INSTITUTE OF CHEMICAL TECHNOLOGY

Bachelor of Chemical Engineering

(B. Chem. Engg.) Syllabus

(2021 – 2022)

The revised syllabus comes into effect for first year Bachelor of Chemical Engineering students from the academic year, July 2021.

Preamble

The B. Chem. Engg. Course of ICT is highly sought after. The Department has been in existence from inception in 1934. The Syllabus is upgraded and revised from time to time to reflect the current needs and demands of society and technology. The last revision had come into effect from Academic year 2015. As per AICTE mandate, the revision was undertaken in December 2020 and this revised syllabus will come into effect from Academic year 2020-2021. The syllabus has been revised in the framework of Outcome based Education. For each course, course outcomes are defined. The course outcomes are related to program outcomes. The syllabus is consistent with the AICTE model curriculum in terms of weightages of different components: Basic Science, Other Engineering disciplines, Core Engineering, Humanities, Electives, Projects, etc.

A syllabus committee was formed within the Department. The committee sought feedback from the alumni, industrial experts, Academicians from other academic Institutes. This feedback was compiled. Discussions were held with other Departmental faculty from Physics, Chemistry, Mathematics, General Engineering, Management experts, etc. Taking into considerations the feedback and discussions the revision has been made. The revised syllabus proposes alternatives to some of the humanities courses which the students can be taken from MOOCs. A provision is also made for an "Open Elective", which the student can choose from MOOC. The "Open Elective" will be a course which student can take from reputed MOOCs and can be from any discipline, Engineering and Technology, Humanities, Arts, etc. It offers freedom to students to choose a subject of their liking. These changes have been proposed to make the syllabus according to the UGC, AICTE and NEP Guidelines, to give freedom to students, to make the learning more holistic and to encourage students to take subjects from Platforms like Swayam and NPTEL.

INSTITUTE OF CHEMICAL TECHNOLOGY
Degree of Bachelor of Chemical Engineering (B. Chem. Engg.) Syllabus
Syllabus Structure for B. Chemical Engineering Course

Semester – I									
No	**Subjects**	**Credits**	**Hrs/Week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M.S.**	**E. S.**	**Total**
CHT 1131	Organic Chemistry-I	4	3	1	0	20	30	50	100
CHT 1211	Analytical Chemistry	3	2	1	0	10	15	25	50
MAT 1101	Applied Mathematics-I	4	3	1	0	20	30	50	100
PYT 1101	Applied Physics – I	4	3	1	0	20	30	50	100
GEP 1101	Engineering Graphics-I	4	2	0	6	50	---	50	100
PYP 1102	Physics Laboratory	2	0	0	4	25	---	25	50
CHP 1132	Organic Chemistry Laboratory	2	0	0	4	25	---	25	50
	TOTAL:	23	13	4	14				550
SEMESTER – II									
No.	**Subjects**	**Credits**	**Hrs/week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CHT 1231	Organic Chemistry-II	4	3	1	0	20	30	50	100
CHT 1341	Physical Chemistry	3	2	1	0	10	15	25	50
CET 1501	Material & Energy Balance Calculations	4	3	1	0	20	30	50	100
MAT 1102	Applied Mathematics-II	4	3	1	0	20	30	50	100
PYT 1103	Applied Physics – II	3	2	1	0	10	15	25	50
CHP 1342	Physical & Analytical Chemistry Lab.	2	0	0	4	25	---	25	50
HUP 1101	Communication Skills	2	0	0	4	50	---	---	50
	Total	22	13	5	8				500
SEMESTER – III									
No.	**Subjects**	**Credits**	**Hrs /week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET 1301	Chem. Eng. Thermodynamics-I	4	3	1	0	20	30	50	100
CET 1105	Momentum Transfer	4	3	1	0	20	30	50	100
GET 1102	Structural Mechanics	3	2	1	0	10	15	25	50
GET 1109	Electrical Engineering and Electronics	3	2	1	0	10	15	25	50
CET 1502	Industrial & Engineering Chemistry	4	3	1	0	20	30	50	100
GEP 1103	Structural Mechanics Lab.	2	0	0	4	25	---	25	50
GEP 1110	Electrical Engg and Electronics Laboratory	2	0	0	4	25	---	25	50
CEP 1715	Engineering Applications of Computers	2	0	0	4	25	---	25	50
	Total	24	13	5	12				550
SEMESTER – IV									
No.	**Subjects**	**Credits**	**Hrs/week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
GET 1107	Energy Engineering	4	3	1	0	20	30	50	100
BST 1102	Introduction to Biological Sci.	4	3	1	0	20	30	50	100
CET 1401	Chemical Engineering Operations	4	2	2	0	20	30	50	100
CET 1302	Chem. Eng. Thermodynamics-II	4	3	1	0	20	30	50	100
GEP 1108	Engineering Graphics -II	2	0	0	4	25	---	25	50
BSP 1103	Biological Sciences Laboratory	2	0	0	4	25	--	25	50
CEP 1701	Chemical Engineering Laboratory-I	3	0	0	6	50	---	50	100
	Total	23	11	5	14				600

SEMESTER – V									
No.	**Subjects**	**Credits**	**Hrs /week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET 1716	Mathematical Methods in Chem. Engg.	4	3	1	0	20	30	50	100
CET 1102	Heat Transfer	4	2	2	0	20	30	50	100
CET 1201	Chemical Reaction Engineering	4	2	2	0	20	30	50	100
CET 1402	Separation Processes	4	2	2	0	20	30	50	100
CET 1202	Biochemical Engineering	3	2	1	0	10	15	25	50
CEP 1704	Chemical Engineering Laboratory-II	3	0	0	6	50	---	50	100
CEP 1702	Process Simulation Lab – I	2	0	0	4	25	---	25	50
	Total	24	11	8	10				600

SEMESTER – VI									
No.	**Subjects**	**Credits**	**Hrs/week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET 1601	Material Science and Engineering	3	2	1	0	10	15	25	50
CET 1203	Multiphase Reaction Engineering	3	2	1	0	10	15	25	50
CET 1503	Process Safety and Environmental Engg	4	2	2	0	20	30	50	100
CET 1703	Chemical Process Control	4	3	1	0	20	30	50	100
	Institute Elective – I	3	2	1	0	10	15	25	50
CEP 1706	Chem. Eng. Laboratory-III	3	0	0	6	50	---	50	100
CEP 1705	Process Simulation Lab – II	2	0	0	4	25	---	25	50
GEP 1XXX	Equipment Design and Drawing	4	2	0	4	25	---	25	50
	Total	26	13	6	14				550

CEP 1710 Internship

- After the end of the sixth semester examination and before the start of the seventh semester, every student will have to undergo an internship. The Internship would be of 6 credits.
- The internship (preferably Industrial 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 8 - 10 Calendar weeks. This period typically start from 1st May and end before 30th July every year. This means the end semester examination of T. Y. B. Chem. Engg. (Semester VI) should be completed by 25th April every year. The Semester VII (4th Year B. Chem. Engg.) should commence w.e.f. 1st Aug every year. The internship may be completed in one or more organizations as described below.
- The internship could be of the following forms:
  (i) 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.
  (ii) research internship in reputed Institutes (within India or Abroad) like, ICT, IITs, NITs, IISC, NCL, IICT 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.

SEMESTER – VII									
No.	**Subjects**	**Credits**	**Hrs/week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET 1504	Chemical Project Engg. & Economics	3	2	1	0	10	15	25	50
CET 1505	Process Development and Engineering	4	3	1	0	20	30	50	100
HUT 1102	Perspectives of Society, Sci. & Tech.*	3	2	1	0	10	15	25	50
	Institute Elective – II	3	2	1	0	10	15	25	50
CEP 1717	Optimization of Chem. Engg. Systems	4	2	0	4	25	---	25	50
CEP 1708	Project 1: Seminar	2	0	0	4	50	---	---	50
CEP 1709	Project 2: Home Paper – I	2	0	0	4	50	---	---	50
CEP 1710	Internship	6	---	---	---	---	---	---	50
	Total	27	11	4	12				450
SEMESTER – VIII									
No.	**Subjects**	**Credits**	**Hrs /week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
HUT 1114	Principles of Management - I*	3	2	1	0	10	15	25	50
HUT 1115	Principles of Management - II*	3	2	1	0	10	15	25	50
CET 1515	Innovations in Chemical Engineering and Technology	3	2	1	0	10	15	25	50
MAT 1106	Design & Analysis of Experiments	4	2	2	0	10	15	25	50
	Engineering Sciences / Basic Sciences Elective (GET/CHT/PYT/MAT)	3	2	1	0	10	15	25	50
	Open Elective from MOOC – I**	3	2	1	0	10	15	25	50
	Institute Elective – III	3	2	1	0	10	15	25	50
CEP 1711	Project 3: Home Paper – II	3	0	0	6	50	---	100	150
	Total	25	14	8	6				500

*** This courses may be offered in the usual classroom mode or online mode as an NPTEL / Swayam course. The Equivalent NPTEL course will be identified by the Department every year.**

**** Students can choose a subject from reputed online platforms like NPTEL, Coursera, Edx, MIT OpenCourseWare, etc. The course can be from any discipline: Engineering and Technology, Humanities, Arts. The course would need to be pre-approved by the Department every year. The Department may also offer specialized courses taught by experts in an online mode.**

Detailed Contents of Syllabus

Semester – I									
No	**Subjects**	**Credits**	**Hrs/Week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M.S.**	**E. S.**	**Total**
CHT 1131	Organic Chemistry-I	4	3	1	0	20	30	50	100
CHT 1211	Analytical Chemistry	3	2	1	0	10	15	25	50
MAT 1101	Applied Mathematics-I	4	3	1	0	20	30	50	100
PYT 1101	Applied Physics – I	4	3	1	0	20	30	50	100
GEP 1101	Engineering Graphics-I	4	2	0	6	50	---	50	100
PYP 1102	Physics Laboratory	2	0	0	4	25	---	25	50
CHP 1132	Organic Chemistry Laboratory	2	0	0	4	25	---	25	50
	TOTAL:	23	13	4	14				550

	Course Code: CHT 1131	**Course Title: Organic Chemistry 1**	**Credits = 4**		
			L	**T**	**P**
	Semester: I	**Total contact hours: 60**	**3**	**1**	**0**
List of Prerequisite Courses					
	HSC Chemistry				
List of Courses where this course will be prerequisite					
	Organic Chemistry – II, Organic Chemistry Laboratory, Other Chemistry Courses, Material and Energy Balance Calculations, Ind. Eng. Chem.,				
Description of relevance of this course in the B. Chem. Engg. Program					
To train the students with respect to basics of mechanism of organic reactions, stereochemistry, and aliphatic chemistry					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	**Basic introduction to organic chemistry**: Reactive intermediates – carbocations, carbanions, carbon radicals, carbenes; their generation.		04		
2	**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		06		
3	**Stereochemistry:** Importance of stereochemistry in molecules around us. Elements of symmetry, stereochemistry of compounds containing one and two carbon atoms. Stereo descriptors – R, S, E, Z. Enantiomers and Diastereomers. Conformations of cyclic and acyclic system.		10		
4	**Haloalkanes:** General reactions. Mechanisms of nucleophilic substitutions reactions (S_N1 &S_N2) and elimination reactions.		12		
5	**Chemistry of carbonyl compounds**: Concept of acidity in carbonyl compounds. Enolate chemistry of carbonyl compounds. Aldol and related reactions with mechanisms-Aldol reaction, Michael addition, Robinson annulation, Stork enamine reaction.		12		
6	**Aromatic compounds**: Resonance stabilization energy, Huckel's rule, substituent effects. Common names of aromatic compounds.		04		
7	**Aromatic electrophilic substitution**: Activating and deactivating functional groups on aromatic compounds, resonating structures, reactions such as Halogenation, Nitration, Friedel Crafts alkylation and acylation, sulfonation of aromatic compounds		12		
List of Text Books/ Reference Books					
1	Organic Chemistry, J. McMurry, Brooks/Cole				
2	Organic Chemistry, T.W.G. Solomons, C.B. Fryhle, John Wiley and Sons Inc				
3	Organic Chemistry, L.G. Wade Jr, Pearson Education				
4	Stereo Chemistry of Carbon compounds, E.L. Eliel, Mcgraw-Hill				
5	Organic Chemistry, Paula Y. Bruice, Pearson Education				
Course Outcomes (students will be able to…..)					
1	Identify functionalities in organic compounds				
2	Write simple mechanism				
3	Appreciate aliphatic chemistry				
4	Appreciate stereochemistry				

	Course Code: CHT 1211	Course Title: Analytical chemistry	Credits = 3		
			L	T	P
	Semester: I	Total contact hours:45	2	1	0

	List of Prerequisite Courses	
	HSC Chemistry	
	List of Courses where this course will be prerequisite	
	Other Chemistry Courses, Physical and Analytical Chemistry Laboratory	

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

The course introduces the students to key concepts of chemical analysis – sampling, selection of analytical method and data analysis. It presents basic techniques like spectroscopy and chromatography. The students should be able to select an appropriate analytical technique and apply it in accordance with its strengths and limitations.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Introduction to chemical analysis, terminology (technique / method / procedure / protocol), broad classification of analytical techniques, good laboratory practices	03
2	Sampling – basics and procedures, preparation of laboratory samples Criteria for selecting analytical methods – precision, sensitivity, selectivity, and detection limit, Calibration and validation	06
3	Data analysis: errors – systematic and random errors, statistical treatment of experimental results, least square method, correlation coefficients	06
4	**Spectroscopic methods:** general principles, UV-visible spectroscopy, fluorescence spectroscopy	08
5	**Electrochemical methods:** general principles, potentiometry, coulometry, voltammetry	08
6	**Chromatographic methods:** general principles, GC, HPLC	08
7	**Applied analysis:** analytical procedures in environmental monitoring, water, soil and air quality, BOD and COD determinations	05

	List of Text Books/ Reference Books	
1	Modern Analytical Chemistry by David Harvey, McGraw-Hill, 1999.	
2	Quantitative Analysis by R. A. Day and A. L. Underwood, Prentice Hall of India, 2001.	
3	Instrumental Methods of Analysis by H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle, Wadsworth Publishing, USA	
4	Fundamentals of Analytical Chemistry by D. A. Skoog, D. M. West, F. James Holler and S. R. Crouch, Cengage Learning, 2014.	
5	Principles of Instrumental Analysis by D. A. Skoog, F. James Holler and S. R. Crouch, Cengage Learning, 2007	

	Course Outcomes (students will be able to…..)	
1	Describe the fundamental concepts related to spectroscopic, electrochemical and chromatographic analysis	
2	Differentiate the analytical methods based on advantages and limitations	
3	Select an optimum technique and measurement conditions for enabling the best selectivity and sensitivity of measurement	
4	Analyze the data to identify any potential sources of errors and plausible ways to minimize the same	

	Course Code: MAT 1101	Course Title: Applied Mathematics I	Credits = 4		
			L	T	P
	Semester: I	Total contact hours: 60	3	1	0
List of Prerequisite Courses					
	HSC Standard Mathematics				
List of Courses where this course will be prerequisite					
	This is a basic Mathematics course. This knowledge will be required in almost all subjects later on				
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	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	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	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	Systems of linear equations, matrices and Gauss elimination, Vectors in IRn, notion of linear independence and dependence. Vector subspaces of IRn, 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		7		
5	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 least methods Diagonalization of matrices and its applications stochastic matrices, Matrix Factorization, Applications such as SVD, PCA etc.		8		
6	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	Power series method of solving ODE's and special functions, Legendre Polynomials Bessel functions and applications		7		
List of Text Books/ Reference Books					
	G. Strang, Linear Algebra and its Applications (4th Edition), Thomson (2006).				
	Howard Anton, Elementary Linear Algebra, Wiley (2016)				
	Arnold J. Insel, Lawrence E. Spence, and Stephen H. Friedberg, Linear Algebra, Pearson				
	E. Kreyszig, Advanced Engineering Mathematics (8th Edition), John Wiley (1999). (Officially prescribed)				
	S. R. K. Iyengar, R. K. Jain, Advanced Engineering Mathematics Narosa.				
	Marsden, J.E., Tromba, Anthony, Weinstein, Alan, Basic Multivariable Calculus.				
Course Outcomes (students will be able to…..)					
1	Students should be able to understand the notion of differentiability and be able to find maxima and minima of functions of one and several variables.				
2	Students should be able to compute surface and volume integrals.				
3	Students should be able to solve systems of linear equations and eigenvalue problems analytically and numerically.				
4	Students should be able to apply concepts of linear algebra in engineering problems.				
5	Students should be able to solve simple first and second order ODE by Analytical methods				
6	Students should be able to solve ordinary differential equations using power series method.				

	Course Code: PYT 1101	Course Title: Applied Physics I	Credits = 4		
			L	T	P
	Semester: I	Total contact hours: 60	3	1	0
	List of Prerequisite Courses				
	XIIth Standard Physics				
	List of Courses where this course will be prerequisite				
	Applied Physics – II, Physics Laboratory, Chemical Engineering Thermodynamics, Momentum and Mass Transfer, Heat Transfer, Material Science and Engineering, Structural Mechanics, etc.				
	Description of relevance of this course in the B. Chem. Engg. Program				
This is a basic physics course. This knowledge will be required in almost all subjects later on. This knowledge is also required for understanding various chemical engineering concepts that will be introduced in courses such as momentum transfer, reaction engineering, separation processes, thermodynamics, heat transfer, etc.					
	Course Contents (Topics and subtopics)		**Reqd. Hours**		
1	**Solid State Physics** Crystal structure of solids: unit cell, space lattices and Bravais lattice, Miller indices, directions and crystallographic planes, Cubic crystals: SSC, BCC, FCC, Hexagonal crystals: HCP, atomic radius, packing fraction, Bragg's law of x-ray diffraction, determination of crystal structure using Bragg spectrometer Semiconductor Physics: Formation of energy bands in solids, concept of Fermi level, classification of solids: conductor, semiconductor and insulator, intrinsic and extrinsic semiconductors, effect of doping, mobility of charge carriers, conductivity, Hall effect.		15		
2	**Fluid Mechanics** Basic concepts of density and pressure in a fluid, ideal and real fluids, Pascal's law, absolute pressure and pressure gauges, basic concepts of surface tension and buoyancy, fluid flow, equation of continuity, Bernoulli's equation, streamlined and turbulent flow, concept of viscosity, Newton's law of viscosity.		10		
3	**Optics and Fibre Optics Diffraction** Introduction to interference and example; concept of diffraction, Fraunhofer and Fresnel diffraction, Fraunhofer diffraction at single slit, double slit, and multiple slits; diffraction grating, characteristics of diffraction grating and its applications. Polarisation: Introduction, polarisation by reflection, polarisation by double refraction, scattering of light, circular and elliptical polarisation, optical activity. Fibre Optics: Introduction, optical fibre as a dielectric wave guide: total internal reflection, numerical aperture and various fibre parameters, losses associated with optical fibres, step and graded index fibres, application of optical fibres.		15		
4	**Lasers** Introduction to interaction of radiation with matter, principles and working of laser: population inversion, pumping, various modes, threshold population inversion, types of laser: solid state, semiconductor, gas; application of lasers.		10		
5	**Ultrasound** Mechanical, electromechanical transducers; propagation of ultrasound, attenuation, velocity of ultrasound and parameters affecting it, measurement of velocity, cavitation, applications of ultrasound.		10		
	List of Text Books/ Reference Books				
	Physics:Vols. I and II – D. Halliday and R. Resnick, Wiley Eastern.				
	Lectures on Physics: Vols. I, II and III – R. P. Feynman, R. B. Leighton and M. Sands, Narosa.				
	Concepts of Modern Physics – A. Beiser, McGraw-Hill.				
	Introduction to Modern Optics – G. R. Fowles , Dover Publications.				
	A Course of Experiments with LASERs – R. S. Sirohi, Wiley Eastern.				
	Optical Fibre Communication – G. Keiser, McGraw-Hill.				
	Optoelectronics – J. Wilson and J. F. B. Hawkes, 2nd ed, Prentice-Hall India.				
	Ultrasonics: Methods and Applications – J. Blitz, Butterworth.				
	Applied Sonochemistry – T. J. Mason and J. P. Lorimer, Wiley VCH.				
	Course Outcomes (students will be able to…..)				
1	Students will be able to state Bragg's Law				
2	Student will be able to apply Bernoulli equation in simple pipe flows				
3	Students will be introduced to the principles of lasers, types of lasers and applications.				
4	Students should be able to calculate resolving power of instruments.				
5	Students should be able to describe principles of optical fibre communication.				

6	Application of acoustic cavitation of Chemical Engineering Processes.	

	Course Code: GEP 1101	Course Title: Engineering Graphics-I	Credits = 4		
			L	T	P
	Semester: I	Total contact hours: 90	2	0	6
List of Prerequisite Courses					
	Basic Geometry				
List of Courses where this course will be prerequisite					
	Engineering Graphics – II, Equipment Design and Drawing-I, Equipment Design and Drawing-II, Home Paper – II, Structural Mechanics,				

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

A student of Chemical Engineering is required to know the various processes and also the equipment used to carry out the processes. Some of the elementary processes like filtration, size reduction, evaporation, condensation, crystallization etc., are very common to all the branches of technology. These and many other processes require machines and equipments. One should be familiar with the design, manufacturing, working, maintenance of such machines and equipments. The subject of "drawing" is a medium through which, one can learn all such matter, because the "drawings" are used to represent objects and processes on the paper. Through the drawings, a lot of accurate information is conveyed which will not be practicable through a spoken word or a written text. Drawing is a language used by engineers and technologists. This course is required in many subjects as well as later on in the professional career.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Orthographic projections	
2	Sectional views	
3	Isometric projections	
4	Missing views (or interpretation of views.)	
5	Projection of solids	
6	Sections of solids	
7	Development of surface	
8	Interpenetration of solids	
List of Text Books/ Reference Books		
	1.Engineering Drawing by N.D.Bhat	
	2. Engineering Drawing by N.H.Dubey	
Course Outcomes (students will be able to…..)		
1	Read Drawing	
2	Can understand different views.	

	Course Code: PYP 1102	Course Title: Physics Laboratory	Credits = 2		
			L	T	P
	Semester: I	Total contact hours: 60	0	0	4
List of Prerequisite Courses					
	Applied Physics - I				
List of Courses where this course will be prerequisite					
	This is a basic physics Laboratory course. This knowledge will be required in almost all subjects later on.				
Description of relevance of this course in the B. Chem. Engg. Program					
This is a basic physics course. Students will be able to learn various concepts by doing experiments on different topics. This knowledge will be required in almost all subjects later on. This knowledge is also required for understanding various chemical engineering concepts that will be introduced in courses such as momentum transfer, reaction engineering, separation processes, thermodynamics, heat transfer, etc.					
	Course Contents (Topics and subtopics)		**Reqd. Hours**		
1	Viscosity				
2	Thermistor				
3	Thermal conductivity				
4	Ultrasonic interferometer				
5	Photoelectric effect				
6	Hall effect				
7	Newton's rings				
8	Dispersive power of prism				
9	Laser diffraction				
10	Resolving power of grating				
List of Text Books/ Reference Books					
	Physics:Vols. I and II – D. Halliday and R. Resnick, Wiley Eastern.				
	Lectures on Physics: Vols. I, II and III – R. P. Feynman, R. B. Leighton and M. Sands, Narosa.				
	Concepts of Modern Physics – A. Beiser, McGraw-Hill.				
	Introduction to Modern Optics – G. R. Fowles , Dover Publications.				
	A Course of Experiments with LASERs – R. S. Sirohi, Wiley Eastern.				
	Optical Fibre Communication – G. Keiser, McGraw-Hill.				
	Optoelectronics – J. Wilson and J. F. B. Hawkes, 2nd ed, Prentice-Hall India.				
	Ultrasonics: Methods and Applications – J. Blitz, Butterworth.				
	Applied Sonochemistry – T. J. Mason and J. P. Lorimer, Wiley VCH.				
Course Outcomes (students will be able to…..)					
1	Students will be able to state various laws which they have studied through experiments				
2	Student will be able to measure transport properties like viscosity, conductivity, etc.				
3	Students will be able to state application of acoustic cavitation				

	Course Code: CHP 1132	Course Title: Organic Chemistry Laboratory	Credits = 2		
			L	T	P
	Semester: I	Total contact hours: 60	0	0	4
List of Prerequisite Courses					
	XIIth Standard Chemistry, Organic Chemistry - I				
List of Courses where this course will be prerequisite					
	Organic Chemistry - II				
Description of relevance of this course in the B. Chem. Engg. Program					
Students should be familiar with common organic compounds, should identify them and should know simple separation methods.					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	Identification of an organic compound through elemental analysis, group detection, physical constants (m.p and b.p) and derivatisation.				
2	Separation and purification of binary mixtures of the type: water soluble-water insoluble, both water soluble, liquid-liquid by distillation, dissociation –extraction ,crystallization, etc				
List of Text Books/ Reference Books					
	Practical Organic Chemistry, by I.L. Finar				
Course Outcomes (students will be able to…..)					
1	Students will be able to list steps for identifying simple organic compounds				
2	Students will be able to list some methods of separation of organic compounds				

SEMESTER – II									
No.	**Subjects**	**Credits**	**Hrs/week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CHT 1231	Organic Chemistry-II	4	3	1	0	20	30	50	100
CHT 1341	Physical Chemistry	3	2	1	0	10	15	25	50
CET 1501	Material & Energy Balance Calculations	4	3	1	0	20	30	50	100
MAT 1102	Applied Mathematics-II	4	3	1	0	20	30	50	100
PYT 1103	Applied Physics – II	3	2	1	0	10	15	25	50
CHP 1342	Physical & Analytical Chemistry Lab.	2	0	0	4	25	---	25	50
HUP 1101	Communication Skills	2	0	0	4	50	---	---	50
	Total	22	13	5	8				500

	Course Code: CHT 1231	**Course Title: Organic Chemistry-II**	**Credits = 4**		
			L	**T**	**P**
	Semester: II	**Total contact hours: 60**	**3**	**1**	**0**
	List of Prerequisite Courses				
	XIIth Standard Chemistry, Organic Chemistry – I, Organic Chemistry Laboratory				
	List of Courses where this course will be prerequisite				
	Other Chemistry Courses, Material and Energy Balance Calculations, Ind. Eng. Chem.,				
	Description of relevance of this course in the B. Chem. Engg. Program				
Students will get introduced to aromatic compounds, heterocyclic chemistry and natural products					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	**Aromatic compounds:** Problems associated with S_NAr reactions and how to overcome. Mechanism for aromatic nucleophilic substitutions.		04		
2	**Haloarenes:** Metallation reaction and reactions of metallo derivatives. Synthesis of haloarenes using S_NAr e.g. Sandmeyer reaction for the synthesis of fluorobenzene on large scale. Substitution reactions of haloarenes including Dow's process for phenol synthesis and effect of electron-withdrawing groups on the substitution		12		
3	**Phenols:** Acidity of phenols. Synthesis from Cumene hydroperoxide. General reactions		06		
4	**Nitro and amino arenes:** General reactions. Basicity of aminoarenes. Diazotization and important reacts of arene diazonium salts. Dyes – Chromophore and auxochrome concent. Azo dyes		08		
5	**Heteroaromatic compounds:** Basic structures and common names, comparison of electronic and structural properties to benzenoid compounds, Reactivity and synthetic routes Pyrrole, Furan, Thiophene, Pyridine.		12		
6	**Spectroscopic techniques for the identification of organic compounds:** Infra-red spectroscopy, Nuclear Magentic Resonance, Mass spectrometry		12		
7	**Chemistry of important natural products:** Terpenes, steroids, carotenoids		06		
	List of Text Books/ Reference Books				
1	Organic Chemistry, J. McMurry, Brooks/Cole				
2	Organic Chemistry, T.W.G. Solomons, C.B. Fryhle, John Wiley and Sons Inc.				
3	Organic Chemistry, L.G. Wade Jr, Pearson Education				
4	Organic Chemistry, Paula Y. Bruice, Pearson Education				
	Course Outcomes (students will be able to…..)				
1	Understand aromaticity and list properties of aromatic compounds				
2	Write simple mechanisms of aromatic reactions				
3	List some of the heterocyclic chemistry and chemistry of natural products				
4	List some properties of heterocyclic compounds and natural products				

	Course Code: CHT 1341	Physical chemistry	Credits = 3		
			L	T	P
	Semester: II	Total contact hours: 45	2	1	0
	List of Prerequisite Courses				
	Xiith Standard Chemistry				
	List of Courses where this course will be prerequisite				
	Chemical Reaction Engineering, Chemical Engg Thermodynamics – I, Chemical Engg Thermodynamics – II, Multiphase Reactor Engg., Env. Engg. and Proc. Safety,				
	Description of relevance of this course in the B. Chem. Engg. Program				
Relevance of reaction rates and parameters affecting the same, concept of interfaces and surfaces and the importance of disperse systems. These concepts are required in many situations which are faced by Chemical Engineers I their professional career					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	**Chemical kinetics –** Introduction, concept of reaction rates and order, experimental methods in kinetic studies, differential and integral methods to formulate rate equations of zero, first and second order		03		
2	**Complex reactions**- parallel, consecutive and reversible reactions, order and molecularity		03		
3	**Kinetics and reaction mechanism**- steady state and rate determining step Mechanism of thermal photochemical chain reactions, polymerization reactions		04		
4	**Surface reactions –** Adsorption, kinetics of surface reactions- Hishelwood and Rideal models of surface reactions		02		
	Theories of reaction rates and temperature effects- collision theory and TST Theory of unimolecular reactions		04		
5	**Kinetics of reactions in solutions-** solvent effects		02		
6	**Fast reactions –** experimental techniques		02		
7	**Surface and interfacial Chemistry –** introduction, surface tension and surface free energy, methods of determining surface and interfacial tensions		02		
8	**Thermodynamics of surfaces –** surface excess, Gibbs adsorption equation, curved surfaces- bubbles, droplets and foams, Kelvin, Young Laplace and Thomson equations, homogeneous nucleation		05		
9	**Liquid- liquid and solid liquid interfaces** – contact angle, wetting and spreading, adhesion and cohesion, contact angle measurements and hysterisis		04		
10	**Surfactants:** Types, adsorption at surfaces and interfaces, surfactant aggregates, factors affecting aggregation phenomena, applications of surfactants and mixed surfactant systems		07		
11	**Disperse systems -** Emulsions microemulsions and foams -. Thermodynamics and stability, HLB values , colloids - preparation, stability, characterization, surface charges and electrical double layer		07		
	List of Text Books/ Reference Books				
1	Introduction to colloid and surface chemistry – D.J.shaw, Butterworth publications				
2	Surfaces interfaces and colloids- Drew Myers- Wiley VCH				
3	Surfactants and interfacial phenomena- Milton J Rosen – Wiley Interscience				
4	Industrial utilization of surfactants principles and applications – M.J. Rosen and M Dahanayake, AOCS Press				
5	Foundations of Colloid science – Robert J Hunter – Oxford university Press				
	Course Outcomes (students will be able to…..)				
1	Understand the importance of interfacial phenomena				
2	Importance and application of surface active agents				
3	Understand the stability and importance of disperse systems				

	Course Code: CET 1501	Course Title: Material and Energy Balance Calculations	Credits = 4		
			L	T	P
	Semester: II	Total contact hours: 60	3	1	0
	List of Prerequisite Courses				
	XIIth Standard Mathematics, Chemistry, Physics, Applied Mathematics – I, Organic Chemistry – I, Applied Physics – I, Analytical Chemistry,				
	List of Courses where this course will be prerequisite				
	This is a basic Chemical Engineering Course. This knowledge will be required in ALL subjects later on.				
	Description of relevance of this course in the B. Chem. Engg. Program				
This is a basic Chemical Engineering course. This knowledge will be required in almost all subjects later on. This subject introduces the various concepts used in Chemical Engineering to the students. The knowledge of this subject is required for in ALL chemical engineering courses such as momentum transfer, reaction engineering, separation processes, thermodynamics, etc. It can be applied in various situations such as process selection, economics, sustainability, environmental impacts						
	Course Contents (Topics and subtopics)		**Reqd. 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 Text Books/ Reference Books				
	Chemical Process Principles, Hougen O.A., Watson K. M.				
	Basic Principles and Calculations in Chemical Engineering, Himmelblau,				
	Stoichiometry, Bhatt B.I. and Vora S.M.				
	Course Outcomes (students will be able to…..)				
1	Students will be able to convert units of simple quantities from one set of units to another set of units				
2	Students will be able to calculate quantities and /or compositions, energy usages, etc. in various processes and process equipment such as reactors, filters, dryers, etc.				

	Course Code: MAT 1102	Course Title: Applied Mathematics II	Credits = 4		
			L	T	P
	Semester: II	Total contact hours: 60	3	1	0

	List of Prerequisite Courses	
	XIIth Standard Mathematics, Applied Mathematics - I	

	List of Courses where this course will be prerequisite	
	This is a basic Mathematics course. This knowledge will be required in almost all subjects later on	

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	**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, Classification of higher order PDEs, Solution of PDEs using separation of variable techniques.	10
3	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 methods	5
4	Numerical methods for solving non-linear algebraic / transcendental etc.: Newton's method, Secant and Regula Falsi	5
5	Interpolation and extrapolation for equal and non-equal spaced data (Newtons Forward, Newtons backward and Lagrange), Numerical integration (trapezoidal rule, Simpson's Rule)	7
6	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	Finite difference methods: Forward difference, Backward difference, and Central differences application of finite difference methods to ODE Boundary value problem and PDE (parabolic, elliptic and hyperbolic)	10

	List of Text Books/ Reference Books	
	Sheldon Ross, A First Course in Probability, Pearson Prentice Hall	
	W.W. Hines, D. C. Montgomery, D.M. Goldsman, Probability and Statistics in Engineering, John-Wiely.	
	Alexander M. Mood, Duane C. Boes, and Franklin A. Graybill, Introduction to the Theory of Statistics, McGraw Hill; 3rd edition (June 1, 1974).	
	An Introduction to Statistics with Python with Applications in the Life Sciences by Thomas Haslwanter, 2016, Springer	
	Learning Statistics with R by Daniel Joseph Navarro, 2015	
	E. Kreyszig , Advanced Engineering Mathematics, 8th Ed., John Wiley (1999).	
	Advanced Engineering Mathematics, S. R. K. Iyengar, R. K. Jain, Narosa	
	Sastry S. S., Introductory Methods of Numerical Analysis, 5th Ed., PHI	
	M. K. Jain, S R K Iyengar and R K Jain, Numerical Methods: For Scientific and Engineering Computation, New Age International Publication	
	Kenneth J Beers Numerical Methods for Chemical Engineering Application Using MATLAB (2007), Cambridge University Press	
	Mark E. Davis, Numerical Methods and Modelling for Chemical Engineers, Dover Publications (2003)	
	Sandip Mazumder, Numerical Methods for Partial Differential Equations (2015), Elsevier	

	Course Outcomes (students will be able to…..)	
1	Students should be able to apply probability distributions in modelling engineering problems.	
2	Students should be able to fit linear and nonlinear regression models to real data.	
3	Students should be able to classify higher of partial differential equation and solve parabolic equation using separation of variables.	
4	Students should be able to solve system of linear algebraic equations.	

5	Students should be able to do numerical integrations of functions.	
6	Students should be able to solve partial differential equations numerically.	

	Course Code: PYT 1103	Course Title: Applied Physics II	Credits = 3		
			L	T	P
	Semester: II	Total contact hours: 45	2	1	0
	List of Prerequisite Courses				
	XIIth Standard Physics, Applied Physics – I, Physics Laboratory,				
	List of Courses where this course will be prerequisite				
	This is a basic physics course. This knowledge will be required in almost all subjects later on				
	Description of relevance of this course in the B. Chem. Engg. Program				
This is a basic physics course. This knowledge will be required in almost all subjects later on. This knowledge is also required for understanding various chemical engineering concepts that will be introduced in courses such as momentum transfer, reaction engineering, separation processes, thermodynamics, heat transfer, etc.					
	Course Contents (Topics and subtopics)		Reqd. Hours		
1	**Quantum Mechanics** Introduction to quantum physics, black body radiation, explanation using the photon concept, photoelectric effect, Compton effect, de Broglie hypothesis, wave-particle duality, Born's interpretation of the wave function, verification of matter waves, uncertainty principle, Schrodinger wave equation, postulates of Quantum Mechanics, particle in box, quantum harmonic oscillator, hydrogen atom (no detailed derivation)		25		
2	**Dielectric and Magnetic Properties of Materials** Introduction to the 'del' operator and vector calculus, revision of the laws of electrostatics, electric current and the continuity equation, revision of the laws of magnetism. Polarisation, permeability and dielectric constant, polar and non-polar dielectrics, internal fields in a solid, Clausius-Mossotti equation, applications of dielectrics. Magnetisation, permeability and susceptibility, classification of magnetic materials, ferromagnetism, magnetic domains and hysteresis, applications.		20		
	List of Text Books/ Reference Books				
	Physics:Vols. I and II – D. Halliday and R. Resnick, Wiley Eastern.				
	Lectures on Physics: Vols. I, II and III – R. P. Feynman, R. B. Leighton and M. Sands, Narosa.				
	Concepts of Modern Physics – A. Beiser, McGraw-Hill.				
	Solid State Physics – A. J. Dekker, 1957, MacMillan India.				
	Perspectives of Modern Physics – A. Beiser, 1969, McGraw-Hill.				
	Course Outcomes (students will be able to…..)				
1	Students will be able to do simple quantum mechanics calculations				
2	Students will be able to define various terms related to properties of materials such as, permeability, polarization, etc.				
3	Students will be able to state some of the basic laws related to quantum mechanics as well as magnetic and dielectric properties of materials				

	Course Code: CHP 1342	Course Title: Physical and Analytical Chemistry Laboratory	Credits = 2		
			L	T	P
	Semester: II	Total contact hours: 60	0	0	4
	List of Prerequisite Courses				
	XIIth Standard Chemistry Courses, Physical Chemistry, Analytical Chemistry				
	List of Courses where this course will be prerequisite				
	This is a basic physical and analytical chemistry laboratory course. The knowledge gained here will be required in many subsequent courses				
	Description of relevance of this course in the B. Chem. Engg. Program				
Students will become familiar with laboratory experimental skills, plan and interpretation of experimental tasks, understand the relevance of principles of physical and analytical chemistry in chemical processes					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
	(8 to 10 experiments will be conducted from following list) 1. To determine the total hardness of given water sample 2. To determine the dissociation constants of a polybasic acid using pH meter 3. To determine pKa of the given weak acid by potentiometric titration 4. To determine the critical micelle concentration (CMC) of the given surfactant by surface tension measurement using a stalagmometer 5. To determine the normality and volume of weak acid and strong acid in the given mixture using conductometric titration 6. To determine the rate constant of hydrolysis of an ester catalyzed by an acid 7. To study the kinetics of the reaction between $K_2S_2O_8$ and KI and hence, determine rate of the reaction 8. To verify Beer – Lambert's Law 9. To determine the equivalent conductance of strong electrolyte at infinite dilution and verify Ostwald's law of dilution, for dissociation of weak electrolyte 10. To determine the molecular weight of the given polymer by viscosity measurements 11. To determine the vitamin C concentration from the given tablet sample by titration 12. Demo of Gas chromatography and FT-IR				
	List of Text Books/ Reference Books				
	Practical physical Chemistry – B.Viswanthan and P.S. Raghavan				
	Practical physical Chemistry- Alexander Findlay				
	Course Outcomes (students will be able to…..)				
1	Identify reaction rate parameters				
2	List simple methods of chemical analysis				
3	Determination of physic chemical parameters using simple laboratory tools				

	Course Code: HUP 1101	Course Title: Communication Skills	Credits = 2		
			L	T	P
	Semester: II	Total contact hours: 60	0	0	4
List of Prerequisite Courses					
	XIIth Standard English				
List of Courses where this course will be prerequisite					
	All				
Description of relevance of this course in the B. Chem. Engg. Program					
This is an important course for the effective functioning of an Engineer. Communication skills are required in all courses					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	Development of communication skills in oral as well as writing.				
2	The writing skills should emphasize technical report writing, scientific paper writing, letter drafting, etc.				
3	The oral communication skills should emphasize presentation skills.				
4	Use of audio-visual facilities like powerpoint, LCD. for making effective oral presentation.				
5	Group Discussions				
List of Text Books/ Reference Books					
	Elements of style – Strunk and white				
Course Outcomes (students will be able to…..)					
1	Students should be able to write grammar error free technical reports in MS Words or equivalent software.				
2	Students should be able to make power point slides in MS PowerPoint or equivalent software.				

SEMESTER – III									
No.	**Subjects**	**Credits**	**Hrs /week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET 1301	Chem. Eng. Thermodynamics-I	4	3	1	0	20	30	50	100
CET 1105	Momentum Transfer	4	3	1	0	20	30	50	100
GET 1102	Structural Mechanics	3	2	1	0	10	15	25	50
GET 1109	Electrical Engineering and Electronics	3	2	1	0	10	15	25	50
CET 1502	Industrial & Engineering Chemistry	4	3	1	0	20	30	50	100
GEP 1103	Structural Mechanics Lab.	2	0	0	4	25	---	25	50
GEP 1110	Electrical Engg and Electronics Laboratory	2	0	0	4	25	---	25	50
CEP 1715	Engineering Applications of Computers	2	0	0	4	25	---	25	50
	Total	24	13	5	12				550

	Course Code: CET 1301	**Course Title:** Chemical Engineering Thermodynamics-I	**Credits = 4**		
			L	**T**	**P**
	Semester: III	**Total contact hours: 60**	**3**	**1**	**0**
	List of Prerequisite Courses				
	XIIth Standard Physics and Chemistry, Applied Mathematics – I, Applied Mathematics – II, Physical Chemistry,				
	List of Courses where this course will be prerequisite				
	This is a basic Chemical Engineering course. It is required in all the Chemical Engineering Courses, such as, Chemical Engineering Thermodynamics – II, Chemical Engineering Operations, Separation Processes, Home Paper – I and II, Seminar, etc.				
	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)		**Reqd. hours**		
1	Concept of Equilibrium: Entropy and Gibbs-Free Energy		4		
2	First Law of Thermodynamics (Open and Closed Systems) and Equations of Change (dU, dH, dA, dG)		4		
3	Residual Properties. Concept of fugacity and fugacity coefficient.		4		
4	P-V-T Correlations, Virial Equation of State, Two and Three Parameter Cubic Equations of State		6		
5	First Order Phase Transition (Clausius Clapeyron Equation)		2		
6	Maxwell's Relations		2		
7	Properties of Real Fluids		4		
8	Introduction to Thermal Exergy and Expansions (Isentropic (Joule-Thomson Cooling) and Isenthalpic)		6		
9	Thermodynamics of Ideal Mixtures and concept of Activity		2		
10	Concept of Partial Molar Properties		2		
11	Equilibrium in Mixtures (and the Raoult's Law Simplification)		2		
12	Calculation of Bubble and Dew Points and T-x-y and P-x-y diagrams for ideal mixtures		4		
13	Isothermal and Adiabatic Flash Calculations		4		
14	Gibbs Duhem Equation and Thermodynamic Consistency		6		
15	Non-Ideal Mixtures and Concept of Excess Properties		4		
16	Equilibrium Measurement and Consistency of Experimental Data		4		
	List of Text Books/ Reference Books				
	Introduction to Chemical Engineering Thermodynamics: Smith, van Ness, Abbott				
	Chemical, Biochemical and Engineering Thermodynamics: S. I. Sandler				
	Phase Equilibria in Chemical Engineering: Walas				
	Molecular Thermodynamics of Fluid Phase Equilibria: Prausnitz				
	Reference Books:				
	Properties of Gases and Liquids: Reid, Prausnitz, Pauling				
	Course Outcomes (students will be able to…..)				
1	Calculate enthalpies, entropies and free energies of real gases from (a) equations of state (b) measured quantities				

2	Calculate saturation pressure and latent heats of vapourization from cubic equations of state.	
3	Calculate bubble and dew points of ideal mixtures and construct T-x-y and P-x-y diagrams	
4	Be able to correlate experimental VLE data of pure component and ideal mixtures with suitable equations.	
5.	Do an adiabatic and isothermal flash calculation	
6.	Do a preliminary exergy analysis of non-reacting systems of ideal mixtures.	

	Course Code: CET 1105	Course Title: Momentum Transfer	Credits = 4		
			L	T	P
	Semester: III	Total contact hours: 60	3	1	0
	List of Prerequisite Courses				
	XIIth Standard Physics and Mathematics, Applied Physics – I and II, Applied Mathematics – I and II				
	List of Courses where this course will be prerequisite				
	This is a basic course required in many subjects such as: Heat Transfer, Chemical Engineering Operations, Separation Processes, Chemical Reaction Engineering, Multiphase Reactor Engineering, Env. Eng. And Process Safety, Seminar, Home Paper I and II, Energy Engineering, etc.				
	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)		**Reqd. 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		8		
3	Fluid moving machinery such as pumps, blowers, compressors, vacuum systems, etc.		8		
4	Particle Dynamics, Boundary layer separation: skin and form drag, Flow through Fixed and Fluidised Beds,		6		
5	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.				
6	Boundary Layer Flows: Blasius equations and solution, Von-Karman integral equations and solutions,		8		
7	Introduction to turbulence: Turbulent pipe flow, basis of Universal velocity profile and its use		6		
8	Similarities in Momentum, Heat and Mass Transfer		8		
	List of Text Books/ Reference Books				
	Transport Phenomena, Bird R.B., Stewart W.E., Lightfoot E.N.				
	Fluid Mechanics, Kundu Pijush K.				
	Fluid Mechanics, F. W. White				
	Unit Operations of Chemical Engineering, McCabe, Smith				
	Course Outcomes (students will be able to…..)				
1	Calculate velocity profiles, forces, pressure drops for simple 1 –D laminar flow situations				
2	Calculate pressure drop in pipelines and equipment for different situations such as single and two phase flow, fixed and fluidized beds				
3	Calculate forces on particles and terminal velocities of particles				
4	Design pumps and piping systems for simple situations				
5	Apply Momentum, Heat and mass transfer concepts to simple situations				

	Course Code: GET 1102	Course Title: Structural Mechanics	Credits = 3		
			L	T	P
	Semester: III	Total contact hours: 45	2	1	0

	List of Prerequisite Courses	
	XIIth Standard Physics and Mathematics, Applied Mathematics-I and II, Applied Physics-I	
	List of Courses where this course will be prerequisite	
	Equipment Design and Drawing I and II, Home Paper, Chemical Project Engineering and Economics	

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

This subject will help students to understand use of basics of Applied Mechanics and Strength of Materials. In engineering equipments which different types of forces are to be considered and how to quantify them. What are different conditions of equilibrium and how to apply them analyse the problems. Importance of centre of gravity and moment of Inertia in Engineering Design. Study of different types of stresses and strains occurring in various components of the structure. Advantages and disadvantages of various geometric sections available for engineering design. This is the foundation course for a good Design Engineer.

	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.	6
3	Concept of 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.	5
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.	7
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.	5
6	Theory of Bending - Assumptions in derivation of basic equation, Basic equation, section modulus, bending stress distribution. Advantages of various geometric sections from bending consideration.	4
7	Problems on shear stress - Concept, Derivation of basic formula. Shear stress distribution for standard shapes. Problems of Shear stress distribution. Conditions under which shear stress is the governing criteria of design.	5
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.	5
9	Introduction to computer aided analysis and design. Representation of stresses and strains on a cubical element. 1-D, 2-D and 3-D analysis and its importance. Basics of formulation of any computer aided analysis program. Preprocessing and post processing of computer aided analysis data and information.	4

	List of Text Books/ Reference Books
	Engineering Mechanics Vol I Statics by B. N. Thadani, Publisher Wenall Book Corporation
	Introduction to Mechanics of Solids by Egor Popov, Prentice Hall of India Pvt. Ltd
	Mechanics of Materials by Ferdinand Beer and E. Russel Johnston, Tata McGraw Hill
	Fundamentals of applied Mechanics by Dadhe, Jamdar and Walavalkar, Sarita Prakashan Pune
	Engineering Mechanics by S. Timoshenko and D. H. Young, McGraw Hill Publications
	Strength of Materials by Ferdinand Singer and Andrew Pytel, Harper Colins Publishers

	Course Outcomes (students will be able to…..)	
1	Understand the use of basic concepts of Resolution and composition of forces.	
2	Analysis of the beams, truss or any engineering component by applying conditions of equilibrium.	
3	List advantages and disadvantages of various geometric sections used in engineering design.	
4	Understand the different stresses and strains occurring in components of structure	
5	Calculate the deformations such as axial, normal deflections under different loading conditions	

	Course Code: GET 1109	Course Title: Electrical Engineering and Electronics	Credits = 3		
			L	T	P
	Semester: III	Total contact hours: 45	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	
	Chemical Process Control, Energy Engineering,	

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,	5
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	4
4	**Single phase transformers**: Principle of working, Efficiency, regulation.	5
5	**Electrical drives**: Basic concepts of different types of Electrical motors as drives, Their suitability for various applications.	4
6	**Regulated power supplies**, Diodes as rectifiers, Half wave and Full wave rectifier, Filters and Regulators	6
7	**Bipolar junction transistors**: Different configurations, Characteristics, Concept of basic amplifier circuits, Amplifier gain, Transistor as switch	6
8	**Introduction to data acquisition and signal conditioning,** Basic concept and Block diagram, Introduction to sensors and transducers, Sensors used in chemical industry such as Temperature, Pressure, level, flow sensors, Concept of Smart Sensors, Concept of conversion of physical quantity to electrical signal, signal conditioning, Introduction to A/D and D/A converters	6
9	**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, comparator and filter circuits	5

	List of Text Books/ Reference Books	
1	Electrical Engineering Fundamentals by Vincent Deltoro	
2	Electronic devices and circuits by Boylstead, Nashelsky	
3	Electrical Machines by Nagrath, Kothari	
4	Electrical Machines by P.S. Bhimbra	
5	Electrical Technology by B.L.Theraja, A.K.Theraja vol I,II,IV	
6	Thyristors and their applications by M.Ramamurthy	
7	Power Electronics by P.S. Bhimbra	

	Course Outcomes (students will be able to…..)	
1	Understand the basic concepts of D.C., single phase and three phase AC supply and circuits Solve basic electrical circuit problems	
2	Understand the basic concepts of transformers and motors used as various industrial drives.	
3	Understand the basic concepts of electronic devices and their applications in power supplies, amplification and instrumentation	
4	Understand the basic concepts of Data acquisition, signal conditioning	

	Course Code: CET 1502	Course Title: Industrial & Engineering Chemistry	Credits = 4		
			L	T	P
	Semester: III	Contact hours: 60	3	1	0
List of Prerequisite Courses					
1	XIIth Standard Chemistry and Physics, Organic Chemistry I & II, Material & Energy Balance Calculations, Physical Chemistry				
List of Courses where this course will be prerequisite					
	Chemical Reaction Engineering, Multiphase Reactor Engineering, Process Development and Engineering, Env. Engg. and Proc. Safety, Home Paper I and II, Seminar, etc.				
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.					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	Overview of Indian chemical industry, raw material and energy sources, role of catalysis, inorganic products, organic intermediates and final products		5		
2	Petroleum refining and cracking operations		5		
3	Industrial processes for ammonia, syngas and hydrogen, methanol, chemicals from oxo-synthesis		4		
4	Organic chemicals based on methanol and ethanol (e.g., formaldehyde, acetaldehyde, acetic acid)		4		
5	Petrochemicals: e.g., ethylene oxide, α-olefins, vinyl acetate, phenol, aniline, LAB, phthalic anhydride, PTA		10		
6	Polymers (e.g., polyethylene / polypropylene)		2		
7	Manufacturing of inorganic acids (sulfuric and nitric acid)		4		
8	Chlor-alkali industry (chlorine, caustic soda, soda ash)		6		
9	Fertilizers (urea and phosphates)		2		
10	Industrial processes using bio-catalysts		2		
11	Production of industrial gases		2		
12	Classification, sampling, analysis, and selection of coal		3		
13	Carbonization		2		
14	Hydrogenation		2		
15	Complete gasification of coal		3		
16	Fuel oil specifications		1		
17	Combustion of solid, liquid, and gaseous fuels		3		
List of Text Books/ Reference Books					
1	Encyclopedia of Chemical Technology, Kirk-Othmer				
2	Ulmann's Encyclopedia of Industrial Chemistry				
3	Industrial Organic Chemistry, Weissermel & Arpe				
4	Chemical Process Industries, Shreve B. Austin				
5	Chemical Process Technology, Moulijn, M. and van Dippen				
6	Dryden's Outlines of Chemical Technology				
7	Elements of Fuels, Furnaces and Refractories, O.P. Gupta				
8	Fuels handbook, Johnson				
Course Outcomes (students will be able to…..)					
1	Draw process flow diagrams/process block diagrams for the manufacture of various chemicals from process description				
2	List out various alternatives for carrying out a particular process and provide recommendations for the best choice				
3	List coal utilization technologies and advantages of clean coal technology				
4	List Principles of combustion systems for solid, liquid and gaseous fuel				

	Course Code: GEP 1103	Course Title: Structural Mechanics Laboratory	Credits = 2		
			L	T	P
	Semester: III	Total contact hours:60	0	0	4
	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 use of basics of Applied Mechanics and Strength of Materials. In engineering equipments which different types of forces are to be considered and how to quantify them. What are different conditions of equilibrium and how to apply them analyse the problems. Importance of centre of gravity and moment of Inertia in Engineering Design. Study of different types of stresses and strains occurring in various components of the structure. Advantages and disadvantages of various geometric sections available for engineering design. 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 To determine Law of Machine for (Screw Jack / Single Purchase Crab, Double Purchase Crab, Differential wheel and axle). To verify forces in single roof truss element. To verify bending moment at various sections for Cantilever beam, Simply supported beam. To verify reactions at the supports for simply supported and beam with overhang. To verify basic Laws of concurrent co-planer forces. To study the deflected shape of link and B.M. in equivalent simply supported beam. To study graphical methods of analysis of forces. To study the Universal testing machine and tests. To study the torsion test and impact test. Non-destructive testing: Smith Hammer test, Ultrasonic pulse velocity test To study the carbonation of concrete To study corrosion of re-inforcement. To study properties of cement composites using various admixtures and additives To study water and chloride penetration in cement composites				
	List of Text Books/ Reference Books				
	Engineering Mechanics Vol I Statics by B. N. Thadani, Publisher Wenall Book Corporation				
	Introduction to Mechanics of Solids by Egor Popov, Prentice Hall of India Pvt. Ltd				
	Mechanics of Materials by Ferdinand Beer and E. Russel Johnston, Tata McGraw Hill				
	Fundamentals of applied Mechanics by Dadne, Jamdar and Walavalkar, Sarita Prakashan Pune				
	Engineering Mechanics by S. Timoshenko and D. H. Young, McGraw Hill Publications				
	Strength of Materials by Ferdinand Singer and Andrew Pytel, Harper Colins Publishers				
	Course Outcomes (students will be able to…..)				
	Further understanding of the concepts in the Theory course of Structural Mechanics				

	Course Code: GEP 1110	Course Title: Electrical Engg and Electronics Laboratory	Credits = 2		
			L	T	P
	Semester: III	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					
	Chemical Process Control				
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: **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				
List of Text Books/ Reference Books					
	Electrical Engineering Fundamentals by Vincent Deltoro				
	Electronic devices and circuits by Boylstead, Nashelsky				
	Electrical Machines by Nagrath, Kothari				
	Electrical Machines by P.S. Bhimbra				
	Electrical Technology by B.L.Theraja, A.K.Theraja vol I,II,IV				
	Thyristors and their applications by M.Ramamurthy				
	Power Electronics by P.S. Bhimbra				
Course Outcomes (students will be able to…..)					
1	Understand the basic concepts of D.C., single phase and three phase AC supply and circuits Solve basic electrical circuit problems				
2	Understand the basic concepts of transformers and motors used as various industrial drives.				
3	Understand the basic concepts of electronic devices and their applications in power supplies, amplification and instrumentation				
4	Understand the basic concepts of Data acquisition, signal conditioning				

	Course Code: CEP 1715 MAT	Course Title: Engineering Applications of Computers	Credits = 2		
			L	T	P
	Semester: III	Total contact hours: 60			4

	List of Prerequisite Courses	
1	XIIth Standard Mathematics and Physics Courses, Applied Mathematics – I and II, Material & Energy Balance Calculations	

	List of Courses where this course will be prerequisite	
1	Process Simulation Lab – I and II, Home Paper I and II	

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

As an engineer, students have to prepare technical reports and give presentations in their professional career and software tools such as word processing, spreadsheet calculations, powerpoint presentations and programming languages such as C/C++ etc help to achieve these objectives.

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.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Introduction to Computer Hardware, Architecture, Networking, Operating systems	4
2	Word processing: Fonts, colors, header, footers, page numbers, alignment, page layouts, tables, creating technical reports, references, track changes	4
3	Spreadsheet calculations: Use of cells, formulas, table calculations, graphs, matrix operations, goal seek, solver, curve fitting, regression	12
4	Power-point presentations: slide design. layout, animations, presentation project	6
5	C/C++ programming: basics, arrays, loops, if-else, switch case, functions, pointers, classes	14
6	solving 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)	12
7	Solving set of linear equations (material balance of distillation column, multiple extraction unit etc)	8

	List of Text Books/ Reference Books	
1	Kanetkar Y. "Let us C", Fifth Edition	
2	Microsoft Office help	

	Course Outcomes (students will be able to…..)	
1	Operate various operating systems such as (windows, linux)	
2	Prepare a technical report	
3	Prepare a technical / professional presentation	
4	Spreadsheet calculations for chemical engineering problems	
5	Develop programming logic and code it in software	

SEMESTER – IV									
No.	**Subjects**	**Credits**	**Hrs/week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
GET 1107	Energy Engineering	4	3	1	0	20	30	50	100
BST 1102	Introduction to Biological Sciences	4	3	1	0	20	30	50	100
CET 1401	Chemical Engineering Operations	4	2	2	0	20	30	50	100
CET 1302	Chem. Eng. Thermodynamics-II	4	3	1	0	20	30	50	100
GEP 1108	Engineering Graphics -II	2	0	0	4	25	---	25	50
BSP 1103	Biological Sciences Laboratory	2	0	0	4	25	---	25	50
CEP 1701	Chemical Engineering Laboratory-I	3	0	0	6	50	---	50	100
	Total	24	13	6	10				600

	Course Code: GET 1107	**Course Title: Energy Engineering**	**Credits = 4**		
			L	**T**	**P**
	Semester: IV	**Total contact hours: 60**	**3**	**1**	**0**
List of Prerequisite Courses					
	Chemical Engineering Thermodynamics-I, Material and Energy Balance Calculations, Applied Physics I and II, Applied Mathematics – I and II				
List of Courses where this course will be prerequisite					
	Process Dev. and Engg., Home Paper I and II, Env. Eng. And Proc. Safety, Chem. Proj. Engg and Eco.,				
Description of relevance of this course in the B. Chem. Engg. Program					
Students will be able to understand various equipments like steam turbine, gas turbine, pumps, compressors and power transmission system.					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1.	Properties of steam, T-S Diagram, Calculation of entropy, enthalpy, specific volume of steam, steam table, Dryness fraction,		4		
2.	Introduction to Steam Power Plant, Rankine cycle, Reheat cycle, Regenerative cycle, Back Pressure Turbine,		6		
3.	Steam Turbine, Classification, Calculation of Power Developed by Steam Turbine, Compounding of Steam Turbine		6		
4.	Boilers, Classification, Study of various Boilers such as Babcock & Wilcox Boiler, Cochran Boiler, La-Mount Boiler, Benson Boiler, Boiler Mountings and Accessories, Boiler Performance, Measurement of Steam Quality		6		
5.	Steam Nozzles, Different types of Steam Nozzles, Variation of area, velocity and specific volume		2		
6.	Elements of Steam condenser, various types of steam condenser, Condenser Efficiency		4		
7.	Compressors, Classification of Compressors, Reciprocating Compressors, Single stage compressor and multistage compressor, P-V diagram, Application of Compressors		3		
8.	Rotary Compressors, Fan, Blower & Compressors, Centrifugal and Axial compressors, Calculation of work done by Centrifugal Blower,		4		
9.	Pumps, Classification of Pumps, Reciprocating Pumps, Centrifugal Pumps, Axial Pumps, Gear Pumps, Maintenance of Pumps		3		
10	Refrigeration : COP of refrigerator and heat pumps ,classification of refrigerants , Nomenclature , properties desired by refrigerants . Vapour compression refrigeration cycle . Methods of increasing COP of VCRS . Vapour absorption refrigeration systems .		6		
11	Internal combustion engines : Thermodynamic cycles such as otto ,diesel and dual cycles. Methods of increasing thermal efficiency and performance of internal combustion engines		4		
12	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 .		4		
13	Renewable energy : Role and importance of non conventional and alternate energy sources such as solar , wind , ocean ,bio-mass and geothermal .		4		
14	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 .		4		
List of Text Books/ Reference Books					
	1. Thermodynamics by P.K. Nag 2. Power plant by Morse				

	3. Heat Engines by P.L. Balani 4. Hydraulic Machines by Jagdish Lal 5. Renewable Energy resources by Tiwari and ghosal ,Narosa publication . 6. Non conventional energy sources , Khanna publications 7. Refrigeration and air conditioning by C.P. Arora 8. Theory of Machines by Rattan .S.S 9. Gas turbine theory by HiH Saravanamutoo.	
Course Outcomes (students will be able to…..)		
1	Discuss the steam formation process and its properties. (K2)	
2	Describe the working of steam boilers, mountings and accessories. (K2)	
3	Explain the working principles of power developing systems such as steam turbines, gas turbines and internal combustion engines. (K2)	
4	Describe the working principle of vapour compression and vapour absorption refrigeration systems. (K2)	
5	Discuss different types of power transmission systems and their typical applications. (K2)	
6	Explain the working principles of power absorbing devices such as pumps and compressors. (K2)	
7	Explain need and importance of various renewable energy sources. (K2)	
8	Employ this knowledge for energy saving in various devices. (K3)	

	Course Code: BST 1102	Course Title: Introduction of Biological Sciences	Credits = 4		
			L	T	P
	Semester: IV	Total contact hours: 60	3	1	0

	List of Prerequisite Courses	
	Xth Standard Biology course, Physical Chemistry	
	List of Courses where this course will be prerequisite	
	Biochemical Engineering, Env. Eng and Proc Safety, Home Paper I and II	

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

The course offers fundamental principles of biochemistry, genetics, molecular biology, and cell biology. Biological function at the molecular level is particularly emphasized and covers the structure and regulation of genes, as well as, the structure and synthesis of proteins, how these molecules are integrated into cells, and how these cells are integrated into multicellular systems and organisms.

The course also offers important contribution to understand chemical reactions present in living organisms. A cell is the smallest self-preserving and self-reproducing unit. Many complex chemical reactions and complex transport processes occur. A cell looks like a chemical plant.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Introduction to cells: Eukaryotes and prokaryotes, Microbial cell Physical, chemical, and evolutionary aspect of life Cell architecture and organelles Cell cytoskeleton and its role Asexual and sexual modes of reproduction: Binary fission, budding, fragmentation, formation of spores, bacterial conjugation, mitosis, and meiosis	12
2	Chemical Components of the cell Chemical bonds and groups, chemical properties of water, weak noncovalent bonds Carbohydrates: Function, Monosaccharides and Disaccharides, Polysaccharides; Glycoconjugates: Proteoglycans, Glycoproteins, and Glycolipids; Working with Carbohydrates Proteins: Function, Peptides and Proteins, Structure of amino acids; Working with Proteins, Three-Dimensional Structure of Proteins Nucleic acids: Function, Structure, chemistry, DNA, RNA and Chromosomes Lipids: Function, Storage Lipids, Structural Lipids in Membranes, Lipids as Signals, Cofactors, and Pigments; Working with Lipids	12
3	General Microbiology: Types and forms of microbes, Different phases of growth, Quantitative measurement of growth, synchronous growth and continuous culture, primary & secondary metabolite production, pure culture, selective methods, maintenance, and preservation, Transport and motility, Cell communication, Intracellular compartments	8
4	Energetics and Metabolism: Enzymes and their controls; Free energy and biological reactions, Redox potentials, Metabolic pathways: Introduction, Glycolysis and citric acid cycle; flux analysis Energy Generation in Mitochondria and Chloroplasts	12
5	Genetics: DNA replication, repair, and recombination; From DNA to Protein: How Cells Read the Genome, Gene expression and regulation: Induction and repression; Lac operon Model	12
6	Introduction to biotechnology, need for biotechnology, current applications of biotechnology (Food, fuel, medical and environmental)	4

	List of Text Books/ Reference Books	
1.	Microbiology, M.J. Pelczar, ECS Chang & N. Kriej ISBN 13:978-0-07-462302-6	
2.	Prescott's Microbiology, Joanne Willey, Linda Sherwood, Christopher J. Woolverton ISBN-10 : 1259281590	
3.	Harpers Illustrated Biochemistry 30th Edition (Harper's Illustrated Biochemistry); by Victor W. Rodwell (Author), David Bender (Author), Kathleen M. Botham (Author), Peter J. Kennelly (Author), P. Anthony Weil (Author)	
4.	Lehninger Principles of Biochemistry, David L. Nelson, Albert L. Lehninger, Michael M. Cox ISBN 071677108X, 9780716771081	

	Course Outcomes (students will be able to…..)	
1	Identify the general structure and function of carbohydrates, lipids, proteins, enzymes, and nucleic	

	acids.	
2	Outline the general processes used by the cell to generate cellular energy from sugar and to generate the energy and reducing agent needed for the citric acid cycle.	
3	Describe how DNA was shown to be the genetic material and how DNA is copied.	
4	Describe the structure and regulation of genes, and the structure and synthesis of proteins.	
5	Predict the results of genetic crosses involving two or more traits when the genes involved are linked or unlinked	
6	Describe how cell divides and mutation takes place	
7	Describe different microorganism and their reproduction cycles	

	Course Code: CET 1401	Course Title: Chemical Engineering Operations	Credits = 4		
			L	T	P
	Semester: IV	Total contact hours:60	2	2	0

List of Prerequisite Courses		
	Material & Energy Balance Calculations, Physical Cheiistry, Organic Chemistry-I and II, Chem. Eng. Thermodynamics-I, Momentum and Mass Transfer	
List of Courses where this course will be prerequisite		
	This is a basic Chem Engg. course. It is required in almost all the courses, such as, Separation Processes, Chemical Engineering Laboratory I, II and III, Process Simulation Lab – I and II, Home Paper I and II, etc.	
Description of relevance of this course in the B. Chem. Engg. Program		
This is a basic Chem Engg. course. The principles learnt in this course are required in almost all the courses and throughout the professional career of Chemical Engineer		
	Course Contents (Topics and subtopics)	**Reqd. 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 Text Books/ Reference Books	
1	Richardson, J.F., Coulson, J.M., Harker, J.H., Backhurst, J.R., 2002. Chemical engineering: Particle technology and separation processes. Butterworth-Heinemann, Woburn, MA.	
2	Seader, J.D., Henley, E.J., 2005. Separation Process Principles, 2 ed. Wiley, Hoboken, N.J.	
3	Svarovsky, L., 2000. Solid-Liquid Separation. Butterworth-Heinemann, Woburn, MA.	
4	McCabe, W., Smith, J., Harriott, P., 2004. Unit Operations of Chemical Engineering, 7 ed. McGraw-Hill Science/Engineering/Math, Boston.	
5	Green, D., Perry, R., 2007. Perry's Chemical Engineers' Handbook, Eighth Edition, 8 ed. McGraw-Hill Professional, Edinburgh.	
6	Dutta, B.K., 2007. Principles of Mass Transfer and Separation Process. Prentice-Hall of India Pvt. Ltd, New Delhi.	
Course Outcomes (students will be able to…..)		
1	Know the significance and usage of different particulate characterization parameters, and equipment to estimate them	
2	Describe Size reduction energy requirements, estimate performance of equipment, selection and sizing of equipment	
3	Analyze filtration data and select systems based on requirements, estimate filtration area for given	

	requirements, understand filter aids and their usage	
4	Draw T-y-x diagrams, and y-x diagrams, operating lines, feed line, bubble point, dew point calculations, ternary phase diagrams, partition coefficient	
5	Describe two common modes of drying, industrial drying equipment	
6	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	

	Course Code: CET 1302	**Course Title:** Chemical Engineering Thermodynamics II	**Credits =** 4		
			L	**T**	**P**
	Semester: IV	**Total contact hours:60**	3	1	**0**
List of Prerequisite Courses					
	Applied Mathematics- I and II, Physical Chemistry, Chemical Engineering Thermodynamics-I				
List of Courses where this course will be prerequisite					
	Separation Processes, Chemical Reaction Engineering, Multiphase Reactor Engineering, Env. Engg. and Proc Safety, Proc. Development and Engineering, Home Paper I and II				
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)		**Reqd. hours**		
1	General Equations of Equilibrium: Equality of Chemical Potentials and Fugacity and Activity Coefficients		2		
2	Models of the Liquid Phase: Activity Coefficient Models (Redlich-Kister, Wilson et al, UNIQUAC and NRTL)		8		
3	Calculation of Excess Properties.		4		
4	Raoult's Law and Modified Raoult's Law. Calculation of Bubble Point, Dew Point, T-x-y and P-x-y diagrams		8		
5	Azeotropy		4		
6	Phase Stability and Liquid-Liquid Phase Splitting		8		
7	Solubility of Gases in Liquids (Unsymmetric Reference states, Henry's Law and the concept of infinite dilution activity coefficient).		2		
8	Solubility of Solids in Liquids		2		
9	Debye Huckel Theory and Salting out of Non-Electrolytes		6		
10	Chemical Equilibrium in Ideal Mixtures		4		
11	Chemical Equilibrium in Non-Ideal Reacting Mixtures		2		
12	Chemical Equilibrium in Heterogenous Reacting Mixtures		2		
13	Chemical Equilibrium in Multi-Reaction Systems		4		
11	Estimation of Activity Coefficients by Group Contribution Methods : UNIFAC Model		4		
List of Text Books/ Reference Books					
	Introduction to Chemical Engineering Thermodynamics: Smith, van Ness, Abbott				
	Chemical, Biochemical and Engineering Thermodynamics: S. I. Sandler				
	Phase Equilibria in Chemical Engineering: Walas				
	Molecular Thermodynamics of Fluid Phase Equilibria: Prausnitz				
Course Outcomes (students will be able to…..)					
1	Use activity coefficient models to calculate excess properties of liquids				
2	Use modified Raoult's law to calculate VLE of non-ideal mixtures				
3	Calculate chemical equilibrium in non-ideal mixtures				
4	Calcuate solubility of gases in liquids including aqueous solutions with electrolyes.				
5	Quantitatively describe salting out effect				
6	Estimate mixture properties from group contribution methods				

	Course Code: GEP 1108	Course Title: Engineering Graphics II	Credits = 2		
			L	T	P
	Semester: IV	Total contact hours: 60	0	0	4
	List of Prerequisite Courses				
	Engineering Graphics – I				
	List of Courses where this course will be prerequisite				
	Equipment Design and Drawing I and II				
	Description of relevance of this course in the B. Chem. Engg. Program				
A student of Chemical Engineering is required to know the various processes and also the equipment used to carry out the processes. Some of the elementary processes like filtration, size reduction, evaporation, condensation, crystallization etc., are very common to all the branches of technology. These and many other processes require machines and equipments. One should be familiar with the design, manufacturing, working, maintenance of such machines and equipments. The subject of "drawing" is a medium through which, one can learn all such matter, because the "drawings" are used to represent objects and processes on the paper. Through the drawings, a lot of accurate information is conveyed which will not be practicable through a spoken word or a written text. Drawing is a language used by engineers and technologists.					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1.	Introduction to assembly and detail drawings		4hrs/ week		
2.	Hexagonal Headed Bolt & Nut assembly				
3.	Assembly of Plummer Block				
4.	Assembly of Footstep Bearing				
5.	Assembly of Stuffing Box				
6.	Preparing Detail Drawing from Assembly of Stuffing Box				
7.	Assembly of Expansion Pipe Joint				
8.	Assembly of Non-Return Valve				
9.	Assembly of Feed Check Valve				
10.	Introduction to Solid Works				
11.	Preparing part drawing, assembly drawing of Plummer Block, Non-Return Valve etc. using Solid Work				
	List of Text Books/ Reference Books				
	1.Machine Drawing by N.D.Bhat				
	2. Machine Drawing by Gill				
	Course Outcomes (students will be able to…..)				
1	Show assembly drawing and Detail Drawing of simple equipment				
2	Show with a diagram the working of Bearings, Stuffing box, Shaft coupling, Pipe Joints, Valves,				
3	Prepare computer aided drawing.				

	Course Code: BSP 1103	Course Title: **Biological Sciences Laboratory**	Credits = 2		
			L	T	P
	Semester: IV	Total contact hours: 30	0	0	4

	List of Prerequisite Courses	
1	Xth Standard Biology course, Physical Chemistry	
	List of Courses where this course will be prerequisite	
	Biochemical Engineering, Env. Eng and Proc Safety, Home Paper I and II	

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

In this course, students will develop basic understanding of biological systems, their monitoring and quantification. The focus is to teach basic skills in handling microorganisms and different qualitative and quantitative analysis techniques. Additionally, analyzing effect of environmental parameters that may have an influence on the growth of the microbe has been addressed through basic experiments.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Microbial Isolation and quantitative measurements • Microscopy • Sample preparation • Dilution & Plating/spectrophotometric • Colony counting (demo of automated colony counter) • Growth kinetics	6
2	Quantitative Analysis • Carbohydrates • Proteins • Lipids • DNA/Nucleic acid (Demo) • CHNS (Demo)	6
3	Enzymology Isolation and assay of enzyme from natural source Primary screening assay for extracellular enzymes	6
4	Environmental stress studies • Aerobic/ Anaerobic stress (Fluorescence microscopy) • Algal growth	6
5	Assays: VitB12 and Antibiotic resistance assays	6

	List of Text Books/ Reference Books
1	Microbiology, M.J. Pelczar, ECS Chang & N. Kriej ISBN 13:978-0-07-462302-6
2	Principles and Techniques of Biochemistry and Molecular Biology Keith Wilson, John Walker; Cambridge University Press (2010) ISBN: 0521516358,9780521516358
	Course Outcomes (students will be able to…..)
1	Develop basic understanding of microbes and their monitoring and quantification
2	Perform the quantitative analysis of biomolecules
3	Understand the Enzyme Kinetics
4.	Understand the responses of biological systems to environment factors

	Course Code: CEP 1701	Course Title: Chemical Engineering Laboratory-I	Credits = 3		
			L	T	P
	Semester: IV	Total contact hours: 90	0	0	6
List of Prerequisite Courses					
1	Momentum and Transfer, Chemical Engineering Operations, Chemical Engineering Operations – I and II				
List of Courses where this course will be prerequisite					
	Chemical Engineering Laboratory II and III, and other Chemical Engineering Courses.				
Description of relevance of this course in the B. Chem. Engg. Program					
Chemical Engineering lab provides students the first hand experience of verifying various theoretical concepts learnt in theory courses. It also exposes them to practical versions of typical chemical engineering equipments and servers as a bridge between theory and practice. This particular lab focuses on fluid dynamics, distillation, filtration, drying and sedimentation.					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	9-13 Experiments on fluid dynamics		24		
2	5-7 Experiments on distillation		16		
3	1-2 Experiments on sedimentation		4		
4	2-3 Experiments on filtration		6		
5	1-2 Experiments on drying		4		
6	2-3 Experiments on Thermodynamics		6		
List of Text Books/ 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…..)					
1	Learn how to experimentally verify various theoretical principles				
2	Visualize practical implementation of chemical engineering equipments				
3	Develop experimental skills				

SEMESTER – V									
No.	**Subjects**	**Credits**	**Hrs /week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET 1716	Mathematical Methods in Chem. Engg.	4	3	1	0	20	30	50	100
CET 1102	Heat Transfer	4	2	2	0	20	30	50	100
CET 1201	Chemical Reaction Engineering	4	2	2	0	20	30	50	100
CET 1402	Separation Processes	4	2	2	0	20	30	50	100
CET 1202	Biochemical Engineering	3	2	1	0	10	15	25	50
CEP 1704	Chemical Engineering Laboratory-II	3	0	0	6	50	---	50	100
CEP 1702	Process Simulation Lab – I	2	0	0	4	25	---	25	50
	Total	24	11	8	10				600

	Course Code: CEP 1716	**Course Title: Mathematical Methods in Chem. Engg.**	**Credits = 4**		
			L	**T**	**P**
	Semester: V	**Total contact hours: 60**	**3**	**1**	**0**
	List of Prerequisite Courses				
1	Applied Mathematics – I and II, Momentum and Mass Transfer, Chem. Eng. Operations, Chem Engg Thermodynamics I and II				
	List of Courses where this course will be prerequisite				
1	Transport Phenomena (CET 1101)				
2	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.					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	Vector algebra: scalar & vector product (application to fluid flow problems)		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)		8		
4	Laplace, z transform (process control applications)		8		
5	Linear algebra (matrix theory) (stability analysis, scaling of equations)		8		
6	Bifurcation analysis (sensitivity analysis)		8		
7	Perturbation analysis (for boundary flow problems, solution of equations, model reduction etc.)		8		
	List of Text Books/ Reference Books				
1	Kreyszig, E. Advanced Engineering Mathematics.				
2	Pushpavanam, S. Mathematical Methods in Chemical Engineering				
3	Kundu, P. and Cohen, I.M. Fluid Mechanics.				
4	Jenson, V.G. and Jeffreys, G.V. Mathematical Methods in Chemical Engineering				
	Course Outcomes (students will be able to…..)				
1	Formulate a Chemical Engineering problem into a mathematical problem				
2	Solve (analytically or numerically) ODE and PDE equations encountered in Chemical Engineering Applications				
3	Assess stability of Chemical Engineering systems				

	Course Code: CET 1102	Course Title: Heat Transfer	Credits = 4		
			L	T	P
	Semester: V	Total contact hours: 60	2	2	0
	List of Prerequisite Courses				
	Momentum and Mass transfer, Applied Mathematics I and II, Material and Energy Balance Calculations				
	List of Courses where this course will be prerequisite				
	Chemical Reaction engineering, Multiphase Reactor Engineering, Process Development and Engineering, Home Paper I and II, Env. Engg. and Process Safety, etc.				
	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)		**Reqd. 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.		4		
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.		2		
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		6		
5	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		12		
6	Finned tube exchangers, air-cooled cross flow exchangers and their process design aspects		3		
7	Compact Exchangers: Plate, Plate fin, Spiral, etc.: Construction, features, advantages, limitations and their process design aspects		3		
8	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.		10		
9	Heat transfer to boiling liquids: Process design aspects of evaporators, natural and forced circulation reboilers		10		
10	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		
11	Basics of Radiative heat transfer and application to Furnace Design		2		
	List of Text Books/ Reference Books				
	Process Heat Transfer, Kern D.Q.				
	Heat Exchangers, Kakac S., Bergles A.E., Mayinger F				
	Process Heat Transfer, G. Hewitt				
	Course Outcomes (students will be able to…..)				
1	Calculate temperature profiles in a slab at steady state				
2	Calculate heat transfer coefficients in various equipment like double pipe heat exchangers, shell and tube heat exchangers, plate heat exchangers, condensation, evaporation, agitated tanks.				
3	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.				
4	Identify and select type of shell and tube exchanger based on TEMA classification.				

	Course Code: CET 1201	Course Title: Chemical Reaction Engineering	Credits = 4		
			L	T	P
	Semester: V	Total contact hours: 60	2	2	0

	List of Prerequisite Courses	
	Physical Chemistry, Material & Energy Balance Calculations, Applied Mathematics I and II, Momentum and Mass Transfer, Chem Engg Thermodynamics I and II	
	List of Courses where this course will be prerequisite	
	Biochemical Engineering, Environmental Engineering and Process Safety, Proc. Dev and Engg., Multiphase Reactor Engineering, Home Paper I and II	

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

	Course Contents (Topics and subtopics)	Reqd. hours
1	Batch reactor (BR), continuous stirred tank reactor (CSTR), plug flow reactor (PFR), packed-bed reactor (PBR)	2
2	Design equations for BR, CSTR, PFR, PBR, and applications of design equations to various series- and parallel- combinations of flow reactors	6
3	Rate laws and stoichiometry	4
4	Isothermal reactor design applied to BR, CSTR, PFR, PBR	6
5	Analysis of rate data: differential method, integral method	4
6	Multiple reactions	4
7	Reaction mechanisms, pathways, bioreactions	6
8	Catalysis and catalytic reactors, catalyst deactivation, external diffusion effects on heterogeneous reactions, diffusion and reaction in solid catalysts;	8
9	Introduction to non-isothermal reactor design	6
10	Residence time distribution in reactors; models for non-ideal reactors	8
11	Mass transfer with chemical reaction in fluid-fluid and fluid-fluid-solid systems; Model contactors, pilot plants, and collection of scale-up data	6

	List of Text Books / Reference Books
1	Elements of Chemical Reaction Engineering – H. Scott FOGLER
2	Chemical Reaction Engineering – Octave LEVENSPIEL
3	The Engineering of Chemical Reactions – Lanny D. SCHMIDT
4	An introduction to Chemical Engineering Kinetics and Reactor Design – Charles HILL
5	Heterogeneous Reactions, Vol. I and II – L. K. Doraiswamy, M. M. Sharma

	Course Outcomes (students will be able to ...)
1	design chemical reactors optimally, using minimum amount of data
2	design experiments in a judicious way to get the required data, if not available
3	fix some problems related to operability and productivity
4	maintain and operate a process in a safe manner
5	increase capacity and/or selectivity and/or safety by improving/changing the reactor type/sequence and/or operating conditions

	Course Code: CET 1402	Course Title: Separation Processes	Credits = 4		
			L	T	P
	Semester: V	Total contact hours:60	2	2	0

List of Prerequisite Courses		
	Material & Energy Balance Calculations, Chemical Engineering Operations – I, Chem. Eng. Thermodynamics-I and II, Momentum Transfer, Applied Mathematics I and II	
List of Courses where this course will be prerequisite		
	Chemical Engineering Laboratory, Process Simulation Lab – I and II, Home Paper I and II, Proc Dev and Engg.,	

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 oc 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)	Reqd. 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	15
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	12
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	12
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.	9
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, 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	12

List of Text Books/ Reference Books

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

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

1	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	
2	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	

3	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	
4	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.	

	Course Code: CET 1202	Course Title: Biochemical Engineering	Credits = 3		
			L	T	P
	Semester: V	Total contact hours: 45	2	1	0
List of Prerequisite Courses					
	Chemical Reaction Engineering, Introduction to Biological Sciences and Bioengineering, Physical Chemistry, Material and Energy Balance Calculations, Chem Engg Thermodynamics I and II, Chem Engg Operations				
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 a requisite for Biobased Industry					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	Introduction to Biotechnology: Role of chemical engineers in biotechnology		2		
2	Basic of Genetic Engineering and Tissue Culture : Recombinant DNA technology		2		
3	Structure function relations of enzymes; Classification,		2		
4	Mechanism of Enzyme action, Enzyme kinetics, inhibition and regulation		2		
5	Enzyme purification and characterization, Coenzymes, cofactors		2		
6	Enzyme reactors, thermostabilization, immobilization of enzymes		2		
7	Enzymes as industrial catalysts- Examples		2		
8	Bioprocess Development		3		
9	Plant and animal cell cultures for the production of biochemicals, Immobilized cells.		4		
11	Kinetics of microbial growth, models and simulations, Batch and continuous culture, Mixed microbial culture ,		4		
12	Biochemical process development and bioreactors using biological catalysts		4		
13	Integration of downstream processing with bioprocessing		4		
14	Transport phenomena in bioreactions and bioreactors		4		
15	Fundamentals of fermentation-submerged fermentation, Fermenter design and basic biochemical engineering aspects of fermentation		4		
16	Reactor design for biochemical reactions and scale up. Process Design for bioproducts, Bioreactor design, Scale up of bioreactions/reactors,		4		
List of Text Books/ Reference Books					
	Biochemical Engineering Fundamentals, Bailey and Olis, Wiley				
	Biotransformations and Bioprocesses, Doble Anilkumar and Gaikar, Marcel Dekker				
Course Outcomes (students will be able to…..)					
1	calculate microbial/enzymatic kinetics parameters				
2	Design enzyme reactors and scale up fermenters				
3	calculate biomass production/substrate requirements				
4	decide process parameters				
5	estimate energy equipments/oxygen requirements				
6	estimate bio-reactor size/time for a given microbial/enzymatic process.				

	Course Code: CEP 1704	Course Title: Chemical Engineering Laboratory-II	Credits = 3		
			L	T	P
	Semester: V	Total contact hours: 90	0	0	6
List of Prerequisite Courses					
1	Material and Energy Balance Calculations, Momentum and Mass Transfer, Chemical Engineering Thermodynamics – I and II, Chem Engg Operations, Chemical Reaction Engineering, Separation Processes				
List of Courses where this course will be prerequisite					
	Students will be able to understand pricinples in a better way so it is required in all the courses				
Description of relevance of this course in the B. Chem. Engg. Program					
Chemical Engineering lab provides students the first hand experience of verifying various theoretical concepts learnt in theory courses. It also exposes them to practical versions of typical chemical engineering equipments and servers as a bridge between theory and practice. This particular lab focuses on heat and mass transfer principles, chemical engineering thermodynamics, adsorption, extraction and crystallization.					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	8-10 Experiments on heat transfer		20		
2	5-7 Experiments on mass transfer		16		
3	3-5 Experiments on chemical engineering thermodynamics		10		
4	2-3 Experiments on adsorption		6		
5	1-2 Experiments on extraction		4		
6	1-2 Experiments on crystallization		4		
List of Text Books/ Reference Books					
1	McCabe W.L., Smith J.C., and Harriott P. Unit Operations in Chemical Engineering, 2014				
2	Kern D.Q. Process heat reansfer, 1950				
3	Treybal R.E. Mass-transfer Operations. 1980				
4	Green D. and Perry R. Perry's Chemical Engineers' Handbook, Eighth Edition, 2007.				
Course Outcomes (students will be able to…..)					
1	Learn how to experimentally verify various theoretical principles				
2	Visualize practical implementation of chemical engineering equipments				
3	Develop experimental skills				

	Course Code: CEP 1702	Course Title: Process Simulation Lab - I	Credits = 2		
			L	T	P
	Semester: V	Total contact hours: 60	0	0	4
List of Prerequisite Courses					
1	Applied Mathematics – I and II, Material & Energy Balance Calculations, Chem. Eng. Thermodynamics-I and II, Momentum and Mass Transfer, Chemical Engineering Operations Engineering Applications of Computers, etc.				
List of Courses where this course will be prerequisite					
1	Process Simulation Lab – II, Home paper I and II, etc.				
Description of relevance of this course in the B. Chem. Engg. Program					
The course will help to write programs for chemical engineering problems in various basic as well as advanced programming software such as C/C++, SciLAB, Python etc. 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)		**Reqd. hours**		
1	C programming/Visual Basic Revisions: Boundary layer on flat plate, Solution of ODE, interpolation, Batch distillation design problem		9		
2	Introduction to Python and SCILAB programming		6		
3	Material and energy balance (a) recycle problems (b) humidity calculations (cooling tower design) (c) adiabatic flame temperature (numerical integration)		6		
4	Thermodynamics: (a) Vapor pressure estimation from equation of state b) VLE data correlation using activity coefficient models (c) High Pressure VLE, gas solubility using EOS		6		
5	Fluid flow: (a) solution to laminar flow problems (numerical) (b) piping system calculations		6		
6	Unit operations: (a) Absorption column design (b) Extractor design		6		
7	Reaction engineering: Concentration profiles of series/parallel reactions, PFR design, estimation of rate constants for catalytic reactions		6		
List of Text Books/ Reference Books					
1	Jelen , B., VBA and Macros: Microsoft Excel 2010				
2	www.scilab.in (Free Books for Chemical Engineering)				
Course Outcomes (students will be able to…..)					
1	Use advanced programming software with built in functions				
2	Write own functions/macros				
3	Solve chemical engineering problems using computers				

SEMESTER – VI									
No.	**Subjects**	**Credits**	**Hrs/week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET 1601	Material Science and Engineering	3	2	1	0	10	15	25	50
CET 1203	Multiphase Reaction Engineering	3	2	1	0	10	15	25	50
CET 1503	Process Safety & Environmental Engg.	4	2	2	0	20	30	50	100
CET 1703	Chemical Process Control	4	3	1	0	20	30	50	100
	Institute Elective – I	3	2	1	0	10	15	25	50
CEP 1706	Chem. Eng. Laboratory-III	3	0	0	6	50	---	50	100
CEP 1705	Process Simulation Lab – II	2	0	0	4	25	---	25	50
GEP 1111	Equipment Design and Drawing-I	4	2	0	4	25	---	25	50
	Total	24	13	6	14				550

	Course Code: CET 1601	**Course Title: Material Science and Engineering**	**Credits = 3**		
			L	**T**	**P**
	Semester: VI	**Total contact hours: 45**	**2**	**1**	**0**
List of Prerequisite Courses					
	Structural Mechanics, Applied Physics I and II,				
List of Courses where this course will be prerequisite					
	Equipment design and drawing I and II, Home Paper I and II, Process Development and Engg. Chem Proj Engg. and Eco				
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)		**Reqd. hours**		
1	Engineering Materials: Classification, study of ferrous and non ferrous materials		3		
2	Phase diagrams of steel, brass and cupronickel and the applications of phase diagrams		5		
3	Effect of structure on properties: subatomic to macroscopic level		5		
4	Modification and control of material properties		4		
5	Polymeric materials , Ceramic materials, Composite materials and Smart materials		4		
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.		10		
7	Theory of failure: Crystal defects, plastic deformation. Types of mechanical failure, fracture , fatigue and creep		10		
8	Criteria for selection of materials in chemical process industry		4		
List of Text Books/ Reference Books					
1	The Essence of Materials for Engineers, Robert W. Messler, Jr.				
2	Materials Science and Engineering, Raghavan V.				
3	Materials Science and Engineering, Van Vlack L.H.				
4	Engineering Materials and Applications, Flin R.A., Trojan P.K.				
Course Outcomes (students will be able to…..)					
1	Students will be able to draw simple Phase Diagram				
2	Describe causes of mechanical failure				
3	List types of corrosion and describe method to control them				

	Course Code: CET 1203	Course Title: Multiphase Reaction Engineering	Credits = 3		
			L	T	P
	Semester: VI	Total contact hours: 45	2	1	0

	List of Prerequisite Courses	
	Chemical Reaction Engineering , Momentum and Mass Transfer (CET 1101: Semester III), Heat Transfer, Chemical Reaction Engineering, Chemical Engineering Operations Separation Processes, Chem Engg Thermodynamics I and II	

	List of Courses where this course will be prerequisite	
	Home Paper I and II, Proc Dev and Engg.,	

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 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

	Course Contents (Topics and subtopics)	Reqd. hours
1	Classification of multiphase reactors, qualitative description, examples of industrial importance	2
	Hydrodynamics, scale-up, process design and performance of the following major classes of multiphase reactors, case studies and problems, w.r.t:	
	- Stirred tank reactors,	10
	- Bubble columns, packed bubble columns, sectionalised bubble columns,	8
	- Internal loop and external loop air-lift reactors, jet loop reactors,	4
	- Fluid-fluid reactors such as spray columns, packed columns, plate columns, static mixers, rotating disc contactors	6
	- Fixed bed reactors, trickle bed reactors,	7
	- Solid-liquid and gas-solid fluidised bed reactors, solid-gas transport reactors	8

	List of Text Books / Reference Books
1	Heterogeneous Reactions, Vol. I and II – L. K. Doraiswamy, M. M. Sharma
2	Fluid Mixing and Gas Dispersion in Stirred Reactors – G. B. Tatterson
3	Bubble Column Reactors – W. D. Deckwer
4	Fluidisation – D. Kunni and O. Levenspiel
5	Gas Liquid Reactions – P. V. Danckwerts
6	Fluidisation – J. F. Davidson and D. Harrison
7	Random Packings and Packed Tower Design – R. F. Strigel

	Course Outcomes (students will be able to ...)
1	calculate operating regime for a given reaction.
2	calculate intrinsic kinetics from the data on model contactors.
3	calculate conversion / selectivity / size / temperature / pressure / power required for conducting a given multiphase reaction equipment.

	Course Code: CET 1503	Course Title: Process Safety and Environmental Engineering	Credits = 4		
			L	T	P
	Semester: VI	Total contact hours: 60	2	2	0
List of Prerequisite Courses					
	Material & Energy Balance Calculations, Chemical Reaction Engineering, Chemical Engineering Operations, Momentum and Mass Transfer, Biochemical Engg., Chem Engg Thermodynamics I and II				
List of Courses where this course will be prerequisite					
	Home Paper I and II, Chem Proc Dev and Engg.,				

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

The course 'Environmental Engineering and Process Safety' is highly relevant in all fields of activities, and process industry in particular. A chemical engineer working in any function of process industry should have working knowledge of all the prevailing safety, environment, and health standards, and may be involved in / responsible for any or all of the following:

- site process safety, environmental affairs
- assisting the Health Safety Environment (HSE) team
- employee safety observations and pre-job risk assessments
- implementation of HSE policies and guidelines to help ensure that all employees, contractors, and visitors enjoy high levels of safety, health and environmental protection; this reduces company's liability exposure.
- improvement of process safety performance and reduction of risk by facilitating Process Hazard Analyses and Layer of Protection Analyses
- incident investigations for process safety and environmental incidents
- recognising information that would be pertinent to process safety documentation and follow through with site personnel to ensure information is well documented
- developing and updating site Policies and Procedures related to process safety and environmental.
- capital and other project teams to identify and resolve regulatory issues, analyse process and property hazards, and establish protective measures to mitigate risks to a tolerable level.
- assisting the plant with government interfaces and inspections.
- training using internal and external resources; provides guidance to site management for implementation of programs or controls to comply with environmental requirements.
- managing site environmental programs including but not limited to waste management, spill prevention & response, etc.
- preparation and submission of reports to appropriate agencies to assure compliance with federal, state and local regulations. Responds to corporate requests in a timely manner.
- obtaining new or revised environmental permits that provide operational flexibility within the schedule established for new projects. Ensure that the operating units can meet all provisions and provide tools to enable compliance.
- providing environmental guidance; develop procedures and training, and HSE support as needed.
- participate in site objectives in the areas of community relations.

The above clearly highlights the necessity and significance of the course. This course will certainly add value to our chemical engineering graduates.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Introduction to all prevailing international standards of Health, Safety, and Environment (HSE); Environmental laws and regulations; Standards (air quality, noise, water), ISO 14000+	4
2	Environmental impact assessment, Life cycle assessment (LCA)	4
3	Pollution prevention in chemical manufacturing, effluent valorisation	2
4	Air pollution; Air pollutants: sources (specific pollutants), effects, and dispersion modelling, air pollution, air quality, pollutants minimisation and control, fugitive emissions (source and control), Noise pollution	6
5	Wastewater treatment; Groundwater and surface water pollution, removal of specific water contaminants; Solid waste; Hazardous waste	6
6	Inherent safety, Major disasters (e.g. Flixborough, UK; Bhopal, India; Seveso, Italy; Pasadena, Texas; Texas City, Texas; Jacksonville, Florida; Port Wentworth, Georgia)	8
7	Toxicology; Industrial hygiene	2
8	Source models; Toxic release and dispersion models	6
9	Fires and explosions; Concepts to prevent fires and explosions	4
10	Chemical reactivity	2
11	Reliefs and reliefs sizing; Hazard identification; Risk assessment	6
12	Safety procedures and designs	4
13	Some case histories	6

List of Text Books / Reference Books		
1	Chemical Process Safety: Fundamentals with Applications – Daniel A. CROWL and Joseph F. LOUVAR	
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	Environmental Engineers' Handbook – Irene LIU (Editor)	
4	Chemical Process Safety Learning from Case Histories – Roy E. SANDERS	
5	Guidelines for Process Safety Documentation – Center for the Chemical Process Safety of the American Institute of Chemical Engineers (AIChE)	
6	Environmental and Health and Safety Management: A Guide to Compliance – Nicholas P. CHEREMISINOFF, Madelyn L. GRAFFA	
7	Environmental Pollution Control Engineering – C. S. Rao	
8	Environmental Engineering – H. S. Peavy	
Course Outcomes (students will be able to…..)		
1	calculate BOD / COD for a given composition of effluent stream, Estimation of bio Kinetics	
2	calculate adiabatic lapse rate and determine conditions for suitability of atmospheric dispersion, effective stack height, chimney design	
3	calculate concentrative of pollutant at any point in the neighbourhood of emission given atmospheric conditions like wind, dispersion, environmental factors etc.	
4	calculate size/time/power required for primary clarifier, secondary treatment, tertiary treatment, sizing of different types of Biological treatments etc.	
5	identify hazards in a given process and assess the same and provide solutions for operating safely.	
6	specify safety requirements for storage and handling of a given chemical.	

	Course Code: CET 1703	Course Title: Chemical Process Control	Credits = 4		
			L	T	P
	Semester: VI	Total contact hours: 60	3	1	0
List of Prerequisite Courses					
	Material and Energy Balance Calculations, Applied Mathematics I and II, Mathematical Methods in Chem Engg., Momentum and Mass Transfer, Chemical Reaction Engineering, Heat Transfer, Chem Engg Operations, Separation Processes,				
List of Courses where this course will be prerequisite					
	Chemical Engineering Laboratory, Procsess Sim Lab, Home Paper I and II, Proc Dev and Engg.				
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)		**Reqd. hours**		
1	Introduction to process control: Motivation, importance, components of control system, control relevant process modeling		3		
2	Dynamics of first, second and higher order systems: Examples systems, characterizing parameters, features, etc.		12		
3	Feedback control: Motivation, elements of feedback control, servo problem, regulatory problem, effect of proportional, integral and derivative action, responses of P, PI and PID controllers		6		
4	Controller selection and design: Controller selection guidelines, controller design criteria, common control loops (level, pressure, flow, temperature), reactor control, distillation control		6		
5	Controller tuning: Open loop tuning, closed loop tuning, direct synthesis, commercial controller tuning packages		6		
6	Stability analysis: Laplace domain analysis, frequency domain analysis		6		
7	Multivariable and advanced control: Cascade control, dynamic matrix control, internal model control, basics of ratio control, split range control, override control, adaptive control, inferential control, model predictive control, geometric control		12		
8	Digital control: Discrete time systems, basics of z-transforms, stability analysis		3		
9	Electronics for control systems: Distributed control system, Programmable Logic Controllers, SCADA, HMI		3		
10	Instrumentation: Basic measurement devices and working principles for level, flow, pressure and temperature, types of control valves, etc.		3		
List of Text Books/ Reference Books					
1	Stephanopoulos, G.Chemical Process Control: An Introduction to Theory and Practice.				
2	Bequette, B.W.Process Control: Modeling, Design, and Simulation.				
3	Seborg, D.E. and Mellichamp, D.A. and Edgar, T.F. and Doyle, F.J.Process Dynamics and Control.				
4	Johnson, C.D.Process Control Instrumentation Technology.				
Course Outcomes (students will be able to…..)					
1	Understand the importance of process dynamics (unsteady state operation)				
2	Design a control strategy for key unit operations (reactor, distillation column, etc)				
3	Tune a controller to reject disturbances or manage operating point transitions				
4	Understand working principles of basic instruments available for flow, pressure, level and temperature measurement				
5	Describe modern industrial control system architecture				

	Course Code: CEP 1706	Course Title: Chemical Engineering Laboratory-III	Credits = 3		
			L	T	P
	Semester: VI	Total contact hours: 90	0	0	6

	List of Prerequisite Courses	
	Material and Energy Balance Calculations, Momentum and Mass Transfer, Heat Transfer, Chemical Reaction Engineering, Chemical Engg Operations, Separation Processes, Chem Engg Lab I and II	
	List of Courses where this course will be prerequisite	
	Home Paper I and II, Chem Proc Dec and Engg.,	

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

Chemical Engineering lab provides students the first hand experience of verifying various theoretical concepts learnt in theory courses. It also exposes them to practical versions of typical chemical engineering equipments and servers as a bridge between theory and practice. This particular lab focuses on chemical reaction engineering, multiphase reaction engineering, process dynamics and control.

	Course Contents (Topics and subtopics)	Reqd. hours
1	5-7 Experiments on Chemical Reaction Engineering	16
2	2-4 Experiments on Bubble column	6
3	3-5 Experiments on MACs	10
4	2-3 Experiments on fluidized beds	6
5	5-7 Experiments on process dynamics	16
6	2-4 Experiments on process control	6
7		

	List of Text Books/ Reference Books	
1	Fogler H.S. Essentials of Chemical Reaction Engineering, 2010	
2	Doraiswami L.K. and Sharma M.M. Heterogeneous reactions, volume I and II.	
3	Stephanopoulos, G.Chemical Process Control: An Introduction to Theory and Practice.	
4	Green D. and Perry R. Perry's Chemical Engineers' Handbook, Eighth Edition, 2007.	
	Course Outcomes (students will be able to…..)	
1	Learn how to experimentally verify various theoretical principles	
2	Visualize practical implementation of chemical engineering equipments	
3	Develop experimental skills	

	Course Code: CEP 1705	Course Title: Process Simulation Lab - II	Credits = 2		
			L	T	P
	Semester: VI	Total contact hours: 60	0	0	4

	List of Prerequisite Courses	
	Applied Mathematics – I and II, Material & Energy Balance Calculations, Chem. Eng. Thermodynamics-I and II, Momentum and Mass Transfer, Chemical Engineering Operations, Engineering Applications of Computers, Process Simulation Lab - I (CEP1702), Chemical Reaction Engineering (CET 1201)	
	List of Courses where this course will be prerequisite	
	Project II – Home paper I and II	

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

In this course, students will develop a computer software for design and optimization of various chemical engineering equipments. This course will help students to complete home paper which is Techno-economic feasibility analysis of chemical manufacturing facility. The course content is similar to the activities carried out by any organization working on "detailed engineering packages" In this course student will learn the widely used chemical engineering software such as ASPEN.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Introduction to process simulation software (Prediction of multicomponent VLE using Aspen, column design, rating, reactor balances)	9
2	Heat transfer: triple effect evaporator, STHE design	6
3	Separation processes: Design of crystallizers, Distillation, Chromatography, spray dryers etc	9
4	Design of multiphase reactors: stirred vessels, Bubble columns	6
5	ASPEN simulation: azeotropic distillation, reactive distillation, column sizing	9
6	Process control: P, PI, PID controller simulations, DCS Control system	6

List of Text Books/ Reference Books		
1	Coker, Ludwig's Applied Process Design for Chemical and Petrochemical Plants	
2	Perry's Chemical Engineering Handbook	
3	Albright's Chemical Engineering Handbook	
4	ASPEN manual	
Course Outcomes (students will be able to…..)		
1	Design any equipment once the guidelines are available	
2	Optimize the process conditions	
3	Techno-economic feasibility analysis of chemical manufacturing facility	

	Course Code: GEP 1111	Course Title: Equipment Design & Drawing	Credits = 4		
			L	T	P
	Semester:VI	Total contact hours: 90	2	0	4
List of Prerequisite Courses					
	Structural Mechanics, Materials Science and Engineering, Engineering Graphics I and IIm				
List of Courses where this course will be prerequisite					
	Home Paper I and II, Equipment Design & Drawing II, Chemical Project Engineering and Economics, Process Dev and Engineering				
Description of relevance of this course in the B. Chem. Engg. Program					
Knowledge of chemicals and chemical producing equipments and plants are essential for professional Chemical engineer and Technologist. This subject will help students to understand use of basics of applied science in the form of mechanics, strength of materials, selection of materials and suitable manufacturing techniques and the details of operating conditions of equipment and its design procedure. This will help Chemical engineer to understand process equipments and their design concept and section of proper equipments for the designed functions of the plats. It will help them to understand various design codes used for fabrication of these equipments and the various types of destructive and non destructive tests performed on equipments before and after assembly of equipment defining its capacity, reliability, and its life.					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	Basic design concepts, use of standards and design stresses and factor of safety, selection of materials, working conditions, corrosion and its effects on equipments. Standard design codes		8		
2	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		8		
3	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.		8		
4	Testing of process equipment, various		8		
5	Mechanical Design of Reaction Vessels. a) Design of shells subjected to internal and external pressures. b) Types of Jackets /Coils used for heating and cooling in reaction vessels and their design. c) Type of agitators and their design. Design of agitator system components such as shafts,stuffing box etc.		8 hours(Theory) 12 hours(Practicals)		
7	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,U tube, Floating head etc. Various codes for heat exchangers.		8 hours (theory) 12 hours (practicals)		
8	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. Tray supports and their design		6 hours (theory) 12 hours (practicals)		
List of Text Books/ Reference Books					
	Process equipment Design By V V Mahajani, S. B. Umarji				
	Equipment Design by Dawande				
	Process equipment Design by Young				
	Welding Technology by O.P. Khanna, Welding Technoloy by Little				
Course Outcomes (students will be able to…..)					
1	Understand the use of basic concepts of science and engineering.				
2	Select of material of construction and fabrication techniques.				
3	Use of design concept for designing process equipment considering its maximum operating conditions.				
4	Use standard equipments and use factor of safety while designing non standard equipments and their components.				
5	Use of safety norms in fabrication of equipments the understand importance of testing of equipments.				

SEMESTER – VII (will be of 10 weeks duration)									
No.	**Subjects**	**Credits**	**Hrs/week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
CET 1504	Chemical Project Engg. & Economics	3	3	1	0	10	15	25	50
CET 1505	Process Development and Engineering	4	4	2	0	20	30	50	100
HUT 1102	Perspectives of Society, Sci. & Tech.*	3	3	1	0	10	15	25	50
	Institute Elective – II	3	3	2	0	10	15	25	50
CEP 1717	Optimization of Chem. Engg. Systems	2	2	0	4	25	---	25	50
CEP 1708	Project 1: Seminar	2	0	0	4	50	---	---	50
CEP 1709	Project 2: Home Paper – I	2	0	0	4	50	---	---	50
CEP 1710	Internship	6	---	---	---	----	---	---	50
	Total	25	15	6	12				450

*** This courses may be offered in the usual classroom mode or online mode as an NPTEL / Swayam course. The Equivalent NPTEL course will be identified by the Department every year.**

	Course Code: CET 1504	**Course Title: Chemical Project Engg and Economics**	**Credits = 3**		
			L	**T**	**P**
	Semester: VII	**Total contact hours: 45**	**2**	**1**	**0**
List of Prerequisite Courses					
	Material and Energy Balance Calculations, Equip Des and Dwg I, Energy Engineering, Ind Eng Chem.				
List of Courses where this course will be prerequisite					
	Home Paper I and II				
Description of relevance of this course in the B. Chem. Engg. Program					
This course is required for the future professional career					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	Introduction to greenfield projects and global nature of projects; Impact of currency fluctuations on Project justification and cash flows andConcepts of "Quality by Design" including typical design deliverables andunderstanding constructability, operability and maintainability during all stages of project execution. Meaning of Project Engineering, various stages of project implementation		6		
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.		8		
4	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.		7		
5	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		7		
6	Process Selection, Site Selection, Feasibility Report		4		
7	Project: Conception to Commissioning: milestones, Project execution as conglomeration of technical and non technical activities, contractual details. Contract: Meaning, contents, Types of contract. Lump-sum Turnkey (LSTK), Eng, Procurement and Construction (EPC), Eng, Procurement and Construction Management (EPCM), Mergers and Acquisitions		6		
8	Reading of Balance Sheets and evaluation of Techno-commercial Project Reports.		3		
9	PERT, CPM, bar charts and network diagrams		4		
List of Text Books/ Reference Books					
	Chemical Project Economics, Mahajani V. V. and Mokashi S M.				
	Plant Design and Economics for Chemical Engineers, Peters M.S., Timmerhaus K.D.				
	Process Plant and Equipment Cost Estimation, Kharbanda O.P.				

Course Outcomes (students will be able to…..)		
1	Calculate working capital requirement for a given project	
2	Calculate cost of equipment used in a plant total project cost	
3	Calculate cash flow from a given project	
4	Select a site for the project from given alternatives	
5	List out various milestones related to project concept to commissioning	

	Course Code: CET 1505	Course Title: Process Development and Engineering	Credits = 4		
			L	T	P
	Semester: VII	Total contact hours: 60	3	1	0

	List of Prerequisite Courses	
	All chemical Engineering subjects, Material Science and Engineering, Env Engg and Proc Safety	
	List of Courses where this course will be prerequisite	
	Home Paper 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)	Reqd. 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 Text Books/ Reference Books	
	Industrial Chemical Process Design, D. L. Erwine	
	Laboratory Chemical Process Development, Anderson N.	
	Organic Unit Processes, Groggins	
	Chemical Process Engineering: Design and Economics, Silla H.	
	Handbook of Chemical Process Development, Chandalia S. B.	
	Conceptual Chemical Plant Design, Douglas J. M.	

	Course Outcomes (students will be able to…..)	
1	to select a strategy for a process from amongst the alternatives	
2	Determine strategy for carrying out a particular process	
3	Prepare specifications for a particular equipment	
4	Calculate utility requirements	

	Course Code: HUT 1102	Course Title: Perspectives of Society Science and Technology	Credits = 3		
			L	T	P
	Semester: VII	Total contact hours: 45	2	1	0
List of Prerequisite Courses					
	All the Science and Engineering Courses so far				
List of Courses where this course will be prerequisite					
	Home Paper I and II				
Description of relevance of this course in the B. Chem. Engg. Program					
This course is relevant for future professional career of a Chemical Engineer.					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	History of Science and Technology and its relevance in the respective era		4		
2	Recent developments in technology (chemical, biotechnology energy, telecommunications, etc.) and their influence on society		4		
3	Economics and Sustainable Development		4		
4	Value system and Ethics in the profession of Technology, Science and Engineering.		3		
5	Problems before the World and India. Various approaches in solving them		3		
6	Integrating Issue: Society and Science		4		
7	Industrial disasters and their effect on science and technology and society		3		
8	Environmental degradation, global warming and their effect on science and technology and society		3		
9	IPR issues and their relevance to science and technology and society		3		
10	Some aspects of future of Society, Technology, Science and Engineering.		3		
11	Interdependence of Theology and Science		3		
12	Impact of climate change on the nexus of water, energy and water		2		
13	Technology and World Peace Role of Innovation and R&D		3		
14	Industry-Academia Interaction to Enhance Standard of Living		3		
List of Text Books / Reference Books					
1	Science, Technology and Society: An Encyclopedia by Sal Restivo, Oxford University Press 2005				
2	Science, Technology and Society: A Sociological Appraoach by Wenda K. Bauchspies, Jennifer Croissant, Sal P. Restivo				
3	Vision of STS: Counterpoints in Science Technology and Society Studies by Stephan H. Cutcliffe, Carl Mitcham, Sunny Press 2012				
Course Outcomes (students will be able to…..)					
1	List some historical scientific developments				
2	State importance and implications of patents and some of the relevant laws				

	Course Code: CEP 1717	Course Title: Optimization of Chemical Engineering Systems	Credits = 2		
			L	T	P
	Semester: VII	Total contact hours: 90	2	0	4
List of Prerequisite Courses					
1	Applied Mathematics – I and II, All the Chemical Engieering Courses				
List of Courses where this course will be prerequisite					
1	Home Paper I and II				
Description of relevance of this course in the B. Chem. Engg. Program					
In this course, various optimization encountered in Chemical Engineering are covered. 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)		**Reqd. hours**		
1	Equation scaling, normalization, convergence		4		
2	Integer programming (simple scheduling)		6		
3	Linear programming (simple production planning, fuel blending)		6		
4	Quadratic programming (data fitting, optimal control)		6		
5	Nonlinear programming (Reflux ratio optimization, consecutive reaction, reactor-separator recycle systems)		10		
6	Mixed integer linear programming (flowsheet optimization, supply chain optimization)		10		
7	Multi-objective optimization (design and operation of chemical processes)		8		
List of Text Books/ Reference Books					
1	Floudas, C.A. Nonlinear and mixed-integer optimization: Fundamentals and applications				
2	Vanderbei, R.J. Linear programming: Foundations and extensions				
3	Collette, Y. and Siarry, P. Multi-objective optimization				
Course Outcomes (students will be able to…..)					
1	Formulate a Chemical Engineering problem into an optimization problem				
2	Solve (analytically or numerically) optimization problems encountered in Chemical Engineering Applications				

	Course Code: CEP 1708	Course Title: Project 1: Seminar	Credits = 2		
			L	T	P
	Semester: VII	Total contact hours: 60	0	0	4
List of Prerequisite Courses					
	All Courses				
List of Courses where this course will be prerequisite					
	Home paper 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)		**Reqd. 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. Weight age 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.				
List of Text Books/ Reference Books					
Course Outcomes (students will be able to…..)					
1	Collect literature on a given topic				
2	Classify the collected literature into various categories.				
3	Summarize and write a few paragraph on each paper				
4	Compare the information content given in different papers				
5	Analyze a particular paper based on principle of Chemical Engineering				
6	Write a report based on his / her work				

	Course Code: CEP 1709	Course Title: Project 2: Home Paper – I	Credits = 2		
			L	T	P
	Semester: VII	Total contact hours: 60	0	0	4
List of Prerequisite Courses					
	All				
List of Courses where this course will be prerequisite					
	Home Paper II				
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)		**Reqd. hours**		
1	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.				
List of Text Books/ Reference Books					
Course Outcomes (students will be able to…..)					
1	Identify market requirement related to a particular chemical				
2	Draw a process block diagram from a given process description.				
3	Select a site for the project				
4	Develop a PFD based on block diagram				
5	Do material and energy for all the equipment in PFD.				

SEMESTER – VIII									
No.	**Subjects**	**Credits**	**Hrs /week**			**Marks for various Exams**			
			L	**T**	**P**	**C. A.**	**M. S.**	**E. S.**	**Total**
HUT 1114	Principles of Management – I*	3	2	1	0	10	15	25	50
HUT 1115	Principles of Management – II*	3	2	1	0	10	15	25	50
CET 1515	Innovations in Chemical Engineering and Technology	3	2	1	0	10	15	25	50
MAT 1106	Design & Analysis of Experiments	4	2	2	0	10	15	25	50
	Elective (Outside Chem.Engg.Dept. GET/CHT/PYT/MAT)	3	2	1	0	10	15	25	50
	Open Elective from MOOC-I**	3	2	1	0	10	15	25	50
	Institute Elective – III	3	2	1	0	10	15	25	50
GEP 1112	Equipment Design and Drawing -II	2	2	0	4	25	---	25	50
CEP 1711	Project 3: Home Paper – II	3	0	0	6	50	---	100	150
	Total	20	12	5	10				450

*** This courses may be offered in the usual classroom mode or online mode as an NPTEL / Swayam course. The Equivalent NPTEL course will be identified by the Department every year.**

**** Students can choose a subject from reputed online platforms like NPTEL, Coursera, Edx, MIT OpenCourseWare, etc. The course can be from any discipline: Engineering and Technology, Humanities, Arts. The course would need to be pre-approved by the Department every year. The Department may also offer specialized courses taught by experts in an online mode.**

	Course Code: HUT 1114	**Course Title: Principles of Management - I**	**Credits = 3**		
			L	**T**	**P**
	Semester: VIII	**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					
This course is essential for effective functioning of students in their professional career					
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	**Introduction and overview**		01		
2	**Management Theories** Taylor,Fayol,Weber, Hawthorne Basic types of sturtcures Span of control,Delegation, Authority, Responsibility		04		
3	**Recruitment** Philosophies Different methods of attracting candidates		03		
4	**Selection** Application blanks Interviews Talent Management Induction		02		
5	**Performance Management** Goal Setting Process Appraisal Methods Appraisal Interview Rating Errors		03		
6	**Training & Development** Identifying Training Needs Training Methods (On the Job & Off the Job) Evaluation of Training		03		
7	**Change Management** Types of Change Theories of Change		03		

	Hurdles to Change Olmosk Strategies of Change	
8	**Knowledge Management** Importance, Benefits Frame work Innovation	03
9	**Motivation Theories** Need Drive Goal Cycle Classification of Motives Theories (Maslow, Herzberg, ERG, Vroom, Equity, 4 Drive Model)	04
10	**Leadership Theories** Blake Mouton Model Hersey Blanchard Model Michigan Model	03
11	**Organizational Culture** Types Understanding & Influencing	03
12	**Conflict Management**	03
13	**Power & Politics**	03
14	**Personality**	03
15	**Perception**	02
16	**HR Laws**	02
List of Text Books/ Reference Books		
	Talent management	
	Innovation and Entrepreneurship, Peter Drucker	
	Essentials of Organizational Behavior, S. Robbins	
	Organizational Behaviour, Luthans F	
	Industrial Management, Spriegel U.S.	
	Select Harvard Business Review Articles & Cases	
Course Outcomes (students will be able to…..)		
1	Students should be able to explain the fundamental concepts of Human Resources Management	
2	Will enable students to understand self and others and thus adapt to Organizational Environment	
3	Will enable students to understand various Management theories and the Organizational Setup	
4	Students should be able to analyze practical situations and be able to provide applicable solutions.	

	Course Code: HUT 1115	Course Title: Principles of Management - II	Credits = 3		
			L	T	P
	Semester: VIII	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					
This course is essential for effective functioning of students in their professional career					

	Course Contents (Topics and subtopics)	Reqd. hours
1	**Organizational Structures** Greiner's Model of Organizational Life Cycle Organic & Mechanistic Structures	03
2	**Marketing Management** Introduction Porter's Value Chain Porter's Five Forces Model Porter's Generic Strategies	03
3	**Four Ps of Marketing** Product Place Price Promotion	07
4	**Production Operations Management**: Production Management Modern Approach, Manufacturing systems, Interface Management. Manufacturing / Operations Strategy – Principles & concept Operations as competitive weapon -- Investment strategy, Capacity strategy, Quality strategy, Technology strategy, Customer focus strategy, Facility location strategy, Product flexibility strategy, Short delivery process strategy, Quick time delivery strategy. Concepts of Productivity, Measurement & Improvement Lean Manufacturing, Value Engineering, Business Process Re-engineering. World Class Manufacturing (WCM) - Principles & concepts, Systems, Processes & tools in WCM, Kanban JIT, Waste identification & elimination Poka Yoke system EHSS management in WCM, HR Dimensions in WCM, WCM in reference to Indian industry and Indian scenario, Maintenance practices	08
5	**Financial Management:** Investment decisions, Linking investment to Product Life Cycle Investment risk analysis and risk control / mitigation Accounting system, Step costing diagram Balance sheet evaluation, Fund Flow analysis, Financial ratios & their evaluation / significance, Cost control by variable analysis Comparable Company evaluation, Budgeting and budgetary control.	10
6	**Quality Management:** Quality – concept / meaning, Modern approach to Quality Management, QA versus QC, Acceptance sampling and statistical quality control, Deming's 14 points of QM, TQM Principles & implementation, ISO 9000–2000, ISO 14000 (Environment) & ISO 50000 (Energy) quality standards.	05
7	**Maintenance Management:** Causes, costs, life profiles, Classifications, Organization, Equipment & plant reliability and availability, Management of shutdowns & turnarounds.	05

8	**Materials Management**: Definition, objectives, organization, stages, factors responsible, value analysis Management of project materials and maintenance materials Purchasing and vendor development, Spares strategy Ware-housing, store-keeping and inventory control.	04
	List of Text Books/ Reference Books	
	Production & Operations Management – An Applied Modern Approach, J. S. Martinich	
	Industrial Management – I, Jhamb L. C. and Jhamb S.	
	Industrial Management, Spriegel U.S.	
	Operations Management for Competitive Advantage, Richard B. Chase, F. Robert Jacobs, Nicholas Acquilano	
	World Class Manufacturing - A strategic Perspective, B.S. Sahay, K.B.C. Saxena A Kumar	
	Management Finance, Varanasay Murthy	
	Financial Management, R. M. Srivastava	
	Quality, John M. Nicholas	
	Quality Planning and Analysis, Juran and Gryna	
	Marketing Management, Philip Kotler	
	Select Harvard Business Review Articles & Cases	
	Course Outcomes (students will be able to…..)	
1	Students should be able to explain the fundamental concepts of Marketing Management& the various aspects therein	
2	Will enable students to understand Fundamental Concepts of Finance and analyse the balance sheet	
3	Will enable students to understand current productivity techniques which could be combined with Engineering knowledge to be applied in the Industry	
4	Students should be able to analyze practical situations and be able to provide applicable solutions.	

	Course Code: CET 1515	Course Title: Innovations in Chemical Engineering and Technology	Credits = 3		
			L	T	P
	Semester:	Total contact hours: 30 Lecture hours + 15 Tutorials	2	1	0

List of Prerequisite Courses

	Organic Chemistry, Applied Physics, Reaction Engineering, Multiphase reactors, Industrial Engineering & Chemistry, Environmental Engineering, Separation Processes, Chemical Engineering Operations, Process Engineering	

List of Courses where this course will be prerequisite

	This is an important course highlighting the innovations in Chemical Technology and should serve as a specialized course for final year graduating students.	

Description of relevance of this course

Innovations play a crucial role while moving up the learning curve of technology attractiveness. Some innovations are game changing and revolutionary, e.g., Haber process, nuclear fission, transistor effect, Ziegler-Natta catalysis, in vitro fertilization, etc. and have been awarded Nobel prizes. The original Nobel lectures (5-6) delivered by the people behind the innovations will comprise a part of the course material to understand their motivation, prevailing circumstances, the conception of ideas/serendipity, approach to problem solving, personality traits, and conducive factors that led to success.

While many innovations require deep fundamental knowledge and correlation of complex observations, there are many that originate from "street smart" thinking, observation of natural phenomena, shifting of knowledge across boundaries, etc. Then there are innovations that emanate from integration of known observations to derive synergy. About 15-20 such case studies will be covered in the course and original patents will serve as course material. It will be the intention to convey to the students that such inventions are within their reach if they can articulate genuine needs and think unconventionally. It will be emphasised that focus on sustainable development will provide impetus to future innovations in chemical technology. A few lectures will be devoted to Indian innovations, including important innovations from ICT.

The third part of the course will deal with protection of intellectual property, pros and cons of patenting, drafting of a patent application – patent claims in particular – responding to examination reports. Case studies of important patent disputes will also be covered.

	Course Contents (Topics and subtopics)	Reqd. Lecture Hours
1	Basic of Innovations with case studies such as e.g., Haber process, β blockers, nuclear fission, transistor effect, Ziegler-Natta catalysis, in vitro fertilization, asymmetric synthesis, olefin metathesis, photovoltaic cell, optical fibre, etc.,	6
2	Overview of Noble Lectures related to innovation to understand Noble laureates' motivation, prevailing circumstances, the conception of ideas/serendipity, approach to problem solving, personality traits, and conducive factors that led to success.	9
3	Overview of Case studies based on patents highlighting the different concepts in innovation and TRIZ methodology introduced by Soviet inventor and science-fiction author Genrich Altshuller will be discussed	9
4	Overview of Patents and IP protection pros and cons of patenting, drafting of a patent application – patent claims in particular – and responding to examination reports.	6
5	Group Assignments, short review projects related to the above topics will be given in the tutorial hours	15

List of Text Books/ References

	Innovation and Entrepreneurship, by Peter Drucker
	Original patents
	Nobel lectures
	Case studies (Losartan Case study, etc.)

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

1	Students should be inspired to work on the most worthy problems and think innovatively
2	Inculcate the personality traits that will foster innovation
3	Recognise that there is more to innovation than having a good idea if one wants to take the idea to its logical conclusion
4	Have an appreciation of IPR protection

	Course Code: MAT 1106	Course Title: Design and Analysis of Experiments	Credits =4		
			L	T	P
	Semester: VIII	Total contact hours: 60	2	2	0
List of Prerequisite Courses					
	Applied Mathematics I				
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. This course is in Semester VIII				
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)		**Reqd. hours**		
1	Fundamental principles of classical design of experiments Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments.		2		
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.		4		
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		8		
4	Factorial designs: Definition, Estimating model parameters, Fitting response curves and surfaces.		4		
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.		8		
6	Plackett Burman methods, Central Composite Design (CCD)		4		
7	Descriptive Statistics, Probability Distribution and testing of Hypothesis using R		6		
8	Regression techniques, diagnostic checks, ANOVA using R and implementation of contrasts.		6		
9	Construction of Balanced Incomplete Block Designs and data analysis using R		6		
10	Analysis of factorial designs using R, understanding output and interpretation.		6		
11	Factorial designs, Data analysis and interpretation.		6		
List of Text Books / 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…..)		
1	Students should be able to understand basic principles of design of experiments.	
2	Students should be able to perform statistical analysis of single experiments and do post hoc analysis.	
3	Students should be able to conduct experiment and analyse the data using statistical methods.	
4	Students should be able to choose an appropriate design given the research problem.	
5	Students should be able to perform statistical analysis of different designs using R and interpret the results.	

	Course Code: CEP 1711	Course Title: Project 3: Home Paper – II	Credits = 3		
			L	T	P
	Semester: VIII	Total contact hours: 90	0	0	6
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)		**Reqd. 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				
List of Text Books/ Reference Books					
Course Outcomes (students will be able to…..)					
1	Students should be able to design, calculate size/power/internals, etc required for all the process equipment in the PFD together with necessary instrumentation, safety aspects.				
2	Students should be able to calculate costs of equipment				
3	Students should be able to perform a techno economic feasibility of the selected process.				

ELECTIVE SUBJECTS

The elective subjects may be added from time to time with prior approval from UGPC/Senate.

1. **PYT 1104E – Molecular Quantum Mechanics (Applied Physics Department)**

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 H_2^+ ion and H_2 molecule, valence bond method

2. **PYT 1105E – Statistical Mechanics (Applied Physics Department)**

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.

3. **CHT 1403E – Advanced Spectroscopy (Applied Chemistry Department)**

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

4. **CHT 1205E – Organometallic Chemsitry (Applied Chemistry Department)**

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

5. **CHT 1206E – Green Chemistry & Catalysis (Applied Chemistry Department)**

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.

6. **CHT 1303 – Theoretical and Computational Chemistry (Applied Chemistry Department)**

Basics: 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.

7. **MAT 1107E – Momentum, Heat and Mass Transfer (Applied Mathematics Department)**

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).

8. **MAT 1108E – Turbulent Flow and CFD (Applied Mathematics Department)**

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)

9. **GET 1303E – Advanced Strength of Materials (General Engineering Department)**

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.

10. **HUT 1105E – Industrial Economics (Humanities)**

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

11. **CET 1506E – Engineering Aspects of Manufacturers of Organic Chemicals (Chemical Engineering Department)**

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.

12. **CET 1204E – Electrochemical Engineering (Chemical Engineering Department)**

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.

13. **CET 1712E – Mathematical Methods in Chemical Engineering (Chemical Engineering Department)**

Classification of problems in Chemical Engineering. Typical problems from heat transfer, catalysis, mass transfer with chemical reaction, dynamics of process equipments, etc. Numerical evaluation of Laplace Transforms.

Separation of variables, Eigen values, Collocation Techniques.

14. **CET 1713E – Statistical Methods in Engineering (Chemical Engineering Department)**

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.

15. **CET 1103E – Heat Transfer Equipment Design (Chemical Engineering Department)**

Classification of Heat Transfer Equipment, direct, indirect, boiling, fired, Fluidised, geometry, construction.

Thermal design methods of heat exchangers : survey, capital NTU, LMTD concept, temperature approach, etc.

Shell and Tube heat exchangers : thermal, mechanical design, hydraulic design and equations, introduction to codes and standards

Extended surface heat exchanger design : plates, plate fins, effectiveness factor.

Heat transfer equipment with phase change, two phase flow maps, and design of equipments for heat transfer and pressure drop.

Fluidised bed and direct heat exchangers design methodology.

Synthesis of optimal heat exchanger networks.

Worked Examples

16. **CET 1205E – Mixing (Chemical Engineering Department)**

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

17. **CET 1507E – Petroleum Reservoir Engineering (Chemical Engineering Department)**

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

18. **CET 1508 – Enhanced Oil Recovery (Chemical Engineering Department)**

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

19. **CET 1104E – Flow Though Porous Media (Chemical Engineering Department)**

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

20. **CET 1509E – Refinery Science and Engineering (Chemical Engineering Department)**

Terminology, Origin, Kerogen, Occurrence, Recovery, Classification, Composition, Evaluation, Fractionation, Identification, Asphaltic constituents, Refining chemistry, Refining distillation, Thermal cracking, Catalytic cracking, Hydroprocessing, Reforming, Treatment processes, Gas cleaning, Products, Petrochemicals

21. **CET 1206E – Fundamentals of Catalytic Science and Engineering (Chemical Engineering Department)**

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

22. **CET 1207E – Homogeneous Catalysis (Chemical Engineering Department)**

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

23. **CET 1208E – Catalytic Green Science and Technology (Chemical Engineering Department)**

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

24. **CET 1602E – Colloid and Interfacial Science (Chemical Engineering Department)**

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

25. **CET 1603E – Interfacial Science and Engineering (Chemical Engineering Department)**

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.

26. **CET 1403E – Adsorptive Separations (Chemical Engineering Department)**

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

27. **CET 1209E – Advanced Biochemical Engineering (Chemical Engineering Department)**

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

28. **CET 1404E – Downstream Processing in Biochemical Industry (Chemical Engineering Department)**

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.

29. **CET 1405E – Advanced Separation Processes**

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

30. **CET 1210E – Introduction to Polymer Engineering (Chemical Engineering Department)**

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.

31. **CET 1604E – Polymer Processing (Chemical Engineering Department)**

Plastic Technology : Moulding, (injection, blow) extrusion, cold-not and vacuum forming multipolymer systems. Equipments design and operating conditions

Fibre Technology : Textile processing, fibre spinning and after treatment. Equipments design and operating conditions

Elastomer Technology : Vulcanisation, Reinforcement compounding

Equipments- 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

32. **CET 1211E – Polymer Reactor Engineering (Chemical Engineering Department)**

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.

33. **CET 1605E – Advanced topics in Polymer Chemistry/Physics Characterisation/Analysis of Polymers (Chemical Engineering Department)**

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.

34. **CET 1510E – Fuels Engineering (Chemical Engineering Department)**

Classification of fuels : G/L/S

Automotive Fuels Bharat Standards II III & IV

Gaseous Fuels:

Natural Gas: Processing for pipe line specs

$CO_2/H_2S/COS$ 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 i) Coal, Indian Coal

ii) Biomass

iii)Refinery Heavy Residue

Power generation, combined cycle, cogeneration

35. **CET 1511E – Plant Utilities (Chemical Engineering Department)**

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

36. **CET 1512E – Project Management: Case Study Approach (Chemical Engineering Department)**

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.

37. **CET 1606E – Advanced Materials (Chemical Engineering Department)**

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.

38. **CET 1513E – Process Systems Engineering (Chemical Engineering Department)**

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

39. **CET 1106 – CFD applications in chemical processes (Chemical Engineering Department)**

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.
Suggested Books:
Versteeg and malalasekera, "An introduction to computational fluid dynamics. The finite volume method", (2007)
Patankar S., "Numerical heat transfer and fluid flow", (1980)

40. **CET 1407 – Process Design of Heat and Mass Transfer Equipment**

(3 Credits: 2 Lectures + 1 Tutorial – 3 hours per week, 45 hrs total)
Advanced Process design aspects of various process equipments 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.

41. **CET 1408 Advanced Membrane Separations**

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
Text books:
Mulder, M.H.V. Membrane Separations, Springer.
Philip, R., Wankat, C. Rate-Based Separations, Springer.
Reference books:
Nunes, S.P., Peinemann, K.V. Membrane Technology in the Chemical Industry, Wiley.
Rautanbach and R. Albrecht, Membrane Processes, Wiley.
Crespo, J.G., Bodekes, K.W. Membrane Processes in Separation and Purification, Kluwer Academic Publications.
Geankoplis, C.J. Transport Processes and Unit Operations, Prentice-Hall.

42. **CET 1607 Biomaterials: Biodegradable Materials for Biomedical Applications**

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
Text Books:
Ratner, Buddy D., et al. Biomaterials Science: An Introduction to Materials in Medicine. 2nd ed. Burlington, MA: Academic Press, 2004. ISBN: 9780125824637.

43. Elective: Machine Learning

	Machine Learning	
	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	8
	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.	9
	Decision Trees, Bagging and Boosting, Random Forests, Gradient Boosting, Artificial Neural Network	12

	Classification problem: Logistic Regression, Support Vector Machines, Receiver operating characteristic (ROC) curves, Area under the curve (AUC) and other related accuracy measures	8
	Multivariate methods: Principal Component Analysis, Factor Analysis, Principal component regression, K-means clustering, Hierarchical Clustering, Multi-dimensional scaling	8
	Software used: R/Python/MATLAB	

Course Outcomes (CO)

(1) Students should be able to understand advantages of machine learning algorithms.
(2) Students should be able to apply machine learning techniques to solve regression problems involving real data.
(3) Students should be able to apply machine learning techniques to solve classification problems involving real data.
(4) Students should be able to apply dimension reduction methods to solve problems involving real data.
(5) Student should be able to use software to build machine learning models and interpret the results.

References:

1. Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python: David Barber A Guide for Data Scientists, (2016), O'Reilly Media.
2. Hands on Machine Learning with R by Bradley Boehmke and Brandon Greenwell, CRC Press, 2020.
3. Introduction to Statistical Learning with Application in R by James, G., Witten, D., Hastie, T. and Tibshirani, R, 2011.
4. All of Statistics: A concise course on Statistical Inference by Larry Wasserman, 2009.
5. The Elements of Statistical Learning by Jerome H. Friedman, Robert Tibshirani, and Trevor Hastie (2001), Springer.
6. Ethem Alpaydin, Introduction to Machine Learning by (2004), The MIT Press, Cambridge.
7. Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques by (2011), Elsevier
8. Machine Learning: A Probabilistic Perspective (Adaptive Computation and Machine Learning series) by Kevin P. Murphy (2012)

44. Elective (Optimization Techniques) (3 credits)

Topics	No. of hrs.
Review of local maximum/minimum	2
Method of Lagrange Multipliers and KKT methods	6
One dimensional Optimization Techniques: Fibonacci search method, Golden section method and interpolation method.	4
Direct Search unconstrained optimization: Powell's method, Nelder-Mead (simplex) method	6
Gradient Search Optimization Methods: Steepest Descent Method, Newton's Method, Conjugate gradient methods	10
Linear Programming: Simplex Method, Revised Simplex Method and other Advanced Methods, Integer Programming	12
Modern Optimization Techniques; Genetic Algorithms, Simulated Annealing, Ant Colony Optimization	5

COURSE OUTCOMES (CO)

(1) Students should be able to understand classical optimization techniques and their numerical implementation.
(2) Students should be able to solve the engineering problems related to maxima and minima in the optimization framework.
(3) Students should be able to apply different methods of linear programming to solve optimization problems.
(4) Students should be able to apply modern optimization techniques to solve engineering problems.

Reference:

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