GURU GOBIND SINGH
INDRAPRASTHA
UNIVERSITY

Duration – 4 Years (Full time)

Program Scheme and Syllabus
Applicable to

Chemical Engineering

CHOICE BASED CREDIT SYSTEM

Effective from 2021-22

UNIVERSITY SCHOOL OF CHEMICAL TECHNOLOGY
GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY
SECTOR-16C, DWARKA, NEW DELHI-110078

 Approved in the 52nd AC meeting held on 22.02.2022 vide agenda item AC52.04

Guru Gobind Singh Indraprastha University

Vision

The University will stimulate both the hearts and minds of scholars, empower them to contribute to the welfare of society at large; train them to adopt themselves to the changing needs of the economy; advocate them for cultural leadership to ensure peace, harmony and prosperity for all.

Mission

Guru Gobind Singh Indraprastha University shall strive hard to provide a market oriented professional education to the student community of India in general and of Delhi in particular, with a view to serving the cause of higher education as well as to meet the needs of the Indian industries by promoting establishment of colleges and Schools of Studies as Centres of Excellence in emerging areas of education with focus on professional education in disciplines of engineering, technology, medicine, education, pharmacy, nursing, law, etc.

Quality Policy

Guru Gobind Singh Indraprastha University is committed to providing professional education with thrust on creativity, innovation, continuous change and motivating environment for knowledge creation and dissemination through its effective quality management system.‖ Rules & Regulations University administration functions while dealing with various issues of administrative and academic significance, within the provisions of the University Act, rules and regulations (Statutes & Ordinances) framed there under.

University School of Chemical Technology

The University School of Chemical Technology recognizes the importance of chemical industry and the need for trained manpower, since establishment of the University in 1999, THE UNIVERSITY has taken the bold and visionary decision to start the University School of Chemical Technology, the only one of its kind in this part of the country after IIT, DELHI. The founding fathers concerned with education required in chemical industry showed extraordinary vision 100 years ago to recognise that education to provide trained manpower could be provided under two broad areas namely Unit Operations and Unit Processes. This framework still holds although it has evolved, expanded and continuously tuned over the last 10 decades to progressively include thermodynamics, reaction engineering, process control, process economics, mathematical and numerical methods, computers, process engineering, separation processes, catalysis hazard and safety etc. each one advancing in its own right with extensive research work both in academia and in industry. The Schoolwas established with the twin objectives of generating effective trained professionals and to keep pace with the R & D activities of this fast-changing field of Chemical Technology. The B.Tech. and M.Tech. (Chemical and Biochemical) programme being offered by the school are based on the pattern of I.I.T.'s and other national and international institutions of repute. The well-structured programmes are meant to impart comprehensive knowledge of various core chemical and biochemical engineering subjects, interdisciplinary courses in Biotechnology, Information Technology, Environment Management, Management Studies through Electives, and industrial exposure through practical training in laboratories and Industrial Units.

Vision

Achieving excellence through active teaching, skill development and research in the areas of chemical and biochemical engineering and allied areas to become a recognized centre for education and research.

Mission

To generate new knowledge by offering graduate and post graduate programme and provide quality manpower with high employment potential in the present liberalised economic climate in the era of globalization.

- To generate new knowledge by offering graduate and post graduate programme.
- Impart quality teaching and train students in addressing the challenges in the Chemical and Biochemical Engineering and allied areas.
- Provide quality manpower with high employment to achieve proficiency in Chemical and Biochemical Engineering through innovative teaching and state of the art laboratories.
- Develop inclusive technologies with a focus on sustainability.
- Team up with industries and research institutes to cater community needs.

Programme Educational Objectives:

The Programme Educational Objectives of Chemical Engineering Programme are:

1. To produce graduates with strong foundation in mathematics, sciences and engineering that will enable them to identify and pursue their personal and professional goals.

2. To produce graduates with strong knowledge in the principles of chemical engineering and professional skills that will enable them to have successful career in chemical and allied industries, government, academic or other organizations.

To prepare graduates having team work spirit, good communication skill and strong sense of humanistic values so that they can perform their assigned duties for current and future societal/technological needs with the responsibility, ethics and ability to assume professional leadership roles.

Programme outcomes (POs)

On successful completion of the B.Tech. in Chemical Engineering from University School of Chemical Technology, G.G.S. Indraprastha University, the graduates will be able to:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme specific outcomes (PSOs):

PSO1. Identify, analyze and solve complex problems encountered in chemical and other allied industries, by applying the principles of chemical engineering and using modern engineering tools such as ASPEN PLUS, MATLAB, ANSYS, DESIGN-EXPERT etc.

PSO2. Design and optimize the chemical process engineering systems, chemical plants and chemical products considering public health, safety and welfare, as well as global, social, environmental and economic aspects.

PSO3. Play an important role in the diversified area of chemical engineering (Industries, Academia and R&D) and professional environmental, and able to carry out multidisciplinary research in the field of environmental engineering, biochemical engineering, nano-science and technology, and material engineering etc.

PSO4. Prepare students with high scholastic attainment to enter graduate programs leading to innovative degrees in chemical engineering or in related professional, scientific, and engineering fields.

Acronyms

BCE:	Biochemical Engineering
BS:	Basic Science
C:	Number of credits assigned to a course / paper
CE:	Chemical Engineering
EAE:	Emerging Area Elective offered by school
ES:	Engineering Science
HS:	Humanities, social science, management
L:	Number of Lecture hours per week
MC:	Mandatory courses
NUES:	An evaluation scheme in which evaluation is conducted by a committee, a teacher or a group of teachers as described in the scheme of study.
OAE:	Open area elective offered by other school or open / emerging area elective offered by the school. This allows the student to have two minor specializations also.
PC:	Programme Core, that is course / paper offered in the discipline of the programme as a compulsory paper.
PCE:	Programme Core Elective, that is elective course / paper offered in the discipline of the programme.
T/ P:	Number of Tutorial / Practical Hours per week

Marking Scheme of Examination

For Theory

1. Teachers Continuous Evaluation: 40 marks
2. Term end Theory Examinations: 60 marks

For Practical/Viva

1. Teachers Continuous Evaluation: 40 marks
2. End Term Practical/Viva: 60 marks

Credit Distribution

Group	Semester (Credits)								Total Credits
	I	II	III	IV	V	VI	VII	VIII	
BS	12	20	3						35
HS	5	4	2			4			15
ES	12	5							17
MS					2				2
PC			23	28	16	8	12	12	102
PCE					4	2	2		8
EAE					4	6	6		16
OAE					4	8	8		20
Total	**29**	**29**	**28**	**28**	**30**	**28**	**28**	**12**	**215**

Note:
Student must earn minimum 200 credits for the Award of B.Tech. Degree. However, Student has to appear in all the courses as per scheme and can drop credits from elective courses only.

Student can obtain degree in Major discipline only, and may opt Minor degree specialization along with Major discipline of Chemical Engineering. In the later case, student should pass all the courses listed under corresponding Minor degree specialization.

FIRST SEMESTER

Group	Code	Paper	L	T/P	Credits
Theory Papers					
ES	ICT 101	Programming for Problem Solving	3	-	3
ES	ICT 103	Electrical Science	3	-	3
ES	ICT 105	Engineering Mechanics	3	-	3
HS	HS 107	Communication Skills-I	3	-	3
BS	BS 109	Engineering Chemistry – I	3	-	3
BS	BS 111	Engineering Mathematics – I	4	-	4
BS	BS 113	Engineering Physics – I	3	-	3
HS/MC	LLB 115*	Indian Constitution	2	-	2
Practical/Viva Voce					
ES	ICT 151	Programming for Problem Solving Lab	-	2	1
ES	ICT 153	Engineering Graphics-I	-	2	1
ES	ICT 155	Electrical Science Lab	-	2	1
BS	BS 157	Engineering Chemistry-I Lab	-	2	1
BS	BS 159	Engineering Physics - I Lab	-	2	1
Total			**24**	**10**	**29**

***NUES: Comprehensive evaluation will be done by the teacher concerned out of total 100 marks. No end term examination shall be held.**

SECOND SEMESTER

Group	Paper Code	Paper	L	T/P	Credits
Theory Papers					
ES	BS 118	Industrial Chemistry	3	-	3
HS	HS 102	Communication Skills – II	3	-	3
BS	BS 104	Engineering Chemistry – II	3	-	3
BS	BS 106	Engineering Mathematics - II	4	-	4
BS	BS 108	Engineering Physics-II	3	-	3
BS	BS 110	Probability and Statistics for Engineers	3	2	4
HS/MC	ICT 114*	Human Values and Ethics	1	-	1
BS/MC	EMES 112	Environmental Studies	4	-	4
Practical/Viva Voce					
ES	ICT 152	Engineering Graphics-II Lab	-	2	1
BS	BS 156	Engineering Chemistry – II Lab	-	2	1
BS	BS 158	Engineering Physics –II Lab	-	2	1
One paper from the following#:					
ES	ICT 154	Workshop Technology	-	2	1
ES	ICT 160	Programming in Python	-	2	
Total			**24**	**10**	**29**

***NUES: Comprehensive evaluation will be done by the teacher concerned out of total 100 marks. No end term examination shall be held.**

THIRD SEMESTER

Theory Papers					
Group	**Paper Code**	**Paper**	**L**	**T/P**	**Credits**
BS	BS 211	Material Science	3	-	3
PC	CT 201	Process Calculations	3	1	4
PC	CT 203	Fluid Mechanics	3	1	4
PC	CT 205	Mechanical Operation	3	1	4
PC	CT 207	Transport Phenomena	3	1	4
PC	CT 209	Engineering Thermodynamics	3	-	3
HS	HS 211	Engineering Economics	2	-	2
Practical/Viva Voce					
PC	CT 261	Mechanical Operation Lab	-	3	2
PC	CT 263	Fluid Mechanics Lab	-	3	2
Total			**20**	**10**	**28**

FOUTRH SEMESTER

Theory Papers					
Group	**Paper Code**	**Paper**	**L**	**T/P**	**Credits**
PC	CT 202	Mass Transfer I	3	1	4
PC	CT 204	Heat Transfer I	3	1	4
PC	CT 206	Chemical Reaction Engineering I	3	1	4
PC	CT 208	Chemical Engineering Thermodynamics	3	1	4
PC	CT 210	Chemical Process Control I	3	1	4
PC	CT 214	Process Industries	3	1	4
Practical/Viva Voce					
PC	CT 262	Chemical Reaction Eng. Lab	-	3	2
PC	CT 264	Instrumentation & Process Control Lab	-	3	2
Total			**18**	**12**	**28**

FIFTH SEMESTER

Theory Papers						
Group	**Paper Code**	**Paper**	**L**	**T/ P**	**Credits**	**Total Credits**
MS	MS 112	Entrepreneurship Mindset	2	-	2	2
PC	CT 301	Mass Transfer II	3	1	4	4
PC	CT 303	Heat Transfer II	3	1	4	4
PC	CT 305	Chemical Process Control II	3	0	3	3
PCE	CT 307	Chemical Reaction Engineering II	3	1	4	4
Emerging area electives (EAE1) (opt any one)						
Modeling and Simulation	CT 309	Introduction to Computational Fluid Dynamics	3	1	4	4
Biochemical Engineering	CT333	Molecular Biology	3	1	4	
Environmental Engineering	CT313	Environmental Biotechnology	3	1	4	
Open area electives (OAE1) (opt any one)						
OAE or MOOCs	CT315	Bioanalytical Techniques	3	1	4	4
	CT317	Water pollution and abatement	3	1	4	
	CT319	Alternative Energy Sources	3	1	4	
Practical/Viva Voce						
PC*	CT361	Summer Training /Summer Project*	-	-	1	1
PC	CT363	Heat Transfer Lab	-	3	2	2
PC	CT365	Mass Transfer Lab	-	3	2	2
Total			**20**	**11**	**30**	**30**

***NUES: Comprehensive evaluation will be done by the teacher concerned out of total 100 marks. No end term examination shall be held.**

SIXTH SEMESTER

Theory Papers						
Group	**Paper Code**	**Paper**	**L**	**T/ P**	**Credits**	**Total Credits**
HS	HS 302	Technical Writing	2	-	2	2
PC	CT 302	Introduction to Petroleum Refining & Petrochemicals	3	0	3	3
PC	CT 304	Computational Methods for Engineers	3	1	4	4
PCE	CT 306	Process Equipment Design I	1	1	2	2
Emerging area electives (EAE2) (opt any one)						
Modeling and Simulation	CT 308	Process Modeling and Simulation	3	1	4	4
Biochemical Engineering	CT 236	Microbiology	3	1	4	
Environmental Engineering	CT 310	Environmental Impact assessment	3	1	4	
Open area electives (OAE2 and OAE3) (opt any two)						
OAE or MOOCs	CT 312	Biosensor and Diagnostic Devices for Healthcare Applications	3	1	4	8
	CT 314	Statistical analysis of process data	3	1	4	
	CT 316	Industrial Microbiology	3	1	4	
	CT 318	Fundamental of Polymer Engineering	3	1	4	
	CT324	Energy and Water Audit for industries	3	1	4	
Practical/Viva Voce						
HS*	ICT352	NSS/NCC/Cultural clubs / TechnicalSociety/Technical club	-	-	2	2
PC	CT 362	Computational Lab	-	2	1	1
Emerging area electives (EAE3) (opt any one)						
Modeling and Simulation	CT 364	Modeling & Simulation Lab	-	3	2	2
Biochemical Engineering	CT 366	Biochemical Engineering Lab	-	3	2	
Environmental Biotechnology	CT 368	Environment Lab	-	3	2	
Total			**18**	**10**	**28**	**28**

SEVENTH SEMESTER

Theory Papers						
Group	**Paper Code**	**Paper**	**L**	**T/ P**	**Credits**	**Total Credits**
PC	CT 401	Process Engineering & Economics	3	0	3	3
PC	CT 403	Chemical Process Safety	3	1	4	4
PCE	CT405	Process Equipment Design II	1	1	2	2
Emerging area electives (EAE4) (opt any one)						
Modeling and Simulation	CT407	Mathematical Methods in Chemical Engineering	3	1	4	4
Biochemical Engineering	CT409	Biosafety, Hazards & IPR issues	3	1	4	
Environmental Engineering	CT411	Industrial Pollution and Waste Management	3	1	4	
Open area electives (OAE4 and OAE5) (opt any two)						
OAE or MOOCs	CT 413	Air Pollution Control Engineering	3	1	4	8
	CT 415	Upstream Processing for fermentation	3	1	4	
	CT 417	Applications of data Science and Machine Learning in Chemical Engineering	3	1	4	
	CT 419	Multiphase Reactor	3	1	4	
	CT421	Hydrogen and Fuel Cell	3	1	4	
Practical/Viva Voce						
PC	CT461	Minor Project	-	6	3	3
PC	CT463	Summer Training Viva[#*]	-	-	2	2
EAE	CT465	Seminar [**]	-	4	2	2
Total			**16**	**15**	**28**	**28**

[#]Training in chemical industry/research in laboratory for a period of 4-6 weeks in summer vacation.

***NUES: Comprehensive evaluation will be done by the teacher concerned out of total 100 marks. No end term examination shall be held.**

[**] Topic of seminar is subjected to minor area of specialization.

EIGHTH SEMESTER

Project/Internship					
Group	**Paper Code**	**Paper**	**L**	**T/P**	**Credits**
PC	CT462	Major Project/ Internship	**-**	**24**	**12**
Total			**0**	**24**	**12**

Detailed Syllabus of B.Tech in Chemical Engineering

FIRST SEMESTER

Group	Code	Paper	L	T/P	Credits
Theory Papers					
ES	ICT 101	Programming for Problem Solving	3	-	3
ES	ICT 103	Electrical Science	3	-	3
ES	ICT 105	Engineering Mechanics	3	-	3
HS	HS 107	Communication Skills-I	3	-	3
BS	BS 109	Engineering Chemistry – I	3	-	3
BS	BS 111	Engineering Mathematics – I	4	-	4
BS	BS 113	Engineering Physics – I	3	-	3
HS/MC	LLB 115*	Indian Constitution	2	-	2
Practical/Viva Voce					
ES	ICT 151	Programming for Problem Solving Lab	-	2	1
ES	ICT 153	Engineering Graphics-I	-	2	1
ES	ICT 155	Electrical Science Lab	-	2	1
BS	BS 157	Engineering Chemistry-I Lab	-	2	1
BS	BS 159	Engineering Physics - I Lab	-	2	1
Total			**24**	**10**	**29**

***NUES: Comprehensive evaluation will be done by the teacher concerned out of total 100 marks. No end term examination shall be held.**

Paper Code: ICT101	Paper: Programming for Problem Solving	L	T/P	C
Paper ID: 164101		3	-	3

Course Objectives:	
1:	To impart basic knowledge about simple algorithms for arithmetic and logical problems so that students can understand how to write a program, syntax and logical errors in 'C'.
2:	To impart knowledge about how to implement conditional branching, iteration and recursion in'C'.
3:	To impart knowledge about using arrays, pointers, files, union and structures to develop algorithms and programs in 'C'.
4:	To impart knowledge about how to approach for dividing a problem into sub-problems and solve the problem in 'C'.

Course Outcomes (CO):	
CO1:	Ability to develop simple algorithms for arithmetic and logical problems and implement them in'C'.
CO2:	Ability to implement conditional branching, iteration and recursion and functions in 'C'
CO3:	Ability to use arrays, pointers, union and structures to develop algorithms and programs in 'C'.
CO4:	Ability to decompose a problem into functions and synthesize a complete program using divide and conquer approach in 'C'.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High)

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	3	3	2	1	1	-	-	-	2	1	1	3
CO2	3	3	2	1	1	-	-	-	2	1	1	3
CO3	3	3	3	1	1	-	-	-	2	1	1	3
CO4	3	3	3	1	1	-	-	-	2	1	1	3

Unit I **[10Hrs]**

Introduction to Programming: Computer system, components of a computer system, computing environments, computer languages, creating and running programs, Preprocessor, Compilation process, role of linker, idea of invocation and execution of a programme. Algorithms: Representation using flowcharts, pseudocode.

Introduction to C language: History of C, basic structure of C programs, process of compiling and running a C program, C tokens, keywords, identifiers, constants, strings, special symbols, variables, data types, I/O statements. Interconversion of variables.

Operators and expressions: Operators, arithmetic, relational and logical, assignment operators, increment and decrement operators, bitwise and conditional operators, special operators, operator precedence and associativity, evaluation of expressions, type conversionsinexpressions.

Unit II[10Hrs]

Control structures: Decision statements; if and switch statement; Loop control statements: while, for and do while loops, jump statements, break, continue, goto statements.

Arrays: Concepts, One dimensional array, declaration and initialization of one dimensional arrays, two dimensional arrays, initialization and accessing, multi-dimensional arrays.

Functions: User defined and built-in Functions, storage classes, Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference, Recursion.

Strings: Arrays of characters, variable length character strings, inputting character strings, character library functions, stringhandlingfunctions. Unit III

Pointers: Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers,

functions returning pointers, Dynamic memory allocation. Pointers to functions. Pointers and Strings
Structures and unions: Structure definition, initialization, accessing structures, nested structures, arrays of structures, structures and functions, self-referential structures, unions, typedef, enumerations.
File handling: command line arguments, File modes, basic file operations read, write and append.
Scope and life of variables, multi-file programming.
C99 extensions. 'C' Standard Libraries: stdio.h, stdlib.h, assert.h, math.h, time.h, ctype.h, setjmp.h, string.h, stdarg.h,unistd.h

Unit IV[10Hrs]

Basic Algorithms: Finding Factorial, Fibonacci series, Searching, Basic Sorting Algorithms- Bubble sort, Insertion sort and Selection sort. Find the square root of a number, array order reversal, reversal of a string, two-way merge sort, stacks, queues, single –link linked list, Binarysearchtree.

Textbooks:

1. *How to solve it by Computer* by R. G. Dromey, Prentice-Hall India EEE Series,1982.
2. *The C programming language* by B W Kernighan and D M Ritchie, Pearson Education,1988.

References:

1. *Programming Logic & Design* by Tony Gaddis, Pearson, 2nd Ed.2016.
2. *Programming Logic and Design* by Joyce Farrell, Cengage Learning,2015.
3. *Engineering Problem Solving With C* by Delores M. Etter, Pearson,2013.
4. *Problem Solving and Program Design in C* by Jeri R. Hanly and Elliot B. Koffman, Pearson,2016.
5. *Structure and Interpretation of Computer Programs* by Harold Abelson and Gerald Sussman with Julie Sussman, MIT Press,1985.
6. *How to Design Programs* by Matthias Felleisen, Robert Bruce Findler, Matthew Flatt, and Shriram Krishnamurthi, MIT Press,2018.
7. *ANSI/ISO 9899-1990, American National Standard for Programming Languages 'C'* by American National Standards Institute, Information Technology Industry Council, 1990(C89).
8. *ISO/IEC 9899:1999. International Standard for Programming Languages – C (ISO/IEC 9899)* by American National Standards Institute, Information Technology Industry Council, 2000(C99).
9. *INCITS/ISO/IEC 9899-2011.American National Standard for Programming Languages 'C'*by American National Standards Institute, Information Technology Industry Council, 2012(C11).

Paper Code: ICT103	Paper: Electrical Science	L	T/P	C
Paper ID: 164103		3	-	3

Course Objectives:	
1:	To impart knowledge of the basics electrical engineering.
2:	To impart knowledge of the working of RLC circuits.
3:	To impart basic knowledge about filters and magnetic circuits.
4:	To impart basic knowledge about electrical machines.

Course Outcomes (CO):	
CO1:	Ability to understand and use Kirchhoff's Laws to solve resistive circuit problems.
CO2:	Ability to analyze resistive, inductive and capacitive circuits for transient and steady state sinusoidal solutions.
CO3:	Understand the first order filters and magnetic circuits.
CO4:	Understand the design of electrical machines.

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High)

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	3	3	3	3	3	-	-	-	1	1	1	2
CO2	3	3	3	3	3	-	-	-	1	1	1	2
CO3	3	3	3	3	3	-	-	-	1	1	1	2
CO4	3	3	3	3	3	-	-	-	1	1	1	2

Unit – I **[10Hrs]**

DC Circuits: Passive circuit components, Basic laws of Electrical Engineering, Temperature Resistance Coefficients. voltage and current sources, Series and parallel circuits, power and energy, Kirchhoff's Laws, Nodal & Mesh Analysis, delta-star transformation, superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem. Time domain analysis of first Order RC & LC circuits.

Unit – II[10Hrs]

AC Circuits: Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three phase balanced circuits, voltage and current relations in star and delta connections.

Unit - III[10Hrs]

D. C. Generators & Motors: Principle of operation of Generators & Motors, Speed Control of shunt motors, Flux control, Rheostatic control, voltage control, Speed control of series motors.

A. C. Generators & Motors: Principle of operation, Revolving Magnetic field, Squirrel cage and phase wound rotor, Starting of Induction motors, Direct on line and Star Delta starters, Synchronous machines.

Unit - IV:[10Hrs]

Transformers: Construction and principle of operation, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.

Measuring Instruments: Electromagnetism, Different Torques in Indicating instruments, Moving Iron Instruments: Construction & Principle, Attraction and Repulsion type; Moving Coil instruments: Permanent Magnet type; Dynamometer type Instruments.

Textbooks:

1. *Electrical Engineering Fundamentals* by Vincent Del Toro, PHI (India), 1989

References:

1. *An Introduction to Electrical Science* by Adrian Waygood, Routledge, 2nd Ed.2019.
2. *Electrical Circuit Theory and Technology* by John Bird, Elsevier,2007.
3. *Principles and Applications of Electrical Engineering* by Giorgio Rizzoni, MacGraw-Hill,2007.
4. *Electrical Engineering* by Allan R. Hambley, Prentice-Hall,2011.
5. *Hughes Electical& Electronic Technology* by Edward Hughes revised by Hohn Wiley, Keith Brown and Ian McKenzie Smith, Pearson,2016.
6. *Electrical and Electronics Technology* by E. Hughes, Pearson,2010.
7. Basic Electrical Engineering by D.C. Kulshrestha, McGraw-Hill,2009.
8. Basic Electrical Engineering by D. P. Kothai and I.J. Nagrath, McGraw-Hill,2010.

Paper Code: ICT105	Paper: Engineering Mechanics	L		T/P	C
Paper ID: 164105		3		-	3

Course Objectives:	
1:	To impart knowledge to solve problems pertaining to force systems, equilibrium anddistributed systems.
2:	To impart knowledge to solve problems of friction and engineering trusses.
3:	To impart knowledge to deal with the problems of kinematics and kinetics of particle
4:	To impart knowledge to deal with the problems of kinematics and kinetics of rigid bodies.

Course Outcomes (CO):	
CO1:	Ability to solve problems pertaining to force systems, equilibrium and distributed systems.
CO2:	Ability to solve problems of friction and engineering trusses.
CO3:	Ability to deal with the problems of kinematics and kinetics of particle
CO4:	Ability to deal with the problems of kinematics and kinetics of rigid bodies.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High)

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	3	3	3	3	2	-	-	-	1	1	1	2
CO2	3	3	3	3	2	-	-	-	1	1	1	2
CO3	3	3	3	3	2	-	-	-	1	1	1	2
CO4	3	3	3	3	2	-	-	-	1	1	1	2

Unit I **[10Hrs]**

Force System: Introduction, force, principle of transmissibility of force, resultant of a force system, resolution of a force, moment of force about a line, Varigon's theorem, couple, resolution of force into force and a couple, properties of couple and their application to engineering problems.

Equilibrium: Force body diagram, equations of equilibrium and their applications to engineering problems, equilibrium of two force and three force members.

Distributed Forces: Determination of center of gravity, center of mass and centroid by direct integration and by the method of composite bodies, mass moment of inertia and area moment of inertia by direct integration and composite bodies method, radius of gyration, parallel axis theorem, polar moment of inertial.

Unit II[10Hrs]

Structure: Plane truss, perfect and imperfect truss, assumption in the truss analysis, analysis of perfect plane trusses by the method of joints, method of section and graphical method.

Friction: Static and Kinetic friction, laws of dry friction, co-efficient of friction, angle of friction, angle of repose, cone of friction, frictional lock, friction in flat pivot and collar bearing, friction in flat belts.

Unit III[10Hrs]

Kinematics of Particles: Rectilinear motion, plane curvilinear motion, rectangular coordinates, normal and tangential coordinates.

Kinetics of Particles: Equation of motion, rectilinear motion and curvilinear motion, work-energy equation, conservation of energy, concept of impulse and momentum, conservation of momentum, impact of bodies, co- efficient of restitution, loss of energyduringimpact.

Unit IV **[10Hrs]**

Kinematics of Rigid Bodies: Concept of rigid body, types of rigid body motion, absolute motion, introduction to relative velocity, relative acceleration (Corioli's component excluded) and instantaneous center of zero velocity, Velocity and acceleration.

Kinetics of Rigid Bodies: Equation of motion, translatory motion and fixed axis rotation, application of

work energy principles to rigid bodies conservation of energy.

Beam: Introduction, types of loading, methods for the reactions of a beam, space diagram, types of end supports, beams subjectedtocouple.

Textbooks:

1.*Engineering Mechanics* by A.K.Tayal, Umesh Publications.

References:

1. 'Engineering Mechanics' by K. L. Kumar, Tata Mc-Graw Hill
2. 'Engineering Mechanics' by S. Timoshenko, D. H. Young, J. V. Rao, Tata Mc-Graw Hill
3. 'Engineering Mechanics-Statics and Dynamics' by Irwing H. Shames, PHI.
4. 'Engineering Mechanics' by Basudev Bhattacharya, Oxford Higher Education

PaperCode: HS107	Paper: Communication Skills – I	L	T/P	C
PaperID: 99107		3	-	3

Course Objectives:

1:	To help them understand the structures of language, and build up the vocabulary.
2:	To enhance language proficiency and communication competence.
3:	To understand basic principles of written communication.
4:	To develop the efficiency of using language for Specific Purposes with clarity.
5:	To be able to critically appreciate the written texts and audio-visual inputs effectively.
6:	To develop the theoretical understanding of interpersonal communication effectively.

Course Outcomes (CO):

CO1:	Ability to understand the basic structure of language
CO2:	Ability to communicate effectively in writing.
CO3:	Ability to present their ideas effectively in professional and demanding situations.
CO4:	Ability to interpret texts and comprehend the extended discourse.

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	-	-	-	-	-	-	-	-	3	3	-	3
CO2	-	-	-	-	-	-	-	-	3	3	-	3
CO3	-	-	-	-	-	-	-	-	3	3	-	3
CO4	-	-	-	-	-	-	-	-	3	3	-	3

Unit-I [8Hrs]
Basic Language Efficiency 1: Parts of Speech, Sentence Structure, Subject-Verb Agreement, Vocabulary, CommonErrors

Unit II[8Hrs]

Basic Language Efficiency 2: Writing Skills: Types of Writing, Paragraph writing,Paraphrasing, Summarizing, PrécisWriting

Unit III **[8Hrs]**
Formal Written Communication: Meetings – Agenda and Minutes,Press release, Letter writing, Notice, Memorandum,E-mails

Unit IV **[8Hrs]**
Appreciating written Texts for comprehension ability:

1. StevenSpielberg's Speech at Harvard Commencement 2016 (https://www.youtube.com/watch?v=TYtoDunfu00)
2. LecturebyJohanRockstrom: LettheEnvironmentGuideourDevelopmenthttp://www.ted.com/talks/johan_rockstrom_let_the_environment_guide_our_development

Textbooks:
1. *High English Grammar and Composition* by Wren, P.C. & Martin H., S.Chand& Company Ltd, NewDelhi.
2. *Technical Communication: Principles & Practice* by Meenakshi Raman, New Delhi: Oxford UniversityPress

References:

1. *Be Grammar Ready: The Ultimate Guide to English Grammar* by John Eastwood, New Delhi, Oxford University Press, 2020.
2. *Communication Skills: A Workbook* by Sanjay Kumar & Pushp Lata, New Delhi, Oxford University Press, 2018.
3. *Basic Technical Communication* by Kavita Tyagi & Padma Mishra, New Delhi, PHI Learning,2012.
4. *Advanced Technical Communication* by Kavita Tyagi & Padma Mishra, New Delhi, PHI Learning,2011.

PaperCode: BS109	Paper: Engineering Chemistry - I	L	T/P	C
PaperID: 99109		3	-	3

Course Objectives:

1:	To impart knowledge about understanding and modeling atomic structure and chemical bonding.
2:	To impart knowledge about understanding and modeling Thermochemistry and Reaction Kinetics.
3:	To impart knowledge about understanding and modeling organic compound structure andreactions.
4:	To impart knowledge about understanding and modeling Stereochemistry.

Course Outcomes (CO):

CO1:	Ability to understand and model atomic structure and chemical bonding.
CO2:	Ability to understand and model Thermochemistry and Reaction Kinetics.
CO3:	Ability to understand and model organic compound structure and reactions.
CO4:	Ability to understand and model Stereochemistry.

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	2	2	3	3	2	-	-	-	1	1	-	1
CO2	2	2	3	3	2	-	-	-	1	1	-	1
CO3	2	2	3	3	2	-	-	-	1	1	-	1
CO4	2	2	3	3	2	-	-	-	1	1	-	1

Unit I **[12Hrs]**

Atomic Structure: Introduction to wave mechanics, the Schrödinger equation as applied to hydrogen atom, origin of quantum numbers, Long form of periodic table on the basis of Electronic configuration s, p, d, f block elements periodic trends, Ionization potential, atomic and ionic radii electron affinity &electro-negativity.

Chemical Bonding: Ionic bond, energy changes, lattice energy Born Haber Cycle, Covalent bond-energy changes, Potential energy curve for H_2 molecule, characteristics of covalent compound, co-ordinate bond-Werner's Theory, effective atomic numbers, A hybridization and resonance, Valence Shell Electron Repulsion theory (VSEPR), Discussion of structures of H_2O, NH_3, BrF_3, SiF_4, Molecular orbital theory, Linear combination of atomic orbitals (LCAO) method. Structure of simple homo nuclear diatomic molecule like H_2, N_2, O_2,F_2.

Unit II **[10Hrs]**

Thermochemistry: Hess's Law, heat of reaction, effect of temperature on heat of reaction at constant pressure (Kirchhoff's Equation) heat to dilution, heat of hydration, heat of neutralization and heat of combustion, Flame temperature. Reaction Kinetics: Significance of rate law and rate equations, order and molecularity, Determinations of order of simple reactions-experimental method, Equilibrium constant and reaction rates -Lindermann, collision and activated complex theories, complex reactions of 1st order characteristicsofconsecutive,reversibleandparallelreactions-Steadystateandnon-steadystateapproach.

Unit III [8Hrs]

Basic concepts of Organics: Inductive, electromeric, mesomeric and hyperconjugative effects. Stability of reaction intermediates. Electrophiles and nucleophiles, concepts of acids and bases. Arrhenius, Lowry-Bronsted and Lewis theory of acids and bases (HSAB), Carbon acids (active methylene groups), super acids. Bonds weaker than covalent bond: Hydrogen bonding - nature, types, stability and effects. IUPAC Nomenclature.

Unit IV[10Hrs]

Stereochemistry: Classification of stereoisomers, diastereomers, Separation of enantiomers. Absolute configuration (R and S), Projection formulae. Stereochemistry of compounds containing two asymmetric C- atoms. Elements of symmetry - center, plane and axis of symmetry, Conformations: Conformations around a C- C bond in acyclic andcycliccompounds.

Textbooks / References:

1. Engineering Chemistry (16th Edition) Jain, Jain, Dhanpat Rai Publishing Company, 2013.
2.Textbook of Engineering Chemistry by Jaya Shree Anireddy, Wiley, 2017
3.Engineering Chemistry by E.R. Nagarajan and S. Ramalingam, Wiley, 2017.

PaperCode: BS111	Paper: Engineering Mathematics – I	L	T/P	C
PaperID: 99111		4	-	4

Course Objectives:

1:	To understand use series, differential and integral methods to solve formulated engineeringproblems.
2:	To understand use Ordinary Differential Equations to solve formulated engineering problems.
3:	To understand use linear algebrato solve formulated engineering problems.
4:	To understand use vector calculusto solve formulated engineering problems.

Course Outcomes (CO):

CO1:	Ability to use series, differential and integral methods to solve formulated engineering problems.
CO2:	Ability to use Ordinary Differential Equations to solve formulated engineering problems.
CO3:	Ability to use linear algebrato solve formulated engineering problems.
CO4:	Ability to use vector calculusto solve formulated engineering problems.

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	2	3	3	3	1	-	-	-	-	-	1	2
CO2	2	3	3	3	1	-	-	-	-	-	2	2
CO3	2	3	3	3	1	-	-	-	-	-	2	2
CO4	2	3	3	3	1	-	-	-	-	-	2	2

Unit I **[8Hrs]**

Partial derivatives, Chain rule, Differentiation of Implicit functions, exact differentials.Maxima, Minima and saddle points, Method of Lagrange multipliers. Differentiation underIntegral sign, Jacobians and transformationsofcoordinates.

Unit II **[12Hrs]**

Ordinary Differential Equations (ODEs): Basic Concepts. Geometric Meaning of y'= f(x, y). Direction Fields, Euler's Method, Separable ODEs. Exact ODEs. Integrating Factors, Linear ODEs. Bernoulli Equation. Population Dynamics, Orthogonal Trajectories. Homogeneous Linear ODEs with Constant Coefficients. Differential Operators. Modeling of Free Oscillations of a Mass–Spring System, Euler–Cauchy Equations. Wronskian, Nonhomogeneous ODEs, Solution by Variation of Parameters.

Power Series Method for solution of ODEs: Legendre's Equation. Legendre Polynomials, Bessel's Equation, Bessels's functions Jn(x) and Yn(x).GammaFunction

Unit III **[10Hrs]**

Linear Algebra: Matrices and Determinants, Gauss Elimination, Linear Independence. Rank of a Matrix. Vector Space. Solutions of Linear Systems and concept of Existence, Uniqueness, Determinants. Cramer's Rule, Gauss– Jordan Elimination. The Matrix Eigenvalue Problem.

Determining Eigenvalues and Eigenvectors, Symmetric, Skew-Symmetric, and Orthogonal Matrices.Eigenbases. Diagonalization. Quadratic Forms.Cayley – Hamilton Theorem(withoutproof)

Unit IV **[10Hrs]**

Vector Calculus: Vector and Scalar Functions and Their Fields. Derivatives, Curves. Arc Length. Curvature. Torsion, Gradient of a Scalar Field. Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field, Line Integrals, Path Independence of Line Integrals, Double Integrals, Green's Theorem in the Plane, Surfaces for Surface Integrals, Surface Integrals, Triple Integrals, Stokes Theorem. Divergence Theorem of Gauss.

Textbooks:

1. *Advanced Engineering Mathematics* by Erwin Kreyszig, John Wiley, 10thEd.,2011.

2. *Mathematical Methods for Physics and Engineering*, by K. F. Riley, M. P. Hobson and S. J. Bence, CUP, 2013. (for UnitI)

References:

1. *Engineering Mathematics* by K.A. Stroud withDexter J. Booth, Macmillan, 2020.
2. *Advanced Engineering Mathematics* by Larry Turyn, Taylor and Francis, 2014.
3. *Advanced Engineering Mathematics* by Dennis G. Zill, Jones & Bartlett Learning, 2018.
4. *Advanced Engineering Mathematics with MATLAB* by Dean G. Duffy, Taylor and Francis, 2017.
5. *Advanced Engineering Mathematics* by Merle C. Potter, Jack L. Lessing, and Edward F. Aboufadel, Springer (Switzerland), 2019.

PaperCode: BS113	Paper: Engineering Physics – I	L	T/P	C
PaperID: 99113		3	-	3

Course Objectives:

1:	To understand thermodynamic principles.
2:	To understand and model oscillations and waves.
3:	To understand and model interference, diffraction and polarization phenomenon.
4:	To understand and appreciate relativistic systems and Lasers.

Course Outcomes (CO):

CO1:	Ability to apply thermodynamic principles to solution of engineering problems.
CO2:	Ability to understand and model oscillations and waves.
CO3:	Ability to understand and model interference, diffraction and polarization phenomenon.
CO4:	Ability to understand and appreciate relativistic systems and Lasers.

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	2	2	3	3	2	-	-	-	1	1	-	2
CO2	2	2	3	3	2	-	-	-	1	1	-	2
CO3	2	2	3	3	2	-	-	-	1	1	-	2
CO4	2	2	3	3	2	-	-	-	1	1	-	2

Unit I **[8Hrs]**

Introduction to Thermodynamics: Fundamental Ideas of Thermodynamics, the Continuum Model, the Concept of a "System"', "State", "Equilibrium", "Process"'. Equations of state, Heat, Zeroth Law of Thermodynamics, Work, first and second laws ofthermodynamics,entropy

Unit II **[8Hrs]**

Waves and Oscillations: Wave motion, simple harmonic motion, wave equation, superposition principle. Introduction to Electromagnetic Theory: Maxwell's equations. Work done by the electromagnetic field, Poynting's theorem, Momentum, Angular momentum in electromagnetic fields, Electromagnetic waves: the wave equation, plane electromagnetic waves, energy carried byelectromagneticwaves

Unit III **[12Hrs]**

Interference: Interference by division of wave front (Young's double slit experiment, Fresnel's biprism), interference by division of amplitude (thin films, Newton's rings, Michelson's interferometer), Coherence and coherent sources

Diffraction: Fraunhofer and Fresnel diffraction; Fraunhofer diffraction for Single slit, double slit, and N-slit (diffraction grating), Fraunhofer diffraction from a circular aperture, resolving power and dispersive power of a grating, Rayleigh criterion, resolving power of opticalinstruments

Polarization: Introduction to polarization, Brewster's law, Malu's law, Nicol prism, double refraction, quarter- wave and half-wave plates, optical activity, specific rotation, Laurent half shade polarimeter.

Unit IV **[12Hrs]**

Theory of relativity: The Michelson-Morley Experiment and the speed of light; Absolute and Inertial frames of reference, Galilean transformations, the postulates of the special theory of relativity, Lorentz transformations, time dilation, length contraction, velocity addition, mass energy equivalence. Invariance of Maxwell's equations under LorentzTransformation.

Introduction to Laser Physics: Introduction, coherence, Einstein A and B coefficients, population inversion, basic principle and operation of a laser, the He-Ne laser and theRubylaser

Textbooks:

1. *Concepts of Modern Physics (SIE)*by Arthur Beiser, Shobhit Mahajan, and S. Rai Choudhury,McGraw-Hill, 2017.

2. *Physics for Scientists and Engineers* by Raymond A. Serway and John W. Jewett, 9thEdition , Cengage, 2017

References:

1. *Modern Physics* by Kenneth S. Krane, Wiley,2020.
2. *Principles of Physics* by Robert Resnick, Jearl Walker and David Halliday, Wiley,2015.
3. *Optics* by Ajoy Ghatak, McGraw Hill,2020.

PaperCode: LLB115	Paper: Indian Constitution	L	T/P	C
PaperID: 99115		2	-	2

Course Objectives:	
1:	To create awareness among students about the Indian Constitution
2:	Tocreateconsciousness among students about democratic principles and enshrined inthe Constitution of India

Course Outcomes (CO):	
CO1:	To understand institutional mechanism and fundamental values enshrined in the Constitution of India
CO2:	To understand the inter-relation between Centre and State Government
CO3:	To understand Fundamental Rights and Duties
CO4:	To understand the structure and functions of judicial systems in the country.

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	-	-	-	-	-	3	-	2	-	-	-	1
CO2	-	-	-	-	-	3	-	2	-	-	-	1
CO3	-	-	-	-	-	3	-	2	-	-	-	1
CO4	-	-	-	-	-	3	-	2	-	-	-	1

Unit I **[6Hrs]**

Introduction to Constitution of India: Definition, Source and Framing of the Constitution of India. Salient Features of the Indian Constitution. Preamble oftheConstitution.

Unit II **[6Hrs]**

Fundamental Rights and Duties: Rights to Equality (Article 14-18).Rights to Freedom (Article 19-22).Right against Exploitation (Article 23-24).Rights to Religion and Cultural and Educational Rights of Minorities (Article 25- 30). The Directive Principles of State Policy – Its significance and application. Fundamental Duties – Necessary obligations and its nature, legal statusandsignificance

Unit III **[6Hrs]**

Executives and Judiciary: Office of President, Vice President and Governor: Power and Functions, Parliament, Emergency Provisions-, President Rule; Union Judiciary: Appointment of Judges, Jurisdiction of the Supreme Court, State Judiciary: Power and functions,WritJurisdiction

Unit IV **[6Hrs]**

Centre- States Relation: Is Indian Constitution Federal in Nature, Legislative relations between Union and States, Administrative Relations between UnionandStates, Financial Relations between Union andStates

Textbooks:

1. *Constitutional Law of India* by J.N Pandey, Central Law Publication, 2018.
2. *Introduction to the Indian Constitution of India*by D.D. Basu, PHI, New Delhi,2021
3. *The Constitution of India* by P.M. Bakshi, Universal Law Publishing Co.,2020.

References:

1. *Indian Constitutional Law* by M.P. Jain, Lexis Nexis, 2013 2.*Constitution of India* byV.N. Shukla, Eastern Book Agency, 2014

PaperCode: ICT151	Paper: Programming for Problem Solving Lab.		L	P	C
PaperID: 164151			-	2	1
Teachers Continuous Evaluation:	40 marks	Term End Examinations:	60 Marks		

Instructions:

1. The course objectives and course outcomes are identical to that of ICT101 (Programming for Problem Solving) as this is the practical component of the corresponding theorypaper.
2. The practical list shall be notified by the teacher in the first week of the classcommencement.

PaperCode: ICT153	Paper: Engineering Graphics-I	L	P	C
PaperID: 164153		-	2	1

Course Objectives:	
1:	The students will learn the introduction of Engineering graphics, various equipment used, various scales, dimensions and BIS codes used while making drawings for various streams of engineeringdisciplines.
2:	The students will learn theory of projections and projection of points.
3:	The students will learn projection of lines and projection of planes.
4:	The students will learn the projection of solid and development of surfaces

Course Outcomes (CO):	
CO1:	To understand the theory of projections and projection of points.
CO2:	Ability to do line projections.
CO3:	Ability to do plane projections.
CO4:	Ability to do solid projections and development of surfaces

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	3	3	3	3	2	-	-	-	1	2	1	2
CO2	3	3	3	3	2	-	-	-	1	2	1	2
CO3	3	3	3	3	2	-	-	-	1	2	1	2
CO4	3	3	3	3	2	-	-	-	1	2	1	2

Unit I

Introduction: Engineering Graphics/Technical Drawing, Introduction to drawing equipments and use of instruments, Conventions in drawing practice. Types of lines and their uses, BIS codes for lines, technical lettering as per BIS codes, Introduction to dimensioning, Types, Concepts of scale drawing, Types of scales Theory of Projections: Theory of projections, Perspective, Orthographic, System of orthographic projection: in reference to quadrants, Projection of Points, Projection in different quadrants, Projection of point on auxiliary planes. Distance between two points, Illustration through simple problems.

Unit II

Projection of Lines: Line Parallel to both H.P. and V.P., Parallel to one and inclined to other, other typical cases: three view projection of straight lines, true length and angle orientation of straight line: rotation method, Trapezoidal method and auxiliary plane method, traces of line.

Unit III

Projection of Planes: Projection of Planes Parallel to one and perpendicular to other, Perpendicular to one and inclined to other, Inclined to both reference planes, Plane oblique to reference planes, traces of planes.

Planes Other than the Reference Planes: Introduction of other planes (perpendicular and oblique), their traces, inclinations etc., projections of points and lines lying in the planes, conversion of oblique plane into auxiliary plane and solution of relatedproblems.

Unit IV

Projection of Solids: Projection of solids in first or third quadrant, Axis parallel to one and perpendicular to other, Axis parallel to one inclined to other, Axis inclined to both the principal plane, Axis perpendicular to profile plane and parallel to both H.P. and V.P., Visible and invisible details in the projection, Use of rotation and auxiliary plane method.

Development of Surface: Purpose of development, Parallel line, radial line and triangulation method, Development of prism, cylinder, cone and pyramid surface for both right angled and oblique solids, Development of surface.

Note: The sheets to be created shall be notified by the concerned teacher in the first week of teaching.

Textbooks:

1. *Engineering Drawing* by N.D. Bhatt, 53rd Ed., Charotar Publishing House Pvt. Ltd., Gujarat,2017.

References:

1. *Engineering Drawing*by P.S. Gill, S.K Kataria & Sons, New Delhi,2013.
2. *Technical Drawing with Engineering Graphics* by Frederick E. Giesecke, Shawna Lockhart, Marla Goodman, and Cindy M. Johnson, 15th Ed., Prentice Hall, USA,2016
3. *Engineering Drawing*by M.B. Shah and B.C. Rana, 3rd Ed., Pearson Education, New Delhi,2009.

PaperCode: ICT155	**Paper: Electrical Science Lab.**		**L**	**P**	**C**
PaperID: 164155			**-**	**2**	**1**
Teachers Continuous Evaluation:	**40 marks**	**Term End Examinations:**	**60 Marks**		

PaperCode: BS157	**Paper: Engineering Chemistry - I Lab.**		**L**	**P**	**C**
PaperID: 99157			**-**	**2**	**1**
Teachers Continuous Evaluation:	**40 marks**	**Term End Examinations:**	**60 Marks**		

PaperCode: BS159	**Paper: Engineering Physics - I Lab.**		**L**	**P**	**C**
PaperID: 99159			**-**	**2**	**1**
Teachers Continuous Evaluation:	**40 marks**	**Term End Examinations:**	**60 Marks**		
Instructions: 1. The course objectives and course outcomes are identical to that of BA113 (Engineering Physics - I) as this is the practical component of the corresponding theorypaper. 2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the school in which the paper is beingoffered.					

SECOND SEMESTER

Group	Paper Code	Paper	L	T/P	Credits
Theory Papers					
ES	BS 118	Industrial Chemistry	3	-	3
HS	HS 102	Communication Skills – II	3	-	3
BS	BS 104	Engineering Chemistry – II	3	-	3
BS	BS 106	Engineering Mathematics - II	4	-	4
BS	BS 108	Engineering Physics-II	3	-	3
BS	BS 110	Probability and Statistics for Engineers	3	2	4
HS/MC	ICT 114*	Human Values and Ethics	1	-	1
BS/MC	EMES 112	Environmental Studies	4	-	4
Practical/Viva Voce					
ES	ICT 152	Engineering Graphics-II Lab	-	2	1
BS	BS 156	Engineering Chemistry – II Lab	-	2	1
BS	BS 158	Engineering Physics –II Lab	-	2	1
One paper from the following#:					
ES	ICT 154	Workshop Technology	-	2	1
ES	ICT 160	Programming in Python	-	2	
Total			**24**	**10**	**29**

***NUES: Comprehensive evaluation will be done by the teacher concerned out of total 100 marks. No end term examination shall be held.**

PaperCode: BS118	Paper: Industrial Chemistry	L	T/P	C
PaperID: 99118		3	-	3

Marking Scheme:

1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75marks

Instruction for paper setter:

1. There should be 9 questions in the term end examinations questionpaper.
2. The first (1st) question should be compulsory and cover the entire syllabus.This question should be objective, single line answers or short answer type question of total 15marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribedtextbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified ifrequired.

Course Objectives:

1:	Learn about the functioning of drugs and dyes.
2:	Learn about the most important ways of preventing corrosion.
3:	Learn about the properties of heterocycles
4:	Learn about techniques of synthesis.

Course Outcomes (CO):

CO1:	Understand the functioning of drugs and dyes.
CO2:	Understand the most important ways of preventing corrosion.
CO3:	Understand the properties of heterocycles
CO4:	Understand techniques of synthesis.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High)

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	3	2	3	3	1	1	1	-	-	-	-	1
CO2	3	2	3	3	1	1	2	-	-	-	-	1
CO3	3	2	3	3	1	-	-	-	-	-	-	1
CO4	3	2	3	3	1	-	-	-	-	-	-	1

Unit-I [10 Hrs]

Polymerization technology, dyes and drugs: classification of polymers, plastics, fibres, elastomers. Dyes: Requirements of a dye, chemical nature, classification, chemistry of representative important dyes. Pharmaceuticals: sulfa drugs, antipyretics and analgesics, antibiotics, antimalarials. Caustic soda & Chlorine. Hydrochloric acid. Sulphur &sulphuricAcid.

Unit-II [10 Hrs]

Corrosion: Corrosion and its economic aspects, Thermodynamics of corrosion, Immunity, corrosivity and passivation. Mechanism and kinetics of Corrosion. Electrochemical methods for corrosion testing.

Corrosion Prevention Techniques: Metallic coatings, organic paints, varnishes, corrosion inhibitors, cathodic and anodic protection. Corrosion Prevention Techniques: Metallic coatings, organic paints, varnishes, corrosion inhibitors, cathodic and anodic protection.

Unit-III [8 Hrs]

Chemistry of Heterocyclic Compounds: Introduction, nomenclature, structures, and reactivities of heterocyclic compounds. Chemistry and reactivity of five and six membered heterocyclic compounds with one hetero atoms. Chemistry of selected industrially important heterocyclic compounds.

Unit-IV [12 Hrs]

Synthetic Methods: Introduction to synthesis, strategy of synthesis. Designing of green synthesis: choice of starting materials, reagents, catalysts and solvents. Basic principles of green chemistry and synthesis of organic compounds involving basic principles of green chemistry methodology of synthesis. New methods in organic synthesis: microwave technique, use of phase transfer catalyst in organic synthesis.

Textbooks and References:

1. J.P. Mukhlyonov: Fundamentals of Chemical Technology.
2. M.G. Rao, M.Sittig: Dryden's out line of Chemicals Technology.
3. Emil Raymond Riegel: Industrial Chemistry.
4. Frank Hall Thorp: Outlines of Industrial Chemistry.
5. M.G. Fontana: Corrosion Engineering, McGraw Hill International Book Co. London.
6. L.L. Shreir: Corrosion, Vol I and Vol II, Newness Butterworths, Edward Arnold Ltd, London.
7. J.C. Scully: Fundamental of Corrosion, Pargmon Press Inc. New York, USA
8. J.A. Joule, K. Mills and G.F. Smith: Heterocyclic chemistry, III Ed., East West Press vt Ltd, ND.
9. A.R. Katrizky and J.A. Boulton: Advances in Heterocyclic chemistry, Vol 1-27, Academic Press, NY.
10. R.M. Achesion: An Introduction to the Chemistry of Heterocyclic Compounds, II Ed, NY

PaperCode: HS102	Paper: Communication Skills - II	L	T/P	C
PaperID: 99102		3	-	3

Course Objectives:

1:	To develop the theoretical framework of communication to understand the professional interaction.
2:	To develop confidence in all aspects of communication whether verbal or non-verbal.
3:	To be able to create error-free and well-formatted formal documents for professional records.
4:	To be able to overcome the barriers to effective communication.
5:	To inculcate the capacity to organize ideas and systematically present them through various media.
6:	To be able to critically appreciate the written texts and audio-visual inputs effectively.

Course Outcomes (CO):

CO1:	Ability to understand basic concepts regarding communication and develop a clear understanding of the flow of thoughts.
CO2:	Ability to apply verbal and non-verbal communication skills in real-life situations.
CO3:	Ability to write and document the information in the appropriate formats.
CO4:	Ability to effectively communicate in interpersonal and intercultural situations without being misunderstood.

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	-	-	-	-	-	-	-	-	3	3	-	3
CO2	-	-	-	-	-	-	-	-	3	3	-	3
CO3	-	-	-	-	-	-	-	-	3	3	-	3
CO4	-	-	-	-	-	-	-	-	3	3	-	3

Unit-I [8Hrs]

Communication as Process: Concept of Communication, Communication as a Process, Formal, Informal and Intercultural communication, Barriers to Effective Communication and remedies, Characteristics of Effective Communication

Unit-II [8Hrs]

Communication Efficiency: Concept of Non-verbal Communication, Elements of Non-verbal Communication – Gestures, Postures, Facial-expressions, Gaze, Eye contact, and Space, Presentation skills – Interviews, Group Discussion, Making presentations with Audio-visual aids, Electronic Communication – Internet and Social media.

Unit-III [8Hrs]

Technical Documents: Definition, Types, Structure, Significant Features of: Resume Writing, Report Writing, Proposal Writing, Dissertation, andResearchPapers

Unit-IV [8Hrs]

Communication in Society and Workplace:

Text 1 – Gender-inclusive Language Background, Purpose, and Guidelines United Nations Gender-inclusive Language

https://www.un.org/en/gender-inclusive-language/index.shtml

Text 2 – Cultural Diversity in India
India: Unity in Cultural Diversity Introduction (P. xii – xviii) https://dsel.education.gov.in/sites/default/files/book_unity_in_diversity.pdf

Text 3 – The Matrix (1999) Genre: Movie (Science Fiction) Dir. The Wachowski Brothers

Textbooks:

1. *High English Grammar and Composition* by Wren, P.C. & Martin H., S. Chand & Company Ltd, New Delhi.
2. *Technical Communication: Principles & Practice* by Meenakshi Raman, New Delhi: Oxford University Press

References:

1. *Be Grammar Ready: The Ultimate Guide to English Grammar* by John Eastwood, New Delhi, Oxford University Press, 2020.
2. *Communication Skills: A Workbook* by Sanjay Kumar & Pushp Lata, New Delhi, Oxford University Press, 2018.
3. *Basic Technical Communication* by Kavita Tyagi & Padma Mishra, New Delhi, PHI Learning, 2012.
4. *Advanced Technical Communication* by Kavita Tyagi & Padma Mishra, New Delhi, PHI Learning, 2011.

PaperCode: BS104	Paper: Engineering Chemistry - II	L	T/P	C
PaperID: 99104		3	-	3

Course Objectives:	
1:	To understand methods to make pure water and use fuels.
2:	To understand the use of techniques used to characterize engineering materials.
3:	To understand the properties and industrial applications of polymers.
4:	To understand the basics of nano-technology and bio chemistry
Course Outcomes (CO):	
CO1:	Ability to make pure water and use fuels and perform energy conversion calculations
CO2:	Ability to use techniques used to characterize engineering materials.
CO3:	Understand the properties and industrial applications of polymers.
CO4:	Understand the basics of nano-technology and bio chemistry

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	2	2	3	3	2	-	-	-	1	1	-	1
CO2	2	2	3	3	2	-	-	-	1	1	-	1
CO3	2	2	3	3	2	-	-	-	1	1	-	1
CO4	2	2	3	3	2	-	-	-	1	1	-	1

Unit I **[10Hrs]**

Water treatment: Introduction, Hardness of water, Disadvantages of hard water, Water-softening-Lime-Soda process, Ion-exchanger polished water, Boiled-feed water, boiler problems-scale, sludge priming and foaming, caustic embrittlement and corrosion.

Fuels: Classification of fuels, Calorific values, Comparison between solid, liquid and gaseous fuels, Bomb calorimeter, Calorific value of gaseous fuel, Theoretical calculation of calorific value of a fuel, Wood, Coal, Analysis of coal, Natural Gas, Producer gas, water gas, Non-Conventional sources of energy.

Unit II **[10Hrs]**

Spectroscopic Techniques: Basic principles of spectroscopic methods. The use of various spectroscopic techniques for the determination of structure of simple compounds. XRD, SEMandTEM.

Unit III **[10Hrs]**

Polymers: Basic concepts & Terminology, such as monomers, Polymers, functionality, Thermoplastics, Thermosets, Linear, Branched, cross linked polymers etc. Different definitions of molecular weight's viz. Mw, Mn, Mv and then determinations, Industrial applications of polymers. General methods of synthesis of organics andtheirapplications.

Unit IV **[10Hrs]**

Nano Technology: Introduction, Properties, Synthesis and characterization of Nanomaterials, Material self- assembly, Nanoscale materials and their applications.

Biochemistry: Molecular basis of life, study of macro molecules: Carbohydrates, Proteins, Lipids, Nucleic acid. Metabolism, basic concepts and design, Glycolysis citric acid cycle oxidative phosphorylation pentose phosphatepathway.

Textbooks/References:

1. *Engineering Chemistry (16th Edition) by Jain, Jain, Dhanpat Rai Publishing Company,2013.*
2. *Textbook of Engineering Chemistry by Jaya Shree Anireddy, Wiley, 2017.*
3. *Engineering Chemistry* byE.R. Nagarajan and S. Ramalingam, Wiley,2017.
4. *Biochemistry* by Lubert Stryer, Jeremy Berg, John Tymoczko, Gregory Gatto 9th Edition 2019. W H Freeman &Co.

PaperCode: BS106	Paper: Engineering Mathematics – II	L	T/P	C
PaperID: 99106		4	-	4

Course Objectives:	
1:	To understand Complex series methods.
2:	To understand Complex analysis
3:	To understand Fourier and Laplace methods
4:	To understand how to solve specific formulated engineering problems using PDE methods.

Course Outcomes (CO):	
CO1:	Ability to use Complex series methods.
CO2:	Ability to use Complex analysis to solve formulated engineering problems
CO3:	Ability to use Fourier and Laplace methods to solve formulated engineering problems
CO4:	Ability to solve specific formulated engineering problems using PDE methods.

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	2	3	3	3	1	-	-	-	-	-	1	2
CO2	2	3	3	3	1	-	-	-	-	-	2	2
CO3	2	3	3	3	1	-	-	-	-	-	2	2
CO4	2	3	3	3	1	-	-	-	-	-	2	2

Unit I **[10Hrs]**

Complex Analysis – I: Complex Numbers and Their Geometric Representation, Polar Form of Complex Numbers. Powers and Roots, Derivative. Analytic Function, Cauchy–Riemann Equations. Laplace's Equation, Exponential Function, Trigonometric and Hyperbolic Functions. Euler's Formula, de'Moivre's theorem (without proof), Logarithm. General Power. Principal Value**.**Singularities and Zeros.Infinity, Line Integral in the Complex Plane, Cauchy's Integral Theorem, Cauchy's Integral Formula, Derivatives of Analytic Functions, Taylor andMaclaurinSeries.

Unit II[10Hrs]

Complex Analysis – II: Laurent Series, Residue Integration Method. Residue Integration of Real Integrals, Geometry of Analytic Functions: Conformal Mapping, Linear Fractional Transformations (Möbius Transformations), Special Linear Fractional Transformations, Conformal Mapping by Other Functions, Applications: Electrostatic Fields, Use of Conformal Mapping. Modeling, Heat Problems, Fluid Flow. Poisson's Integral FormulaforPotentials

Unit III[10Hrs]

Laplace Transforms: Definitions and existence (without proof), properties, First Shifting Theorem (s-Shifting), Transforms of Derivatives and Integrals and ODEs, Unit Step Function (Heaviside Function).Second Shifting Theorem (t-Shifting), Short Impulses. Dirac's Delta Function. Partial Fractions, Convolution. Integral Equations, Differentiation and Integration of Transforms. Solution of ODEs with Variable Coefficients, Solution of
Systems of ODEs. Inverse Laplace transform and its properties.
Fourier Analysis: Fourier Series, Arbitrary Period. Even and Odd Functions. Half-Range Expansions, Sturm-Liouville Problems. Fourier Integral, Fourier Cosine and Sine Transforms, Fourier Transform. Usage of Fourier analysis for solution of ODEs. Inverse Fourier transform anditsproperties.

Unit IV[10Hrs]

Partial Differential Equations (PDEs): Basic Concepts of PDEs. Modeling: Vibrating String, Wave Equation. Solution by Separating Variables. Use of Fourier Series. D'Alembert's Solution of the Wave Equation. Characteristics. Modeling: Heat Flow from a Body in Space. Heat Equation:Solution by Fourier series.Steady Two-Dimensional Heat Problems. Dirichlet Problem. Heat Equation: Modeling Very Long Bars.Solution by Fourier Integrals and Transforms. Modeling: Membrane, Two-Dimensional Wave Equation. Rectangular Membrane. Laplacian in Polar Coordinates. Circular Membrane. Laplace's Equation in Cylindrical and Spherical Coordinates. Potential. Solution of PDEs byLaplaceTransforms.

Textbooks:

1. *Advanced Engineering Mathematics* by Erwin Kreyszig, John Wiley, 10thEd., 2011.

References:

1. *Engineering Mathematics* by K.A. Stroud withDexter J. Booth, Macmillan, 2020.
2. *Advanced Engineering Mathematics* by Larry Turyn, Taylor and Francis,2014.
3. *Advanced Engineering Mathematics* by Dennis G. Zill, Jones & Bartlett Learning,2018.
4. *Advanced Engineering Mathematics with MATLAB* by Dean G. Duffy, Taylor and Francis,2017.
5. *Advanced Engineering Mathematics* by Merle C. Potter, Jack L. Lessing, and Edward F. Aboufadel, Springer (Switzerland),2019.
6. *Mathematical Methods for Physics and Engineering*, by K. F. Riley, M. P. Hobson and S. J. Bence, CUP, 2013.

PaperCode: BS108	Paper: Engineering Physics - ll	L	T/P	C
PaperID: 99108		3	-	3

Course Objectives:	
1:	To learn about the quantum nature of reality.
2:	To learn about quantum statistics and its significance.
3:	To learn about the band theory of solids and properties and characteristics of diodes.
4:	To understand the basics of physical basis of biology.

Course Outcomes (CO):	
CO1:	Understand and appreciate the quantum nature of reality.
CO2:	Understand quantum statistics and its significance.
CO3:	Understand the band theory of solids and properties and characteristics of diodes.
CO4:	To have an understanding of the physical basis of Biology.

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	2	2	3	3	2	-	-	-	1	1	-	1
CO2	2	2	3	3	2	-	-	-	1	1	-	1
CO3	2	2	3	3	2	-	-	-	1	1	-	1
CO4	2	2	3	3	2	-	-	-	1	1	-	1

Unit-I [12Hrs]

Quantum Mechanics: Introduction: Wave particle duality, de Broglie waves, the experiment of Davisson and Germer, electron diffraction, physical interpretation of the wave function, properties, the wave packet, group and phase velocity, the uncertainty principle. The Schrödinger wave equation (1D), Eigen values and Eigen functions, expectation values, simple Eigen value problems – solutions of the Schrödinger's equations for the free particle, the infinite well, the finite well, tunneling effect, the scanning electron microscope, the quantum simple harmonic oscillator (qualitative), zeropointenergy.

Unit-II [12Hrs]

Quantum Statistics: The need for statistics , statistical distributions: Maxwell Boltzmann, Bose-Einstein and Fermi-Dirac statistics, their comparisons, Fermions and Bosons, Applications of quantum statistics: 1. Molecular speed and energies in an ideal gas; 2. The Black body spectrum, the failure of classical statistics to give the correct explanations – Bose-Einstein statistics applied to the Black Body radiation spectrum; Fermi- Dirac distribution, free electron theory, electronic specific heats, Fermi energy and average energy; Dying stars.

Unit-III [12Hrs]

Band Theory of Solids: Origin of energy bands in solids, motion of electrons in a periodic potential- the Kronig– Penny model (Qualitative). Brillouin zones, effective mass, metals, semi-conductors and insulators and their energy band structures. Extrinsic and Intrinsic semiconductors, doping – Fermi energy for doped and undoped semiconductors, the p-n junction (energy band diagrams with Fermi energy), the unbiased diode, forward and reverse biased diodes – tunnel diodes, zener diode, photo diode itscharacteristics,LED

Unit-IV [4Hrs]

Introduction to Physics in Biology: Overview : from molecules to life - the building blocks of biology, DNA Packing and Structure, The relationship between shape and function of biomolecules, Numbers and Sizes, System Variability and Spatial Scales, Timescales inBiologicalSystems

Textbooks:

1. *Concepts of Modern Physics (SIE)*by Arthur Beiser, Shobhit Mahajan, and S. Rai Choudhury,McGraw – Hill, 2017.

2. *Modern Physics* by Kenneth S. Krane, Wiley,2020.

References:

1. *Physics for Scientists and Engineers* by Raymond A. Serway and John W. Jewett, 9th Edition , Cengage, 2017
2. *Principles of Physics* by Robert Resnick, Jearl Walker and David Halliday, Wiley, 2015.
3. *Solid State Electronic Devices ,by*Streetman and Ben G Prentice Hall India Learning Private Limited; 2006
4. https://drive.google.com/file/d/169AQBvIzHzbRjZU6M8oe260ZUWp7iUm1/view [part of NPTEL Lectures https://nptel.ac.in/courses/115/101/115101121/#

PaperCode: BS110	Paper: Probability and Statistics for Engineers	L	P	C
PaperID: 99110		3	2	4

Course Objectives:	
1:	To understand probability and probability distributions.
2:	To understand methods of summarization of data.
3:	To understand and use test for hypothesis.
4:	To understand methods for design experiments and analysis.
Course Outcomes (CO):	
CO1:	Ability to solve probability problems and describe probability distributions.
CO2:	Ability to describe and summarize data.
CO3:	Ability to use test for hypothesis.
CO4:	Ability to design experiments and analyze using ANOVA.

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	-	3	1	1	1	-	-	-	-	-	1	2
CO2	-	3	1	1	1	-	-	-	-	-	1	2
CO3	-	3	2	2	1	-	-	-	-	-	2	2
CO4	-	3	3	3	1	-	-	-	-	-	2	2

Unit-I [10 Hrs]

Basics: Probability and Statistical models, Sample Spaces and Events, Counting Techniques, Interpretations and Axioms of Probability, Unions of Events and Addition Rules, Conditional Probability, Intersections of Events and Multiplication and Total Probability Rules, Independence, Bayes' Theorem, Random Variables.

Discrete and Continuous Random Variables and Distributions: Probability Distributions and Probability Mass / density Functions, Cumulative Distribution Functions, Mean and Variance of a RandomVariable, Discrete and continuous Uniform Distribution, Binomial Distribution, Geometric and Negative BinomialDistributions, Hyper geometric Distribution, Poisson Distribution. Normal Distribution, Normal Approximation to the Binomial, and Poisson Distributions; Exponential Distribution, Erlang and Gamma Distributions, Weibull Distribution, Lognormal Distribution,BetaDistribution.

Unit-II [10Hrs]

Joint Probability Distributions for Two Random Variables, Conditional Probability Distribution sand Independence, Joint Probability Distributions for Two Random Variables, Covariance and Correlation, Common Joint Distributions, Linear Functions of Random Variables, General Functions of Random Variables, Moment- Generating Functions.

Numerical Summaries of Data, Stem-and-Leaf Diagrams, Frequency Distributions and Histograms, Box Plots, Time Sequence Plots, Scatter Diagrams, Probability Plots. Point Estimation, Sampling Distributions and the Central LimitTheorem without proof, General Concepts of Point Estimation, Methods of Point Estimation, Statistical Intervals for a SingleSample.

Unit-III [10Hrs]

Hypotheses Testing for a Single Sample: Tests on the Mean of a Normal Distribution with Variance Known / Unknown, Tests on the Variance and Standard Deviation of a Normal Distribution, Tests on a Population Proportion, Testing for Goodness of Fit, Nonparametric tests (Signed, Wilcox on), Similarly Statistical Inference for Two Samples.

Regression and Correlation: Linear Regression, Least Squares Estimators, Hypotheses testing for simple linear regression, Confidence Intervals, Adequacy of model, Correlation, Transformed Variables, Logistic Regression. Similarly, for multiple linear regression including aspects of MLR.

Unit-IV [10Hrs]

ANOVA and Design of experiments: Designing Engineering Experiments, Completely Randomized Single-Factor Experiment, The Random Effects Model, Randomized complete block design, Concept of Factorial Experiments, Two Factor Factorial Experiments, GeneralFactorialExperiments, 2^k Factorial Designs, ResponseSurfaceMethodsandDesigns.SQC:QualityimprovementandStatistics,ControlChartsincluding and R or S charts, P and U charts, and timeweightedcharts.

Note: At least two laboratories practical in each unit to be conducted. The list of practical's to be notified by the concerned teacher to the school where the students are admitted at the start of the teaching in the semester.

Textbooks:

1.*Applied Statistics and Probability for Engineers* by Douglas G. Montgomery and Runger, Wiley, 2018

References:

1. *Miller and Freund's Probability and Statistics for Engineers* by Richard A. Johnson, Pearson, 10thEd.,2018.
2. *Probability & Statistics for Engineers & Scientists* by Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Pearson, 2016.
3. *Statistics and probability with applications for engineers and scientists using Minitab, R and JMP*, C. Gupta, Irwin Guttman, and Kalanka P. Jayalath, Wiley, 2020.
4. *Probability and Statistics for Engineering and the Sciences*, Jay Devore, Cengage Learning,2014.
5. *Probability and Statistics in Emgineering*, William W. Hines, Douglas C. Montgomery, David M. Goldman, and Connie M. Borror, Wiley,2003.

PaperCode: ICT114	Paper: Human Values and Ethics	L	P	C
PaperID: 164114		1	-	1

Course Objectives:	
1:	To help students regulate their behavior in a professional environment as employees
2:	To make students aware of the impact of taking non-ethical engineering decisions.
3:	To understand that mind and desire control is needed for being ethical.
4:	To understand organizational culture and to adapt to varying cultures withoutcompromising ethical values

Course Outcomes (CO):	
CO1:	Realize the importance of human values.
CO2:	Understand that excessive desires of the mind make a person unethical and restless,while fewer desires lead to peace and professional progress
CO3:	Assess different types of risks involved in unethical practices. Know various means ofprotestingagainst unethical practices.
CO4:	Assess the benefits of restraining from unethical practices like bribery, extortion,nepotism, nexusbetween politicians and industrialists.

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	-	-	-	-	-	3	-	3	1	1	-	1
CO2	-	-	-	-	-	3	-	3	1	1	-	1
CO3	-	-	-	-	-	3	-	3	1	1	-	1
CO4	-	-	-	-	-	3	-	3	1	1	-	1

Unit I **[3Hrs]**

Human Values: Morals, Values, Ethics, Integrity, Work ethics, Service learning, Virtues, Respect for others, Living peacefully, Caring, Sharing, Honesty, Courage,Valuing time, Cooperation, Commitment, Empathy, Self- confidence, Challenges in the workplace,Spirituality

Unit II[3Hrs]

Engineering Ethics: Senses of engineering ethics, Variety of moral issues, Types of inquiries, Moral dilemma, Moral autonomy, Moral development (theories), Consensus and controversy, Profession, Models of professional roles, Responsibility, Theories about right action (Ethical theories), Self-control, Self-interest, Customs, Religion, Self-respect, Case study: Choice of the theory

Engineering as experimentation, Engineers as responsible experimenters, Codes of ethics, Industrial standards, a balanced outlook on law, Case study:Thechallenger

Unit III **[3Hrs]**

Safety definition, Safety and risk, Risk analysis, Assessment of safety and risk, Safe exit, Risk-benefit analysis Safety lessons from 'the challenger', Case study: Power plants,Collegiality and loyalty, Collective bargaining, Confidentiality, Conflict of interests, Occupational crime, Human rights, Employee rights, Whistle blowing, Intellectualpropertyrights.

Unit IV **[3Hrs]**

Globalization, Multinational corporations, Environmental ethics, Computer ethics, Weapons development, Engineers as managers, Consulting engineers, Engineers as expert witness, Engineers as advisors in planning and policy making, Moral leadership, Codes of ethics, Engineering council of India, Codes of ethics in Business Organizations

Textbooks:

1. *A Textbook on Professional Ethics and Human Values*, by R. S. Naagarazan, New Age Publishers, 2006.

References:

1. *Professional Ethics and Human Values* by D. R. Kiran, McGraw-Hill,2014.
2. *Engineering Ethics, by Charles E Harris and Micheal J Rabins, Cengage Learning Pub.,2012*
3. *Ethics in Engineering, Mike Martin and Roland Schinzinger, McGraw Hill Pub.,2017.*
4. *Unwritten laws of Ethics and Change in EngineeringbyThe America Society of Mechanical Engineers,2015.*
5. *Engineering Ethics by Charles B. Fleddermann, Pearson,2014.*
6. *Introduction to Engineering Ethics* by Mike W. Martin and Roland Schinzinger, McGraw-Hill,2010.
7. *Engineering Ethics: Concept and Cases* by Charles E. Harris, Michael S. Pritchard and Michael J.Rabins, Cengage,2009.
8. *Ethics in Engineering Practiceand Research* by Caroline Whitbeck, Cambridge University Press,2007.

PaperCode: EMES112	Paper: Environmental Studies	L	P	C
PaperID: 99112		4	-	4

Course Objectives:

1:	The course is designed to impart basic knowledge of the environment and its components.
2:	The course deals in creating awareness about the energy resources and current environmental problems faced by the world.
3:	To understand and learn about environment pollution, related case studies and measures taken for control to pollution.
4:	To understand and explore different approaches of conserving and protecting environment for the benefit of society.

Course Outcomes (CO):

CO1:	Environmental Studies course will provide necessary information and knowledge about the various aspects of environment, ecosystems and related biodiversity.
CO2:	Students will be able to learn and understand about the availability and sustainable use of resources, environmental problems and their short term and long term impacts to humans.
CO3:	Course will help them to learn about environmental policies and protocols, social issues and role of human in conservation and protection ofenvironment.
CO4:	Overall, course will help students to develop skills and ability of understanding environment-human relationship.

Course Outcomes (CO to Programme Outcomes (PO)) Mapping (scale 1: low, 2: Medium, 3: High)

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO10*	*PO11*	*PO12*
CO1	-	1	1	-	-	2	3	2	1	1	1
CO2	-	1	1	-	-	2	3	2	1	1	1
CO3	-	1	1	-	-	2	3	2	1	1	1
CO4	-	1	1	-	-	2	3	2	1	1	1

Unit I **[16Hrs]**

Fundamentals:The Multidisciplinary nature of environmental studies: Definition, components, scope and importance, need for public awareness;

Ecosystems: Concept, Structure and function of an ecosystem, energy flow in ecosystems, food chain, food web, ecological pyramids, ecological succession; Introduction to types, characteristics features, structure and function of different ecosystems including forest, grassland, desert and aquatic ecosystem;

Biodiversity: Introduction to biodiversity-definition, genetics, species, ecosystem diversity, biogeographical classification of India, value of biodiversity-consumptive uses, productive, social, ethical, aesthetic and option values, biodiversity at global, national and local level, India as a mega diversity nation, endangered and endemic species of India, hot spots of biodiversity, threats to biodiversity – habitat loss, poaching of wild life, man wildlife conflicts and conservation of biodiversity-in-situ andex-situconservation.

Unit II [8Hrs]

Renewable and Non-renewable Resources:Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources-green fuel.

Water Resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems

Forest resources: Use and over-exploitation, deforestation, Timber extraction, mining, dams and their effects on forest and tribal people, case studies

Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies

Food resources: World food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies
Landresources:Landasaresource,landdegradation,maninducedlandslides,soilerosionanddesertification.
Role of individual in conservation of natural resources, Resource Management-Sustainabledevelopment.

Unit III **[8Hrs]**

Environmental Pollution: (a) Air Pollution: Types of pollutants, source, effects, sink & control of primary pollutants CO, NOX, HC, SO_x and particulates, effect of pollutants on man & environment: photochemical smog, acid rain and global warming, CO2 Sequestration. (b) Water Pollution: Classification of Pollutants, their sources, waste water treatment (domestic and industrial). (c) Soil Pollution: Composition of soil, classification and effects of solid pollutants and their control. (d) Solid Waste Management: Classification, waste treatment and disposal methods; compositing, sanitary land filling, thermal processes, recycling and reuse methods. (e) Hazardous wastes - Classification, radioactive, biomedical & chemical, treatment and disposal- Physical, chemical and biological processes. (f) Marine Pollution: Causes, effects and control of marine pollution, coastal zone management (g) Thermal pollution: Causes, effects and control of marine pollution, coastal zone management.
Disaster Management: Floods, earth quake, cycloneandlandslides

Unit IV [13Hrs]

Environmental Policies, Human Population and Environment
Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents, case studies; Some important Environmental laws, issues involved in enforcement of environment legislations, Green bench; carbon footprint, Montreal and Kyoto Protocol, conservation of Biological Diversity, The Chemical Weapons Convention, Environment Impact Assessment; population growth and variation among nations, Impacts on environment and human health, human right, Tribal people and rights, Human and wildlife conflicts in Indian context, Environmental ethics; Role of government and non-government organizations in public awareness and environmentimprovement.
Field work (equal to 5 hours): visit to local areas to document environmental assets, study of simple ecosystems, study and identification of common plants, birds and insects.

Suggested Readings and References:

1. A textbook of environmental studies, R. Gadi, S. Rattan, S. Mohaptra, Kataria Publication,2014.
2. Elements of environmental sciences & engineering, P. Meenakshi, PHI Learning Pvt Ltd,2014.
3. Basics of Environment and Ecology, A. kaushik& C.P. Kaushik, New Age International Publishers,2010.
4. Fundamental concepts in environmental studies, D.D. Mishra, S Chand & Co. Ltd.,2008.
5. Textbook of environmental studies, E. Barucha, UGC,2005.
6. Environmental studies, B. Joseph, Tata McGraw-Hill Publishing Company Ltd.,2005.

PaperCode: ICT152	Paper: Engineering Graphics-II	L	P	C
PaperID: 164152		-	2	1

Course Objectives:	
1:	The students will learn sectioning of solid figures.
2:	The students will understand 3D projections. They will have understanding of isometric and obliqueprojections.
3:	The students will have understanding of perspective projections,
4:	The students will learn computer aided drafting.

Course Outcomes (CO):	
CO1:	Ability to draw sectional diagrams of solids
CO2:	Ability to draw 3S projections (isometric and oblique).
CO3:	Ability to draw perspective projections.
CO4:	Understand and use a CAD tool (AutoCAD).

Course Outcomes (CO to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	3	3	3	3	2	-	-	-	1	2	1	2
CO2	3	3	3	3	2	-	-	-	1	2	1	2
CO3	3	3	3	3	2	-	-	-	1	2	1	2
CO4	3	3	3	3	2	-	-	-	1	2	1	2

Unit I

Section of Solids: Definition of Sectioning and its purpose, Procedure of Sectioning, Illustration through examples, Types of sectional planes-application to few examples.

Unit II

Isometric Projection: Classification of pictorial views, Basic Principle of Isometric projection, Difference between isometric projection and drawing, Isometric projection of solids such as cube, prism, pyramid and cylinder.

Oblique Projection: Principle of oblique projection, difference between oblique projection and isometric projection, receding lines and receding angles, oblique drawing of circle, cylinder, prism and pyramid.

Unit III

Perspective Projection: Principle of perspective projection, definitions of perspective elements, visual ray method, vanishing point method.

Conversion of 3D to 2D figures.

Unit IV

Introduction to CADD: Interfacing and Introduction to CAD Software, Coordinate System, 2D drafting: lines, circles, arc, polygon, etc., Dimensioning, 2-D Modelling, Use of CAD Software for engineering drawing practices.

Note: The sheets to be created shall be notified by the concerned teacher in the first week of teaching.
Textbooks:

1. *Engineering Drawing* by N.D. Bhatt, 53rd Ed., Charotar Publishing House Pvt. Ltd., Gujarat,2017.

References:

1. *Engineering Drawing*by P.S. Gill, S.K Kataria & Sons, New Delhi,2013.
2. *Technical Drawing with Engineering Graphics* by Frederick E. Giesecke, Shawna Lockhart, Marla Goodman, and Cindy M. Johnson, 15th Ed., Prentice Hall, USA,2016
3. *Engineering Drawing*by M.B. Shah and B.C. Rana, 3rd Ed., Pearson Education, New Delhi,2009.
4. *AutoCAD 2017 for Engineers &Designers*by Sham Tickoo,,Dreamtech Press2016.

PaperCode: BS156	Paper: Engineering Chemistry - II Lab.		L	P	C
PaperID: 99156			-	2	1
Teachers Continuous Evaluation:	40 marks	Term End Examinations:	60 Marks		

PaperCode: BS158	Paper: Engineering Physics - II Lab.		L	P	C
PaperID: 99158			-	2	1
Teachers Continuous Evaluation:	40 marks	Term End Examinations:	60 Marks		

PaperCode: ICT154	Paper: Workshop Technology	L	P	C
PaperID: 164154		-	2	1

Course Objectives:

1:	The students will learn basics of safety precautions to be taken in lab. / workshop
2:	The students will have an overview of different machines used in workshop and the operationsperformed on these machines.
3:	The students will have understanding of various welding processes.
4:	The students will have understanding of sheet metals hop and fitting shop

Course Outcomes (CO):

CO1:	Ability to safely work in a Lab./workshop.
CO2:	Ability to use machines (lathe, mill, shaper, planer, grinder, drill).
CO3:	Ability to weld.
CO4:	Ability to use sheet metal tools and fitting shop tools.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High)

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	2	1	2	2	3	3	-	-	-	-	-	2
CO2	2	1	2	2	3	1	-	-	-	-	-	2
CO3	2	1	2	2	3	1	-	-	-	-	-	2
CO4	2	1	2	2	3	1	-	-	-	-	-	2

Unit I

Safety, precautions and maintenance: Safety in shop, safety devices, safety and precautions - moving machine and equipment parts, electrical parts and connections, fire, various driving systems like chain, belt and ropes, electrical accidents, an overview of predictive, preventive and scheduled maintenance, standard guidelines to be followed in shop.

Unit II

Introduction to machine shop: Introduction to Lathe, Milling, shaper, Planer, grinder, drilling and overview of operations performed on these machines by making some jobs.

Unit III

Introduction to welding shop: Welding, types of welding, tools and applications, gas welding and arc welding, edge preparation, various joints formation by gas welding and electric arc welding.

Unit IV

Introduction to sheet metal shop: Sheet metal tools and operations, formation of a box using sheet. Introduction to fitting shop: Introduction to fitting, tools and applications, some jobs in fitting shop.

Textbooks:

1.*Workshop Technology Vol. 1 and Vol. 2*, Hajra Choudhary and Roy, Media Promoters and Publishers, 2018.

References:

1. *A course in Workshop Technology Vol.1 and Vol. 2*, B. S. Raghuvanshi, Dhanpat Rai and Company,2015.
2. *Workshop Technology (Manufacturing Processes)*, Khurmi and Gupta, S. Chand Publication,2010.

PaperCode: ICT160	Paper: Programming in Python	L	P	C
PaperID: 164160		-	2	1

Course Objectives:	
1:	The students will learn the Programming in the Python Language
2:	The students will learn usage of language implemented data structures.
3:	The students shall learn the object oriented features of the Python Language.
4:	The students will learn usage of the Numpy, Panda and Matplotlib

Course Outcomes (CO):	
CO1:	Ability to write procedural programmes in Python.
CO2:	Ability to write programs using standard data structures.
CO3:	Ability to use object-oriented paradigm to write program in Python.
CO4:	Ability to use Numpy, Panda and Matplotlib modules to write programs.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (scale 1: low, 2: Medium, 3: High)

CO/PO	*PO01*	*PO02*	*PO03*	*PO04*	*PO05*	*PO06*	*PO07*	*PO08*	*PO09*	*PO10*	*PO11*	*PO12*
CO1	-	1	2	1	3	-	-	-	1	1	1	1
CO2	-	1	2	1	3	-	-	-	1	1	1	1
CO3	-	1	2	1	3	-	-	-	1	1	1	1
CO4	-	1	2	1	3	-	-	-	1	1	1	1

Unit I

Identifiers, keywords, statements & expressions, variables, operators, precedence & associativity, data types, indention, comments, console I/O, type conversion. Control flow statements (if family; while & for loops; continue & break statements), exception handling. Functions, command line arguments.

Unit II

String management & usage, Lists, Dictionaries, Tuples & Sets. The operations on these data structures. Filter, Map and Reduce Function,

Unit III

Object Oriented Programming: Properties / attributes, methods, inheritance, class variables & functions, static methods, delegation, abstract base classes, Generic function.
File Handling.

Unit IV

Numpy: Dtypes, Multidimensional Arrays, Slicing,Numpy Array & Memory, Array element-wise operations, Numpy Data I/O, floating point numbers, Advanced Numpydtypes.
Pandas: Using series and Dataframes, Indexing &Reindexing, Deleting and merging items, Common operations, Memory usage and dtypes, Pipes, Displyingdataframes, Rolling & Filling operations.
Matplotlib: Setting defaults, Legends, Subplots, Sharing Axes, 3D surfaces.

Note: Atleast two laboratory practicals in each unit to be conducted. The list of practicals to be notified by the concerned teacher at the start of the teaching in thesemester.

Textbooks:

1. *Introduction to Python Programming*, Gowrishankar S. and Veena A., CRC Press,2019.
2. *Python Programming for Data Analysis*, Jose Unpingco, Springer Nature,2021.

References:

1. *Python: An Introduction to Programming*, James R. Parker, 2nd Ed., Mercury Learning And Information, 2021.
2. *Introduction to Computation and Programming Using Python*, John V. Guttag, The MIT Press,2021.
3. *Python Programming: A Practical Approach*, Vijay Kumar Sharma, Vimal Kumar, Swati Pathak, and Shashwat Pathak, CRC Press, 2021.

THIRD SEMESTER

Theory Papers					
Group	**Paper Code**	**Paper**	**L**	**T/P**	**Credits**
BS	BS 211	Material Science	3	-	3
PC	CT 201	Process Calculations	3	1	4
PC	CT 203	Fluid Mechanics	3	1	4
PC	CT 205	Mechanical Operation	3	1	4
PC	CT 207	Transport Phenomena	3	1	4
PC	CT 209	Engineering Thermodynamics	3	-	3
HS	HS 211	Engineering Economics	2	-	2
Practical/Viva Voce					
PC	CT 261	Mechanical Operation Lab	-	3	2
PC	CT 263	Fluid Mechanics Lab	-	3	2
Total			**20**	**10**	**28**

BS- 211(Material Science)	3 L	0 T	0 P	3 Credit

Course Objectives

1. To familiarize students with the fundamental aspects of materials science
2. To introduce students to the basic structure of solids, classification of materials based on the structure and the correlation between the structure and properties.
3. To help students understand and distinguish between various materials based on their structure and properties and hence their engineering applications
4. To expose students to emerging advanced material technology

Course Outcomes

1. Students familiarize themselves with the fundamental aspects of materials science
2. Students understand the basic structure of solids, classification of materials based on the structure and the correlation between the structure and properties.
3. Students understand learn to and distinguish between various materials based on their structure and properties and hence their engineering applications.
4. Students are introduced to emerging trends in advanced material technology and applications.

Course Content

UNIT 1 (15 Hrs)

Introduction to material science and engineering: Structure of solids: Introduction to engineering materials, Forces, atomic structures and chemical boding – ionic, covalent and metallic, van de Waal's bond -interatomic distance curves. Structure property correlations in engineering materials. Brief descriptions of Metals, Ceramics, Glass, Polymers, Composites and Semiconductors – properties and applications.

UNIT 2 (15 Hrs)

Crystal Structure and X-ray diffraction: Directions, Planes & Miller Indices; concept & properties of reciprocal Lattice. X –Rays Diffraction: Crystal structure, Bravais lattice, production &absorption of X-rays, Bragg's Law, intensities of diffracted beams, XRD equipment, crystal structure determination, indexing XRD pattern, Electron & Neutron diffractions.

UNIT 3 (12 Hrs)

Novel Materials – Properties and applications: (a) Introduction to superconductors (b) nano engineered materials in energy and environmental applications. (c) biodegradable materials (qualitative and introductory)

Text and Reference Books

[1] Materials Science and Engineering: An Introduction: 9th Edition, William D. Callister Jr. and David G. Reth wisch 984 page; Wiley (December 2013)

[2] Introduction to Materials Science for Engineers; 8th Edition James F. Shackelford.696 pages: Pearson (April 2014)

[3] Foundations of Materials Science and Engineering; 5th Edition William F. Smith and Javad Hashemi. 1088 page; McGraw –Hill Education (April 2009)

[4] Online resources

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	3	3	1	2	3	3	3	3	2	3

CO2	2	3	2	3	3	2	3	3	3	3	1	3
CO3	2	3	3	2	2	2	3	3	3	1	3	3

CT-201(Process Calculations)	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objectives

The course will serve as a basis for all further chemical engineering courses that are part of the curriculum.

Course Outcomes

1. Develop mastery over process calculations relevant to chemical engineeringprocesses
2. Students will be able to handle elementary flow-sheeting, material and energy balance calculations withoutandwithchemicalreactions,andinvolvingconceptslikerecycle,bypassandpurge.
3. Be familiar with equations of state and properties of gases and liquids, including phase transition

Course Content

UNIT 1 **(8Hrs)**

Concept of units, physical quantities in chemical engineering and their significance, dimensionless groups, "basis" of calculations.

UNIT 2 **(18Hrs)**

Material Balance: Introduction, solving material balance problems with and without chemical reactions,concept of stoichiometry,mole balance,Material Balance: Recycle, bypass and purge.

Gases, Vapors and Liquids: Equation of state, Vapor pressure and its Characteristics, Determination of vapor pressure using empirical laws, Clausius-Clapeyron equation, Cox chart, Duhring's plot

UNIT 3 **(15Hrs)**

Energy Balance: Open andclosedsystem, Heat Capacity, Calculation of Enthalpy changes. Energy balances with chemical reaction: Heat of reaction, Heat of combustion.

UNIT 4 **(15Hrs)**Crystallization, Dissolution,Humidity and Saturation, humid heat, humid volume, Dew point& Bubble pointHumidity chart and its applications.

Text and Reference Books

[1] Basic Principles and Calculations in Chemical Engineering, Himmelblau, D. M., Riggs, J. B. 8thEd., Pearson India Education Services, 2015.
[2] Stoichiometry, Bhatt, B. I., Vora, S. M., 4thEd., Tata McGraw Hill Publishing Company Ltd,2015.
[3] Chemical Process Principles, Part-I Material & Energy Balances, Hougen, O. A., Watson, K. M., Ragatz, R. A.,2ndEd., CBS Publishers & Distributors, 2004.
[4] Stoichiometry and Process Calculations, Narayanan, K.V.,Lakshmikutty, B., Prentice Hall of India, 2012.
[5] Process Calculations, Venkataramani, V., Anantharaman, N., Begum, K. M. Meera Sheriffa, 2nd Ed., Prentice Hall of India, 2011.
[6] Chemical Process Calculations, Sikdar, D. C., Prentice Hall of India, 2013.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	3	1	3	2	1	3	1	1	3
CO2	3	3	2	3	1	3	2	1	3	1	1	3
CO3	3	3	2	3	1	3	2	1	3	1	1	3

CT-203(Fluid Mechanics)	3 L	1 T	0 P	4 Credit

Course Objectives

The Objective is to introduce students to the basic concepts of compressible and non-compressible fluid flow and understand fluid mechanics involved in functioning of basic equipments required in chemical industries such as pumps, valves, fittings and fluidized beds etc.

Course Outcomes

1. The students will be able to establish force balance in static systems including application of Bernoulli's theorem to compute pressure drop in different flow systems.
2. The students will be able to describe function and performance of flow metering.
3. The students will be able to understand fixed bed system and determine minimum fluidization velocity in fluidized bed.

Course Content

UNIT 1 **(15Hrs)**

Fluid statics and properties of fluid pressure measurement, forces on submerged bodies. Equation of continuity and motion, Navier-Stokes equation and its applications. Bernoulli's Equation and its applications. Different types of fluids such as (Newtonian and non-Newtonian fluids, Laminar and Turbulent flows).

Incompressible Flow & Fluidization concept: Laminar and turbulent flow in pipes, Velocity distribution in pipes, Frictional losses in pipes and fittings. Pressure drop calculations and friction factor, Estimation of economic pipe diameter.

UNIT 2 **(15Hrs)**

Measurement and Control of Flowing Fluids, Principles and operation of variable head meter and variable area meter. Fluid moving machineries such as pumps, blowers, compressors, turbines etc. Application and selection of valves and their significance in process industries.

UNIT 3 **(13 Hrs)**

Laminar flow, Turbulence, boundary layer theory and flow, Reynold's stress,Flow past immersed bodies, Drag and lift forces, Motion of solids through a fluid.

UNIT 4 **(13 Hrs)**

Flow of compressible fluid: Basic equations, Flow through ducts, venturimeter, orifice meter, convergent-divergent nozzles, Laval Nozzle, Fanno flow.

Text and References Books

[1] Unit Operations of Chemical Engineering, McCabe W.L,Smith J.C. and Harriott P.,McGraw Hill International Edition, Singapore

[2] Introduction to Fluid Mechanics, Fox and McDonald, John Wiley & Sons

[3] Fluid Mechanics, Douglus J. F., Gasiorek J.M., Swaffield J.A., Addison-Wesley Longman

[4] Introduction to Chemical Engineering, Badger W.L. and Banchero J.T.,Tata McGraw Hill

[5] Chemical Engineering, Vol .1, Coulson J.M. and Richardson J.F, Butterworth Heinemann, Oxford.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	3	2	1	3	1	1	3
CO2	3	3	3	3	1	3	2	1	3	1	1	3

CO3	3	3	3	3	1	3	2	1	3	1	1	3

CT-205(Mechanical Operations)	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objectives

The course objective is to introduce students to the numerous industrial operations dealings with the particulate solids, their handling in various unit operations, and those in which particle- fluid interactions are important.

Course Outcomes

1. Students will be able to calculate drag force and terminal settling velocity for singleparticles and calculate pressure drop in fixed and fluidizedbeds.
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 theirusage.

Course Content

UNIT 1 **(15Hrs)**

Size Reduction: Size reduction of solids, Energy requirements for size reduction, Concept of crushing and grinding and their empirical laws, Work index, Particle sizedistribution. Mechanical Separation: Screening: Stationary screens, Grizzlies, Trommels and vibrating screens, Screen effectiveness

UNIT 2 **(15Hrs)**

Filtration: Concept of filtration, Different types of filtrations (Plate and Frame filter press, Continuous rotary vacuum filter, Filter aids etc)

Sedimentation: One dimensional motion of particles through fluid. Batch and continuous thickeners

Centrifuge: Types of centrifuges (Tubular bowl centrifuge, disks centrifuge, and batch basket centrifuge).

Separators: Cyclone separators, electrostatic and magnetic precipitator.

UNIT 3 **(06Hrs)**

Concept of Conveying, Types of conveying systems(Mechanical and pneumatic conveying system), Storage and handling of materials, Design and powerrequirement.

UNIT 4 **(20Hrs)**

Application of mechanical operation equipment's;Agitation and mixing of liquids. Conditions of fluidization, aggregate and particulate fluidization, Flow through packed and fluidized Beds.

Text and References Books

[1] Unit Operations of Chemical Engineering, McCabe W.L Smith J.C. and Harriott P., McGraw Hill,Singapore.
[2] Chemical Engineering, Vol.1, Coulson J.M. and Richardson J.F, Butterworth Heinemann, Oxford
[3] Introduction to Chemical Engineering, Badger W.L. and Banchero J.T.,Tata McGraw Hill
[4] Unit Operations of Chemical Engineering Vol .1, Chattopadhya, P., Khanna Publishers.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	3	3	1	3	1	1	3
CO2	3	3	3	3	1	3	3	1	3	1	1	3
CO3	3	3	3	3	1	3	3	1	3	1	1	3

CT-207(Transport Phenomena)	3 L	1 T	0 P	4 Credit

Course Objectives

To be able to analyze various transport processes with understanding of basic principles, method of solution and their limitations.

Course Outcomes

1. To understand the basic principles of mass, energy and momentum transfer and their applications.
2. To derive the fundamental transport equations that governs mass, heat and momentum transfer and associated initial and boundary conditions.
3. To formulate and solve analytically the steady and time dependent flow/heat/mass transfer problems either individually or coupled for simple geometries.
4. To analyze industrial problems along with appropriate approximations and boundary conditions.

Course Content

UNIT 1 **(15Hrs)**

Philosophy and fundamentals of three transport phenomena: Importance of transport phenomena and analogous nature of transfer process. Basic concepts and conservation of laws. Molecular transport of momentum, Newton's law of viscosity, Fourier law of heat conduction, and Fick's law of diffusion. Transport coefficients – viscosity, thermal conductivity and mass diffusivity.

UNIT 2 **(11Hrs)**

The equations of change for isothermal systems: The equation of continuity, the equation of motion, the equation of mechanical energy, the equation of angular momentum, the equations of change in terms of the substantial derivative, use of the equations of change to solve flow problems. Velocity distributions in turbulent flow: comparisons of laminar and turbulent flows.

UNIT 3 **(15Hrs)**

Shell momentum balances and velocity distributions in laminar flow: Shell momentum balances and boundary conditions, flow of a falling film, flow through a circular tube, flow through annulus, flow of two adjacent immiscible fluids, creeping flow around a sphere.

Shell energy balances and temperature distributions in solids and laminar flow: Shell energy balances, boundary conditions, heat conduction with an (electrical heat source, nuclear heat source, viscous heat source, chemical heat source), heat conduction through composite walls, heat conduction in a cooling fin, forced convection, free convection.

UNIT 4 **(15Hrs)**

Concentration distributions in solids and laminar flow: Shell mass balances, boundary conditions, diffusion through a stagnant gas film, diffusion with a heterogeneous and homogeneous chemical reaction, diffusion into a falling liquid film (gas absorption and solid dissolution)

Text and References Books

[1] Transport Phenomena, R.B. Bird, W.E. Stewart and E.W. Lighfoot, Second Edition, John Wiley & Sons, 2005.

[2] Transport Processes and Separation Process Principles, Christie J. GeanKoplis, 4th Edition, Pearson, 2015.

[3] Fundamentals of Momentum Heat and Mass Transfer, J.R. Wilty, C.E. Wicks, R.E. Wilson and, G.L. Rorrer, 4th Edition, John Wiley & Sons, 2001.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-209(Engineering Thermodynamics)	3 L	0 T	0 P	3 Credit

Course Objectives

The objective of this course is to learn about the basics of thermodynamics laws, thermodynamic properties as well as conceptual information of refrigeration and liquefaction

Course Outcomes

1. The students will get a good understanding work and heat interactions.
2. The students will be able to analyze energy conversion.
3. The students will be able to understand phenomena occurring in Refrigeration and liquefaction

Course Content

UNIT 1 **(10 Hrs)**

First law of Thermodynamics and other basic concepts: Dimensions, units, work, heat, energy, Enthalpy, Equilibrium state, Phase rule, Introduction to Heat capacity and Heat effects

Volumetric properties: PVT behavior of pure substances, ideal gas, real gas, Cubic Equation, Virial Equation and Generalized Correlations for liquid and gases

UNIT 2 **(12 Hrs)**

Second law of thermodynamics and Entropy: Statements and significance, heat engines, Kelvin-Planck and Clausius statements and their equality, reversible and irreversible processes, Carnot cycle, thermodynamic temperature scale, entropy and related calculations, T-S diagrams, properties of pure substances, Use of steam table and Mollier diagram.

UNIT 3 **(10 Hrs)**

Heat Effects: Latent heat of pure substance, Standard heat of reaction, Heat of formation & Combustion, Heat effects of Industrial Reactions. Property changes of mixing, Heat effects of mixing

Thermodynamic properties of fluids: Fluid property relations for homogenous phases, thermodynamic diagram, Residual properties from Virial Equation of state, generalized property correlation for gases, two phase systems

Thermodynamics of flow processes: Flow of compressible fluids through ducts, compression processes, turbines.

UNIT 4 **(10 Hrs)**

Production of Power from Heat: Steam Power Plant, Internal Combustion Engines, Jet Engines

Refrigeration and liquefaction: Carnot refrigerator, vapor–compression cycle, Absorption Refrigeration, Choice of refrigerant, comparison of refrigeration cycles, liquefaction processes, heat pumpand Rankine power cycle.

Text and References Books

[1] Chemical, Biochemical, and Engineering Thermodynamics by Sandler S. I. John Wiley and Sons, 5th Edition, 2017 Inc., NewYork

[2] Introduction to Chemical Engineering Thermodynamics by SmithJ.M, Van Ness H.C., Abbott M. M, The McGraw Hill Companies, Inc.,8th Edition, 2019 USA

[3] Introductory Chemical Engineering Thermodynamics, by Elliott J. R. and Lira C. T., Prentice Hall, 2nd Edition, 2012.

[4] Applied Thermodynamics for Engineering Technologists by Eastop T. D. and McConkey A., Addison Wesley Longman Ltd.,5th Edition, 2002 England.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	3	3	1	3	1	1	3
CO2	3	2	3	2	1	3	2	1	3	1	1	3
CO3	3	2	3	2	1	2	3	1	3	1	1	3

HS-211(Engineering Economics)	2 L	0 T	0 P	2 Credit

Course Objective

This course intends to expose the students to the basic principles in economic theory and illustrate with application.

Course Outcomes

1. To impart the knowledge of economic decisions, optimization and equilibrium at both individual and aggregate level.
2. To build analytical capacity to comprehend, analyze and suggest solution to an economic problem.
3. To assess the role of market mechanism in shaping the economic outcomes, individual and market behavior

Course Content

UNIT 1 Introduction to Economics **(6 Hrs)**

Problem of scarcity and choices, Opportunity cost, Production Possibility Frontier, Economic System, Micro-Macro Paradox, Elements of Demand and Supply, Diamond water Paradox

UNIT 2 Consumer and Producer Theory **(8 Hrs)**

Marginal Utility, Indifference Curve Analysis, Elasticity of Demand and Supply, Production Function, Law of variable Proportion, Law of Returns to scale

UNIT 3 Market Structure **(8 Hrs)**

Perfect competition, Monopoly, Monopolistic Competition and oligopoly

UNIT 4 Income Distribution and Factor Pricing Input Market **(6 Hrs)**

Determination of rent, wages, profit and interest, National Income accounting

Text and References Books

[1] Principal of Economics, Lipsey & Crystal, Oxford University Press
[2] Samuelson Nordhans Economic, Tata Mc Graw Hill, Ed, New Delhi

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	3	3	2	2	3	3	3	3	2	3
CO2	2	3	3	3	3	2	3	3	3	3	2	3
CO3	2	3	3	2	2	2	3	3	3	3	3	3

CT-261(Mechanical Operation Lab)	0 L	0 T	3 P	2 Credit

Laboratory Objectives

Practice on actual equipment's of Mechanical Operation.

Laboratory Outcomes

1. To learn particle analysis of heterogeneous mixtures using sieve analysis to calculate particle diameter, specific surface area and screen effectiveness.
2. To develop ability to do experiments on size reduction, sedimentation and filtration, drying etc.

List of Experiments for Mechanical Operation

1. Verification of Stokes' Law
2. Experiment based on Sedimentation
3. Experiment on Leaf Filter
4. Experiment on Rotary Vacuum Filter
5. Experiment on Plate & Frame Filter Press.
6. Experiment on Screen Separation
7. Experiment on Size reduction by Jaw Crusher
8. Experiment on Rod Mill
9. Experiment on Ball mill
10. Studies on drying characteristics of Tray Dryer
11. Studies on drying characteristics Rotary Dryer
12. Experiment on Agitation and mixing

CT-263(Fluid Mechanics)	0 L	0 T	3 P	2 Credit

Laboratory Objective

Practice on actual equipment's of Fluid Mechanics

Laboratory Outcomes

1. To develop ability to do experiments in fluid flow meters such as venturi, orifice and to do performance test on pumps.
2. To develop ability to conduct experiments and verify Bernoulli's theorem and pipe fitting.

List of Experiments for Fluid Mechanics

1. Calibration of orifice meter.
2. Calibration of venturi meter.
3. Performance characteristics of pump.
4. Power consumption in agitated vessel.
5. Pressure drop in pipe and other fittings.
6. Bernoulli's experiment.
7. Flow through packed bed or Flow through fluidized bed.
8. Flow through weirs or notches (Rectangular/Triangular).

FOURTH SEMESTER

Theory Papers					
Group	**Paper Code**	**Paper**	**L**	**T/P**	**Credits**
PC	CT 202	Mass Transfer I	3	1	4
PC	CT 204	Heat Transfer I	3	1	4
PC	CT 206	Chemical Reaction Engineering I	3	1	4
PC	CT 208	Chemical Engineering Thermodynamics	3	1	4
PC	CT 210	Chemical Process Control I	3	1	4
PC	CT 214	Process Industries	3	1	4
Practical/Viva Voce					
PC	CT 262	Chemical Reaction Eng. Lab	-	3	2
PC	CT 264	Instrumentation & Process Control Lab	-	3	2
Total			**18**	**12**	**28**

CT-202(Mass Transfer I)	3 L	1 T	0 P	4 Credit

CourseObjectives

To learn about the basic principles of unit operations (absorption, humidification and drying) and design of equipment's involved.

Course Outcomes

1. Concept of molecular diffusion in gas, liquid and solids, and determination of diffusion coefficient.
2. Concept of various mass transfer theories, and determination of mass transfer coefficient and mass transfer rate.
3. To understand the fundamentals and basic principles of absorption, humidification and drying with industrial applications.
4. To design of absorption, humidification and drying equipment.

Course Content

UNIT 1 **(20 Hrs)**

Fundamentals of Mass Transfer: Molecular diffusion in gases, liquids and solids, Convective mass transfer and mass transfer coefficients, Interphase mass transfer, Theories of mass transfer, Mass transfer accompanied by chemical reaction.

UNIT 2 **(14 Hrs)**

Absorption: Equilibrium solubility of gases in liquids Choice of solvents Co-current and counter-current multistage operation Concept of ideal stage, stage efficiency, operating line Design of packed tower Concept of height of transfer unit, Determination of number of transfer unit, height equivalent theoretical plate.

UNIT 3 **(12 Hrs)**

Humidification/Dehumidification and drying:

Wet bulb, dry bulb and adiabatic saturation temperatures, Concept of humidity, method of changing humidity, Use of psychometric charts (temperature/ humidity and enthalpy/humidity charts), estimation of air quality construction and calculations for cooling tower.

Concept of drying and its mechanism, Drying equilibrium, Drying rate curves,Classification and application of drying equipmentEstimation of drying time and Process design of dryers.

UNIT 4 **(10 Hrs)**

Crystallization theory of solubility, phase diagram (temperature solubility relationship), population balance analysis, method of moments for rate expression for volume area and length growth, crystal size distribution, Product removal operation, Programmed evaporative and cooling (rate expressions), Dominant size ideal classified bed, melt crystallization, process design of crystallizer and the operation, selection and specification of different crystallizers like OSLO, Swenson Walker, Agitated type etc, Performance evaluation of crystallizer.

Text and Reference Books

[1] Mass-Transfer Operation, Robert E. Treybal, McGraw Hill, Third Edition, 1981.

[2] Principles of Mass Transfer and Separation Processes, Binay K Dutta, Prentice-Hall India, 2015.

[3] Transport Processes and Separation Process Principles, Christie J. GeanKoplis, Pearson, Fourth Edition, 2016.

[4] Unit Operations of Chemical Engineering, McCabe W.L., Smith J.C. and Harriott P. McGraw Hill International edition, Singapore, Seventh Edition, 2005.

[5] Principles and Modern Applications of Mass Transfer Operations, Jaime Benitez, John Wiley & Sons, 2017.

[6] Principles of Unit Operations, Foust A.S., John Wiley & Sons, Singapore,1994.

[7] Separation Process Engineering, Philip C. Wankat, Pearson Education, Inc., 2014

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3	3	3	2	1	3	2	1	3	1	1	3
CO2	3	3	3	2	1	3	2	1	3	1	1	3
CO3	3	3	3	2	1	3	2	1	3	1	1	3
CO4	3	3	3	2	1	1	2	1	1	1	1	3

CT-204(Heat Transfer I)	3 L	1 T	0 P	4 Credit

Course Objectives

The objective of the subject is to make student familiar with the basic Concepts of Heat Transfer, heat transfer mechanisms and design of heat exchangers

Course Outcomes

1. Illustrate principles of heat transfer of different heat exchanging phenomena.
2. Apply laws of heat transfer for energy balance of chemical processes
3. Solve heat transfer problems using different heat transfer laws

Course Content

UNIT 1 **(12 Hrs)**

Conduction: Fourier's law Steady-state heat transfer through plane wall and composite slabs, cylinders and spheres, Thermal contact resistance, Critical thickness of insulation, Optimum thickness of insulation.

UNIT 2 **(12 Hrs)**

Convection: Free and Forced convection,Individual and overall heat transfer coefficients, Log-mean temperature difference (LMTD); Dimensional analysis of heat transfer, Equivalent diameter, General equation for forced convection, Thermal boundary layer,Analogy between heat and momentum transfer.

UNIT 3 **(12 Hrs)**

Radiation: Stefan Boltzmann law, Kirchoff's law and their applications, Black body and Grey body, View factor, Radiant heat exchange between surfaces.

UNIT 4 **(20 Hrs)**

Heat exchangers: Type of different heat exchangers and their design (Double pipe, Shell and tube, finned tube and Compact heat exchangers)

Condensers (horizontal and vertical) and reboilers (thermosiphon and kettle), Partial condensers. Type of evaporators with accessories; Capacity and Steam economy, Boiling point rise/elevation, Multiple effect evaporators,Design of single and multiple effect evaporators.

Text and References Books

[1] Heat Transfer, Holman J. P., McGraw Hill, New York.
[2] Process Heat Transfer, Kern D. Q., Tata Mc Graw Hill Edition.
[3] Unit Operations of Chemical Engineering, McCabe W.L.,Smith J.C. & Harriott P., McGraw Hill Singapore.
[4] Transport Processes and Unit Operations, GeankoplisC.J., Prentice Hall of India
[5] Fundamentals of Heat and Mass Transfer, Dewitt et al., John Willey & Sons
[6] Chemical Engineering Vol.1, Coulson J.M. and Richardson J.F. Butterworth Heinemann, Oxford
[7] Heat Transfer, Chapman A. J., Mac Millan, New York
[8] Fundamentals of Momentum, Heat and Mass Transfer, Welty J.R., Wilson R.E., and Wicks C.E., John Wiley & Sons, Inc. New York

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	1	3	2	1	3	1	1	3
CO2	3	2	3	2	1	2	2	1	2	1	1	3
CO3	3	2	2	2	1	3	2	1	3	1	1	3

CT-206 (Chemical Reaction Engineering I)	3 L	1 T	0 P	4 Credit

Course Objectives

The course is designed for understanding the (i) Basic Concepts of Kinetics and Rate Laws and (ii) Classification, design equations, rating and RTD of batch and continuous reactor

Course Outcomes

1. Students will understand the fundamentals of chemical kinetics and identify reaction mechanisms.
2. Design chemical reactors involving heat effects optimally using minimum amount of data.
3. Operate reactors in a safe manner for single and multiple reactions.
4. Design, analyze and compare ideal and non-ideal reactors and bioreactors

Course Content

UNIT 1 **(11 Hrs)**

Overview of Chemical Reaction Engineering: Classification of Reactions, Concept of reaction rate, Variables affecting the rate of reaction

Kinetics of Homogeneous Reactions: The Rate Equation, Concentration and Temperature dependent term of rate equation Searching for a reaction mechanism, predictability of specific Reaction Rate from Theory

UNIT 2 **(15 Hrs)**

Interpretation of Batch Reactor Data: Constant-volume Batch Reactor, Varying-volume Batch Reactor, Temperature and Reaction Rate, The Search for a Rate Equation

Ideal Reactors for a Single Reaction: Ideal Batch Reactors, Steady-State Mixed Flow Reactors, Steady-State Plug Flow Reactors.

UNIT 3 **(15 Hrs)**

Residence Time Distribution: E & F Curve, Age Distribution of Fluid, RTD, conversion in Non-Ideal Flow Reactors. Concept of Tank in Series and Dispersion model

UNIT 4 **(15 hrs)**

Design for Single Reactions: Size comparison of single reactors, Yield & Selectivity, Multiple-Reactor Systems, Recycle Reactor, Autocatalytic Reactions, Design of single and multiple reactions, irreversible 1^{st} order reaction in series, irreversible series-parallel reaction

Temperature and Pressure Effects: Single Reactions, Optimum temperature progressions, Adiabatic and Non-adiabatic operations, Exothermic reactions in mixed flow reactors

Text and Reference Books

[1] Chemical Reaction Engineering by Octave Levenspiel, John Wiley & Sons 3rd Edition, 2006.
[2] Elements of Chemical Reaction Engineering by H. Scott Fogler, Prentice Hall 4^{th} Edition 2015.
[3] Kinetics and Mechanisms of Chemical Transformation: J. Rajaram and J. C. Kuriacose-Macmillan India Ltd. New Delhi 2015
[4] Chemical Reactor Analysis and Design, Froment G.F. & Bischoff, John Wiley & Sons, 3^{rd} Ed 2010.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	1	3	2	1	3	1	1	3
CO2	3	3	3	2	1	3	2	1	3	1	1	3
CO3	3	3	3	2	1	3	2	1	3	1	1	3

CT-208 (Chemical Engineering Thermodynamics)	3 L	1 T	0 P	4 Credit

Course Objectives

To learn about the essential concepts of classical thermodynamics so that students will comprehend the breadth as well as the limitations of thermodynamics for various separation and reaction processes.

Course Outcomes

1. To introduce the basic principles of solution thermodynamics and to give students a strong foundation for further studies in chemical engineering.
2. To train students to apply knowledge in thermodynamics to the solution of industrial problems both in separation and reactions.
3. To understand the fundamental concepts of chemical engineering thermodynamics and to explain these concepts to other chemical engineers.

Course Content

UNIT 1 **(16 Hrs)**

Solution Thermodynamics: Fundamental property relations, Phase Equilibrium, partial properties, ideal gas mixture, fugacity, Activity Coefficient: effect of temperature and pressure, fugacity coefficient for a pure species and for species in solution and correlation for the fugacity coefficients, excess properties. Activity Coefficient Equations: Margueles, van Laar, Wilson, NRTL, UNIQUAC, UNIFAC,

Liquid phase properties from vapour liquid equilibrium data. Models for the excess Gibb's energy. Change of properties due to mixing, heat effect of mixing process.

Vapor Liquid Equilibria: Nature of Equilibrium, Phase rule, VLE: Qualitative behavior, Simple model for VLE, VLE by modified Raoult's law, VLE from K Values, Henry's law & Dilute solutions, Chemical potential: effect of temperature and pressure.

UNIT 2 **(14 Hrs)**

Phase Equilibrium: Phase rule. Vapour-liquid equilibrium at low to moderate pressures. High pressure vapour-liquid equilibrium. Liquid-liquid equilibrium. Osmotic equilibrium and Osmotic pressure.

UNIT 3 **(13 Hrs)**

Chemical Reaction Equilibrium: Equilibrium & Stability, Liquid/Liquid Equilibrium, Vapor/Liquid/Liquid Equilibrium, Solid/Liquid Equlibirium, Solid/Vapor Equilibrium, Equilibrium adsorption of gases on solids: pure gas adsorption & Heat of adsorption, Osmotic equilibrium & Osmotic pressure

UNIT 4 **(13 Hrs)**

Thermodynamic Analysis of Processes: Work and energy functions, availability, heat exchange, mixing and separation processes.

Text and Reference Books

[1] Introduction to Chemical Engineering Thermodynamics, Smith J.M , Van Ness H.C., Abbott M. M , ,8th Edition, The McGraw Hill Companies, Inc.,USA, 2019.

[2] Chemical, Biochemical, and Engineering Thermodynamics, Sandler S. I. 5thEdition, John Wiley and Sons, Inc., NewYork, 2017

[3] Introductory Chemical Engineering Thermodynamics, Elliott J. R. and Lira C. T., 2nd Edition, Prentice Hall, 2012

[4] Engineering and Chemical Thermodynamics Paperback, Milo D. Koretsky, John Wiley and Sons, Inc., New York, 2009.

[5] A Textbook of Chemical Engineering Thermodynamics, K.V. Naraynan, PHI, 2013.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	2	2	1	3	1	1	3

CO2	3	2	3	2	1	2	2	1	3	1	1	3
CO3	3	3	3	2	1	3	2	1	3	1	1	3

CT-210(Chemical Process Control I)	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objectives

1. To introduce fundamentals of various measuring instruments and process controller.
2. To understand the mathematical models based on transfer function approach for single loop systems, dynamic response of open loop and closed loop systems, stability analysis and controller tuning methods.

Course Outcomes

1. Understanding the working principle of various measuring instruments
2. Importance of control aspects in chemical processes.
3. Understanding of dynamic behavior and stability criterion of control systems.
4. Understanding of design/tuning of controllers.

Course Content

UNIT 1 **(10 Hrs)**

Concept of measurement: Error, Accuracy, Sensitivity, Instrumentation for process variables such as pressure, temperature, level and flow of fluids.

UNIT 2 **(15 Hrs)**

Transfer function, Concept of automatic control, Feedback control, Control loop and its components, Dynamic behavior of first and second order, Interacting, Non-interacting & higher order systems, Distance-velocity lag.

UNIT 3 **(11 Hrs)**

Laplace domain analysis of closed loop systems; Stability analysis of feedback system: Routh stability and Root Locus Diagrams.

UNIT 4(20 Hrs)

Frequency response techniques: Bode and Nyquist stability criterion.

Design of feedback control system/tuning of controllers: Simple performance criteria, Quarter decay response and Minimum error integral criteria.

Text and Reference Books

[1] Process System Analysis and Control, Coughanowr, D.R. and Koppel, L.B., McGraw Hill 3rd edition, 2009

[2] Chemical Process Control- An introduction theory and practice, Stephanopolous, G., Prentice Hall of India 1984

[3] Process Dynamics & Control, Seborg D. E., T. F. Edger and D. A. Mellichamp, John Wiley & Sons, 4th edition 2017.

[4] Coulson & Richardson's Chemical Engineering, Richardson J. F., Peacock D.G., Elsevier, Volume 3/3rd edition 1994.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	1	1	3	2	1	3	1	1	3
CO2	3	3	3	2	2	3	2	1	3	1	1	3
CO3	3	3	3	1	2	3	2	1	3	1	1	3
CO4	3	3	3	3	1	3	2	1	3	1	1	3

CT-214(Process Industries)	3 L	1 T	0 P	4 Credit

Course Objectives

1. To elaborate the manufacturing of various inorganic and organic chemicals.
2. Discuss the process flow diagram and various process parameters
3. Identify and solve engineering problems during production
4. Study current scenario of chemical & allied process industries.

Course Outcomes

1. Ability to understand the manufacturing of various inorganic and organic chemicals
2. Ability to understand the process flow diagram and various process parameters
3. Ability to identify and solve engineering problems during production
4. current scenario of chemical & allied process industries.

Course Content

UNIT 1 **(20 Hrs)**

National and International scenario of chemical & allied process industries

Introduction and classification of chemical process industries, Symbols used flow diagrams and Types of flow sheets, Overview of safety and safe practices, Environmental and energy conservation measures, Waste disposal.

Introduction to industrial acids: Sulfuric acid, DCDA process; Nitric Acid and its manufacturing by Ostwald Process

UNIT 2 **(12 Hrs)**

Chlor-alkali industries: Chlorine-caustic soda, Soda-ash, Modified Solvay process (Raw materials, Manufacturing Process, Flow-sheet, Sequence of operation, and Major engineering problems).

Cement industries: Raw materials, Manufacturing Process, Flow-sheetand Major engineering problems

UNIT 3 **(12 Hrs)**

Fertilizer Industries:Types of fertilizers, Synthesis of ammonia and Urea

Hydrogen Manufacturing process.

Manufacturing and Refining process of sugar

Pulp and paper Industries:Raw materials for pulping, Various pulping techniques, Manufacturing process of paper, Recovery of chemicals from black liquor,

UNIT 4 **(12 Hrs)**

Introduction to Fuels: (Solid, liquid and gaseous)

Text and Reference Books

[1] Outlines of Chemical Technology, Dryden, C. E., and Rao, M.G. (Ed.), Affil. East West Press, 2009.
[2] Chemical Process Industries, Austins, G.T., Sherve's, MGH 5th Ed. 2016.
[3] Introduction to Chemical Engineering, S. K. Ghoshal, S. K. Sanyal and S. Datta, Tata McGraw Hill, New Delhi, 2006.
[4] Encyclopedia of Chemical Technology, Kirk & Othmer, Wiley, 5th edition.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	1	1	3	3	1	3	1	1	3
CO2	3	1	1	1	1	3	3	1	3	1	1	3
CO3	3	1	1	1	1	3	3	1	3	1	1	3
CO4	3	1	1	1	1	3	3	1	3	1	1	3

CT-262(Chemical Reaction Engineering Lab)	0 L	0 T	3 P	2 Credit

Laboratory Objectives

Chemical Reaction Engineering lab provides the opportunity to the students for verifying various theoretical concepts learnt in theory courses. It also serves as a bridge between theory and practice.

Laboratory Outcomes

Students will learn to:

- Calculate rate, rate constant, activation energy and order of reaction.
- Understand the fundamental principles of reaction kinetics in different reactors through practical experimentation for non-catalytic homogeneous saponification reaction.
- Study the residence time distribution in a different ideal reactor.

List of experiments

1. To determine the residence time distribution coefficient for a CSTR for step input
   (i) For two constant volume reactor
   (ii) For two different RPM of agitator with constant volume
2. To determine the residence time distribution and dispersion coefficient for a CSTR with pulse input
3. To determine the residence time distribution for a PFR with step input.
   (i) For two different volume reactor (same diameter, different length)
   (ii) For two constant volume reactor (different diameter, same length)
4. To determine the residence time distribution and dispersion coefficient for a PFR with pulse input
5. To determine the residence time distribution for a fixed bed reactor with step input.
   (i) Different particle size (same length and same diameter)
   (ii) Different length of bed (diameter of bed and particle same)
6. To determine the residence time distribution and dispersion coefficient for a fixed bed reactor with pulse input.
7. To study the effect of temperature on the reaction kinetics in batch reactor
8. To study the saponification reaction in a CSTR for two different volume reactors.
9. To study the saponification reaction in a PFR for two different volume reactors.
10. To study the saponification reaction in a fixed bed reactor for two different volume reactor.
11. To study the homogeneous catalytic reaction (Oil Transesterification) for different catalyst concentrations.

CT-264(Instrumentation and Process Control Lab)	0 L	0 T	3 P	2 Credit

Laboratory Objectives

To equip the students with practical understanding of various instruments of Process control lab

Laboratory

- Understand the fundamental principles underlying process control through practical experimentation
- Learn the inherent characteristics of control valve.
- To implement PID controller on various control processes.
- To determine control valve characteristics

List of experiments

1. To study of fluid flow control system.
2. To study of air pressure control system using suitable controller
3. To study of temperature control system in combination of suitable controllers.
4. To study of level control system of tank.
5. To study the effect of different controllers on the dynamics of a first order system.
6. To study the Interacting and non-interacting systems of tanks.
7. To study the performance of cascade control system & to maintain desired level in a tank with flow.

FIFTH SEMESTER

Theory Papers						
Group	**Paper Code**	**Paper**	**L**	**T/ P**	**Credits**	**Total Credits**
MS	MS 112	Entrepreneurship Mindset	2	0	2	2
PC	CT 301	Mass Transfer II	3	1	4	4
PC	CT 303	Heat Transfer II	3	1	4	4
PC	CT 305	Chemical Process Control II	3	0	3	3
PCE	CT 307	Chemical Reaction Engineering II	3	1	4	4
Emerging area electives (EAE1) (opt any one)						
Modeling and Simulation	CT 309	Introduction to Computational Fluid Dynamics	3	1	4	4
Biochemical Engineering	CT333	Molecular Biology	3	1	4	
Environmental Engineering	CT313	Environmental Biotechnology	3	1	4	
Open area electives (OAE1) (opt any one)						
OAE or MOOCs	CT315	Bioanalytical Techniques	3	1	4	4
	CT317	Water Pollution and Abatement	3	1	4	
	CT319	Alternative Energy Sources	3	1	4	
Practical/Viva Voce						
PC*	CT361	Summer Training /Summer Project*	-	-	1	1
PC	CT363	Heat Transfer Lab	-	3	2	2
PC	CT365	Mass Transfer Lab	-	3	2	2
Total			**20**	**11**	**30**	**30**

***NUES: Comprehensive evaluation will be done by the teacher concerned out of total 100 marks. No end term examination shall be held.**

MS-112(Entrepreneurship Mindset)	2 L	0 T	0 P	2 Credit

Course Objectives

1. To provide a foundation for basic entrepreneurial skills and to acquaint students with the world of entrepreneurship and inspire them to set up and manage their businesses.
2. To acquaint students with the process of creativity and innovation.
3. To expose students to various aspects of entrepreneurship and business.
4. To expose students to case studies on successful entrepreneurs.

Course Outcomes

Students will be able to understand and learn:

1. Basic of entrepreneurial skills
2. Creativity and innovation for opportunity recognition
3. Analyzing opportunities and drafting a business plan.
4. Case studies of successful entrepreneurs serve as an inspiration to students.

Course Content

UNIT 1 **(7 Hrs)**

Introduction: The Entrepreneur; Characteristics and myths of entrepreneurship, Theories of Entrepreneurship, Entrepreneurial mindset- Creativity (Development of creative ideas) and Innovation (Types of innovation).

UNIT 2 **(7 Hrs)**

Promotion of Venture and Writing a business plan: Opportunity Analysis, External Environment Analysis in terms of (Economic, Social and Technological Analysis). Business plan- Concept of business plan, types of business plan. Development, execution and implementation of business plan.

UNIT 3 **(7 Hrs)**

Entrepreneurship Support: Entrepreneurial Development Programmes (EDP): different types of EDPs, Role of Government in Organizing EDPs, Institutions supporting small business enterprises (Central level, State level, other agencies, Industry associations).

UNIT 4 Practical: **(7 Hrs)**

- Presenting a business plan
- Project on Startup India or any other government policy on entrepreneurship
- Discussion on why startup fails, Role of MSME etc.
- Discussion on role of entrepreneur in economic growth.
- Discussion on technology park.
- Case study on successful Indian entrepreneurs.

Text and Reference Books

[1] Charantimath (8th Ed., 2014), Entrepreneurship Development and Small Business Enterprise, Pears Education.
[2] Bamford C.E (1st Ed 2015), Entrepreneurship: A Small Business Approach, McGraw Hill Education.
[3] Hisrich et al. (2013), Entrepreneurship, McGraw Hill Education
[4] Balaraju, Theduri (2012), Entrepreneurship Development: An Analytical Study, Akansha Publishing House.
[5] David, Otis, (2014), A Guide to Entrepreneurship, Jaico Books Publishing House, Delhi.
[6] Kaulgud, Aruna, (2012), Entrepreneurship Management, Vikas Publishing House, Delhi.
[7] Chhabra, T.N. (2014), Entrepreneurship Development, Sun India.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	3	3	2	2	3	3	3	3	2	3
CO2	2	3	3	3	3	2	3	3	3	3	2	3

CO3	2	3	3	2	2	2	3	3	3	3	3	3
CO4	2	3	3	2	2	2	3	3	3	3	3	3

CT-301(Mass Transfer II)	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objectives

To learn about the basic principles of unit operations (Distillation, Extraction and Adsorption) and Design of equipment's involved.

Course Outcomes

Students will be able to:

1. Analyze vapor-liquid, liquid-liquid and solid-liquid equilibrium data.
2. Understand the fundamentals and basic principles of distillation, liquid-liquid extraction, solid-liquid extraction, and adsorption with industrial applications.
3. Determine the number of stages and separation efficiency in distillation, extraction and adsorption for co-current, counter-current and cross-current operations.
4. Design the Distillation, Extraction and Adsorption equipment's.

Course Content

UNIT I **(18 Hrs)**

Distillation: Fundamentals of vapor-liquid equilibrium, Vapor-liquid diagrams (x-y and T-x-y diagrams), Different laws (Henry's laws, Raoult's laws and Dalton's laws), Batch and Flash distillation for binary and multicomponent systems. Continuous multistage fractionation of binary and multicomponent systems. Steam distillation, McCabe-Thiele method (Conceptual design of binary distillation columns, Calculation of number of stages), Enthalpy-concentration diagram, Partial vaporization/condensation, Fenske-Underwood-Gilliland method for multicomponent distillation. Distillation in packed tower.

UNIT 2 **(10 Hrs)**

Liquid-Liquid Extraction: Liquid-liquid equilibrium, Choice of solvent, Concept of single/smultistage co-current/counter current extraction and its design calculations, Equipments for liquid-liquid extraction.

UNIT 3 **(14 Hrs)**

Adsorption: Theory of adsorption, Use of adsorbents, Nature, characteristics and applications of adsorbents. Types of adsorption (Batch and continuous adsorption), Adsorption equilibria and kinetics. Concept of multi-component adsorption, Concept of Isotherms: Types of isotherms (Langmuir, Freundlich) and their significance, BET theory. Adsorbers: Types of adsorbers and Design of fixed bed adsorbers.

UNIT 4 **(14 Hrs)**

Ion Exchange & Leaching: Theory, Process and Operation Membrane Separation: Basic principle, Types of membrane separation (Micro-filtration, Ultra-filtration, Nano-filtration and Reverse osmosis) and their applications.

Text and Reference Books

[1] Mass-Transfer Operation, Robert E. Treybal, McGraw Hill, Third Edition, 1981.
[2] Principles of Mass Transfer and Separation Processes, Binay K Dutta, Prentice-Hall India, 2015.
[3] Transport Processes and Separation Process Principles, Christie J. GeanKoplis, Pearson, Fourth Edition, 2016.
[4] Unit Operations of Chemical Engineering, McCabe W.L., Smith J.C. and Harriott P. McGraw Hill International edition, Singapore, Seventh Edition, 2005.
[5] Microfiltration and Ultrafiltration, Principles and Applications, Leos J. Zeman, Andrew L. Zydney, Marcel Dekker Inc., 2016.
[6] Ultrafiltration and Microfiltration Handbook, Munir Cheryan, CRC Press, 2016.
[7] Principles and Modern Applications of Mass Transfer Operations, Jaime Benitez, John Wiley & Sons, 2017.
[8] Principles of Unit Operations, Foust A.S. John Wiley & Sons, Singapore,1994.
[9] Separation Process Engineering, Philip C. Wankat, Pearson Education, Inc., 2014.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	3	2	1	1	1	1	3
CO2	3	3	3	3	1	3	2	1	1	1	1	3
CO3	3	3	3	3	1	3	2	1	1	1	1	3
CO4	3	3	3	3	1	3	2	1	1	1	1	3

CT-303(Heat Transfer II)	3 L	1 T	0 P	4 Credit

Course Objectives

1. To understand the fundamentals of multi-dimensional steady and unsteady state heat conduction
2. To understand fundamentals of multiphase heat transfer and designing of heat transfer equipment.

Course Outcomes

Students will be able to:

1. Take into consideration the effects of heat transfer appropriately when performing thermal analyses on engineering systems.
2. Learn and analyze problems involving multi dimension heat conduction in simple geometries and develop solutions for transient heat conduction in simple geometries.
3. Design a heat exchanger which may help them carry out experiments and work with heat exchangers in a laboratory/industry.

Course Content

UNIT 1 **(14 Hrs)**

Heat Conduction: Two-dimensional steady state heat conduction, Unsteady state unidirectional heat conduction, Different methods for solving heat transfer problems (Analytical, Graphical method & Numerical Methods), Lumped heat capacity system, Transient heat flow in a semi-infinite solid, Convection boundary conditions, Transient numerical method.

UNIT 2 **(8 Hrs)**

Boiling and Condensation: Condensation heat transfer phenomenon, Film condensation inside horizontal tubes, Condensation of a vapour from a non-condensable gas, Boiling heat transfer, Simplified relations for boiling heat transfer with water.

UNIT 3 **(10 Hrs)**

Heat Exchanger design: Theory and basic design procedure of heat transfer , Different types of heat exchanger (Double pipe, Shell and tube) and their general design considerations, Calculations for heat-transfer coefficient and pressure drop for Tube-side and Shell side.

UNIT 4 **(10 Hrs)**

Heat transfer in (Fluidized bed, Packed bed and agitated vessel): Heat transfer to the containing wall, Determination of effective thermal conductivity of a packed bed of solid particles. Heat transfer between the bulk fluid and external surface of solid particles, Jacketed vessels, Internal coils, Agitated vessels

Text and Reference Books

[1] Heat Transfer, Holman J. P., McGraw Hill, Tenth Edition, New York, 2010.
[2] Process Heat Transfer, Kern D. Q., Tata McGraw Hill, First Indian Edition, 2011.
[3] Unit Operations of Chemical Engineering, McCabe W.L., Smith J.C. and Harriott P., McGraw Hill, International Seventh edition, New York, 2005.
[4] Chemical Engineering design, Coulson and Richardson's Chemical Engineering, Sinnott R. K., Elsevier Butterworth-Heinemann, volume 6, Fourth edition, Linacre House, Jordan Hill, Oxford OX2 8DP, 30 Corporate Drive, MA 01803, 2005.
[5] Fundamentals of Momentum, Heat Transfer and Mass transfer, Welty J.R., Wicks C.E., Wilsons R.E., Rorrer G., John Wiley & Sons Inc., Fifth Edition, USA, 2008.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-305(Chemical Process Control II)	3 L	0 T	0 P	3 Credit

Course objectives

1. To Understand fundamentals of advanced control systems.
2. To Understand the concept of Feed-forward and Ratio Control system.
3. To Understanding loop interaction and decoupling of interacting loops in multivariable process control.
4. Design strategies for control of common industrial unit operations.
5. Introduction to process control using digital computers.

Course Outcomes

Students will be able to understand

1. Multiple loop control systems.
2. Multivariable process control.
3. Design of controllers; to select the best control configurations.

Course Content

UNIT 1 **(15 Hrs)**

Analysis and design of complex control system: Different Control systems (Multiple loop, Cascade control selective, Split ranges, Feed forward Ratio control Adaptive and inferential) control system.

UNIT 2 **(10 Hrs)**

Design of multivariable process control: Loop interactions, Pairing rule of control and manipulated variables, Decoupling of interacting loops.

UNIT 3 **(12 Hrs)**

Process control using digital computers: Digital computer control loops, Z-transforms.

UNIT 4 **(5 Hrs)**

Introduction to batch process control.

Text and Reference Books

[1] Process System Analysis and Control, Coughanowr, D.R. and Koppel, L.B., McGraw Hill 3rd edition, 2009.

[2] Chemical Process Control - An Introduction to Theory and Practice, Stephanopolous, G. Prentice Hall of India 1984.

[3] Principals and Practice of Automatic Process Control, Carlos A. Smith and Armando B. Corripio, John Wiley & Sons 3rd edition, 2006.

[4] Process Dynamics & Control, Seborg D. E., T. F. Edger and D. A. Mellichamp, John Wiley & Sons, 4th edition 2017.

[5] Coulson & Richardson's Chemical Engineering, Richardson J. F., Peacock D.G., Elsevier, Volume 3/3rdEdition 1994.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-307 (Chemical Reaction Engineering II)	3 L	1 T	0 P	4 Credit

Course Objectives

1. To learn basic Concepts of Catalysis
2. To understand kinetics and Mechanistic aspects of Catalysts
3. To Design and Rating of Catalytic Reactors
4. To understand design Aspects of Gas-Liquid, Solid–liquid, Reactors

Course Outcomes

Student should be able to:

1. Design catalytic reactors.
2. Identify regions of mass transfer control and reaction rate control and calculate conversion.

Course Content

UNIT 1 **(15 Hrs)**

Introduction to Catalysis, Types of catalysis (Homogeneous and Heterogeneous catalysis). Preparation and characterization of catalysts. Physical and Chemical adsorption, Adsorption isotherms, Determination of BET surface area and pore volume of the Catalyst. Kinetics of solid catalyzed gas phase reaction.

UNIT 2 **(15 Hrs)**

Solid-fluid catalyzed reactions: Catalysis and different steps in catalytic reactions, Concept of porous catalyst and its performance equation, Rate equation for Surface kinetics, pore diffusion resistance, , Interaction of physical and chemical rate processes, effectiveness factor, selectivity, product distribution in multiple reactions, effect of pore distribution, experimental methods for finding rates. Different catalytic reactors.

UNIT 3 **(15 Hrs)**

Gas-solid catalyzed and non-catalytic reactions, rate equations for non-catalytic reactions, laboratory reactors, collection and interpretation of rate data. Fluid-fluid reactions: Overall rate equations, application to reactor design, Yield and selectivity of non-catalytic reactions.

UNIT 4 **(11 Hrs)**

Solid-fluid noncatalytic reactions: Shrinking core model for spherical particles of unchangeable size, determination of rate-controlling steps and application to design of reactors, Gas-solid reactions, different models for gas-solid reactions.

Text and Reference Books

[1] Chemical Reaction Engineering, Levenspiel O., John Wiley & Sons (Asia), 3rd Ed., 2000.
[2] Chemical Engineering Kinetics, Smith J.M., McGraw Hill 3rd Ed., 1980.
[3] Elements of Chemical Reaction Engineering, Scott Fogler H., Prentice Hall of India, 2nd Ed., 1999.
[4] Chemical Reactor Analysis and Design, Froment G.F. & Bischoff, John Wiley & Sons, 2nd Ed 1990
[5] Chemical and Catalytic Reaction Engineering, Carberry, J. J., Dover Books on Chemistry, 2001.
[6] Chemical Reactor Analysis and Design Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde, John Wiley & Sons, Incorporated, 2010.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	3	2	1	1	1	1	3
CO2	3	3	3	3	1	3	2	1	1	1	1	3

CT-309(Introduction to Computational Fluid Dynamics)	3 L	1 T	0 P	4 Credit

Course Objectives

1. Introduction to fundamentals of Computational Fluid Dynamics
2. Application of Computational Fluid Dynamicsin Chemical engineering: Analysis of Fluid mechanics and Heat transfer.

Course Outcomes

1. Improve the student's understanding of basic principles of transport phenomenon
2. Student will have the ability to learn and use modern CFD software tools for solving problems in chemical engineering
3. Improve student's research skills by visualizing and analyzing the results.

Course Content

UNIT 1 **(15Hrs)**

Introduction: CFD application in Chemical Engineering, Review of Partial differential equations- Parabolic, Hyperbolic and Elliptic equation, Conservation equation; mass; momentum and energy equations

UNIT 2 **(15Hrs)**

Principles of Solution of the Governing Equations: Finite difference, Finite element method and Finite volume Methods, Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, Mesh generation: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation.

UNIT 3 **(15Hrs)**

Solution Algorithms: Discretization schemes for pressure, momentum and energy equations - Explicit and implicit Schemes, First order upwind scheme, second order upwind scheme, QUICK scheme, SIMPLE, SIMPLER and PISO algorithm, pressure-velocity coupling algorithms, velocity-stream function approach, solution of Navier-Stokes equations.

UNIT 4 **(11Hrs)**

CFD Solution Procedure: Problem setup – creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization. case Studies: Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass and momentum transfer problem.

Text and Reference Books

[1] Computational Fluid Dynamics, Anderson J.D., Mc-Graw Hills (1995).
[2] Numerical Heat Transfer and Fluid Flow, Suhas V. Patankar. Taylor and Francis (1980).
[3] Computational Methods for Fluid Dynamics, J H Ferziger and M Peric, Springer (2002).
[4] Computer Simulation of Flow and Heat Transfer, P.S. Ghoshdastidar, Tata McGraw-Hill (1998).
[5] Computational Fluid Flow and Heat Transfer, K. Muralidhar and T. Sundararajan, Narosa Publishing House (2009).
[6] Introduction to computational fluid dynamics, P. Niyogi, S.K. Chakrabarty, and M.K. Laha, Pearson education (2006).
[7] Numerical Methods for Engineers, S. K. Gupta, New Age Publishers, 2nd Edition (1995).

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	1	3	3	1	1	1	1	3
CO2	3	1	1	1	1	3	3	1	1	1	1	3
CO3	3	1	1	1	1	3	3	1	1	1	1	3

CT- 333(Molecular Biology)	3 L	1 T	0 P	4 Credit

Course Objective

1. Introduction to structure and function of nucleic acids and other biomolecules in the cell.
2. To understand Central Dogma and different Cellular Processes being carried in the cell.
3. Introduction to concepts of Gene expression and Regulation.

Course Outcomes

Student will be able to:

1. Understand the structure of nucleic acids and their packaging in the nucleus.
2. Understand Cell division and its regulation
3. Understand Central Dogma: Mechanism of replication of DNA, Transcription, Translation and Gene regulation.
4. Understand concept of Cell Signaling.
5. Apply the knowledge in Molecular Biology Laboratory experiments.

Course Content

UNIT 1 **(16 Hrs)**

Structure and function of nucleus: Organization of the chromosome; Eu and Heterochromatins; Nucleosome; chromosomal proteins and its packaging.

Chromosome biology: Ultra structure of chromosomes, Types of chromosomes, chromosomal aberration (Numerical & structural), chromatin

Molecular Genetics: Cell cycle, Cell division, mechanism of cell division - Mitosis and meiosis. Cell cycle regulation.

UNIT 2 **(18 Hrs)**

Cell Signaling: General principles of cell Signalling, Signalling via G-Protein linked cell-surface Receptors, Signalling via Enzyme- linked cell-surface Receptors, target cell adaptation.

The biochemical basis of inheritance: DNA as the genetic material; DNA structure and replication in Prokaryotes and eukaryotes; nucleotide sequence composition: Unique, Middle and highly repetitive.

UNIT 3 **(14 Hrs)**

Transcription and translation machinery in Prokaryotic and eukaryotic system. Genetic Code Regulation of gene expression in E. coli - operon concept; hormonal control of gene expression in eukaryotes.

UNIT 4 **(8 Hrs)**

Microscopy: Compound, Phase contrast, Fluorescent, Confocal, EM, Fractionation: Cell rupture techniques, Fractionation of subcellular organelles by centrifugation, Flow cytometry.

Text and Reference Books

[1] Molecular Biology of the Cell. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, 5th Edition December 2007.

[2] Cell and Molecular Biology, Gerald Karp Sixth Edition, 2010.

[3] Molecular Biology of the Gene. J. Watson, T. A. Baker, S.P.Bell, A. Gann, M. Levine & R. Losick, Pearson education, 5th edition, 2006.

[4] Genetics: a conceptual approach. Benjamin Pierce 7th Edition.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT- 313(Environmental Biotechnology)	3 L	1 T	0 P	4 Credit

Course Objectives

This course will emphasize upon the recent development of biotechnology for harnessing microbial potential in environmental applications.

Course Outcomes

Students will be able to:

1. Understand the role of microorganism for treatment of waste/effluent.
2. Learn the different types of biological process.
3. Identify challenges, environmental issues, and process optimization.
4. Learn concepts of Biotransformation and biodegradation of pollutants.

Course Content

UNIT 1 **(11Hrs)**

Introduction: Pollution monitoring, Biotechnological treatment of wastes.

Introduction of water microbiology: Waterborne infectious agents and control of pathogenic microbes in water, sewage and sludge. Waste water characteristics, physical, chemical and biological. Waste water treatment, activated sludge processes, biological nutrient removal, waste water treatment efficiency assessment

UNIT 2 **(15Hrs)**

Aerobic processes of secondary treatment: Activated sludge, lagoons, stabilization ponds, suspended growth, nitrification, trickling filters, rotating biological contactors, anoxic suspended growth and fixed film denitrification.

UNIT 3 **(15Hrs)**

Anaerobic processes of treatment: Biological concepts, suspended growth and fixed film processes and reactor configuration, Sequential batch reactor for combined processes (aerobic and anaerobic).

UNIT 4 **(15Hrs)**

Tertiary Treatment: Effluent disposal and reuse.

Bioenergy from biological waste: Production of biogas and bio hydrogen from various biological wastes by fermentative processes. Biotransformation and biodegradation of Pollutants, Methods for determining biodegradability and biodegradation of lignocellulose, PAH, agricultural chemicals.

Molecular biological techniques in the characterization of environmental populations of microorganisms. Emerging technologies, biosensors and microprobes.

Text and Reference Books

[1] Environmental bio Technology, Sayler & Fox and S. K. Aggarwal

[2] Environmental Biotechnology, Foster C.F., John Ware D.A., Ellis Horwood Ltd., 1987.

[3] Environmental Biotechnology, A.K. Chatterjee.

[4] Environmental Biotechnology, Principles and Applications, Bruce E Rittman and Perry L McCarty, McGrawhill Higher education.

[5] Environmental Biotechnology, Hans-Joachim Jördening and J Winter, WILEY-VCH Verlag Gmbh& Co.

[6] Bioremediation and Natural Attenuation by Pedro J JAlvarage and Walter A Illman, Wiley Interscience.

[7] Environmental Biotechnology, Vol 10 Handbook of Environ. Eng. L K Wang et al, Humana Press.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT- 315 (Bioanalytical Techniques)	3 L	1 T	0 P	4 Credit

Course Objectives

To create broad understanding of principles, applications and instrumentation of tools and techniques used for analysis of biomolecules.

Course Outcomes

Student will be able to

1. Understand Basic concepts of types of Microscopy and Centrifugation Techniques
2. Learn the theoretical and practical aspects of Electrophoresis and Chromatography Techniques
3. Learn the concepts of different kinds of Spectroscopy, Calorimetry and Radioisotope
4. Learn the concepts of different kinds of Immuno techniques and Molecular Biology techniques

Course Content

UNIT 1 **(8 Hrs)**

Microscopy: Light, Electron (Scanning and Transmission), Phase Contrast, Fluorescence Microscopy, Atomic Force Microscopy, Freeze-Fracture Techniques.

Centrifugation: Techniques and Their Applications, Differential Centrifugation, Zonal, Density Gradient and Ultracentrifugation Techniques.

UNIT 2 **(10 Hrs)**

Electrophoresis: Paper, and Gel Electrophoresis-Nucleic Acid and Proteins, Native and SDS PAGE, Isoelectric focusing, Two-dimensional electrophoresis.

Chromatography: Principles, Chromatographic performance parameters, Types: Paper, TLC, Adsorption, Partition, Ion-exchange, Reverse phase, Size Exclusion, Gel filtration, Affinity, Gas chromatography, High Pressure Liquid Chromatography (HPLC).

UNIT 3 **(14 Hrs)**

Spectrophotometry: Ultraviolet and visible light spectroscopy, Fluorescence spectroscopy, Luminometry, Circular dichroism spectroscopy, Infrared and Raman spectroscopy, Nuclear magnetic resonance, X-ray diffraction, Mass spectroscopy (LC-MS, MALDI-TOF, ES-MS).

Calorimetry: Differential scanning calorimetry, titration calorimetry.

Radioisotope Techniques: Radioactivity, Units of radioactivity, Radioactive decay. Use of radioisotopes in research, In vivo and in vitro labelling techniques. Autoradiography, Effect of radiations on biological system.

UNIT 4 **(10 Hrs)**

Immunological Techniques

Principles: Antigen-Antibody Interactions, Polyclonal antisera and Monoclonal antibodies Agglutination reactions, Immunoassays- ELISA and its types, RIA, Immunoblotting, FACS, Immunofluorescence.

Molecular Biology Techniques, Isolation of Nucleic acids, PCR, Cloning and Expression.

Text and Reference Books

[1] Walker J. and Wilson K (2010), Principles and Techniques-Practical Biochemistry, 7th Edition, Cambridge University Press, London.
[2] Upadhayay, A; Upadhyay, K and Nath N. (2002), Biophysical Chemistry: Principles &Techniques, Himalaya Publication House, New Delhi.
[3] Richard E. Venn (2003), Principal and Practice of Bioanalysis. Taylor and Francis.
[4] Slater R.J. (2002), Radioisotopes in Biology-A Practical Approach, Oxford University.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	3	2	2	3	3	3	3	2	3
CO2	2	3	3	3	3	2	3	3	3	3	2	3
CO3	2	3	3	2	2	2	3	3	3	3	3	3

CO4	2	3	3	2	2	2	3	3	3	3	3	3

CT- 317(Water Pollution and Abatement)	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objectives

1. To create broad understanding about water pollution and its effects on human and ecosystem health.
2. To learn about major water pollutants, their sources, physical, chemical, and biological transformations, and its impacts.
3. To learn about water quality monitoring, and Pollution control technologies.
4. Details about the design features of unit operations for wastewater control, including pre-treatment, primary, secondary, and advanced treatments.

Course Outcomes

Students will be able to:

1. Learn about major water pollutants and their effects on human health and the environment
2. Understand various categories of water pollution and the strategies and regulations to manage water pollution.
3. Describe unit operations used for wastewater treatment
4. Gain knowledge about various unit operations and unit processes used in water treatment plant.

Course Content

UNIT 1 **(10 Hrs)**

Water Pollution, classification of types of water pollutants, their sources, and effects on human health and the environment

UNIT 2 **(10 Hrs)**

Physico-chemical characterization of wastewater, various national and international water quality standards, water and industrial wastewater pollution management strategies and policies.

UNIT 3 **(12 Hrs)**

Water treatment techniques, coagulation, flocculation, skimming, floatation, etc. Pretreatment, Primary, secondary, and tertiary treatment techniques (settling, filtration, aerobic and anaerobic digestion, activated sludge process, trickling filter

UNIT 4 **(10 Hrs)**

Advanced wastewater treatment processes, Industrial Wastewater Treatment Technologies Classification of industrial effluents Specific treatment processes.

Text and Reference Books

[1] Weber, W.J. Physicochemical processes for water quality control, John Wiley and sons, Newyork, 1983.
[2] Peavy, H.S., Rowe, D.R., Tchobanoglous, G. Environmental Engineering, McGraw Hills, New York 1985.
[3] Metcalf and Eddy, Wastewater engineering, Treatment and Reuse, Tata McGraw-Hill, New Delhi, 2003.
[4] Benefield, L.D. and Randall C.W. Biological Processes Design for wastewaters, Prentice-Hall, Inc. Eaglewood Cliffs, 1982.
[5] Grady Jr. C.P.L and Lin H.C. Biological wastewater treatment: Theory and Applications, Marcel Dekker, Inc New York, 1980.
[6] Metcalf & Eddy, Inc. Wastewater Engineering, Treatment and Reuse. 3rd Edition, Tata McGraw-Hill, New Delhi, 2003.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	1	1	3	3	1	3	1	1	3

CO2	3	1	1	1	1	3	3	1	3	1	1	3
CO3	3	1	1	1	1	3	3	1	3	1	1	3
CO4	3	1	1	1	1	3	3	1	3	1	1	3

CT-319 (Alternative Energy Sources)	**3 L**	**1T**	**0P**	**4 Credits**

Course Objectives

1. Describe sources and uses of energy.
2. Define renewable and non-renewable energy.
3. Provide examples of common types of renewable and non-renewable resources.

Course Outcomes

Students will be able to

1. Recognize and describe common strategies for energy conservation on an individual, local, and worldwide scale. Also, understand advantages and disadvantages of using renewable resources.
2. Understand and explain, in general terms, how passive solar heating, hydropower and wind power work and

Course Content

UNIT 1 **(10 Hrs)**

Introduction: Principles of Renewable Energy. Energy and sustainable development, fundamentalsand social implications. worldwide renewable energy availability, renewable energy availability in India

UNIT 2 **(10 Hrs)**

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces. Solar radiation Measurements Pyrheliometers, Pyrometer, Sunshine Recorder. Solar Thermal systems: Flat plate collector. Solar distillation. Solar pond electric power plant. Solar electric power generation- Principle of Solar cell, Photovoltaic system for electric power generation, advantages, Disadvantages and applications of solar photovoltaic system

UNIT 3 **(10 Hrs)**

Wind Energy: Properties of wind, availability of wind energy in India; Wind velocity and power from wind. Major problems associated with wind power. Basic components of wind energy conversion system (WECS). Classification of WECS: Horizontal axis- single, double and multiblade system. Vertical axis- Savonius and darrieus types.

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations. Ocean Thermal Energy Conversion: Principle of working, OTEC power stations in the world, problems associated with OTEC.

UNIT 4 **(10 Hrs)**

Biomass Energy: Introduction, Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies -fixed dome; Urban waste to energy conversion; Biomass gasification (Downdraft)Green Energy: Introduction, Fuel cells: Classification of fuel cells – H_2; Operating principles, Zero energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy, problem associated with hydrogen energy.

Text and Reference Books

[1] Nonconventional Energy sources, G D Rai, Khanna Publication, Fourth Edition.
[2] Energy Technology, S.Rao and Dr. B.B. Parulekar, Khanna Publication.
[3] Solar energy, Subhas P Sukhatme, Tata McGraw Hill, 2nd Edition, 1996.
[4] Principles of Energy conversion, A.W.Culp Jr., McGraw Hill, 1996.
[5] Non-Convention Energy Resources, ShobhNath Singh, Pearson, 2018.
[6] Principles of Energy conversion, A. W. Culp Jr., McGraw Hill, 1996 2. Non-Convention Energy Resources, Shobh Nath Singh, Pearson, 2018.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	3	3	1	1	1	1	3
CO2	3	3	3	3	1	3	3	1	1	1	1	3

CT-361 (Summer Training /Summer Project) *	-	-	-	1 Credit

Outcomes

To equip the students with practical understanding and training about industry/research practices in a suitable industry/ research laboratory.

Assessment

Students should obtain training in chemical industry/research laboratory for a period of 4-6 weeks in summer and get acquainted with practical understanding and training about industry/research laboratory practices. At the end of the training period, each student should submit a training report along with the certificate obtained from the respective industry/research laboratory to the department for assessment by a panel of examiners.

***NUES: Comprehensive evaluation by the teacher concerned out of 100 marks.**

CT-363 (Heat Transfer Lab)	0 L	0 T	3 P	2 Credit

Laboratory Outcomes

To train the students to develop working knowledge on different types of heat transfer equipment.

List of experiments

Determination of heat transfer co-efficient in following equipment's

1. Shell & tube heat exchanger.
2. Double pipe heat exchanger.
3. Plate type heat exchanger.
4. Finned tube heat exchanger.
5. Vertical condenser.
6. Horizontal condenser.
7. Agitated vessel.
8. Film wise and drop wise condensation unit.

CT-365 (Mass Transfer Lab)	0 L	0 T	3 P	2 Credit

Laboratory Outcomes

To train the students to develop working knowledge on different types of mass transfer processes.

List of Experiments

1. Studies of batch distillation.
2. Studies of fractional distillation.
3. Studies on liquid-liquid extraction.
4. Studies on solid-liquid extraction.
5. Study of absorption in packed column.
6. Studies of Kinetic and Isotherm using suitable adsorbent.

SIXTH SEMESTER

Theory Papers						
Group	**Paper Code**	**Paper**	**L**	**T/ P**	**Credits**	**Total Credits**
HS	HS 302	Technical Writing	2	-	2	2
PC	CT 302	Introduction to Petroleum Refining & Petrochemicals	3	0	3	3
PC	CT 304	Computational Methods for Engineers	3	1	4	4
PCE	CT 306	Process Equipment Design I	1	1	2	2
Emerging area electives (EAE2) (opt any one)						
Modeling and Simulation	CT 308	Process Modeling and Simulation	3	1	4	4
Biochemical Engineering	CT 236	Microbiology	3	1	4	
Environmental Engineering	CT 310	Environmental Impact Assessment	3	1	4	
Open area electives (OAE2 and OAE3) (opt any two)						
OAE or MOOCs	CT 312	Biosensor and Diagnostic Devices for Healthcare Applications	3	1	4	8
	CT 314	Statistical Analysis of Process Data	3	1	4	
	CT 316	Industrial Microbiology	3	1	4	
	CT 318	Fundamental of Polymer Engineering	3	1	4	
	CT324	Energy and Water Audit for Industries	3	1	4	
Practical/Viva Voce						
HS*	ICT352	NSS/NCC/Cultural clubs / TechnicalSociety/Technical club	-	-	2	2
PC	CT 362	Computational Lab	-	2	1	1
Emerging area electives (EAE3) (opt any one)						
Modeling and Simulation	CT 364	Modeling & Simulation Lab	-	3	2	2
Biochemical Engineering	CT 366	Biochemical Engineering Lab	-	3	2	
Environmental Biotechnology	CT 368	Environment Lab	-	3	2	
Total			**18**	**10**	**28**	**28**

HS-302(Technical Writing)	**2 L**	**0 T**	**0 P**	**2 Credit**

Course Objectives

1. To help them understand the structures of language, and build up the vocabulary.
2. To enhance language proficiency and communication competence.
3. To understand basic principles of written communication.
4. To develop the efficiency of using language for Specific Purposes with clarity.
5. To be able to critically appreciate the written texts and audio-visual inputs effectively.
6. To develop the theoretical understanding of interpersonal communication effectively.

Course Outcomes

1. Ability to understand the basic structure of language
2. Ability to communicate effectively in writing.
3. Ability to present their ideas effectively in professional and demanding situations.
4. Ability to interpret texts and comprehend the extended discourse.

Course Content

UNIT 1 **(7 Hrs)**

Types of writing – Descriptive, Narrative, Argumentive, Discursive, Reflective, Literary, Evaluative Writing.

Technical Writing – Definition, Purpose and Characteristics of Technical Writing, Researching, Summarizing, Paraphrasing.

Difference between Technical writing and Literary writing.

UNIT 2 **(7 Hrs)**

Process of Writing – Prewriting Stage, Writing Stage and Post-writing stage.

Writing Technical Documents –Audio-Visual Aids, Use of Electronic media and Internet, Making Presentations, Documenting Meetings: Agenda and Minutes

UNIT 3 **(7 Hrs)**

Technical Writing Applications: Memorandum, Definition, Description, Set of Instructions. Professional Communication, Letters and Job Applications,

UNIT 4 **(7 Hrs)**

Technical Writing Applications: Reports, Proposals and Research papers

Style and Format – Arrangement of the content, Front Material, Body and End Material

Referencing the sources of Information – Citations, References and Bibliography, Appendix.

Text and Reference Books

[1] Forsyth, Sandy and Lesley Hutchison. Practical Composition, Edinburgh Oliver and Boyd, 1981.

[2] Guffey, Mary Ellen. Business Communication, Cincinnati, South-Western College Publishing, 2000.

[3] Sides, Charles H. How to Write and Present Technical Information, Cambridge, Cambridge University Press, 1999.

[4] Raman Meenakshi and Sharma Sangeeta. Technical Communication: Principles & Practice, New Delhi: Oxford University Press, 2012.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-302 (Introduction to Petroleum Refining & Petrochemicals)	3 L	0 T	0 P	3 Credit

Course Objectives

1. To study the petroleum engineering
2. To understand crude oil processing, fractionation
3. Understand various operations like cracking etc. in the industry
4. To understand petrochemicals and their importance

Course Outcomes

1. Understanding the role of petroleum as energy source amidst world energy scenario
2. Learning design and operation of petro refineries and petrochemical complexes
3. Identifying challenges, energy security issues and environmental issues and process intensification
4. Techno-economic analysis & trouble shooting

Course Content

UNIT 1 **(10 Hrs)**

Petroleum - Origin and Occurrence, Exploration and Evaluation of crude oil, Properties of crude oil Problems, Prospects &Challenges of petroleum refining in India and worldwide.

Testing methods, Specifications and Properties of petroleum products like LPG, Kerosene, Petrol, Diesel, Lubricating Oil, Bitumen.

UNIT 2 **(18 Hrs)**

Processing of Crude Petroleum - Atmospheric and Vacuum distillation, Column control schemes

Introduction of various processes (Cracking, Reforming, Alkylation, Isomerization, polymerization)

UNIT 3 **(6 Hrs)**

Concept of desulphurization and de-asphalting of various liquid fuels (Gasoline, Kerosene and Diesel oil).

UNIT 4 **(6 Hrs)**

Introduction to Petrochemicals: Indian and Global Overview and growthtrend of petrochemicals industries

Sources of petrochemicals, Classification, Exploration, Extraction of different petrochemicals like Natural gas and Petroleum

Text and Reference Books

[1] Petroleum Refining Technology, Dr. Ram Prasad, Khanna publisher,(2018 reprint)
[2] Modern petroleum refining processes, Bhaskara rao B.K, Oxford & IBH Publishing Co Pvt Ltd., 6ed (2018)
[3] Petroleum Refining Technology, Mall I.D., CBS publisher,(2017 reprint)
[4] Handbook of Petroleum Refining, James G. Speight, CRC Press, (2016)
[5] A textbook on Petrochemicals, Rao B. K. B., 2nd Edition, Khanna publisher, (1996).
[6] Petrochemical Process Technology, I D Mall, macmillan,2006

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-304(Computational Methods for Engineers)	3 L	1 T	0 P	4 Credit

Course Objectives

Understanding of mathematical methods with the theory involved in solving chemical and biochemical engineering problems.

Course Outcomes

1. The students would be able to solve chemical and biochemical engineering problems using computational methods.
2. The students would be able to understand the mathematical methods with the principles involved in the solving the chemical and biochemical engineering problems.

Course Content

UNIT 1 **(13Hrs)**

Formulation of mathematical models from engineering aspects: Applicationoflawofconservation(mass,momentumand energy), Classification of mathematical models, Models resulting from different equations (algebraic equations, ordinary differential equations and partial differential equations).

UNIT 2 **(15 Hrs)**

Solution of linear algebraic equation using (Matrix, Tridiagonal matrix, Thomson algorithm). Solution methods for nonlinear algebraic equations (Bisection algorithm, Successive substitution, Newton-Raphson method).

UNIT 3 **(15 Hrs)**

Numerical solution of ordinary and partial differential equations from engineering aspects, Initial and boundary value problems, Mathematical formulation of finite difference equation, Classification of partial differential equations and types of boundary conditions, Finite difference methods in analysis of stage wise processes, Relaxation method and Crank Nicolson method.

UNIT 4 **(13 Hrs)**

Application of Laplace Transform in solving engineering problems, Theories and techniques to analyse models of population growth, reaction kinetics, etc.

Text and Reference Books

[1] Applied Mathematics in Chemical Engineering, Mickley, H.S., Sherwood, T.K., & Reed, C.E., McGraw Hill.
[2] Numerical Methods for Engineers, Gupta, S.K., New Age Publishers.
[3] Applied Mathematical methods for Chemical Engineers, Norman W. Loney, CRC Press
[4] Mathematical Methods in Chemical and Biological Engineering, Binay K. Dutta, CRC
[5] Mathematical Methods in Chemical & Environmental Engineering, Ajay K Ray and S. K. Gupta, Thomson.
[6] Mathematical Methods in Chemical Engineering, V.G. Jenson and G.V. Jeffreys, Academic Press.
[7] Mathematical Models in Biology. L. Edelstein-Keshet McGraw-Hill Education.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	3	3	1	1	1	1	3
CO2	3	3	3	3	2	3	3	1	1	1	1	3

CT-306(Process Equipment Design I)	1 L	1 T	0 P	2 Credit

Course Objectives

Basic Concepts of Mechanical design of Unfired Process Vessels

Course Outcomes

1. To make student understand the mechanical aspects of designing pressure vessels, lining, supports, & head.
2. Illustrate design of heat exchangers and distillation columns (mechanical aspects)

Course Content

UNIT 1 **(7 Hrs)**

Concept of pressure vessel codes and design of pressure vessel under internal pressure: Codes & Standards, Design consideration (stress, elasticity, fatigue, fracture, creep, temperature effect), Materials of construction (ferrous, non-ferrous, alloy, plastic, glass etc), Lining of vessel, Corrosion and types, Corrosion prevention, Non-destructive tests for vessels

Combined loading, Types of loading, optimum proportions of vessel, Closure for vessel: flat, formed tori-spherical, elliptical, hemispherical, conical etc,

Vessel support design: Type, Selection and Design (Skirt, saddle, Bracket, Lug and leg) anchor bolts,

Flanges and gaskets design: Classification, selection and design.

Nozzles: reinforcement, design of compensation, Area for area method

UNIT 2 **(7 Hrs)**

Storage vessels: Loss mechanisms, Estimation of volume of storage tank, Storage Tank designs (Horizontal and Spherical), Floating roof types

High pressure vessel: Theories of elastic failure, Mono-block and Multi-layer construction, materials of construction, and enclosures for high – pressure vessels.

Pipe design: Pipe thickness, Economic pipe diameter, Estimation, Pipe size selection, Pipe supports, Design of pipe for oil and gas transportation, Optimum size of delivery line in pump operation.

UNIT 3 **(7 Hrs)**

Mechanical design of Heat Exchanger Equipment's: Shell and tube heat exchanger: tube sheet thickness, differential expansion, thermal stresses, size and number of tie rods and spacers, Determination of shell thickness, allowable deflection, Preparation of spec sheet for heat exchangers.

UNIT 4 **(7 Hrs)**

Process Design of separation Units: Distillation columns (sieve, plate and bubble cap), absorption columns (packed), venture scrubber, falling film), adsorption columns, liquid-liquid extraction columns, deflection and stresses (tray supported on peripheral ring/truss) Shell thickness at different heights, support for tray,Furnaces, reboilers, Condenser and its types(Horizontal and vertical condensers), Evaporators, Jacketed and Coiled agitated vessels, Design of cooling tower, pumps, compressors.

Text and Reference Books

[1] Introduction to Chemical Equipment Design, Mechanical Aspects, Bhattacharya, B.C., CBS Publisher.
[2] Process Equipment Design, M.V.Joshi and V.V., MacMillan India Ltd.3rd Edition, 2000.
[3] Applied Process Design for chemical and petrochemical plants, volume 1, 2, &3 , 3rd Ed.
[4] Process Design of Equipment, S.D.Dawande, Central Techno Publications, Nagpur, 2000.
[5] Indian Standard Specifications IS-803, 1962; IS-4072, 1967; IS-2825, 1969.
[6] Chemical Engineers Handbook, R.H. Perry, McGraw-Hill, 1934.
[7] Unit Operation of Chemical Engineering, W.L.McCabe, J.C.Smith and Harriet, McGraw-Hill.
[8] Chemical Engineering, J.M. Coulson and J.Richardson, Asian Books Printers Ltd.Vol. 6.
[9] Structural Analysis and design of process equipment M H. Jawed and J. R. Ferr, John Wiley & sons.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	3	3	1	1	1	1	3
CO2	3	3	3	3	1	3	3	1	1	1	1	3

CT-308 (Process Modeling & Simulation)	3 L	1 T	0 P	4 Credit

Course Objectives

To provide the basic concepts for modeling and simulation of Chemical processes and Equipment's

Course Outcomes

1. Analyze physical and chemical phenomena involved in various Chemical process
2. Understanding the principle of mass, energy and momentum conservation equations.
3. Develop mathematical models for various chemical processes
4. Understanding the various approaches of process techniques
5. Concept of Chemical Process Simulators

Course Content

UNIT 1 **(13 Hrs)**

Mathematical Modelling: Models, Basis of mathematical model, types of mathematical model, fundamental laws of modeling, model building, modelling difficulties, differential and population balance models,stochastic, and empirical models, unit models, use and importance of mathematical models in process design.

UNIT 2 **(13 Hrs)**

Fundamental laws: Continuity equations, energy equations, equation of state, equilibrium, & Chemical Kinetics.Models of Reactors: Plug flow, Constant and variable holdup CSTRs under isothermal and non-isothermal conditions, Batch etc, one dimensional and two-dimensional fixed bed reactor models, fluidized bed reactor models; Model of mass transfer :Ideal binary distillation column and nonideal multi-component distillation column, Batch distillation with holdup etc, Single component vaporizer, Multi-component flash drum, Absorption column, Gravity flow tank, humidifier, dehumidifiers, Crystallizers; Heat Transfer Models: Evaporators, Heat Transfer in a Bar, Heat Exchangers.

UNIT 3 **(15 Hrs)**

Application of numerical methods in digital simulation: Interactive convergence methods, Interval halving, Newton Raphson method, False position, Explicit convergence method, Wegstein method, Muller method, Numerical integration of ordinary differential equations; Explicit numerical integration algorithms, Euler method, Runga-Kutta method, Implicit method

UNIT 4 **(15 Hrs)**

Process flow simulation: Steady state simulation, concept of unit computation, block diagrams development, signal flow graph, partition, tearing convergence block and control block concept, process matrices, identification of recycle sets through process matrices.

Introduction to generic software's for Modeling and Simulation.

Text and Reference Books

[1] Process Modelling, Simulation and Control, Luyben, W.L., McGraw Hill Book Co.1990.
[2] Chemical Process Simulation, Hussain Asgher, Wiley eastern Ltd., New Delhi.
[3] Process Plant Simulation, Babu, B.V., Oxford University Press, 2004.
[4] Modelling and Simulation in Chemical Engineering, Franks, R.G.E., Wiley Inter science.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-236(Microbiology)	3 L	1 T	0 P	4 Credit

Course Objectives

1. To provide knowledge of microscopy, microbes, and their action
2. To understand the classification of microbes, their isolation, and the cultivation methods.
3. To understand bioenergetics
4. To learn about Acellular organisms, their classification, and involvement in lysogeny
5. To enable students to learn the microbial growth models and their applications to unicellular/multicellular growth in liquid medium, Microbial metabolism, and microbial interaction.
6. To make students acquainted with the microbiological techniques of preservation for short/ long-term usage.

Course Outcomes:

Students completing the course will be able to-

1. Identify the microbial flora morphologically and count their numbers using microscopic methods.
2. Learn growth curve of microbes and do quantitative measurements of growth and its rate.
3. Well equipped with methods used in microbiology for isolation, preservation, and maintenance of pure cultures using aseptic culturing techniques.
4. Get knowledge of microbial interaction with environment, microbial metabolism in aerobic and anaerobic cultures,and physical and chemical control of microorganism with applications
5. Application of microorganism in various fields-Agriculture, food, environment, medicine, public health and industry

Course Content

UNIT 1 **(15Hrs)**

Scope and History of Microbiology:Scope and History of Microbiology, Classification, Characterization, Identification and Nomenclature ofMicroorganisms, Microscopy,Morphological, Structural and Biochemical characteristics of prokaryotes and eukaryotes (bacteria, yeast, mold, algae, protozoa, actinomycetes).

Cultivation of Microorganisms: Microbiological media, physical conditions required for growth.

UNIT 2(15Hrs)

Reproduction and Growth of Microorganism: Modes of cell division, growth curve of microbes, Quantitative measurement of growth.

Methods in Microbiology: Chemical, Physical and Biological methods of selection of microorganisms, Methods of isolating pure cultures, Maintenance and preservation of pure cultures, microbial mutation.

UNIT 3 **(18 Hrs)**

Microbial Metabolism: Metabolic pathways and Bioenergetics, Aerobic and Anaerobic growth, Transport of nutrients across cell membranes.

Physical and Chemical Control of Microorganism: Major groups of antimicrobial agents, Mode of action and practical applications.

Energy Transduction Mechanisms in Microbial Cell: Aerobic and anaerobic respiration, Microbial photosynthesis, Transduction, Transformation, Conjugation.

Microbial Interaction: - Roles of microbes in Nitrogen, Carbon and Sulphur cycles, Application of Microorganism in various Fields: - Agriculture, food, environment, medicine, public health and industry.

UNIT 4(8Hrs)

Viruses: Classification, morphology and composition, DNA and RNA bacteriophages, Lysogeny and lytic cycle.

Text and Reference Books

[1] Fundamentals of Microbiology by Pelczar M J, Chan E C S and Krieg N R “,McGraw Hill,NewYork, 2008

[2] Fundamental Principles of Bacteriology by Salle A J, Tata McGraw Hill, NewDelhi, 1984

[3] Text in Microbiology by Stanier R Y, McMillan PressLondon, 5th Ed. 1999
[4] Prescott's Principles of MicrobiologybyJoanne Willey and Kathleen Sandman and Dorothy Wood, 11 ed. Mc Graw Hill, 2020
[5] Industrial Microbiology by Casida L E, New Age International Publishers, NewDelhi, 2016

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	3	2	1	3	2	2	3
CO2	3	2	2	1	1	3	2	1	3	2	2	3
CO3	3	2	2	2	1	3	2	1	3	2	2	3
CO4	3	2	2	2	1	3	2	1	3	2	2	3
CO5	3	2	2	1	1	3	2	2	3	2	2	3

CT-310(Environmental Impact Assessment)	3 L	1 T	0 P	4 Credit

Course Objectives

To impart knowledge about EIA methodology and environmental laws

Course Outcomes

1. Student would be able to prepare EIA report.
2. Student would be able to understand Documentation of EIA, Environmental Management plan and Post project monitoring

Course Content

UNIT 1 **(15Hrs)**

Evolution of EIA – Concepts – Methodologies – Screening – Scoping – Base line studies - Mitigation – Matrices – Check list.

UNIT 2 **(15Hrs)**

Rapid and Comprehensive EIA – Legislative and Environmental clearance procedures in India – Prediction tools for EIA.

UNIT 3 **(15Hrs)**

Assessment of impacts – Air – Water – Soil – Noise – Biological.

UNIT 4 **(11 Hrs)**

Socio cultural environment – Public participation – resettlement and rehabilitation.
Documentation of EIA – Environmental Management plan – Post project monitoring – Environmental Audit – Life cycle assessment – EMS - Case studies in EIA.

Text and Reference Books

[1] Canter R.L., Environmental Impact Assessment, Mc Graw Hill International Edition, 1997.
[2] John G. Rau and David C. Wooten (Ed), Environmental Impact Analysis Handbook, McGraw Hill Book Company.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	3	2	1	3	1	1	3
CO2	3	2	2	1	1	3	2	1	3	1	1	3

CT-312 (Biosensor and Diagnostic Devices for Healthcare Applications)	3 L	1 T	0 P	4 Credit

Course Objectives

1. Be able to identify different classes of biosensors and describe their functioning principles and recognize limitations of biosensors in real-life applications
2. Be able to extend engineering principles to biosensor development and to design point-of-care biosensors
3. Understand the principles and concepts of transducers and their application in biosensor design
4. Understand fundamentals of diagnostic devices and biomarker testing in biological fluids

Course Outcomes

1. Apply basic principles of biology and engineering to design biosensors
2. Apply principles and concepts of electrochemistry to designelectrochemical biosensors
3. Recognize different types of functional materials, and their application in biosensor design
4. Apply principles and concepts of sensing and engineering to design biosensors fordetection of markers in biofluids

Course Content

UNIT 1 **(12 Hrs)**

Introduction to Sensor Architecture: Types of sensors; Components and design; Ideal requirements; Biosensor classification; Main elements in biosensors; Biomolecules in biosensor: DNA, enzyme, antibody, antigen, protein and aptamer; Amplification Techniques (PCR), EISA(enzyme-linked immunosorbent assay).

UNIT 2 **(14 Hrs)**

Basics of Detection Methods: Fluorescence Spectroscopy; UV-Vis Absorption and Emission; Surface Plasmon Resonance; Colorimetry; and Electrochemical detection.

UNIT 3 **(20 Hrs)**

Electrochemical Sensors: Electrochemical detection methods: Redox processes, and electron transfer; Electrochemical cells for measurements; Processes at electrode surface, and mass transport of material to the electrode surface; Active DC electrochemical techniques: voltammetry, amperometry, immobilized enzyme-electrodes; Impedance Spectroscopy; Potentiometry for small molecule and ion detection.

UNIT 4 **(10 Hrs)**

Point-of-care Sensing: Microfluidics and paper-based diagnostics; Yarn and textile-based sensing

Text and Reference Books

[1] Environmental Analysis by Electrochemical Sensors and Biosensors, L.M. Moretto and K. Kalcher, Springer, New York, 2015
[2] Biosensors and their Applications, V.C.Yang and T.T. Ngo, Kluwer Academic/Plenum Publisher, New York, 2000.
[3] Sensors in Biomedical Applications: Fundamentals, Technology and Applications, G. Harsanyi, Technomic Publishing Company, 2000
[4] Biosensors, E.A.Hall, open University Press, Milton Keynes, 1990.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	3	3	2	2	3	3	3	3	2	3
CO2	2	3	3	3	3	2	3	3	3	3	2	3
CO3	2	3	3	2	2	2	3	3	3	3	3	3
CO4	2	3	3	2	2	2	3	3	3	3	3	3

CT-314(Statistical Analysis of Process Data)	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objective

To develop an understanding of statistical techniques used in Chemical engineering related to process operations, R & D planning, data analysis, business analytics, and troubleshooting,

Course Outcomes: student will be able to

1. Understand probability models to comprehend how it affects process data and plant management.
2. Understand the statisticalconcepts and apply statistical concepts to analyze data that can assist in future for troubleshooting and process capability estimation
3. Perform regression analysis, learn how to create models, and then keep an eye out for stability sections during the process.

Course Content

UNIT 1 (8 hrs)

Introduction to statistics: role of statistics in engineering, data measurement, frequency distributions, types of data graphs, quantitative data graphs. qualitative data graphs, graphical depiction of two-variable numerical data

UNIT 2 (12Hrs)

Descriptive statistics: measures of central tendency and measures of variability: ungrouped data, measures of central tendency and variability: grouped data, measures of shape, continuous distributions: uniform distribution, normal distribution, exponential distribution, Statistical Inference: Sampling theory, Central Limit Theorem, Hypothesis Testing

UNIT 3 (10 Hrs)

Probability: introduction to probability, methods of assigning probabilities, structure of probability, marginal, union, joint, and conditional probabilities, addition laws, multiplication laws, conditional probability

UNIT 4 (10Hrs)

Simple Regression Analysis and Correlation: correlation, introduction to simple regression analysis, determining the equation of the regression line, residual analysis, using residuals to test the assumptions of the regression model, standard error of the estimate, coefficient of determination, estimation, regression to develop a forecasting trend line

Text and Reference Books

[1] Ken Black, Applied Business Statistics, 7th Edition, Wiley India, 2012.
[2] Douglas C. Montgomery and George C. Runger, "Applied statistics and probability for engineers", 7th edition, John Wiley, 2018.
[3] R.E. Walpole, Myers, R.H., Myers, S.L. and Ye, K., Probability, and Statistics for Engineers and Scientists, 9th edition Pearson Education, 2012.
[4] K.M. Ramachandran and Chris P. Tsokos, "Mathematical statistics with applications", 3rd edition, academic press, 2020.

Course outcome (CO) TO Programme outcomes (PO) Mapping (Scale 1: Low; 2:Medium; 3: High								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	2	1	2	3
CO2	3	3	3	2	2	1	2	3
CO3	3	3	3	2	2	1	2	2

CT-316 (Industrial Microbiology)	3 L	1 T	0 P	4 Credit

Course Objective

The course objective is to introduce students to the numerous industrial microbial products and basic concepts related to their production.

Course Outcomes

1. To interpret basic concepts for the production of microbial products. Fermentation and separation technology
2. To learn about the different types of Bioreactors and their use.
3. To analyze the principles, and techniques for improving the yield and desired properties in via strain improvement strategies.
4. They will be able to apply the knowledge related to processes, equipment for industrial purpose and solve the problems.

Course Content

UNIT 1 **(12 Hrs)**

Introduction to Fermentation Technology: Basic idea on fermentation process, submerged, stationary, solid and semi-solid – with their merits and demerits. Types of Media for Industrial fermentations; Media Optimization; Sterilization of Industrial Media; Media sterilization. Preparation of microbial inoculum for Industrial fermentations.

UNIT 2 **(12 Hrs)**

Commercial strain development: Induced mutations, Over producing decontrolled mutants, Catabolic derepressed mutants; Genetically engineered strain; Protoplast fusion technique. Improvement of strain by Site directed mutagenesis and Protein engineering. Definition, methods and application. Improving microbial strain for production of Amino acids Lysine, nucleosides and nucleotides. Methods for production of 5' IMP and 5'GMP by fermentation.

UNIT 3 **(10 Hrs)**

Microbial processes for production of valuables: Introduction on microbial growth and its kinetics. Primary and secondary metabolites and their regulation. Microbial production of organic acids, antibiotics, alcohol, bakers yeast, Single cell protein (SCP); Vitamins. Organisms used (wild and mutated). production method- process, recovery of products separation parameters, purification steps. Applications.

UNIT 4 **(10 Hrs)**

Microbial Enzyme Technology: Microbial process for production of enzymes. Commercial production of enzymes; amylases, proteases, cellulase. Enzyme Modification - site directed mutagenesis; Importance of Stability of enzymes; Enzyme stabilization by selection and protein engineering for T4 Lysozyme; Principles & techniques of immobilization of Enzymes, Application of immobilized enzyme in Industrial processes.

Text and References Books

[1] Prescott's and Dunn's, A. Industrial Microbiology, 4th edition. CBS Publishers, New Delhi , India , 1987.
[2] L.E. Cassida.Jr, Industrial Microbiology, New Age International Publisher.
[3] Bailey &Olis, Biochemical Engineering Fundamentals, MGH.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	1	1	1	1	1	2	1	1	1	1	2
CO2	2	3	1	1	1	1	1	1	1	1	1	
CO3	2	1	1	3	1	1	1	1	1	1	1	2
CO4	1	1	3	1	1	2	2	1	1	1	1	2

CT-318 (Fundamentals of Polymer Engineering)	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objectives

1. The course goal is to discuss engineering aspects of polymers,
2. Elaborate elements of polymer engineering knowledge that necessary to use polymers for our daily life as well as in engineering fields.

Course Outcomes

1. The student will familiar with fundamental knowledge of structure-properties relationship of polymers and their linked with applications.
2. The student will demonstrate an understanding of approaches to engineering views of polymer synthesis and kinetics.
3. The student will gain experiences in applying unique properties of polymers to solve problems and challenges in our life.
4. The student will demonstrate the ability to develop case studies of polymers with a focus on fundamentals, fabrication, characterization, and applications.

Course Content

UNIT 1(6 Hrs)

Architecture and Properties of Polymers:

The petrochemical industry-building blocks of polymers, Structure-properties and classifications, Molecular weight and its distribution, Thermo-physical properties.

UNIT 2(16 Hrs)

Polymer Reaction Engineering:

The mechanism of polymer formation, Polymerization Processes, Polymerization reactors, Reaction engineering of step growth and chain growth polymerization.

UNIT 3 (10 Hrs)

Polymer Physics:

Thermodynamics of Polymer solution and mixtures, Diffusion through polymeric materials, Flow behaviorof polymeric fluids and polymer rheology.

UNIT 4 (10 Hrs)

Technology of Polymers:

Unit operations of polymer processing, Polymer compounding, Properties of commodity and engineering polymers, Polymer products and its applications.

Text and Reference Books

[1] Polymer Science and Technology, Ebewele R. O., CRC, 1996.
[2] Fundamentals of Polymers, Kumar A., and Gupta R. K., McGraw-Hill, 1998.
[3] Plastics Engineering, Crawford, P.J., Butterworth, Heinemam, 3rd Ed., 1998.
[4] Polymer Science and Technology, Fried J.R., Prentice Hall of India, 1999.
[5] Principles of Polymerization, Odian George, 3rd Ed., John Wiley & Sons.
[6] Principles of Polymerization, Odian George, 3rd Ed., John Wiley & Sons.
[7] Plastics Materials, Brydson J.A., Butterworth Scientific, current edition.
[8] Encyclopedia of Polymer Science and Technology, Herman F. Mark, Norman G.Gaylord, and Norbert M. Bikales, Wiley-Interscience, New York. 3rd Ed

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	3	3	1	1	1	1	3
CO2	3	3	3	3	1	3	3	1	1	1	1	3
CO3	2	1	1	1	2	1	1	1	3	2	2	3
CO4	2	1	1	1	2	1	1	1	3	2	2	3

CT-324 (Energy and Water Audit for industries)	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objective

The course is designed with an objective to make student understand the energy audit and water audit in industries.

Course Outcomes

1. To enable the students to understand the demand and gaps in energy sectors, its conservation and audit procedure in industries.
2. Introduce students to water demand management concepts, to understand that water audit leads to water conservation and to identify challenges in implementation of water audit in industries.

Course Content

UNIT 1 **(15 Hrs)**

Energy Scenario: Energy needs of growing economy, Long term energy scenario, Energy pricing, Energy sector reforms, Energy and environment: Air pollution, Climate change, Energy security, Energy sonservation and its importance, Energy strategy for the future, Energy conservation Act-2001 and its features.

Energy Management and Audit: introduction to energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Energy audit instruments.

UNIT 2 **(15 Hrs)**

Boilers: Combustion in boilers, Performances evaluation, Feed water treatment, Energy conservation opportunities in boiler. Identifying opportunities for energy savings. General fuel economy measures in furnaces, Waste heat recovery.

HVAC system: Coefficient of performance, Capacity, Factors affecting Refrigeration and Air conditioning system performance and savings opportunities. Classification and Advantages of Waste Heat Recovery system, analysis of waste heat recovery for Energy saving opportunities

UNIT 3 **(14 hrs)**

Introduction and basic concepts to water audit: Global water resources, Hydrologic cycle, Watershed zoning, Interrelation of water resources with other natural resources and the environment, Water allocation and water scheduling; Integrated Water Resources Management (IWRM), Water resource planning – concept, preliminary study, feasibility study, detailed planning, Design of water distribution system, Hydrologic Processes – evaporation, transpiration and precipitation

UNIT 4 **(12 Hrs)**

Water Audit and Accounting: Water audit instrumentation, metering and accounting, preparing water circuit diagram and water balance with industry-specific case studies, Detailed water auditing planning, Detailed water accounting and planning, Biophysical information acquisition and management, targeted biophysical assessment, Multi-scalar biophysical analysis and modelling, Specific water consumption & benchmarking, Understanding water utilities basics - pumps and cooling towers, Advanced water & wastewater treatment technologies, Water audit in industries, audit of the various processes within the industry using water, reduction in water losses. Generation and estimation of waste water at various processes in industrial production, concept of zero liquid discharge, quantity of water recycled in industry, incentives, policies and implementation, Water and wastewater costing and cost benefit analysis

of water saving schemes.

Text and Reference Books

[1] Industrial Energy audit: Study and approach of Energy Audit and Conservation in Industrial Area by RajindraAparnathi, 1st Ed Lap Lambart Academic Pub.2020
[2] Energy Conservation in Residential, Commercial and Industrial facilities by HA Gabbar, 1st Ed. IEEE Press series, 2018
[3] Optimizing energy efficiencies in industry By G.G. Rajan, Tata McGraw Hill, Pub. Co., 2002
[4] Water Resources Systems Planning and Management, Vol. 51 by Jain, S.K. and V.P. Singh, 1st Ed. Elsevier Science 2003
[5] Water Resources Systems Planning and Management: An introduction to methods, Models and Applications By DP Locuks, E Beek, Springer 1st Ed 2017.
[6] Industrial water resource management: Challenges and opportunities for corporatewaterstewardship By PK SenGupta, 1st Ed. Wiley Blackwell 2017.
[7] Handbook on Energy Audit and Environment Management, By Teri Bookstore 2006.
[8] Industrial Energy Management and Utilization by L.C. Witte, P.S. Schmidt, D.R. Brown, Hemisphere Publication, Washington.
[9] Handbook of Energy Audits by Albert Thumann, William J. Younger, 8th Ed. CRC Press, 2008.
[10] Water accounting and auditing A sourcebook by Charles Batchelor,JippeHoogeveen, Jean-Marc Faurès and Livia Peiser,FAO Water reports Food and Agriculture Organization of United Nations Rome, 2016.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	3	1	3	3	1	1	1	1	3
CO2	3	1	1	3	1	3	3	1	1	1	1	3

CT-362(Computational Lab)	0 L	0 T	2 P	1 Credit

Laboratory Objectives

To solve problems involving fluid flow operations, reaction engineering, thermodynamics, mechanical operations, heat and mass transfer operation using commercially available software.

Laboratory Outcomes

To solve linear algebraic equation and nonlinear algebraic equation using MATLAB.
To solve ordinary differential equation and partial differential equation using MATLAB.
To solve problems involving fluid flow operations, reaction engineering, thermodynamics, mechanical operations, heat and mass transfer operation using MATLAB.

List of problems to be solved

1. To understand various features, commands, functions, codes etc. used in MATLAB.
2. To solve single variable and multivariable linear algebraic equation, nonlinear algebraic equation using MATLAB.
3. To solve ordinary differential equation (initial value and boundary value problems) and simultaneous differential equation using MATLAB.
4. To solve partial differential equation using MATLAB.
5. To solve problems involving fluid flow operations, reaction engineering, thermodynamics, mechanical operations, heat and mass transfer operation etc. using MATLAB

CT-364 (Modelling & Simulation Lab)	0 L	0 T	3 P	2 Credit

Laboratory Objectives

To provide hand on practice of commercial simulation software for modeling and simulation of Chemical processes.

LaboratoryOutcomes

It will help to understand:

1. Application of process simulator in chemical engineering.
2. Application of process thermodynamics for stream property calculation.
3. Basics of process simulator and simulation technique of Flow sheet.
4. Process dynamics

Content

Application of the following software packages to assigned problems:
1. ASPEN PLUS
2. ASPEN DYNAMICS
3. ASPEN CUSTOMER MODELER

CT-366(Biochemical Engineering Lab)	0 L	0 T	3 P	2 Credit

Course Objectives

To acquaint students with Bioreactor and its use for fermentations.

Course Outcomes

The students completing the course will be able to get-

1. Understanding for fermenter and its operation
2. Learn immobilization methods for cell/enzyme.
3. Familiarity with techniques of volumetric mass transfer coefficient using, static, and chemical methods.
4. Study the growth of E. coli or yeast in fermenter and evaluate the growth kinetic.
5. Develop knowledge of operation of various fermentation parameters monitors and controllers.

List of Experiments

1. Batch Reactor and its parts and operation of bioreactor.
2. To estimate growth kinetic parameters of Escherichia coli.
3. To determine mixing time in a stirred tank reactor (STR).
4. Estimation of cell maintenance coefficient and true growth yield by studying the mass and energy balance during cell growth.
5. Comparison between aerobic and anaerobic fermentation.
6. To determine Residence Time Distribution (RTD) for a CSTR.
7. Immobilization of the enzymes over the carriers.
8. Immobilization of the cells over the carriers.
9. Studies on the kinetics of immobilized enzyme and immobilized cells

CT-368(Environment Lab)	0 L	0 T	3 P	2 Credit

Laboratory Objective

To determine the various water/ waste water characteristics through group tasks.

Laboratory Outcomes

Students will learn about the physical and chemical characteristics of water.

List of experiments

1. Determination of pH and Alkalinity in water.
2. Determination of Color and Turbidity in water.
3. Determination of TS, TDS and TSS in water.
4. Determination of Hardness in water.
5. Determination of Nitrates in water.
6. Determination of Heavy metals in Water.

SEVENTH SEMESTER

Theory Papers						
Group	**Paper Code**	**Paper**	**L**	**T/ P**	**Credits**	**Total Credits**
PC	CT 401	Process Engineering & Economics	3	0	3	3
PC	CT 403	Chemical Process Safety	3	1	4	4
PCE	CT405	Process Equipment Design II	1	1	2	2
Emerging area electives (EAE4) (opt any one)						
Modeling and Simulation	CT407	Mathematical Methods in Chemical Engineering	3	1	4	4
Biochemical Engineering	CT409	Biosafety, Hazards & IPR issues	3	1	4	
Environmental Engineering	CT411	Industrial Pollution and Waste Management	3	1	4	
Open area electives (OAE4 and OAE5) (opt any two)						
OAE or MOOCs	CT 413	Air Pollution Control Engineering	3	1	4	8
	CT 415	Upstream Processing for fermentation	3	1	4	
	CT 417	Applications of data Science and Machine Learning in Chemical Engineering	3	1	4	
	CT 419	Multiphase Reactor	3	1	4	
	CT421	Hydrogen and Fuel Cell	3	1	4	
Practical/Viva Voce						
PC	CT461	Minor Project	-	6	3	3
PC	CT463	Summer Training Viva[#*]	-	-	2	2
EAE	CT465	Seminar [**]	-	4	2	2
Total			**16**	**15**	**28**	**28**

#Training in chemical industry/research in laboratory for a period of 4-6 weeks in summer vacation.

***NUES: Comprehensive evaluation will be done by the teacher concerned out of total 100 marks. No end term examination shall be held.**

**** Topic of seminar is subjected to minor area of specialization.**

CT-401(Process Engineering & Economics)	3 L	0 T	0 P	3 Credit

Course Objectives

Introduce concepts of chemical process engineering, economics, and troubleshooting.

Course Outcomes

Student will be able to

1. Understand concept of process design.
2. Troubleshoot real-time chemical processes.
3. Perform optimal plant operation.

Course Content

UNIT 1 **(8 Hrs)**

Conceptualization, diagram and analysis of chemical processes, Block Flow Diagram (BFD) and Process Flow Diagram (PFD) and Piping and Instrumentation Diagram (P&ID), Detailed engineering concepts and mapping (Startup, Construction, Site selection and layout).

UNIT 2 **(12 Hrs)**

Economic design criteria, Financing the corporate ventures, Concept of Financial statements reports and ratios, Estimation methods for Capital cost and manufacturing cost,

Time value of money, Profitability analysis, Depreciation, amortization and depletion, sensitivity and uncertainly analysis

Use of Heuristics, cost equations and cost curves for designing a process

UNIT 3 **(10 Hrs)**

Choice of batch v/s continuous process Time cycle for batch processes, Design and scheduling of Batch processes, Concept of dedicated and multiproduct plant facilities, Sizing of vessels in batch plant, Inventories

UNIT 4 **(12 Hrs)**

Efficient utilization of energy; heat exchanger network (PINCH technology).

Strategy of scale-up and design of chemical processes

Process trouble shooting and debottlenecking, Ethics and Professionalism in process engineering, salient features of patent literature.

Text and Reference Books

[1] Analysis, Synthesis, and design of Chemical Processes R Tutron, R C Ballie, A B Whiting and J AShaeiwitz, Eastern Economy 4th Ed, 2015.

[2] Plant Design and Economics for Chemical Engineers, M S Peters, K D Timmerhaus, Mc GrawHill, 5th Ed, 2017.

[3] Chemical Process Design and Integration, R Smith, Wiley India 2nd Ed, 2006.

[4] Process Engineering Economics, James R Couper, CRC Press, 2003.
[5] System Methods of Chemical Process Design, L T Beigler, I E Grossman and A W Westerberg, Prentice Hall International 1st Ed, 1997.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	1	3	3	1	1	1	1	3
CO2	3	3	1	2	1	3	3	1	1	1	1	3
CO3	3	3	3	2	1	3	3	1	1	1	1	3

CT-403 (Chemical Process Safety)	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objectives

1. To ensure that workers are not exposed to harmful levels by monitoring and reduction of toxic, noise and radiation.
2. To estimate consequences of fires and explosion including design procedures to reduce fire and explosion hazards and to understand various techniques for identifying hazards leading to fire, explosion or toxic release.
3. To determine the consequences of an accident including the rate of material release and the physical state of the material.

Course Outcomes

The students will be able to:

1. Identify the potential hazards and hazardous conditions associated with the processes and equipment involved in the chemical process industries.
2. Describe and apply the principles and approach of inherently safer design to reduce and eliminate fire and explosion hazards
3. Perform consequence analysis and learn statistical methods to determine the effectiveness of safety programs and hence determine if a process is safe or not
4. Determine failure frequencies of the entire system using event tree and fault tree.

Course Content

UNIT 1 **(10 Hrs)**

Industrial hygiene and safety aspects: related to toxicity, noise, radiation, Identification, Evaluation, Control

Fires and Explosions: Flammability Characteristics of liquids & vapors, minimum oxygen concentration (MOC), Ignition Energy, Ignition sources, Explosions: Detonation & Deflagration, combined explosions, BLEVE, Blast Damage due to overpressure.

UNIT 2 **(12 Hrs)**

Hazard identification: Various Techniques - Dow Index and HAZOP.

Consequence analysis: Flow of liquid/vapors through hole, flashing liquid, Pool evaporation.

UNIT 3 **(12 Hrs)**

Design to prevent fire & explosions: Inserting, controlling static electricity, explosion proof equipments & instruments, ventilation, sprinkler systems. Introduction to Reliefs: Location of Reliefs; Relief Types and Characteristics. Hazards / Risk Assessment: Event trees, fault trees, reliability, probability.

UNIT 4 **(8 Hrs)**

Emergency planning: Elements of emergency planning, on-site/ off-site emergency plans.

Case studies: Bhopal Tragedy, Flixborough Disaster, Mexico Disaster.

Text and Reference Books

[1] Chemical Process Safety Fundamentals with Applications, Daniel A Crowl, Joseph F. Louvar, 3rd Edition, Prentice Hall, 2013.
[2] Loss Prevention in Process Industries: Hazard Identification Assessment and Control, Lees, F.P, Butterworth-Heinemann, 4th Edition, 2012
[3] Introduction to Process Safety for Undergraduates and Engineers, CCPS, 1st Edition, Wiley - AIChE

Publication, 2016.
[4] Lessons from Disaster: How Organizations Have No Memory and Accidents Recur, Trevor Kletz, Gulf Publishing, 1993.
[5] Guidelines for Risk Based Process Safety, CCPS, 1st Edition, Wiley - AIChE Publication 2007.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	1	3	3	1	1	1	1	3
CO2	3	3	3	2	1	3	3	1	1	1	1	3
CO3	3	3	3	2	1	3	3	1	1	1	1	3
CO4	3	3	3	2	1	3	3	1	1	1	1	3

CT-405 (Process Equipment Design II)	**1 L**	**1 T**	**0 P**	**2 Credit**

Course Objectives

The course is designed with an objective to make student understand the detailed design of various chemical process equipment's.

Course Outcomes

1. Student will be able to design various separation equipments: liquid-liquid/solid-liquid etc
2. Student will be able to design conventional heat exchangers as well as new and advanced heat exchangers.
3. Student will be able to design the basics of different type of reactors

Course Content

UNIT 1 **(10 Hrs)**

Designing of various Separation Equipment
-Solid-Solid separations: Centrifuge, floatation separators, electrostatic separators
-Liquid-Solid separators: Thickeners and clarifiers, plate and frame filter, rotary filter, rotary dryer
-Separation of dissolved solids: design of evaporators and crystallizers
-Liquid - Liquid separators: Design of decanters, plate separators etc. Design of Distillation Tower, absorption column, extraction column, packing, type of packing
-Separation of dissolved solids: design of leaching equipment
-Gas-Solid separations: Design of gravity settlers, wet scrubbers, electrostatic precipitator

UNIT 2 **(10 Hrs)**

Design of various heat transfer equipments
shell and tube heat exchanger, plate and frame heat exchangers, spiral heat exchangers etc, Design of reboilers, condensers, Finned tube heat exchangers, fired heaters

UNIT 3 **(4 Hrs)**

Design of Reactors
Design of Packed bed and fluidized bed reactors, Design of CSTR and PFR, Trickle Bed reactor etc

UNIT 4 **(4 Hrs)**

Mixing Equipment's
Design of agitators and mixers

Text and Reference Books

[1] Chemical Engineering and Design, Principle, Practices and economics of plant and process design, R. Sinnot, Coulson and Richardson, Vol. 6. Ed. 4th, 2005
[2] Perry's Chemical Engineer's Handbook, R. H. Perry, D.W. Green, 7th Ed., McGraw Hill, 1998.
[3] Applied Process Design for Chemical and Petrochemical plants, Gulf Professional Publishing, Volume 1, 2 & 3, 4th, Ed. 2007
[4] Chemical Process Equipment, J R Couper, W R Penny, J R Fair, S.M Valas, Elsevier, 2nd Ed 2004.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	3	3	1	1	1	1	3
CO2	3	3	3	3	1	3	3	1	1	1	1	3
CO3	3	3	3	3	1	3	3	1	1	1	1	3

CT-407 (Mathematical Methods in Chemical Engineering)	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objective

1. To describe various chemical engineering problems into mathematical form by applying appropriate microscopic and macroscopic balances.
2. To solve the model equations by means of analytical methods with the aim of approximate quantification of a physical phenomenon.

Course Outcomes

At the end of the course, the student should be able to:

1. Formulate the physical problems encountered in chemical engineering into mathematical equations.
2. Identify the appropriate analytical solution technique and to solve the model equation.
3. Analyze the results of the different solution techniques.
4. Perform nonlinear analysis.

Course Content

UNIT 1 **(15 Hrs)**

Mathematical formulation of chemical engineering problems based on first principles: Classification of mathematical models, Mathematical models leading to algebraic equations, ordinary differential equations and partial differential equations. Types of chemical engineering problems: Stage-wise operations, Steady state and unsteady state diffusion of heat and mass in rectangular, cylindrical and spherical geometry; Reaction in continuous stirred tank reactor; Diffusion with reaction; Flow through porous media etc.

UNIT 2 **(15 Hrs)**

Analytical solution of ordinary differential equations encountered in chemical engineering problems: Order and degree, first order differential equations, second order differential equations, Linear differential equations, Simultaneous differential equations.

UNIT 3 **(20 Hrs)**

Analytical solution of partial differential equations encountered in chemical engineering problems: Classification of partial differential equations, Types of boundary conditions, Method of separation of variables, Perturbation methods, Integral method.

UNIT 4 **(6 Hrs)**

Non-linear analysis: Phase plane analysis, Bifurcation behavior.

Text and Reference Books

[1] Mathematical Methods in Chemical Engineering. Pushpavanam, S., PHI
[2] Mathematical Methods in Chemical Engineering. Jenson V.G and Jeffreys, G.V., Academic Press, 2012.
[3] Mathematical Methods in Chemical and Biological Engineering, Dutta, B.K., CRC Press, 2017

[4] Applied Mathematics in Chemical Engineering, Mickley, H.S., Sherwood, T.K., and Reed, C.E., McGraw Hill, N.Y.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	1	3	1	1	1	1	3
CO2	3	3	3	3	1	1	3	1	1	1	1	3
CO3	3	3	3	3	1	1	3	1	1	1	1	3
CO4	3	3	3	3	1	1	3	1	1	1	1	3

Emerging Area Electivefor minor specialization in Biochemical Engineering

CT-409(Biosafety, Hazards & IPR issues)	3 L	1 T	0 P	4 Credit

Course Objectives

To understand importance and need of biosafety protocols, bioethics and Intellectual Property rights.

Course Outcomes

Students should be able to understand:

1. Basics of biosafety and bioethics and its impact.
2. Recognize importance of implementation of biosafety practices and guidelines in research for safe research environment
3. Containment principles, technologies and practices to prevent unintentional exposure to biological hazards and their accidental release into the environment
4. Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).
5. Recognize necessity and application of different types of intellectual property rights.

Course Content

UNIT 1 **(12 Hrs)**

Biotechnology and Society: Introduction to science, technology and society, biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs. private funding, biotechnology in international relations, globalization and development divide.

UNIT 2 **(20 Hrs)**

Bioethics: Legality, morality and ethics, the principles of bioethics: autonomy, human rights, beneficence, privacy, justice, equity etc. Ethical issues – ethical issues against the molecular technologies. Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National & International. The expanding scope of ethics from biomedical practice to biotechnology, ethical conflicts in biotechnology - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, bioethics vs. business ethics, ethical dimensions of IPR, technology transfer and other global biotech issues.

UNIT 3 **(12 Hrs)**

Biosafety concepts and issues: Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards, biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and the world. Legal issues – legal actions taken by countries for use of the molecular technologies. Social issues - public opinions against the molecular technologies.

Introduction to the concept of containment level and Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).

Biosafety in the laboratory institution: Laboratory associated infections and other hazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/ institution Biosafety regulations in the handling of recombinant DNA processes and products in institutions and industries, biosafety assessment procedures in India and abroad.

UNIT 4 **(12Hrs)**

Intellectual Property Rights – Why IPR is necessary, TRIPS & IPR, IPR – national & international scenario, IPR protection of life forms.

Patents, copyrights, trademarks, patent act (1970), patent (amendment) act (2002), salient features and different types of patent and patent specifications. Filling and processing of applications for patents, biopiracy and biocolonialism.

Text and Reference Books

[1] Thomas, J.A., Fuch, R.L. (2002). Biotechnology and Safety Assessment (3rd Ed). Academic Press.
[2] Fleming, D.A., Hunt, D.L., (2000). Biological safety Principles and practices (3rd Ed). ASM Press, Washington.
[3] Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions
[4] Encyclopedia of Bioethics (3rd Ed.) - Thomson-Gale-Macmillan, 2016.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-411 (Industrial Pollution and Waste Management)	3 L	1 T	0 P	4 Credit

Course Objectives

Comprehensive analysis of Waste management and Industrial pollution.

Course Outcomes

Students will learn about:

1. Pollution caused by industries
2. Strategies to save environment from water, air, and solid waste pollution.
3. Management of waste and knowledge of other global issues.

Course Content

UNIT 1 **(6 Hrs)**

Introduction to Water Treatment: National & International Scenario; World-wide Water resources Management; Water quality standards – Drinking water standards; Industrial effluent standards

UNIT 2 **(15Hrs)**

Physico-Chemical Treatment Technology: Aeration, Ion-exchange, Ozone treatment, adsorption. Chemical coagulation-precipitation, settling, flocculation theorems, Chlorination, advanced scheme for municipal water treatment.

Biological Treatment: Basics of biological water treatment, relevant kinetics, biological reactor configurations, Activated sludge process, trickling filtration, lagoon treatment, submerged aerators, upward flow sludge blanket reactor, rotating disc biological contactors, advances in biological treatment.

UNIT 3 **(15 Hrs)**

Air Pollution: Environmental threats, Role of Atmosphere in dispersion, Plume behavior, Dispersion problems and Stack Design, Control devices –Cyclone Separators, ESP, Venturi scrubber, gravity separator, filters, Design Problems, Abatement of gaseous pollutants & VOCs,

UNIT 4 **(20 Hrs)**

Solid Waste analysis and characterization, Hazardous waste Characterization, Environmental legislation for solid and hazardous waste disposal and transport, Risk Assessment, Waste minimization and resource recovery, Waste stabilization, techniques, Chemical, physical and biological treatment Landfill, Sanitary and Hazardous Wastes, Incineration.

Text and Reference Books

[1] Wastewater Engineering: Treatment And Reuse, Metcalf & Eddy, Inc., George Tchobanoglous, 2017.
[2] Basics of Solid and Hazardous Waste Mgmt. Tech., KantiL.Shah Prentice Hal, 1999.
[3] Solid and Hazardous Waste Management, S.C. Bhatia Atlantic Publishers & Dist., 2007.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3:

High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	3	3	1	1	1	1	3
CO2	3	2	2	1	1	3	3	1	1	1	1	3
CO3	3	2	2	1	1	3	3	1	1	1	1	3

CT-413 Air Pollution Control Engineering	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objectives

To introduce the students to the basics of air pollution, Principles, Concepts, Methods adopted in the air quality management. and Design of air pollution control system, its principle, and applications.

Course Outcomes

In this course students will-

1. Learn the fundamentals of air pollution and its associated environmental impacts.
2. Learn to describe the key concepts of air quality management.
3. Imparts knowledge on the impacts of air pollution on different aspects such as policy, human health, and various contemporary technological innovation for betterment of air quality.
4. Provides information on the effects of air pollution on various facets, including human health, policy, and various modern technological innovations for improved air quality.

Course Content

UNIT 1 **(8 Hrs)**

Introduction: Air pollution- Definition, Sources and Classification of air pollutants, Air pollution episodes, Effects of air pollutants on human health, Vegetation and Materials. Air Quality Standards and Legislation: Air pollution control legislation, Air quality criteria and standards, Ambient air quality standards, Emission standards.

UNIT 2 **(8 Hrs)**

Elements of regulatory control Measurement and Monitoring of Air Pollutants: Types of Air sampling, Sampling train, sampling of particulate and gaseous pollutants, stack emission monitoring, analysis and measurement of particulate and gaseous pollutants.

UNIT 3 **(12 Hrs)**

Air Pollution Meteorology: Urban micro-meteorological concepts-boundary layer structure, air pollution pathways, air quality phenomena-inversion, ventilation, urban heat island, atmospheric stability classification, plume behaviour, wind velocity profiles, wind and pollution rose diagrams Air Quality Management : scales of air pollution problems, emission inventory, air quality management concept, elements of air quality management, statistical techniques in air quality data analysis and air quality indices air quality management practices in developed and developing countries.

UNIT 4 **(14 Hrs)**

Basics of Air Pollution Control: Principles and methods used to control gaseous and particulate pollutants and selection of air pollution control equipment. Air Pollution Control Equipment: Settling chamber, cyclone separators, wet and dry scrubbers, bag filters, electrostatic precipitators Vehicular Emissions Control: emissions from gasoline, diesel, CNG and biodiesel engines, catalytic converters and filters.

Indoor Air Pollution Control: Sources and types of indoor air pollutants, control of indoor air pollution Current Issues: hazardous air pollutants, CO_2 budgeting, air pollution effects on climate change, global air pollution, air pollution mitigation and adaptation to climate change Air Laboratory-particulate matter sampling, gaseous sampling, indoor air sampling, bio aerosols sampling and stack monitoring.

Text and Reference Books

[1] Wark, K., Warner, C.F., and Davis, W.T., Air Pollution: Its Origin and Control, Addison-Wesley Longman,1998.
[2] Boubel, R.W., Fox, D.L., Turner, D.B., Stern, A.C., "Fundamentals of Air Pollution", Academic Press. 2005.
[3] Seinfeld, J.H., Pandis, S.N., Atmospheric Chemistry and Physics, John Wiley, 2006.
[4] Lodge, J.P. (Ed.), "Methods of Air Sampling and Analysis", CRC Press, 1988.
[5] Gurjar, B.R., Molina, L., Ojha, C.S.P. "Air Pollution: Health and Environmental Impacts", CRC Press. 2010.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	3	3	1	1	1	1	3
CO2	3	3	3	3	1	3	3	1	1	1	1	3

CT-415 (Upstream Processing for Fermentation)	3 L	1 T	0 P	4 Credit

Course Objectives

To impart to students an understanding of the biochemical manufacturing processes that use recombinants in fermentations, microbes, plants, and animal cell culture to produce industrial products.

Course Outcomes

1. Basic understanding of upstream processing used in biochemical manufacturing via fermentation.
2. To learn the theoretical and practical aspects of different microbial, animal and plant cell culturing and maintenance, their media formulations, and their products analysis.
3. To learn the concepts of different kinds of bioreactors used in biochemicals manufacturing via fermentation
4. To learn the concepts of different kinds of industrially important microbes, and their fermented products.

Course Content

UNIT 1 **(6 Hrs)**

Introduction to Upstream Processing: The upstream biomanufacturing via fermentation, Microbial biomass, microbial enzymes and microbial metabolites, recombinant proteins and other important products, different transformation processes, the chronological development of fermentation industries, and the component parts of a fermentation process

UNIT 2 **(12 Hrs)**

Cell Growth Systems: Microbial Growth in batch Culture, Aseptic Techniques, Cell Cycle in Bioprocesses Kinetics of Microbial Growth in Batch, Continuous, and Fed-batch. Comparison of batch and continuous cultures in industrial processes. Applications of fed-batch culture, Examples of the fed-batch culture types.

Isolation, preservation and improvement of industrially important microorganisms: Isolation of microbes, Isolation methods involving selection of desired characteristics and Isolation methods not utilizing selection of desired characteristics, screening methods, preservation of industrially important microbes, Lyophilization, Quality Control of preserved stock cultures, Improvements of industrial microbes, Isolation of mutants which do not produce feedback inhibitors or repressors, Isolation of mutants with enhanced yield of secondary metabolites, Use of recombinant systems for improvement of the industrial microorganisms. Selection of strains, resistant to infection, more stable, non-foaming, tolerant to media components and low oxygen, development of strains to produce new fermentation products.

UNIT 3 **(8 Hrs)**

Media for industrial fermentations: Introduction, Media and its formulation, Carbon and Energy sources, Factors influencing the choice of carbon source, examples of commonly used carbon sources-carbohydrates, oils and fats, hydrocarbon and their derivatives, nitrogen sources, minerals, chelators, buffers and growth factors. Metabolic regulators to media- precursors, inhibitors, and inducers. Oxygen requirements for fast metabolism, medium optimization, Antifoam. Sterilization of medium, Design of batch sterilization, del factor, methods for batch sterilization, sterilization of fermenter, feed, and fermented waste. Sterilization of inlet and exhaust air in the fermenter, Filter sterilization and filter design. Immobilization of Cells, Proteins and Enzymes, Different types of support materials, Immobilized cells and Enzymes.

UNIT 4 **(16 Hrs)**

Bioreactor Design, Engineering, Process Sensing and Control: Basic functions of a fermenter, Aseptic operation and containment, Construction materials, Aeration and agitation, Controllers for temperature, pH, and foam, The reactor parts as baffles, sparger etc., Ports for inoculation, sensors, acid/base addition, and foam control, monitoring and control of various parameters, valves and steam traps. Sampling and sample handling for Process control,

Bioreactor types: Airlift bioreactors, Fluidized-bed bioreactor, Hollow fibre bioreactors, Perfusion bioreactor, Solid state bioreactors, Rotating biological contactors, and Photobioreactors.

Fermenter Design, Gas-Hold-up in bioreactors, Impeller selection, Mass transfer in fermenter, Oxygen transfer rate, K_La determination methods, Factors affecting K_La, Relation between K_La and power consumption, relation between power consumption and operating variables, Rheological behaviour of fermentation fluids,

Process Analytical Technologies: Methods for measuring process variables such as temperature control, pH control, foam control, agitation (stirrer speed) control, inlet and outlet air flow control, Dissolved oxygen, and pressure control. Manual and automatic control systems.

Text and Reference Books

[1] Principles of Fermentation Technology, Second Edn., P F Stanbury, A. Whitaker, and S. J. Hall, Elsevier, 1995.
[2] Bioprocess Engineering, Second Edn., M.L. Shuler and F. Kargi, Prentice Hall of India, 2005.
[3] Biochemical engineering, second edition, S. Aiba, A. E. Humphrey, and N. F. Millis, Academic Press, Inc., New York (1973).
[4] Upstream Industrial Biotechnology, 2 Volume Set, Michael C. Flickinger, 2013.
[5] Cell Culture and Upstream Processing Paperback – Illustrated, by Michael Butler (Editor), 2007.

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Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-417(Applications of Data Science and Machine Learning in Chemical Engineering)	3 L	1 T	0 P	4 Credit

Course Objective

1. To learn basics of Data Science and Python
2. To able to use application of AI and Machine learning in Chemical Engineering
3. To understand the concepts of State Space Representation, Exhaustive search, Heuristic search together with the time and space complexities.
4. To learn different knowledge representation techniques.

Course Outcomes

1. Student will be able to use Data Science through Python
2. Student will be able to apply the knowledge in Chemical Engineering like Decision support system, process control, modeling and simulation

Course Content

UNIT 1 **(10 Hrs)**

Data Analysis With MS-Excel Excel: Fundamentals Excel for Data Analytics; Data Visualization with Excel; Excel Power Tools Classification; Problems using Excel Information; Measure in Excel Regression; Problems Using Excel; SQL Basics; Advanced SQL; Deep Dive into User Defined Functions; SQL Optimization and Performance;

UNIT 2 **(10 Hrs)**

Python With Data Science: Introduction to Python and IDEs; Python Basics; Object Oriented Programming; Extract Transform Load Data Handling with NumPy Data; Manipulation Using Pandas Data Preprocessing; Data Visualization

UNIT 3 **(10 Hrs)**

Introduction to Artificial Intelligence (AI) and Machine Learning (ML); Types of learning problems: Supervised, Unsupervised, Semi-supervised; Overview of optimization techniques; Introduction to software used in AI & ML

UNIT 4 **(12 Hrs)**

Solving problems in Chemical Engineering (like decision support system, process control, modeling and simulation) applying rule-based AI & ML tools and lifecycle: (i) Data preprocessing: Data visualization, Outlier detection, & Smoothing techniques, Data scaling (Need for Scaling – Scale invariance, Standardization, Normalization), Dimensionality reduction, Feature extraction, selection (ii)

Model Evaluation & identification: Performance metrics, analysis, Model selection, Hybrid cross-Validation methods (iii) Model development: (a) Classification – (Logistic regression, Naïve Bayes classifier, K-nearest neighbors, Support vector machines, Decision trees, Random forests, Boosting), (b) Regression - (Linear regression – Simple, Multiple, Kernel, Regression analysis, Neural Network.

Text and Reference Books

[1] Hastie, T., Tibshirani, R., Friedman, J.H., The Elements of Statistical Learning Data Mining, Inference, and Prediction, Second Edition, Springer, 2009
[2] Abu-Mostafa, Y.S., Magdon-Ismail, M., Hsuan-Tein, L., Learning from Data. AML Book, 2012.
[3] Gareth, J., Witten, D., Hastie. T., Tibshirani, R., An Introduction to Statistical Learning with Applications in R, Springer-Verlag, 2013.
[4] Müller, A. C., Gudio, S., Introduction to Machine Learning with Python, O'Reilly Media, Inc., 2016.
[5] Shalev-Shwartz, S. and Ben-David, S., Understanding Machine Learning: From Theory to Algorithms, Cambridge University Press, 2014.
[6] Dr Gypsy Anand/ Dr Rupam Sharma Data Science Fundamentals & Practical Approaches
[7] Bharti Motwani Data Analytics using Python, bpb 2020.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	3	3	1	1	1	1	3
CO2	3	3	3	3	1	3	3	1	1	1	1	3

CT-419(Multiphase Reactor)	3 L	1 T	0 P	4 Credit

Course Objective

1. To learn general theory of multiphase reactions in a multiphase reactor.
2. Introduction to types of multiphase flow reactors and their functioning, advantage and disadvantages and challenges along with future direction of research will be discussed.

Course Outcome

Students will be able to understand:

1. Functioning of Trickle bed reactors, Bubble Column Slurry Reactor and three phase fluidized bed reactors.
2. Modeling of continuous integral reactors, modelling of semi-batch reactors.

Course Content

UNIT 1 **(14 Hrs)**

General Theory of Multiphase Reactions:

Introduction, Kinetic models in three phase systems, Analysis of differential reactors, zero order reactions, Reversible reactions, Analysis of some special problems

UNIT 2 **(14 Hrs)**

Modeling of Reactors

Modeling of continuous integral reactors, modelling of semi-batch reactors.

UNIT 3 **(12Hrs)**

Dynamics of Multiphase Systems

Introduction and general Concepts, Dynamics of three phase semi-batch adsorbers, fixed bed systems and dynamics of three phase reactors.

UNIT 4 . **(14 Hrs)**

Examples of Multiphase Reactors

Trickle Bed Reactors, Bubble Column slurry reactor and three phase fluidized bed reactors.

Text and Reference Books

[1] Three phase Catalytic Reactors by P.A. Ramachandran and R. V. Chaudhary, Gordon and Breach Science Publishers.

[2] Design of multi-phase reactors by Vishwas Govind Pangarkar, John Wiley and Sons.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	3	3	1	1	1	1	3
CO2	2	3	3	3	1	3	1	1	1	1	1	3
CO3	1	2	3	1	3	2	2	1	1	1	1	1
CO4	3	2	1	1	1	1	3	1	1	1	1	3

CT-421(Hydrogen and Fuel Cell)	**3 L**	**1 T**	**0 P**	**4 Credit**

Course Objective

1. To Learn about Hydrogen and Fuel Cells, Hydrogen storage technology, and Hydrogen Safety.
2. As a technology that holds promise for sustainable development, clean energy, and alternative fuels for transportation

Course Outcomes

The students will:

1. Learn Specific developments on Fuel Cells.
2. Use the basic principles and mechanisms of different fuel cells in practical and real-world applications.
3. Analyze advantages / disadvantages and hydrogen generation/storage technologies.
4. Compare and select appropriate hydrogen cell technologies for various applications.

Course Content

UNIT 1 **(6 Hrs)**

Hydrogen Production: Fossil fuels, electrolysis, thermal decomposition, Catalytic decomposition, photochemical, photocatalytic, hybrid; Biological processes and limitations

UNIT 2 **(6 Hrs)**

Fuel Cell: Principle of working, Basic-thermodynamics, Reaction kinetics, Charge, and mass transport. Modelling a Fuel Cell. Fuel Cell Characterization: System and components' characterization Fuel Cell Technology: Types of Fuel Cells, Fuel Cell systems and sub-systems, system, and sub-system integration; Power management, Thermal management; Pinch analysis.

UNIT 3 **(20 Hrs)**

Hydrogen storage technology – pressure cylinders, liquid hydrogen, metal hydrides, carbon Fibers – reformer technology – steam reforming, partial oxidation, auto thermal reforming – CO removal, Hydrogen Storage materials: Metal hybrids, Nanostructured metal hydrides, Non-metal hydrides, Carbohydrates, Synthesis of hydrocarbons, Aluminum, Liquid organic hydrogen carriers (LOHC), Ammonia, Amine borane complexes, Nano borohydrides and nano catalyst doping, imidazolium ionic liquids, phosphonium borate, Carbonite substances, Metal Organic frameworks, Activated Carbons, Carbon nanotubes, Clathrate hydrates, Glass capillary arrays.

UNIT 4 **(8 Hrs)**

Hydrogen Safety – History of accident, physiological, physical, and chemical hazards; hydrogen

properties associated with hazards; Hazard spotting, evaluation, and safety guidelines; Hydrogen safety codes and standards. Hydrogen economy.

Text and Reference Books

[1] Francesco Dalena, Angelo Basile, Claudio Rossi, Bioenergy Systems for The Future: Prospects for Biofuels and Biohydrogen, 1st Edition, Elsevier.
[2] Jean-Marie Tarascon, Patrice Simon, Electrochemical Energy Storage.
[3] Energies: V Smil, MIT Press, Cambridge, 1999.
[4] Mehmet Sankir, Nurdan Demirci Sankir, Hydrogen Production Technologies, John Wiley Sorensen, B. (2005) Hydrogen and Fuel Cells, Elsevier Academic Press, USA.
[5] Julie A. Kerr, Introduction to Energy and Climate: Developing A Sustainable Environment, T&F/Crc Press.
[6] Angelo Basile, Francesco Dalena, Cahterine E. Gregoire Pedro, Francis Lau, Advances in Hydrogen Energy, Springer Iet Publishing, Hydrogen Production, Separation and Purification for Energy (Energy Engineering)
[7] Bent Sørensen and Giuseppe Spazzafumo. Hydrogen and Fuel Cells: Emerging Technologies and Applications, 3rd Edition.

CT-461(Minor Project)	0 L	0 T	6 P	3 Credit

Course Objective

With project work, students can integrate their knowledge from different subjects and apply it creatively and critically to situations that arise in real life.

Course Outcomes

1. Students can communicate their thoughts and ideas both orally and in writing in a clear and effective manner.
2. Students learn to work as a team to achieve common goals.
3. Students will be able to create, develop, and assess project-related ideas and information as well as draw connections between various knowledge domains.

Content

Any topic of research or study as allotted to the student.

Guidelines for feasibility report and for Experimental work

Content (for feasibility report)	Content (For experimental work)
Title page with well-defined title; acknowledgment, certificate, Content, List of figure/tables, notations, Abstract	
Chapter 1: Introduction (general introduction, market survey, physical and chemical properties, safety and hazards and uses)	Chapter 1: Introduction
Chapter 2: Process description and selection	Chapter 2: Detailed literature review
Chapter 3: Material balance and Energy balance	Chapter 3: Methods/Experimental setup and analysis techniques Chapter 4: Results and discussions (if available)
Spiral bound, Pages- numbered, All heading/ subheading with numbers, References and Appendices.	

CT-463 (Summer Training Viva[#])[*]	**-**	**-**	**-**	**2 Credit**

Outcomes

To provide students with training and a practical understanding of industry and research practices in an appropriate industry and research laboratory

Assessment

Students should obtain training in chemical industry/research laboratory for a period of 4-6 weeks in summer vacation and get acquainted with practical understanding and training about industry/research laboratory practices. At the end of the training period, each student should submit a training report along with the certificate obtained from the respective industry/research laboratory to the department for assessment by a panel of examiners.

*NUES: Comprehensive evaluation by the teacher concerned out of 100.

[#]Training in chemical industry/research in laboratory for a period of 4-6 weeks in summer vacation.

CT-465(Seminar)**	**0 L**	**4 T**	**2 P**	**2 Credit**

- Student will be required to prepare a critical review of selected emerging area and submit in the form of a standard typed report.
- The student will also be required to make an oral presentation of the report.

** Topic of seminar is subjected to minor area of specialization.

EIGHTH SEMESTER

Project/Internship					
Group	**Paper Code**	**Paper**	**L**	**T/P**	**Credits**
PC	CT462	Major Project/ Internship	-	**24**	**12**
Total			**0**	**24**	**12**

CT-462 (Major Project/ Internship)	0 L	0 T	24 P	12 Credit

Objectives

Project Work provides a learning experience in which students have the opportunity to synthesize knowledge from various areas of learning, and apply it critically and creatively to real-life situations.

Outcomes

1. Students can express their ideas clearly and effectively, both verbally and in written form.
2. Students can learn the work as a team to achieve common goals.
3. Students will able to make links across different areas of knowledge and to generate, develop and evaluate ideas and information related to the project.

Content: Any topic of research or study as allotted to the student.
Guidelines for feasibility report and for experimental work

Content (for feasibility report)	**Content (For experimental work)**
Chapter 4: Process equipment design, at least one major separation, heat transfer and reaction equipment process as well as mechanical design in detail with specification sheet.	**Chapter 5:** Results and discussions
Chapter 5: Economical analysis: Estimation of FCI & operation cost, Cash flow, profitability analysis, DCFROR, Pay out period etc **Safety and hazard analysis (HAZOP) of small section**	**Chapter 6:** Conclusion and Scope of Work
Spiral bound, page numbers, all heading/ subheading with numbers, References and appendices	Spiral bound, page numbers, all heading/ subheading with numbers, References and

	appendices