><td></td></tr>
<tr><td colspan="6">List of Textbooks / Reference Books</td><td></td></tr>
<tr><td>1</td><td colspan="5">Ratner, Buddy D., et al. Biomaterials Science: An Introduction to Materials in Medicine. 2nd ed. Burlington, MA: Academic Press, 2004. ISBN: 9780125824637</td><td></td></tr>
<tr><td>2</td><td colspan="5">Ratner, Buddy D., et al. Biomaterials Science: An Introduction to Materials in Medicine. 2nd ed. Burlington, MA: Academic Press, 2004. ISBN: 9780125824637</td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

Elective	Course Code: CETXXXXE	Course Title: Advanced Membrane Separations	Credits = L	T	P
	Semester:	Total contact hours:			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			Reqd Hours		
	Introduction : classification and definitions Membrane Processes and their applications: Microfiltration, Ultrafiltration and micelle-enhanced ultrafiltration, Nanofiltration, Reverse osmosis, Dialysis, piezodialysis, electrodialysis, Pervaporation and membrane distillation, Gas permeation,Liquid membranes, Ion exchange membranes Transport mechanisms, and mathematical modelling Membranes: Design of membranes, Characterization Polarisation and fouling: Polarisation phenomena and fouling concentration polarization, Characteristic flux behaviour in pressure driven membrane operation, Membrane fouling, Methods to reduce fouling Process design: modules and configurations: Capillary, hollow fibre, tubular, Plate and frame, Spiral wound Membrane reactors and their applications in biotechnology				
List of Textbooks / Reference Books					
1	Mulder, M.H.V. Membrane Separations, Springer.				
2	Philip, R., Wankat, C. Rate-Based Separations, Springer.				
3	Reference books:				
4	Nunes, S.P., Peinemann, K.V. Membrane Technology in the Chemical Industry, Wiley.				
5	Rautanbach and R. Albrecht, Membrane Processes, Wiley.				
6	Crespo, J.G., Bodekes, K.W. Membrane Processes in Separation and Purification, Kluwer Academic Publications.				
7	Geankoplis, C.J. Transport Processes and Unit Operations, Prentice-Hall				
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td>Course Title: Process Design of Heat and Mass Transfer Equipment</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td>Total contact hours: 45</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Prerequisite Courses</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="5">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="4">Advanced Process design aspects of various process equipment will be considered through several case studies; and will cover: hydrodynamic characteristics, heat and mass transfer characteristics, selection criteria, etc. The topics will include some of the following equipment (but not limited to):
(1) Equipment for heat transfer: plate heat exchangers, plate fin exchangers, finned tube exchangers, thermo-siphon reboilers, evaporators, condensers, etc.
(2) Equipment for Unit operations: plate and packed columns, spray towers, etc.
(3) Equipment for Multiphase reactions: Stirred tanks, gas inducing reactors, bubble columns / modified bubble columns, air-lift reactors, packed and plate columns, trickle bed reactors, ejectors, etc.</td><td></td></tr>
<tr><td colspan="6">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="5">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

Elective	Course Code: CETXXXXE	Course Title: CFD applications in chemical processes	Credits = 3		
			L	T	P
	Semester:	Total contact hours: 45	2	1	0
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			Reqd Hours		
	Derivation of equations of momentum and energy for turbulent flows. Finite volume technique One dimensional heat conduction and flow Grid generation Space and time discretization Pressure velocity coupling (simple, simpler & SIMPLEC) OpenFOAM software, simulation of pipe flow, backward step, flow past cylinder Commercial software, simulation of pipe flow, backward step, flow past cylinder, stirred vessel, bubble column, cyclone separator, spray dryer etc.				
List of Textbooks / Reference Books					
	Versteeg and malalasekera, “An introduction to computational fluid dynamics. The finite volume method”, (2007)				
	Patankar S., “Numerical heat transfer and fluid flow”, (1980)				
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

Elective	Course Code: CETXXXXE	Course Title: Process Systems Engineering	Credits = 3		
			L	T	P
	Semester:	Total contact hours:			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			Reqd Hours		
	Introduction to Systems Engineering: Systems and their origin, examples of problems in Systems Engineering Foundations of Systems Engineering: Scope and Formulation of Engineering Problems, Goals, Objectives, Specifications and Constraints, Types of Models; Hierarchical decomposition of systems, Types of Problems: Forward solution and inversion of models Structural Analysis of Systems: Graphs and digraphs: Representation of systems, Partitioning and Precedence Ordering of systems, Structural analysis of modeling equations, Structural controllability and observability of systems, Applications to engineering problems Steady State Analysis of Systems: Formulating steady-state models and simulations, Degrees of freedom and design specifications, The Sequential-Modular Strategy, The Equation-Oriented Strategy, Applications to engineering problems Optimization of Systems: Theory and Algorithms: Basic concepts and definitions, Linear programming, Unconstrained nonlinear optimization, Nonlinear Programming, Combinatorial optimization, Applications to engineering problems Simulation of Dynamic Systems: Basic concepts: Systems described by ODEs and DAEs, Formulating dynamic simulations; consistent initialization, Numerical integration of ODEs and DAEs, Modeling-simulation of hybrid Discrete/Continuous systems, Applications to engineering systems Model-Based Process Control: The nature of feedback control, The concept of model-based control systems, Design and analysis of model-based control systems applications				
List of Textbooks / Reference Books					
	Versteeg and malalasekera, “An introduction to computational fluid dynamics. The finite volume method”, (2007)				
	Patankar S., “Numerical heat transfer and fluid flow”, (1980)				
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

Elective	**Course Code: CETXXXXE**	**Course Title: Project Management: Case Study Approach**	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			**Reqd Hours**		
	Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution : conception to commissioning. Project execution as conglomeration of technical and non technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team : Role of each member. Importance Project site : Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process				
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Advanced Materials</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Nanostructured Materials:
Metal nano particles, their structure and properties , Carbon nano tubes: manufacture, properties and applications. Nano materials in catalysis.
Composite Materials: Polymer composites, metal-metal composites, polymer-metal composites, metal- ceramic composites.
Superconducting Materials: Principles of superconductivity, properties, advantages and limitations of superconductors. Applications , superconductors
Smart Materials: Shape memory alloys, Auxetic materials and Biomimmicking materials. Stimulii for sensors and actuators</td><td></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td>Course Title: Plant Utilities</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td>Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Prerequisite Courses</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="5">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="4">Role of Process Utilities in process industries. Impact on Project economics
Water, its characteristics and its conditioning and treatment for process industries e.g. boiler feed water, cooling water. Recycling aspects of water from blow downs.
Application of steam systems in chemical process plants, design of efficient steam heating systems, condensate utilization, flash steam, steam traps.
Characteristics properties, classification, selection and industrial applications
Characteristics of air and air receivers, instrument air. Inert gas generation
Vacuum system engineering.
Electrical Power :
HT/LT
Area classification,
Motors/drives selection accordingly.
Single line diagram.
Emergency Drives Identification
Emergency power. Inverters, DG sets. Etc.
Estimation of utilities
Utilities Audit</td><td></td></tr>
<tr><td colspan="6">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="5">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

Elective	**Course Code: CETXXXXE**	**Course Title: Fuels Engineering**	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			**Reqd Hours**		
	Classification of fuels : G/L/S , Automotive Fuels Bharat Standards IV Gaseous Fuels: Natural Gas: Processing for pipe line specs, CO2/H2S/COS Removal , Gas dehydration, Gas compression for pipe line transport, Coal bed methane, Bio Gas (methane) CNG: As auto fuel,Compression, CNG stations LNG : Liquefaction of NG JT effect, closed & open cycle , Storage of LNG, Transportation of LNG, vessels / truck, terminal, Gasification of LNG to NG for pipeline transport Liquid Fuels: Refinery sources, Reforming for fuels , LPG : Domestic and Auto LPG Storage and handling, Manufacture and Storage (Partly in I&EC) Petrol, Diesel, Aviation Turbine Fuel, HSD, LDO. Furnace oil, Fuel oil, LSHS. Biofuels : bioethanol, biodiesel Solid Fuels : Characterization, Coal, Biomass, Residue from Refinery, Plastic waste, Municipal domestic waste Combustion of Fuels : Basic equation, air requirement norms for excess air, Heating value : GHV/LHV Calculations for mixture of components, Wobbe number for Gaseous Fuels definition and significance, Burners : Gas/Liquid/Hydrogen, Flue gas composition, Dew point calculations, Treatment of flue gas to meet local standards,Carbon Credit Gasification of Coal, Indian Coal, Biomass, Refinery Heavy Residue, Power generation, combined cycle, cogeneration				
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td>Course Title: Advanced topics in Polymer Chemistry/Physics Characterisation/Analysis of Polymers</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td>Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Prerequisite Courses</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="5">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="4">Structure/property relationship : Morphology & Cristallinity Mechanical and Chemical properties
Structure/Rheology relationships
Rheology, elasticity, Viscoelasticity, yield and fracture chemical resistance
Properties of commercial polymers. PE, PP, Acrylic, amides & peptides phenolic & Urethane resins
Role of Additives : Type of additives and their role in altering the properties
Polymer composites : Carbon filled, fibre filled etc. Reinforced polymers
Analysis of polymer solubility, thermodynamics and phase equilibrium of polymer solutions, End group analysis, Colligative property measurement, Light scattering, Solution viscosity and molecular size and wt distribution. Spectroscopic methods, microscopy, thermal analysis.
Selection of polymers, domestic and engineering usage</td><td></td></tr>
<tr><td colspan="6">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="5">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

Elective	**Course Code: CETXXXXE**	**Course Title: Polymer Reactor Engineering**	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			**Reqd Hours**		
	Kinetic modelling, concept of reactor design, optimisation and control of polymerisation process, isolation and separation of monomers/catalyst/by products etc for Bulk polymerisation, Solution polymerisation, Emulsion polymerisation, suspension polymerisation with case studies Kinetic modelling of co-polymerisation processes				
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

Elective	**Course Code: CETXXXXE**	**Course Title: Polymer Processing**	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			**Reqd Hours**		
	Plastic Technology : Moulding, (injection, blow) extrusion, cold-not and vacuum forming multipolymer systems. Equipment design and operating conditions Fibre Technology : Textile processing, fibre spinning and after treatment. Equipment design and operating conditions Elastomer Technology : Vulcanisation, Reinforcement compounding Equipment- design & operating conditions, environmental impact Recycle of polymers : Reprocessing techniques and limitations Selection of polymers : domestic & engineering usage Rheological and mechanical measurements concept of solution viscosity				
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Introduction to Polymer Engineering</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Introduction to Polymers : Classification based on application and history, Natural and synthetic polymers and types e.g. fibres, rubbers, adhesives, resins, plastics, etc.
Classification based on properties/structures : Thermoplastic, thermosetting, crystalline, amorphous, molecular weights status, transitions, glass transition temperature
Polymer formation/modification : Functionality and reactions, chain, ionic, condensation, co-ordination, complex polymerisation, Kinetic schemes, Orders of reactions, Cross-linking, Co-polymerisation, Heat effects
Polymerisation Processes and methods of manufacture : Bulk, Solution, Suspension and emulsion polymerisation with examples, polystyrene, polyethylene/propylene, styrene-Butadiene, poly urethane, Epoxy, PET, Kinetics, reaction rates, diffusional limitations, Biodegradable polymers</td><td></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Advanced Separation Processes</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Membrane Processes : Principles of various membrane processes like Reverse Osmosis, pervaporation, gas separation and electro dialysis. Design equations and module design. Concentration polarization.
Adsorption and Ion Exchange Processes : Adsorption and ion exchange equilibria. Various isotherms. Contact filtration, design of fixed bed adsorber including breakthrough cuurve.
Chromatographic Separations : Principles of chromatographic separation, criteria for effective separation, supports and methodology and process design.
Separation of Racemic Mixtures : Principles of racemic modification and their application in separation of racemic mixtures with specific examples.
Dissocaition Extraction, Reactive Extraction</td><td></td></tr>
<tr><td colspan="6">List of Textbooks / Reference Books</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td>Course Title: Downstream Processing in Biochemical Industry</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td>Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Prerequisite Courses</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="5">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="4">Separation processes in biochemical industry, Separation processes for bulk chemicals and proteins, special needs, Unit operations on biochemical industry, such as filtration, centrifugation, heat and mass transfer , Solvent extraction: liquid liquid extractions, phase diagrams, thermodynamics of liquid liquid extraction, physical vs reactive extraction, liquid ion exchangers, design of extractors, two phase flow in extractors, modelling and simulation of extractors, Aqueous two phase extraction, affinity partitioning, dye ligand partitioning, Reverse micellar extraction of proteins and enzymes, Adsorption: physical and chemical adsorption, theories of adsorption, ion exchange resins and polymeric adsorbents, adsorption of small molecular weight bioproducts such primary and secondary metabolic products of cells, Protein purifications, precipitation, affinity precipitation, adsorptive and chromatographic separations of proteins, design of adsorption columns, Methods of operation., Gel permeation chromatography, metal ligand chromatography, dye ligand chromatography, affinity chromatography, expanded bed chromatography,
Applications in biochemical industry</td><td></td></tr>
<tr><td colspan="6">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="5">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Advanced Biochemical Engineering</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Biotechnology, Biochemistry and microbiology, Enzymatic reactions, cell culturing
Enzyme engineering, enzyme modifications, stability, reactivity and selectivity considerations
Genetics and Genetic engineering, DNA recombinant technology, Hybridoma technology, single cell proteins, gene manufacturing
Fermentation and design of fermenters with modified organisms
Bioprocess simulations, molecular modelling for protein synthesis and drug design, protein engineering
Applications in fermentation industry, pharmaceutical industry, medical field such as gene therapy, Biomedical engineering
Bioreactor design, Scale up of bioreactions/reactors, Downstream processing in biochemical industry
Organic synthesis using enzymes</td><td></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Adsorptive Separations</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Separation Processes: overview, alternative separation techniques, Mass separating agents
Adsorbents: Molecular sieves activate carbon,zeolites alumina, silica ion exchangers, Polymeric adsorbents
Physical and Reactive adsorption: Selectivity engineering in catalysis, Gaseous and liquid adsorption, Thermodynamics of adsorption, Statistical thermodynamics of adsorption phenomena, Surface excess, theories of adsorption. Separations: Bulk separation, purifications, Concentration and recovery from dilute solutions: metals, organic chemicals, microelectronics
Design of adsorbers: Gaseous and liquid phase adsorption
Theoretical analysis of diffusion in relation to adsorption in micropores
Chromatographic separations: Bulk chemicals separations, Purification, refining operations, Biochemical applications
Novel separation techniques using adsorbents, Industrial examples</td><td></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

Elective	**Course Code:** CETXXXXE	**Course Title:** Interfacial Science and Engineering	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			**Reqd Hours**		
	Definitions: Chemical and physical properties of interfaces, Introduction to surface mechanisms and thermodynamics, capillarity, meniscus shapes, contact angle, surface tension and its measurement, Laplace Equation, Young's equation, Kelvin Equation, Gibbs equation, equilibrium criteria, dividing surface, monolayers and films, mobile and fixed interfaces Interfacial areas and degrees of wetting, aerosols, liquid liquid and particulate dispersions, Bubbles,and drops aphrons. Microphases: Definitions and dynamics, Micelle formation surfactants CMC, structures of micelles,swollen micelle and microemulsions models, phase diagrams, Macroemulsions, Mechanical vs thermodynamic stability, HLB, Bancroft rule and other systems, Foams Colloids, Film elasticity, drainage, association, Langmuir Blodgets film production. Experimental techniques of measurement of relevant properties: surface tension, solubilization, thermodynamic properties, spectroscopic techniques Rheological aspects of two phase (involving microphases) flow and transport, visco elasticity of surfactant solutions. Solubilization and catalysis by microphases: Models, theories and data, surface potential and equations of state, double layer theory, layer Debye□Huckel theory, Thermodynamics of solubilization, Hydrotropy Emulsification and Demulsification, foam breakage, theories of coalescence, and agglomeration, Brownian motion, shear and other models. Applications: Adsorption, foam fractionation, froth floatation Enhanced oil recovery, Novel separation processes, Coagulation, Flocculation, Microelectronics, surface vapour deposition, other applications with techniques Monte Carlo simulation for molecular dynamics of structures, graphics software for structural display., Diffusion on the surface and in microphases			
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

Elective	**Course Code:** CETXXXXE	**Course Title:** Colloid and Interfacial Science	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			

List of Prerequisite Courses		
List of Courses where this course will be prerequisite		
Description of relevance of this course in the B. Chem. Engg. Program		
Course Contents (Topics and subtopics)		**Reqd Hours**
	Capillarity: Definition, Existence of surface tension/surface free energy, Laplace equation, Young Equation, Capillarity rise phenomena, Measurement of surface tension, Contact angle Wetting characteristics Surface Thermodynamics : Surface thermodynamic properties, Kelvin Eqn. Gibbs eqn, Surface Excess, Monolayer phase Adsorption: Localised vs Mobile adsorption, Adsorption isotherms Langmuir, Freundlich, BET etc., Potential theory, Adsorption from solution, Electrical Diffuse Double layer theory, Debye Huckel theory scaled particle theory, Stern layer, Surfactant adsorption Micelles: Classes of surfactants, synthesis of surfactants, Micelle structures, Determination of HLB, Models for micelle formation, Swollen micelles, Hydrotropy Solubilization in micelles :Location of solubilizate in micelles, Measurement of solubilization, Spectroscopic methods:NMR, Fluorescence, IR etc, Detergency, selective solubilization Emulsions :Micro and macro emulsions, Stability of emulsions (Mechanical vs. thermodynamic), Bancroft rule, deemulsification, HLB for emulsion, multiple emulsions, applications Foams: Gibbs triangle, Film elasticity, drainage of films, Foam, defoaming, applications of foams	
List of Textbooks / Reference Books		
Course Outcomes (students will be able to….)		
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Catalytic Green Science and Technology</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Green synthesis and heterogeneous catalysis, Metal and supported metal catalysis, metal-support interaction, Metal oxides and determination of acidity and basicity, Nature and type of supports , Solid acid catalysis, Solid base catalysis, Catalyst design, preparation and activation, Clay and modified clays, Ion exchange resins, Zeolites and zeotypes , Heteropoly acids, Inorganic-organic catalysts, Immobilised enzymes, zeozymes, complexes, Electrochemical catalysis, Photocatalysis, Microwave catalysis, Ultrasound catalysis, Synergistic catalysis, Important examples from, Refinery industry -FCC, reforming, platforming, hydroforming, polymerisation, alkylation, isomerisation; hydrodesulfurisation, hydronitrogenation, Pharmaceutical and fine chemical industry, Dyestuff and intermediate industries, Perfume and flavour industry, Polymer industry, Textile industry, Paint industry, Edible oil industry, Food industry, Waste water treatment, Catalysis for auto-exhaust pollution abatement, DeNox, DeSOx technologies</td><td></td></tr>
<tr><td colspan="6">List of Textbooks / Reference Books</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Homogeneous Catalysis</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="5">Course Contents (Topics and subtopics)</td><td colspan="2">Reqd Hours</td></tr>
<tr><td></td><td colspan="4">Examples, Single phase and multiphase catalytic reactions, Acid--base catalysis, Transition metal catalysis, Bio-catalysis : Microbes and enzymes, Phase transfer catalysis, Micellar catalysis, Microemulsion catalysis, Electron transfer catalysis, Heteropoly acid catalysis, Homogeneous polymer catalysis, Heterogenisation of homogeneous catalysts, Catalysis by microwaves and ultrasound, Catalyst recovery and reuse</td><td colspan="2"></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="4"></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="4"></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="4"></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="4"></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="4"></td><td colspan="2"></td></tr>
<tr><td colspan="5">Course Outcomes (students will be able to….)</td><td colspan="2"></td></tr>
<tr><td></td><td colspan="4"></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="4"></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="4"></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="4"></td><td colspan="2"></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td>Course Title: Fundamentals of Catalytic Science and Engineering</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td>Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Prerequisite Courses</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="5">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="4">Relevance and examples, Atom economy and green chemistry concepts, Homogenous and heterogeneous catalysis, Fundamentals of homogeneous catalysis and mechanisms and kinetics, Fundamentals of adsorption, isotherms, energetics, structural and dynamic considerations, Mechanisms, models and kinetics of surface reactions, Fractal models, Determination of surface structure though modern methods , Significance of Pore structure and models, Solid and surface chemistry of catalysis, Quantum mechanical, molecular mechanical and hybrid models, Catalyst design through artificial intelligence and computer modelling, Poisoning, promotion, deactivation and selectivity , Catalytic process engineering , Measurement of catalytic rates and kinetic parameters, Types of reactors</td><td></td></tr>
<tr><td colspan="6">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="5">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Flow Though Porous Media</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Relevance of pore structure in science and technology, Examples from oil reservoirs, catalysis, soil science, membranes, aquifers, foods, polymers, biology, etc., Pore structures and their determination, Capillarity and wettability, Models of pore structure, Wettability and flow histories, Single phase flow, Multiphase flow, Percolation processes and network models, Fractal models, Simulations of macroscopic properties, Pore level mechanisms of flow, Diffusion and dispersion in porous media, Membrane transport, Analysis of trickle and packed beds, Ultrafiltration, Models of catalyst poisoning and deactivation, Geostatistics</td><td></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Enhanced Oil Recovery</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Residual oil and tracer studies, Defining enhanced oil recovery, Basic equations for fluid flow in porous media, Petrophysics and petrochemistry, Phase behaviour and fluid properties, Efficiency of waterflooding , Pore level mechanisms, Mobility control , capillary number, bond number correlations, Heterogeneity of pore structure and reservoirs, Thermal methods , Steam stimulation, steam flooding and hot water drive, Combustion- forward and reverse, Ancillaries in thermal methods, Miscible flooding, Surfactant flooding, Microemulsion flooding, Foam flooding, Polymer flooding, Micellar-polymer flooding, Alkaline flooding, Carbon dioxide flooding, Inert gas injection, Reactive gas injection, Microbial recovery</td><td></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Petroleum Reservoir Engineering</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Energy sources, world scenario, oil pricing, Genesis of petroleum and migration, Composition of petroleum and its classification, Petroleum reservoirs, Exploration and drilling technology, Well logging and well completion, Core analysis, Capillarity and wettability, Models of pore structure and multiphase flow , Well stimulation and production strategy, Well pressure behaviour, Gas reservoir engineering, Fluid displacement and frontal displacement; Buckley-Leverett theory, Material balance, Decline curve analysis, Well patterns and displacement efficiencies, Primary recovery, Gravity drainage, Waterflooding , Mechanisms of microscopic and macroscopic flow, Transportation of oil and gas, Production rate, reservoir life, Heavy oil and tar sand technologies, Residual oil determination, Computer modelling of reservoirs, Tertiary recovery methods</td><td></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Mixing</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Examples of industrial importance
Flow pattern, power consumption, classification of impellers, internals
Mechanism of mixing, Blending in viscous and turbulent system, Suspension of solid particles, Heat transfer, Gas-liquid dispersion, Liquid-liquid dispersions, Three phase dispersions, Solid-solid mixing, emulsions, pastes, Mass transfer at gas-liquid, liquid-liquid, solid-solid and solid-liquid interface
Process design and scale-up considerations case studies</td><td></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

Elective	Course Code: CETXXXXE	Course Title: Statistical Methods in Engineering	Credits = 3		
			L	T	P
	Semester:	Total contact hours:			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			Reqd Hours		
	Continuous and discrete probability distributions, normal, chi-square, gamma, Poisson distributions. Applications. t-Tests, F-Test, Homogeneity tests, Quality Control. Acceptance sampling Linear regression and lack of fit Contingency tables.				
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

Elective	**Course Code: CETXXXXE**	**Course Title: Electrochemical Engineering**	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			**Reqd Hours**		
	Introduction to eletrochemical engineering. Theoretical aspects and special features of electrochemical process. Role of mass transfer in a variety of electrochemical processes. Some aspects of electrochemical reactor design. Scale-up and optimization of reactors				
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

Elective	**Course Code: CETXXXXE**	**Course Title: Engineering Aspects of Manufacturers of Organic Chemicals**	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			**Reqd Hours**		
	Special features of process parameters and reactors used for typical organic processes such as hydrogenation, oxidation, alkylation, nitration, sulphonation etc. Different strategies of conducting reactions. Introduction to a few name reactions such as Friedel Crafts reactions, Sandmeyers reaction, Darzens condensation, etc. Typical reaction schemes for the synthesis of medium and low volume chemicals, with an emphasis on the alternative flow sheets of the entire process				
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Industrial Economics</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Nature and Significance of Economics
Demand and supply / elasticity of demand and supply, price determination, demand forecasting
theory of firm : (A) financial aspects : cost analysis, revenue structure, conditions for profit maximisation, different market structures (B) technical aspects : factors of production, role of entrepreneur, laws of return, returns to scale.
Money market and capital market, evolution of money and banking, foreign exchange and currency de-valuation.
Budget, taxation, public expenditure, borrowing and deficit financing
Development issues and economic planning in India, Role of public sector / liberalisation / privatisation / globalization</td><td></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CETXXXXE</td><td colspan="2">Course Title: Advanced Strength of Materials</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Analysis of Trusses - Condition for perfect truss, redundancy, stable, unstable truss. Analysis of truss by method of joints, method of sections.
Torsion of a circular shaft - concept, basic derivation, shear stress distribution, simple problem.
Short and Long columns (Struts) - Basic concept, crippling load, end conditions. Euler's and Rankine's approach (without derivations)
Thick and Thin cylinders - concept of radial, longitudinal stresses, behaviour of thin cylinders. Problems on thin cylindrical and spherical shells. Behaviour of thick cylinders (theory only).
Advance stresses and strains – Representation of stress and strain at a point, Stress stain relationship, plane stress and plane strain. Transformation of stresses and its importance, Principal stresses and strains, maximum shearing stress, Mohr's circle its use and construction.
Basics of Engineering Design - Steps in the engineering design, Importance of analysis, 1-D, 2-D and 3-D analysis and interpretation of results. Design philosophies, factor of safety, Force displacement relationship, Strain deformation relationship, Introduction to finite element packages. Computer aided analysis and design.
Composite Materials – Types of composite materials, fillers for composites, polymer composites, fibres and matrix for a composite material, Types of fibres, their properties, woven and non woven fibres, manufacturing of polymer composite materials. Mechanics of composite materials, Properties and testing of composite materials, Uses of composite materials.
Advance materials for industrial applications - Advances in materials, Materials used for coatings, anticorrosive coatings, special purpose floorings, water proofing compounds, Various polymers and epoxies used for industrial applications. Different types of performance enhancing and special purpose construction chemicals. Plasticizers and super-plasticizers, air entraining agents, accelerators and retarders, viscosity modifying agents, corrosion inhibitors</td><td></td></tr>
<tr><td colspan="6">List of Textbooks / Reference Books</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

Elective	**Course Code: MATXXXXE**	**Course Title: Turbulent Flow and CFD**	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			**Reqd Hours**		
	Derivation of equations of momentum and energy for turbulent flows. Modelling of turbulent flows: kinetic energy, algebraic stress model, Low Reynolds number model, LES model etc. Turbulent boundary layer flows and similar solutions Grid generation Use of Control volume method, Methods of lines, Finite difference, Finite element and various algorithms (SIMPLE, SIMPLER & SIMPLEC etc) to solve the momentum, energy and mass transfer equations for simulation of some practical problems (Simulation of stirred vessel, Natural convection flow inside a closed chamber etc)				
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
MATXXXXE</td><td colspan="2">Course Title: Momentum, Heat and Mass Transfer</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Derivation of equation of momentum, energy, mass transfer in curvilinear coordinate system, constitutive equation (Newtonian & Non Newtonian fluids), Flow in some simple cases - Flow between two concentric cylinders, flow between two concentric rotating cylinders, hydrodynamics of bearings lubrication, steady flow around a sphere (theory of very slow motion).
Singular perturbation theory, derivation of bounder layer equations (using singular perturbation theory), similar and non similar solutions for some forced, mixed and natural convection problems (using bounder layer theory) .
Flow stability, theory of ordinary diffusion in liquids, diffusion with homogenous chemical reaction, diffusion into a falling liquids films (forced convection mass transfer)</td><td></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CHTXXXXE</td><td>Course Title: Theoretical and Computational Chemistry</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td>Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Prerequisite Courses</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="5">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="4">Wave character and wave functions, De Broglie equation, normalization and orthogonalization,
Quantum mechanical operators, Schrodinger equation, particle in an infinite square well potential, quantum mechanical harmonic oscillator, angular momentum operator and rigid rotor, Born Oppenheimer approximation, potential energy surfaces, self consistent field wave functions,
Computauional methods: Molecular mechanics, MO theory, semi empirical and ab initio methods, SCF theory, Hartree Fock method, DFT</td><td></td></tr>
<tr><td colspan="6">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="5">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

Elective	**Course Code: CHTXXXXE**	**Course Title: Green Chemistry and Catalysis**	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			**Reqd Hours**		
	Concept of Green Chemistry: Twelve principles of green chemistry, E factor, Waste management Types of catalysis: Homogeneous and Heterogeneous catalysis. Catalytic cycles Organometallic compounds used as catalysts: Pd, Rh, and Ru in C-C bond formation. Catalytic properties of mononuclear compounds Homogeneous catalysis: Hydrogenation, hydroformylation, hydrocyanation, Hydrosilylation, Wilkinson catalysts, Chiral ligands and chiral induction, Ziegler-Natta catalysts Mercuration and oxymercuration Organopalladium catalysts: Suzuki coupling, Heck coupling and related cross coupling reactions. Alkene oligomerization and metathesis. Catalytic oxidations and reductions: Epoxidation, dihydroxylations. including carbonylation, decarbonylation, olefin isomerization, arylation Important catalytic reactions: Monsanto acetic acid process, Wacker process, Heck reaction				
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

<table>
<tr><td rowspan="2">Elective</td><td>Course Code:
CHTXXXXE</td><td colspan="2">Course Title: Organometallic Chemistry</td><td colspan="3">Credits = 3</td></tr>
<tr><td>Semester:</td><td colspan="2">Total contact hours:</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Prerequisite Courses</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">List of Courses where this course will be prerequisite</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Description of relevance of this course in the B. Chem. Engg. Program</td></tr>
<tr><td colspan="6">Course Contents (Topics and subtopics)</td><td>Reqd Hours</td></tr>
<tr><td></td><td colspan="5">Nature of C-M bond: Metal-carbon bond with main group and transition elements.
Factors controlling metal-carbon bond formation. Methods of M-C bond formation. Nomenclature and heptacity. Electron counting and 16 and 18 electron rules - applications and exceptions. Stability. Stereochemical nonrigidity in organometallic compounds.
Structure and bonding of metal alkyls and aryls. Complexes with CO and related ligands, olefins, acetylenes and related unsaturated molecules. Organic transition metal complexes as protective and stabilizing groups for double bond, triple bond, propyl cation and short lives species. Complexes with cyclopentadiene and arenes and other CnHn sandwich and half-sandwich complexes. Hydride, dinitrogen and dihydrogen complexes
Bimetallic and cluster complexes: Structure and applications in catalysis
Basic organometallic reactions: Ligand substitution, oxidative reactions, migratory reactions, migratory insertion, extrusion, oxidative addition, reductive elimination, reductive elimination –mechanism and stereochemistry.
Nucleophilic regents with C-M bond: Li, Mg, Al, Ti and Ce alkyls; Organicuprates, organic zinc reagents
Alkyne complexes: Pauson Khand reaction. The use of stoichiometric transition metal complexes in the synthesis of complexes organic molecules - enantioselective synthesis via organometallic compounds.
Organo silicon compounds, boranes, carboranes and, metallocarboranes, organo platinum complexes, metallocenes
Importance of organometallic compounds in Biological systems</td><td></td></tr>
<tr><td colspan="7">List of Textbooks / Reference Books</td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="6">Course Outcomes (students will be able to….)</td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="7">K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating</td></tr>
</table>

Elective	**Course Code:** CHTXXXXE	**Course Title:** Advanced Spectroscopy	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			**Reqd Hours**		
	UV-VIS spectroscopy - Woodward rules, aromatic and heterocyclic compounds IR spectroscopy: FT technique, group frequencies, vibrational coupling. NIR spectroscopy. New applications Raman spectroscopy: Stokes, anti-Stokes and Releigh scattering, rotational and vibrational transitions. Raman vs IR. NMR spectroscopy: Pulse technique, FID, and FT. Relaxation and saturation phenomena, quadrupole relaxation, isotopomers. H1 NMR: Chemical shifts and factors affecting the same, spin-spin coupling of different systens, different spin systems, coupling constants. Simplification of complex spectra: Double resonance and decoupling, lanthanide shift reagents, INDOR technique. C13 NMR: Basics, doble resonance, 2D NMR: H1-H1- COSY, H1-C13 HETCOR- APT and DEPT, C13-C13 connecticity: INADEQUATE F19 and P31 NMR Through space interactions: NOE and NOESY Solid state NMR and MAS. Mass spectrometry: Basics, EI and CI techniques. Isotopic abundance, fragmentation, rearrengment of ions, Maclaferty rearrangement, retrodiels-alder reaction. Hyphenated techniques: GC-MS, LC-MS, LC-MS-MS, GC-IR, GC-AIS, GC-NMR, LC-NMR ESR spectroscopy: Theory, experimental technique, Hyperfine splitting Mossbaur spectroscopy Structure elucidation using combined stereoscopic methods Emission: Flame photometry, ICP, Ark-Spark spectra, Phosphorescence, XRF				
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					

Elective	**Course Code:** PYTXXXXE	**Course Title:** Statistical Mechanics	**Credits = 3**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			

List of Prerequisite Courses		
List of Courses where this course will be prerequisite		
Description of relevance of this course in the B. Chem. Engg. Program		
Course Contents (Topics and subtopics)		**Reqd Hours**
	Basic Statistical Approach to a System Applicability of the statistical approach to a system, equilibrium and fluctuations, irreversibility and approach to equilibrium, counting of system states – macrostates and microstates, equiprobability postulate, concept of statistical ensemble, number of accessible states of a system, phase space. Ensemble approach to Thermodynamics of Physical Systems Isolated system – microcanonical ensemble, system in contact with a heat reservoir, canonical ensemble, Maxwell-Boltzmann distribution as an example, mean values in a canonical ensemble, partition function for a canonical ensemble, relation to thermodynamics. Generalised Interactions Grand canonical ensemble, systems with variable number of particles, chemical potential, partition function for a grand canonical ensemble, relation to thermodynamic variables. Applications to Multi-phase Systems Stability conditions for a homogeneous system, equilibrium between phases, phase transformations, general relations for a system with several components, general conditions for chemical equilibrium, chemical equilibrium between ideal gases, the equilibrium constants in terms of partition functions.	
List of Textbooks / Reference Books		
Course Outcomes (students will be able to….)		
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Elective	**Course Code: PYTXXXXE**	**Course Title: Molecular Quantum Mechanics**	**Credits =**		
			L	**T**	**P**
	Semester:	**Total contact hours:**			
List of Prerequisite Courses					
List of Courses where this course will be prerequisite					
Description of relevance of this course in the B. Chem. Engg. Program					
Course Contents (Topics and subtopics)			**Reqd Hours**		
	Revision of Basic Concepts Schrodinger equation for the hydrogen atom, solution in terms of radial and angular wavefunctions, significance of quantum numbers, atomic spectra. The quantum harmonic oscillator, eigenvalues and eigenfunctions (no detailed derivation), significance of 'zero-point' energy. Origin of Molecular Spectra Analysis of diatomic molecule as a rigid rotator, rotational and vibrational energy levels of a simple diatomic molecule. Approximation methods in Quantum Mechanics Brief introduction to perturbation theory with simple examples, variational theorem, analysis of helium atom as an example. Molecular Quantum Mechanics Molecular orbital and valence bond theories for diatomic molecules, Born-Oppenheimer approximation, LCAO method in H2+ ion and H2 molecule, valence bond method				
List of Textbooks / Reference Books					
Course Outcomes (students will be able to….)					
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating					