NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH

SYLLABI
FOR B.TECH. PROGRAM

From 2017-18 Batch onwards

DEPARTMENT OF CHEMICAL ENGINEERING

SCHEME OF INSTRUCTION

B.Tech (Chemical Engineering) Course Structure

I - Year

Physics Cycle							
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	MA101	Mathematics - I	3	0	0	03	BSC
2	HS101	English for Technical Communication	2	0	2	03	HSC
3	PH101	Physics	3	0	0	03	BSC
4	EC101	Basic Electronic Engineering	3	0	0	03	ESC
5	CE102	Environmental Science and Engineering	2	0	0	02	ESC
6	BT101	Engineering biology	2	0	0	02	ESC
7	CS101	Problem Solving & Comp Programming	3	0	0	03	ESC
8	CS102	Problem Solving & Comp Programming Lab	0	1	2	02	ESC
9	PH102	Physics Laboratory	0	1	2	02	BSC
10	EA101	EAA: Games and Sports	0	0	3	00	MDC
		TOTAL	**18**	**2**	**9**	**23**	

Chemistry Cycle							
S.No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	MA151	Mathematics – II	3	0	0	03	BSC
2	ME102	Engineering Graphics	1	1	4	04	ESC
3	CY101	Chemistry	3	0	0	03	BSC
4	EE101	Basic Electrical Engineering	3	0	0	03	ESC
5	ME101	Basic Mechanical Engineering	3	0	0	03	ESC
6	CE101	Engineering Mechanics	3	0	0	03	ESC
7	ME103	Workshop Practice	0	1	2	02	ESC
8	CY102	Chemistry Laboratory	0	1	2	02	BSC
9	EA151	EAA: Games and Sports	0	0	3	00	MDC
		TOTAL	**16**	**3**	**11**	**23**	

II - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA201	Mathematics – III	3	0	0	3	BSC
2	CY201	Industrial Organic Chemistry	3	0	0	3	BSC
3	CH201	Chemical Process Calculations	3	1	0	4	PCC
4	CH202	Fluid and Particle Mechanics	3	1	0	4	PCC
5	CH203	Mechanical Operations	3	0	0	3	PCC
6	CH204	Chemical Engineering Thermodynamics – I	3	0	0	3	PCC
7	CH205	Fluid and Particle Mechanics Lab	0	1	2	2	PCC
8	CH206	Chemical Processing Lab	0	1	2	2	PCC
		TOTAL	**18**	**4**	**4**	**24**	

II - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA251	Mathematics – IV	3	0	0	3	BSC
2	CH251	Chemical Engineering Thermodynamics – II	3	1	0	4	PCC
3	CH252	Heat Transfer	3	1	0	4	PCC
4	CH253	Mass Transfer-I	3	1	0	4	PCC
5	CH254	Chemical Reaction Engineering – I	3	1	0	4	PCC
6	CH255	Process Instrumentation	3	0	0	3	PCC
7	CH256	Chemical Reaction Engineering Laboratory	0	1	2	2	PCC
8	CH257	Heat Transfer Laboratory	0	1	2	2	PCC
		TOTAL	**18**	**6**	**4**	**26**	

III - Year I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CH301	Chemical Reaction Engineering – II	3	0	0	3	PCC
2	CH302	Mass Transfer – II	3	1	0	4	PCC
3	CH303	Elements of Transport Phenomena	3	1	0	4	PCC
4	CH304	Chemical Technology	3	0	0	3	PCC
5	CH305	Industrial Safety and Hazard Mitigation	3	0	0	3	PCC
6		Elective – I	3	0	0	3	DEC
7	CH306	Computational Methods in Chemical Engineering Lab	0	1	2	2	PCC
8	CH307	Mass Transfer Laboratory	0	1	2	2	PCC
9	EP349	EPICS	0	0	0	2*	
		TOTAL	**18**	**4**	**4**	**24**	

*Credits are not considered for computation of SGPA and CGPA

III - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CH351	Process Dynamics and Control	3	1	0	4	PCC
2	CH352	Process Equipment Design (Open Book)	3	1	0	4	PCC
3	CH353	Petroleum Refining Processes	3	1	0	4	PCC
4	CH354	Pollution Control in Process Industries	3	0	0	3	PCC
5		Elective – II	3	0	0	3	DEC
6		Open Elective – I	3	0	0	3	OPC
7	CH355	Minor Research Project	0	1	2	2	PCC
8	EP399	EPICS	0	0	0	2*	
		TOTAL	**18**	**4**	**2**	**23**	

*Credits are not considered for computation of SGPA and CGPA

IV - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CH401	Plant Design and Process Economics	3	1	0	4	PCC
2		Elective-III	3	0	0	3	DEC
3		Elective-IV	3	0	0	3	DEC
4		Open Elective-II	3	0	0	3	OPC
5	CH402	Design and Simulation Laboratory	0	1	4	3	PCC
6	CH403	Process Instrumentation and Control Laboratory	0	1	2	2	PCC
7	CH449	Project Work Part-A	0	0	3	2	PRC
		TOTAL	**12**	**3**	**9**	**20**	

IV - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	SM451	Industrial Engineering and Management	3	0	0	3	HSC
2		Elective – V	3	0	0	3	DEC
3		Elective – VI	3	0	0	3	DEC
4		Elective – VII	3	0	0	3	DEC
5	CH451	Mandatory Audit Course*	0	0	0	0	MDC
6	CH499	Project Work Part-B	0	0	6	4	PRC
		TOTAL	**12**	**0**	**6**	**16**	

***The result of the Mandatory Audit Course (Self Study) completed by the student either in 6th or 7th semester will be reported in this semester

List of Electives

III Year I Semester

CH311 Pharmaceuticals and Fine Chemicals

CH312 Renewable Energy Sources

CH313 Fuel Cells and Flow Batteries

CH314 Energy Management

CH315 Corrosion Engineering

CH316 Nanotechnology

CH317 Polymer Technology

CH318 Material Science for Chemical Engineers

III Year II Semester

CH361 Wastewater Treatment

CH362 Fertilizer Technology

CH363 Food Technology

CH364 Green Technology

CH365 Pulp and Paper Technology

CH366 Catalysis

CH367 Experimental & Analytical Techniques

CH368 Complex Fluids

CH369 Natural Gas Engineering

IV Year I Semester

CH411 Biochemical Engineering

CH412 Interfacial Science

CH413 Statistical Thermodynamics

CH414 Petrochemical Technologies

CH415 Scale up Methods

CH416 CO_2 Capture & Utilization

CH417 Natural Gas Processes, Modeling and Simulation

CH418 Introduction to Tribology

CH5111 Process Modelling and Analysis

CH5114 Statistical Design of Experiments

CH5115 Chemical Process Synthesis

CH5117 Nuclear Power Technology

CH5119 Piping Engineering

CH5212 Data Analytics

IV Year II Semester

CH461 Micro scale Unit Operations

CH462 Process and Product Design

CH463 Mathematical Methods in Chemical Engineering

CH464 Introduction to macromolecules

CH5161 Optimization Techniques

CH5162 Process Scheduling and Utility Integration

CH5164 Advanced Mass Transfer

CH5165 Computational Fluid Dynamics

CH5166 Process Intensification

CH5262 Soft Computing Techniques

List of Open Electives

(Not offered to Chemical Engineering Students)

CH390 Nanotechnology and Applications

CH391 Industrial Safety Management

CH392 Industrial Pollution Control

CH393 Soft Computing Methods for Control

CH440 Data driven modeling

CH441 Fuel Cell Technology

CH442 Design of Experiments

CH443 Carbon capture, sequestration and utilization

Mandatory Audit Course (Self Study)

Every student is required to complete at least one course offered by the following agencies. The student is required to take prior approval from the Department, before registering for any course. The student can register for such a course either in 6th Semester or 7th semester. Unless the student submits a pass certificate, he/she shall not be eligible for the award of degree.

SAChE: Safety and Chemical Engineering Education Certification Program – www.aiche.org

SWAYAM:

www.swayam.gov.in *NPTEL:*

www.onlinecourse.nptel.ac.in

Course Era:

www.coursera.org

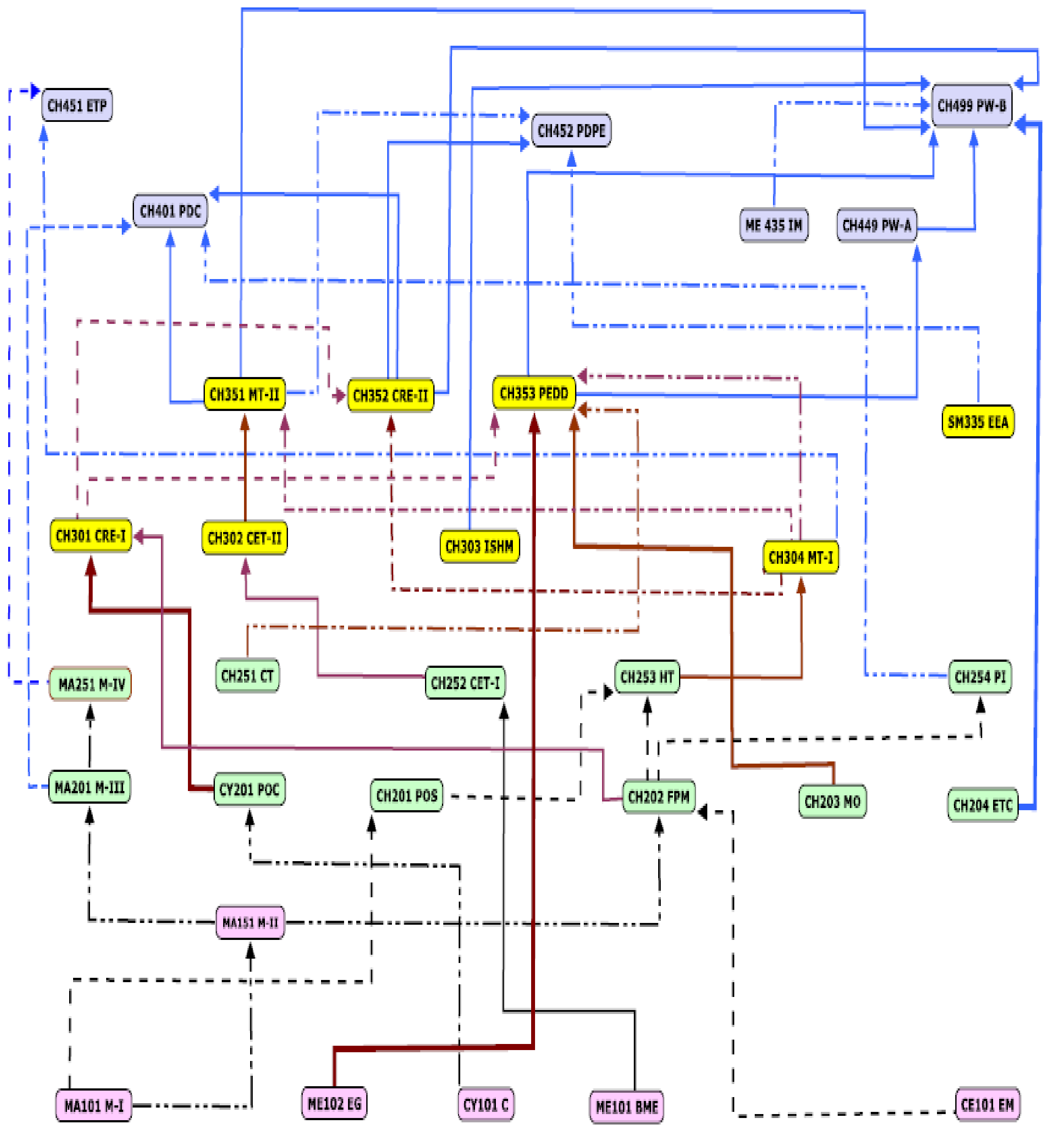
Free Online Courses: www.edx.org

MIT Open Course ware: www.ocw.mit.edu

1. Definition of Pre-requisite: The student should have studied that subject which is mentioned as Pre-requisite.
2. Course with same name but with different code number indicates that the subject pertains to different departments and also the syllabus is different.
3. EPICS Project is offered in two parts as Part-A in III Year II Semester and Part-B in IV Year I semester, with Two credits each. The credits earned are not counted for Computation of SGPA and CGPA. The course is not mandatory. It is Optional. Interested students can take it.
4. In first year syllabus, Engineering Biology is included in Physics cycle and Basic Mechanical Engineering is included in Chemistry cycle. This is with effect from 2018-2019 onward

B.TECH IN CHEMICAL ENGINEERING

PRE-REQUISITE CHART



DETAILED SYLLABUS

MA 101	MATHEMATICS – I	BSC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the students will be able to

CO1	solve the consistent system of linear equations
CO2	apply orthogonal and congruent transformations to a quadratic form
CO3	determine the power series expansion of a given function
CO4	find the maxima and minima of multivariable functions
CO5	solve arbitrary order linear differential equations with constant coefficients
CO6	apply the concepts in solving physical problems arising in engineering

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO2	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO3	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO4	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO5	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO6	3	3	1	3	1	-	-	-	-	-	-	-	-	1	2

Detailed Syllabus:

Matrix Theory: Linear dependence and independence of vectors; Rank of a matrix; Consistency of the system of linear equations; Eigenvalues and eigenvectors of a matrix; Caley-Hamilton theorem and its applications; Reduction to diagonal form; Reduction of a quadratic form to canonical form - orthogonal transformation and congruent transformation; Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices.

Differential Calculus: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions; Asymptotes; Curvature; Curve tracing; Functions of several variables - partial differentiation; total differentiation; Euler's theorem and generalization; Change of variables - Jacobians; maxima and minima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers.

Ordinary Differential Equations: Geometric interpretation of solutions of first order ODE �′ = ��(�,�); Exact differential equations; integrating factors; orthogonal trajectories; Higher order linear differential equations with constant coefficients - homogeneous and non-homogeneous; Euler and Cauchy's differential equations; Method of variation of parameters; System of linear differential equations; applications in physical problems - forced oscillations, electric circuits, etc.

Reading:

1. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 5th Edition, 2016.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2015.
3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015.

HS101	ENGLISH FOR TECHNICAL COMMUNICATION	HSC	2-0-2	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand basic principles of grammar and vocabulary
CO2	Write clear and coherent paragraphs
CO3	Write effective résumé, cover letter and letters for a variety of purposes
CO4	Prepare technical reports and interpret graphs
CO5	Develop reading comprehension skills
CO6	Comprehend English speech sounds, stress and intonation

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	1	-	-	-	3	-	1	-	-	-
CO2	-	-	-	-	-	1	-	-	-	3	-	1	-	-	-
CO3	-	-	-	-	-	1	-	-	-	3	-	1	-	-	-
CO4	-	-	-	-	-	1	-	-	-	3	-	1	-	-	-
CO5	-	-	-	-	-	1	-	-	-	3	-	1	-	-	-
CO6	-	-	-	-	-	1	-	-	-	3	-	1	-	-	-

Detailed Syllabus:

1. Grammar Principles (Correction of sentences, Concord) and Vocabulary Building (synonyms and antonyms): Idioms and Phrasal verbs--patterns of use and suggestions for effective employment in varied contexts
2. Effective Sentence Construction - strategies for bringing variety and clarity in sentences- removing ambiguity - editing long sentences for brevity and clarity
3. Reported speech - contexts for use of reported speech - its impact on audiences and readers- active and passive voice- reasons for preference for passive voice in scientific English
4. Paragraph-writing: Definition of paragraph and types- features of a good paragraph - unity of theme- coherence- linking devices- direction- patterns of development.
5. Note-making - definition- the need for note-making - its benefits - various note formats- like tree diagram, block or list notes, tables, etc.

6. Letter-Writing: Its importance in the context of other channels of communication- qualities of effective letters-types -personal, official, letters for various purposes- emphasis on letter of application for jobs - cover letter and resume types -examples and exercises
7. Reading techniques: Definition- Skills and sub-skills of reading- Skimming and Scanning - their uses and purposes- examples and exercises.
8. Reading Comprehension - reading silently and with understanding- process of comprehension- types of comprehension questions.
9. Features of Technical English - description of technical objects and process- Report-Writing- definition- purpose -types- structure- formal and informal reports- stages in developing report- proposal, progress and final reports-examples and exercises
10. Book Reviews- Oral and written review of a chosen novel/play/movie- focus on appropriate vocabulary and structure - language items like special vocabulary and idioms used

Language laboratory

1. English Sound System -vowels, consonants, Diphthongs, phonetic symbols- using dictionary to decode phonetic transcription-- Received Pronunciation, its value and relevance- transcription of exercises
2. Stress and Intonation –word and sentence stress - their role and importance in spoken English-Intonation in spoken English -definition, patterns of intonation- –falling, rising, etc.- use of intonation in daily life–exercises
3. Introducing oneself in formal and social contexts- Role plays- their uses in developing fluency and communication in general.
4. Oral presentation - definition- occasions- structure- qualities of a good presentation with emphasis on body language and use of visual aids.
5. Listening Comprehension -Challenges in listening, good listening traits, some standard listening tests- practice and exercises.
6. Debate/ Group Discussions-concepts, types, Do’s and don’ts- intensive practice.

Reading:

1. English for Engineers and Technologists (Combined Edition, Vol. 1 and 2), Orient Black Swan, 2006.
2. Ashraf, M Rizvi. Effective Technical Communication. Tata McGraw-Hill, 2006.
3. Meenakshi Raman and Sangeetha Sharma, Technical Communication: Principles and Practice 2nd Edition, Oxford University Press, 2011.

Software:

1. Clear Pronunciation – Part-1 *Learn to Speak English.*
2. Clear Pronunciation – Part-2 *Speak Clearly with Confidence*
3. Study Skills
4. English Pronunciation

PH101	PHYSICS	BSC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the students will be able to

CO 1	Solve engineering problems using the concepts of wave and particle nature of radiant energy.
CO 2	Understand the use of lasers as light sources for low and high energy applications
CO 3	Understand the nature and characteristics of new Materials for engineering applications.
CO 4	Apply the concepts of light propagation in optical fibers, light wave communication systems, holography and for sensing physical parameters.
CO 5	Apply the knowledge of Solar PV cells for choice of materials in efficient alternate energy generation.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	-	-	-	-	-	-	-	-	-	1	1
CO2	3	3	1	1	-	-	-	-	-	-	-	-	-	1	1
CO3	3	3	1	1	-	-	-	-	-	-	-	-	-	1	1
CO4	3	3	1	`1	-	-	-	-	-	-	-	-	-	1	1
CO5	3	3	1	1	-	-	-	-	-	-	-	-	-	1	1

Detailed Syllabus:

Quantum Mechanics: Concepts and Experiments that led to the discovery of Quantum Nature. Heisenberg uncertainty principle; Schrodinger time independent and time dependent wave equations, The free particle problem - Particle in an infinite and finite potential well, Quantum mechanical tunneling. MB, BE and FD distributions.

Wave and Quantum Optics:

Interference and Diffraction: Concept of interference and working of Fabry-perot Interferometer and its application as wavelength filter. Multiple beam diffraction and Working of diffraction Gratings, Application of Grating as wavelength splitter.

Polarization Devices: Principles, Working and applications of Wave Plates, Half Shade Polarimeter, Polariscope, Isolators and Liquid Crystal Displays.

Lasers: Basic theory of Laser, Concept of population inversion and Construction and working of He-Ne, Nd-YAG, CO_2 Lasers, LED, White light LED, Semiconductor Laser, Holography and NDT.

Optical Fibers: Structure, Types, Features, Light guiding mechanism and applications in Communications and Sensing.

Solar Cells: Solar spectrum, photovoltaic effect, materials, structure and working principle, I-V characteristics, power conversion efficiency, quantum efficiency, emerging PV technologies, applications.

Magnetic and Dielectric Materials:

Magnetic Materials and Superconductors: Introduction - Weiss Theory of Ferromagnetism – Properties – Domains – Curie Transition - Hard and soft magnetic materials – Spinel Ferrites – Structure – Classification – Applications - Meissner effect - Type-I and Type-II Superconductors – Applications.

Dielectric Materials: Introduction to Dielectrics, Dielectric constant – Polarizability - Properties and types of insulating materials - Polarization mechanisms in dielectrics(Qualitative) – Frequency and temperature dependence of polarization – Dielectric loss Clausius-Mossotti Equation(Qualitative)– dielectric Breakdown – Applications.

Functional and Nano Materials:

Functional Materials: Fiber reinforced plastics, fiber reinforced metals, surface acoustic wave materials, Bio-materials, high temperature materials and smart materials - Properties and applications.

Nanomaterials: Introduction, classification, properties, different methods of preparation and applications.

Reading:

1. Halliday, Resnic and Walker, Fundamentals of Physics, John Wiley, 9th Edition, 2011.
2. Beiser A, Concepts of Modern Physics, McGraw Hill International, 5th Edition, 2003.
3. Ajoy Ghatak, Optics, Tata McGraw Hill, 5th Edition, 2012.
4. S.O. Pillai,Solid State Physics, New Age Publishers, 2015.

EC101	BASIC ELECTRONIC ENGINEERING	ESC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the students will be able to

CO1	Comprehend the characteristics of semiconductor devices, and operational amplifiers
CO2	Understand the principles of working of amplifiers
CO3	Understand and design of simple combinational and basics of sequential logic circuits
CO4	Understand the principles of electronic measuring instruments and Transducers
CO5	Understand the basic principles of electronic communication

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	-	-	1	-	-	-	-	-	-	-	-	-
CO2	3	3	1	-	-	1	-	-	-	-	-	-	-	-	-
CO3	3	3	1	-	-	1	-	-	-	-	-	-	-	-	-
CO4	3	3	1	-	-	1	-	-	-	-	-	-	-	-	-
CO5	3	3	1	-	-	1	-	-	-	-	-	-	-	-	-

Detailed Syllabus:

Electronics Systems: Introduction to electronics, review of p-n junction operation, diode applications, Zener diode as regulator.

Transistor and applications: Introduction to transistors, BJT Characteristics, biasing and applications, simple RC coupled amplifier and frequency response. FET and MOSFET characteristics and applications.

Feedback in Electronic Systems: open loop and closed loop systems, Negative and positive Feedback, merits and demerits, Principles of LC and RC oscillators.

Integrated Circuits: Operational amplifiers – characteristics and linear applications

Digital Circuits: Number systems and logic gates, Combinational Logic circuits, Flip-Flops, counters and shift registers, data converters, Analog to Digital and Digital to Analog converters (ADC/DAC's), Introduction to microprocessors and microcontrollers.

Laboratory measuring instruments: principles of digital multi-meters, Cathode ray oscilloscopes (CRO's).

Electronics Instrumentation: Measurement, Sensors, principles of LVDT, strain gauge and thermocouples. Introduction to data acquisition system.

Principles of Communication: Need for Modulation, Definitions of various Modulation and Demodulation techniques, AM radio transmitter and receiver, brief understanding of FM and mobile communications.

Reading:

1. Bhargava N. N., D C Kulshreshtha and S C Gupta, Basic Electronics & Linear Circuits, Tata McGraw Hill, 2nd Edition, 2013.
2. Malvino and Brown,Digital Computer electronics, McGraw Hill, 3rd Edition,1993.
3. Keneddy and Davis, Electronic Communication Systems, McGraw Hill, 4th Edition, 1999.
4. Helfrick and Cooper, Modern Electronic Instrumentation and Measurement Techniques, Prentice Hall India, 2011.
5. Salivahanan, N Suresh Kumar, Electronic Devices and circuits, McGraw Hill publications,3rdEdition, 2012.
6. Neil Storey, Electronics A Systems Approach, Pearson Education Publishing Company Pvt. Ltd, 4th Edition, 2009.

CE102	ENVIRONMENTAL SCIENCE AND ENGINEERING	ESC	2-0-0	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the students will be able to

CO1	Identify environmental problems arising due to engineering and technological activities and the science behind those problems.
CO2	Estimate the population - economic growth, energy requirement and demand.
CO3	Analyse material balance for different environmental systems.
CO4	Realize the importance of ecosystem and biodiversity for maintaining ecological balance.
CO5	Identify the major pollutants and abatement devices for environmental management and sustainable development

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	-	-	2	3	1	-	-	-	-	1	2	-
CO2	3	3	3	-	-	2	3	1	-	-	-	-	1	2	-
CO3	3	3	3	-	-	2	3	1	-	-	-	-	1	2	-
CO4	3	3	3	-	-	2	3	1	-	-	-	-	1	2	-
CO5	3	3	3	-	-	2	3	1	-	-	-	-	1	2	-

Detailed Syllabus:

Introduction to Environmental Science: Environment and society, major environmental issues: Ozone layer depletion, Acid rains, global climate change etc., sustainable development, Environmental impact assessment, environmental management

Natural Resources Utilization and its Impacts: Energy, minerals, water and land resources, Resource consumption, population dynamics, urbanization.

Ecology and Biodiversity: Energy flow in ecosystem, food chain, nutrient cycles, eutrofication, value of biodiversity, biodiversity at global, national and local levels, threats for biodiversity, conservation of biodiversity

Water Pollution: Sources, types of pollutants and their effects, water quality issues, contaminant transport, self-purification capacity of streams and water bodies, water quality standards, principles of water and wastewater treatment.

Air Pollution: Sources, classification and their effects, Air quality standards, dispersion of pollutants, control of air pollution, automobile pollution and its control.

Solid Waste Management: Sources and characteristics of solid waste, effects, Collection and transfer system, disposal methods

Reading:

1. G.B. Masters, Introduction to Environmental Engineering and Science, Pearson Education, 2013.
2. Gerard Kiely, Environmental Engineering, McGraw Hill Education Pvt. Ltd., Special Indian Edition, 2007.
3. W P Cunningham, M A Cunningham, Principles of Environmental Science, Inquiry and Applications, Tata McGraw Hill, 8th Edition, 2016.
4. M. Chandrasekhar, Environmental science, Hi Tech Publishers, 2009.

BT101	ENGINEERING BIOLOGY	ESC	2 – 0 – 0	2 Credits

Pre-requisites: None.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Realize the significance of biomolecules for sustaining life
CO2	Identify the difference between unicellular to multi-cellular organisms
CO3	Understand heredity, variation and central dogma of life
CO4	Analyse and understand the concepts of biology for engineering the cell

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-
CO2	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-
CO3	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-
CO4	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-

Detailed Syllabus:

Molecules of life, water and carbon - chemical basis of life, protein structure and function, nucleic acids and the RNA world, carbohydrates, lipids, membranes and first cells.

Cell structure and function, inside the cell, cell–cell Interactions, cellular respiration and fermentation, photosynthesis, cell cycle, biological signal transduction.

Gene structure and expression, Mitosis, Meiosis, Mendel and the gene, DNA and the gene: synthesis and repair, how genes work, transcription, RNA processing, and translation, control of gene expression, analysing and engineering genes, genomics.

Engineering concepts in biology – genetic engineering, disease biology and biopharmaceuticals, stem cell engineering, metabolic engineering, synthetic biology, neuro transmission, biosafety and bioethics.

Reading:

1. Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Biological Science, Pearson Education India, 2016.
2. Reinhard Renneberg, Viola Berkling and Vanya Loroch, Biotechnology for Beginners, Academic Press, 2017.

CS101	PROBLEM SOLVING AND COMPUTER PROGRAMMING	ESC	3 – 1 – 2	5 Credits

Pre-requisites: None.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Design algorithms for solving simple mathematical problems including computing, searching and sorting
CO2	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems
CO3	Explore the internals of computing systems to suitably develop efficient algorithms
CO4	Examine the suitability of data types and structures to solve specific problems
CO5	Apply control structures to develop modular programs to solve mathematical problems
CO6	Apply object oriented features in developing programs to solve real world problems

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	-	-	-	-	-	-	-	-	-	2
CO2	3	2	3	2	3	-	-	-	-	-	-	-	-	-	2
CO3	3	2	3	2	3	-	-	-	-	-	-	-	-	-	2
CO4	3	2	3	2	3	-	-	-	-	-	-	-	-	-	2
CO5	3	2	3	2	3	-	-	-	-	-	-	-	-	-	2
CO6	3	2	3	2	3	-	-	-	-	-	-	-	-	-	2

Detailed Syllabus:

Theory:

Fundamentals of Computers, Historical perspective, Early computers, Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

Problem solving techniques – Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms.

Number systems and data representation, Basics of C++, Basic data types.

Numbers, Digit separation, Reverse order, Writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs, Conditional statements - If-else, Switch-case constructs, Loops - while, do-while, for.

Functions –Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion, Introduction to pointers.

Sorting and searching algorithms, large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions

Magic square and matrix operations using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays

String processing, File operations.

Structures and Classes - Declaration, member variables, member functions, access modifiers, function overloading, Problems on Complex numbers, Date, Time, Large Numbers.

Laboratory:

1. Programs on conditional control constructs.
2. Programs on loops (while, do-while, for).
3. Programs using user defined functions and library functions.
4. Programs on arrays, matrices (single and multi-dimensional arrays).
5. Programs using pointers (int pointers, char pointers).
6. Programs on structures.
7. Programs on classes and objects.

Reading:

1. Walter Savitch, Problem Solving with C++, Pearson, 9th Edition, 2014.
2. Cay Horstmann, Timothy Budd, Big C++, Wiley, 2nd Edition, 2009.
3. R.G. Dromey, How to solve it by Computer, Pearson, 2008.

PH102	PHYSICS LABORATORY	BSC	0 – 1 – 2	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Use CRO, signal generator, spectrometer, polarimeter and GM counter for making measurements
CO2	Test optical components using principles of interference and diffraction of light
CO3	Determine the selectivity parameters in electrical circuits
CO4	Determine the width of narrow slits, spacing between close rulings using lasers and appreciate the accuracy in measurements

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	-	3	-	-	-	-	3	2	-	-	-	1	-
CO2	3	2	-	3	-	-	-	-	3	2	-	-	-	1	-
CO3	3	2	-	3	-	-	-	-	3	2	-	-	-	1	-
CO4	3	2	-	3	-	-	-	-	3	2	-	-	-	1	-

Detailed Syllabus:

1. Determination of Wavelength of Sodium light using Newton's Rings.
2. Determination of Wavelength of He-Ne laser – Metal Scale.
3. Measurement of Width of a narrow slit using He- Ne Laser.
4. Determination of Specific rotation of Cane sugar by Laurent Half-shade Polarimeter.
5. Determination of capacitance by using R-C circuit.
6. Determination of resonating frequency and bandwidth by LCR circuit.
7. Measurement of half-life of radioactive source using GM Counter.
8. Diffraction grating by normal incidence method.

Reading:

1. Physics Laboratory Manual.

MA 151	MATHEMATICS - II	BSC	3-0-0	3 Credits

Pre-requisites: MA101-Mathematics-I

Course Outcomes: At the end of the course, the students will be able to

CO 1	analyze improper integrals
CO 2	evaluate multiple integrals in various coordinate systems
CO 3	apply the concepts of gradient, divergence and curl to formulate engineering problems
CO 4	convert line integrals into surface integrals and surface integrals into volume integrals
CO 5	apply Laplace transforms to solve physical problems arising in engineering

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO2	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO3	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO4	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO5	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2

Detailed Syllabus

Integral Calculus: Convergence of improper integrals; Beta and Gamma integrals; Differentiation under integral sign; Double and Triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals.

Vector Calculus: Scalar and vector fields; vector differentiation; level surfaces; directional derivative; gradient of a scalar field; divergence and curl of a vector field; Laplacian; Line and Surface integrals; Green's theorem in a plane; Stoke's theorem; Gauss Divergence theorem.

Laplace Transforms: Laplace transforms; inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function; Convolution theorem; Applications of Laplace transforms - solving certain initial value problems, solving system of linear differential equations, finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses etc.

Reading:

1. R. K. Jain and S. R. K. Iyengar, *Advanced Engineering Mathematics*, Narosa Publishing House, 5th Edition, 2016.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2015.
3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015.

ME102	ENGINEERING GRAPHICS	ESC	1 - 1 - 4	4 Credits

Pre-requisites: None.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Recall BIS standards and conventions while drawing Lines, printing Letters and showing Dimensions.
CO2	Classify the systems of projection with respect to the observer, object and the reference planes.
CO3	Construct orthographic views of an object when its position with respect to the reference planes is defined.
CO4	Analyse the internal details of an object through sectional views.
CO5	Relate 2D orthographic views to develop 3D Isometric View.
CO6	Construct 2D (orthographic) and 3D (isometric) views in CAD environment.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	2	-	1	-	-	-	1	2	-	-	-	-	-
CO2	2	2	2	-	1	-	-	-	1	2	-	-	-	-	-
CO3	2	2	2	-	1	-	-	-	1	2	-	-	-	-	-
CO4	2	2	2	-	1	-	-	-	1	2	-	-	-	-	-
CO5	2	2	2	-	1	-	-	-	1	2	-	-	-	-	-
CO6	2	2	2	-	1	-	-	-	1	2	-	-	-	-	-

Detailed Syllabus:

Introduction: Overview of the course, Lines Lettering and Dimensioning: Types of lines, Lettering, Dimensioning, Geometrical Constructions, Polygons, Scales

Orthographic Projection: Principles of Orthographic projection, Four Systems of Orthographic Projection.

Projection of Points: Projections of points when they are situated in different quadrants.

Projections of Lines: Projections of a line parallel to one of the reference planes and inclined to the other, line inclined to both the reference planes, Traces.

Projections of Planes: Projections of a plane perpendicular to one of the reference planes and inclined to the other, Oblique planes.

Projections of Solids: Projections of solids whose axis is parallel to one of the reference planes and inclined to the other, axis inclined to both the planes.

Section of Solids: Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section.

Isometric Views: Isometric axis, Isometric Planes, Isometric View, Isometric projection, Isometric views – simple objects.

Auto-CAD Practice: Introduction to Auto-CAD, DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES

Reading:

1. N.D. Bhat and V.M. Panchal, Engineering Graphics, Charotar Publishers, 2013.
2. Sham Tickoo, AutoCAD 2017 for Engineers & Designers, Dreamtech Press, 23rd Edition, 2016.

CY101	CHEMISTRY	BSC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the students will be able to

CO1	The basic knowledge of the organic reaction mechanism and intermediates.
CO2	The basic knowledge of methods of chemical structure analysis and the instrumentation involved.
CO3	The potential energy aspects of fuel cells, rechargeable batteries and new materials for their fabrication.
CO4	About optical fibres, liquid crystals, LCD, LED, OLED, conducting polymers and their applications.
CO5	The quantum and thermodynamic aspects of various types of bonding, coordination complexes and chemical and enzymatic reactions.
CO6	The synthetic methodologies, importance and applications of nanomaterials in different fields.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	-	2	-	2	-	2	-	-	-	-	1	-
CO2	3	3	3	-	2	-	2	-	2	-	-	-	-	1	-
CO3	3	3	3	-	2	-	2	-	2	-	-	-	-	1	-
CO4	3	3	3	-	2	-	2	-	2	-	-	-	-	1	-
CO5	3	3	3	-	2	-	2	-	2	-	-	-	-	1	-
CO6	3	3	3	-	2	-	2	-	2	-	-	-	-	1	-

Detailed syllabus

Quantum Chemistry and Chemical Bonding: Emergence of Quantum Theory; Postulates of Quantum Mechanics, Operators and Observables, Schrodinger Equation, Particle in a One-Dimensional Box and Colour of Conjugate Molecules, Hetero-diatomic Molecule as Harmonic Oscillator and Rigid Rotor, Hydrogen Atom, LCAO-MO Theory (MO Diagram of CO and NO Molecules).

Chemical Thermodynamics, Equilibrium and Kinetics: Enthalpy and Free Energy Changes in Chemical Reactions; Relevance of C_p and C_v in Gas Phase Reactions, Chemical Potential; Heat Capacity of Solids, Absolute Entropy and Third Law of Thermodynamics, Rates of Enzyme-Catalysed Homogeneous and Heterogeneous Surface-Catalysed Chemical Reactions

Electrochemistry and Chemistry of Energy Systems: Electrodes and Electrochemical Cells; Potentiometric and Amperometric Sensors; Li-Ion and Ni-Cd Rechargeable Batteries; Fuel Cells (Methanol-Oxygen); Electrochemical Theory of Corrosion; Factors Affecting Rate of Corrosion; Sacrificial Anodic and Impressed Current Cathodic Protection of corrosion.

Coordination Chemistry and Organometallics: Shapes of Inorganic Compounds; Crystal Field and Molecular Orbital Theories; MO-Diagram for an Octahedral Complex; Metal Ions in Biology; Organometallic Chemistry (Metal Carbonyls).

Basics of Organic Chemistry: Classification of Organic reaction and their mechanisms. Reaction intermediates: formation, structure and properties. Named Reactions: Skraup's synthesis, Diels-Alder reaction, Click Reactions.

Engineering Materials and Application: Introduction to Optical fibres, types of optical fibres, applications of optical fibres. Liquid Crystals: LCD, LED, OLED, Conducting Polymers and applications.

Instrumental Methods of Chemical Analysis: Gas- and Liquid-Chromatographic Separation of Components of Mixtures; UV-Visible, FTIR, NMR and Mass Spectral Methods of Analysis of Structures of Organic Compounds.

Reading:

1. P. Atkins and Julio de Paula, Physical Chemistry, Freeman & Co. 8^{th} Edition, 2017.
2. Atkins and Shriver, Inorganic Chemistry, Oxford University Press, 4^{th} Edition, 2008.
3. Clayden, Greaves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2014.
4. Shashi Chawla, Engineering Chemistry, Dhanpat Rai & Co. 2017.
5. Paula Bruce, Organic Chemistry, Pearson, 8^{th} Edition, 2013.

EE101	BASIC ELECTRICAL ENGINEERING	ESC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the students will be able to

CO1	Analyze and solve electric and magnetic circuits
CO2	Identify the type of electrical machines for a given application
CO3	Recognize the ratings of different electrical apparatus
CO4	Identify meters for measuring electrical quantities and requirements of illumination

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	-	-	-	1	-	-	-	-	-	-	-	-
CO2	3	3	2	-	-	-	1	-	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	1	-	-	-	-	-	-	-	-
CO4	3	3	2	-	-	-	1	-	-	-	-	-	-	-	-

Detailed Syllabus:

DC Circuits: Kirchoff's Voltage and Current Laws, Superposition Theorem, Star-Delta Transformations

AC Circuits: Complex representation of Impedance, Phasor diagrams, Power & Power Factor, Solution of 1-ϕ Series & Parallel Circuits, Solution of 3-ϕ circuits and Measurement of Power in 3-ϕ circuits

Magnetic Circuits: Fundamentals and solution of Magnetic Circuits, Concepts of Self and Mutual Inductances, Coefficient of Coupling

Single Phase Transformers: Principle of Operation of a Single Phase Transformer, EMF Equation, Phasor Diagram, Equivalent Circuit of a 1-ϕ Transformer, Determination of Equivalent circuit parameters, calculation of Regulation & Efficiency of a Transformer

DC Machines: Principle of Operation, Classification, EMF and Torque Equations, Characteristics of Generators and Motors, Speed Control Methods and Applications

Three Phase Induction Motor: Principle of Rotating Magnetic Field, Principle of Operation of 3-ϕ Induction Motor, Torque – Speed Characteristics of 3-ϕ Induction Motor, Applications

Measuring Instruments: Moving Coil and Moving Iron Ammeters and Voltmeters
Illumination: Laws of illumination and luminance.

Reading:

1. Edward Hughes, Electrical & Electronic Technology, Pearson, 12th Edition, 2016.
2. Vincent Del Toro, Electrical Engineering Fundamentals, Pearson, 2nd Edition, 2015.
3. V N Mittle and Arvind Mittal, Basic Electrical Engineering, Tata McGraw Hill, 2nd Edition, 2005.
4. E. Openshaw Taylor, Utilization of Electrical Energy, Orient Longman, 2010.

ME101	BASIC MECHANICAL ENGINEERING	ESC	3 - 0 - 0	3 Credits

Pre-requisites: None.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify Materials for Engineering Applications
CO2	Describe the functions and operations of Conventional, NC, CNC and 3D Printing methods of manufacturing.
CO3	Select a power transmission system for a given application.
CO4	Understand the concepts of thermodynamics and functions of components of a power plant.
CO5	Understand basics of heat transfer, refrigeration, internal combustion engines and Automobile Engineering.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	1	-	1	1	-	-	-	-	-	-	2	-
CO2	3	3	3	1	3	1	1	-	-	-	-	-	-	2	-
CO3	3	3	3	1	-	1	1	-	-	-	-	-	-	2	-
CO4	3	3	3	1	-	1	1	-	-	-	-	-	-	2	-
CO5	3	3	3	1	-	1	1	-	-	-	-	-	-	2	-

Detailed Syllabus:

Engineering Materials: Introduction to Engineering Materials, Classification and Properties

Manufacturing Processes: Castings – Patterns & Moulding, Hot Working and Cold Working, Metal Forming processes: Extrusion, Drawing, Rolling, Forging, Welding – Arc Welding & Gas Welding, Soldering, Brazing.

Machine Tools: Lathe – Types – Operations, Problems on Machining Time Calculations, Drilling M/c – Types – Operations, Milling M/c – Types – Operations – Up & Down Milling, Shaping M/c –Operations–Quick Return Mechanism, Planer M/c.– Operations–Shaper Vs Planer, Grinding M/c–Operations. Introduction to NC/CNC Machines, 3D Printing

Power Transmission: Transmission of Power, Belt Drives, Gears and Gear Trains –Simple Problems

Fasteners and Bearings: Fasteners – Types and Applications, Bearings – Types and Selection, Thermodynamics: Energy Sources – Conventional/Renewable, Thermodynamics – System, State, Properties, Thermodynamic Equilibrium, Process & Cycle, Zeroth law of Thermodynamics, Work & Heat, First law – Cyclic process, Change of State, C_p, C_v, Limitations of First law, Thermal Reservoirs, Heat Engine, Heat Pump/Refrigerator, Efficiency/CoP, Second law, PMM2, Carnot Cycle, Entropy – T-s and P-v diagrams.

Thermal Power Plant: Layout of Thermal Power Plant & Four circuits – Rankine cycle, T-s & P-v diagrams, Boilers – Babcock & Wilcox, Cochran Boilers, Comparison of Fire Tube &Water Tube Boilers, Steam Turbines – Impulse Vs. Reaction, Compounding – Pressure & Velocity Compounding, Condensers – Jet Condenser and Surface Condenser; Cooling Towers.

I.C. Engines: 2-Stroke & 4-Stroke Engines, P-v Diagram; S.I. Engine, C.I. Engine, Differences

Refrigeration: Vapor Compression Refrigeration Cycle – Refrigerants, Desirable Properties of Refrigerants

Heat Transfer: Modes of Heat Transfer, Thermal Resistance Concept, Composite Walls & Cylinders, and Overall Heat Transfer Coefficient – problems

Automobile Engineering: Layout of an Automobile, Transmission, Clutch, Differential, Internal Expanding Shoe Brake

Reading:

1. M.L. Mathur, F.S. Mehta and R.P. Tiwari, R.S. Vaishwnar, Elements of Mechanical Engineering, Jain Brothers, New Delhi, 2008.
2. Praveen Kumar, Basic Mechanical Engineering, Pearson Education, India, 2013.
3. P.N. Gupta, M.P. Poonia, Elements of Mechanical Engineering, Standard Publishers, 2004.
4. C.P. Gupta, Rajendra Prakash, Engineering Heat Transfer, NemChand Brothers, New Delhi, 1994.
5. B.S. Raghuvanshi, Workshop Technology, Vol. 1&2, Dhanpath Rai & Sons, New Delhi, 1989.

CE101	ENGINEERING MECHANICS	ESC	3 – 0 – 0	3 Credits

Pre-requisites: None.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Determine the resultant force and moment for a given system of forces
CO2	Analyze planar and spatial systems to determine the forces in members of trusses, frames and problems related to friction
CO3	Calculate the motion characteristics of a body subjected to a given force system
CO4	Determine the deformation of a shaft and understand the relationship between different material constants
CO5	Determine the centroid and second moment of area

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	-	-	1	-	-	-	-	-	-	-	1	-
CO2	3	3	2	-	-	1	-	-	-	-	-	-	-	1	-
CO3	3	3	2	-	-	1	-	-	-	-	-	-	-	1	-
CO4	3	3	2	-	-	1	-	-	-	-	-	-	-	1	-
CO5	3	3	2	-	-	1	-	-	-	-	-	-	-	1	-

Detailed syllabus:

Introduction - Specification of force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space, Degrees of freedom - Equilibrium Equations, Kinematics – Kinetics – De' Alemberts principle, Degree of Constraints – Freebody diagrams.

Spatial Force systems - Concurrent force systems - Equilibrium equations – Problems, Problems (Vector approach) – Tension Coefficient method, Problems (Tension Coefficient method), Parallel force systems - problems, Center of Parallel force system – Problems.

Coplanar Force Systems - Introduction – Equilibrium equations – All systems, Problems on Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Method of joints, Method of sections, Method of sections, Method of members, Friction – Coulombs laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

Mechanics of Deformable Bodies - Stress & Strain at a point- Normal and shear stresses, Axial deformations – Problems on prismatic shaft, tapered shaft and deformation due to self-weight, Deformation of Stepped shaft due to axial loading, Poisson's Ratio – Bulk Modulus - Problems, change in dimensions and volume.

Centroid & Moment of Inertia - Centroid and M.I – Arial – Radius of Gyration, Parallel axis– Perpendicular axis theorem – Simple Problems.

Dynamics of Particles - Rectilinear Motion – Kinematics Problems, Kinetics – Problems, Work & Energy – Impulse Moment, Curvilinear Motion – Normal and tangential components.

Reading:

1. J.L. Meriam, L.G. Kraige, Engineering Mechanics, John Wiley &Sons, 7th Edition, 2012.
2. Timoshenko, Young, Engineering Mechanics, McGraw Hill Publishers, 3rd Edition, 2006.
3. Gere, Timoshenko, Mechanics of Materials, CBS Publishers, 2nd Edition, 2011.

ME103	WORKSHOP PRACTICE	ESC	0 - 0 – 3	2 Credits

Pre-requisites: None.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Study and practice on machine tools and their operations
CO2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
CO3	Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
CO4	Apply basic electrical engineering knowledge for house wiring practice

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	-	-	1	-	-	2	2	-	-	-	2	-
CO2	3	3	1	-	-	1	-	-	2	2	-	-	-	2	-
CO3	3	3	1	-	-	1	-	-	2	2	-	-	-	2	-
CO4	3	3	1	-	-	1	-	-	2	2	-	-	-	2	-

Detailed Syllabus:

Fitting Trade: Preparation of T-Shape Work piece as per the given specifications, Preparation of U-Shape Work piece which contains: Filing, Sawing, Drilling, Grinding, and Practice marking operations.

Plumbing: Practice of Internal threading, external threading, pipe bending, and pipe fitting, Pipes with coupling for same diameter and with reducer for different diameters and Practice of T-fitting, Y-fitting, Gate valves fitting.

Machine shop: Study of machine tools in particular Lathe machine (different parts, different operations, study of cutting tools), Demonstration of different operations on Lathe machine, Practice of Facing, Plane Turning, step turning, taper turning, knurling and parting and Study of Quick return mechanism of Shaper. Demonstration of the working of CNC and 3D Printing Machines.

Power Tools: Study of different hand operated power tools, uses and their demonstration and Practice of all available Bosch Power tools.

Carpentry: Study of Carpentry Tools, Equipment and different joints, Practice of Cross Half lap joint, Half lap Dovetail joint and Mortise Tenon Joint.

CY102	CHEMISTRY LABORATORY	BSC	0- 1 - 2	2 Credits

Pre-requisites: None.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Select a suitable methodology and compare the strategies involved in the estimation of metal content, iodine content, active chlorine or hardness of water for various applications.
CO2	Apply a selective instrumental method in the place of tedious and complex titration processes for repeated and regulated analysis of acids, bases, redox compounds, etc.
CO3	Test and validate optical activity, corrosion inhibitor efficiency and absorption isotherm of selective compounds and processes.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	-	2	-	2	-	2	-	-	-	-	1	-
CO2	3	3	3	-	2	-	2	-	2	-	-	-	-	1	-
CO3	3	3	3	-	2	-	2	-	2	-	-	-	-	1	-

Detailed Syllabus:

Cycle-I

1. Standardization $KMnO_4$ solution: Understanding the redox process, electron transfer, importance of qualitative and quantitative analysis.
2. Estimation of Hematite: Understanding the importance on purity of a ore, % of metal content (for Fe).
3. Hardness of Water: Understanding the of metal complexes, multi dentate ligands, importance of purity of ground water, (EDTA method; complexometry).
4. Analysis of bleaching powder for available chlorine: Understanding the importance and purity of potable water, back titration (Iodometry).
5. Preparation of nanomaterials: Understanding the importance of nanomaterials, their preparation and characterization.

Cycle II

1. pH metry: Concept of pH, Instrumentation, calibration, determination of the concentrations by instrumental methods
2. Conductometry: Concept of conductivity, importance of conductivity

3. Potentiometry: Determination of the redox potential of the reaction
4. Colorimetry: Importance of Beers and Lamberts law,
5. Photochemical experiment: Importance of visible light and its application for a redox process, importance of coloring agent
6. Preparation of bakelite / polypyrrole: Concepts of organic reactions and application for the organic material preparation.
7. Corrosion experiment: Concept of corrosion, importance of corrosion agents
8. Adsorption experiment: Understanding phenomena of adsorption and absorption
9. Analysis of a drug: Importance of the purity, concentrations of a drug molecule.
10. Preparation of bakelite / red azo dye / Aspirin / Fe(acac) / polypyrrole: Concepts of organic reactions and application for the organic material preparation

Reading:

1. Charles Corwin, Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Pearson Education, 2012.
2. David Collins, Investigating Chemistry: Laboratory Manual, Freeman & Co., 2006.

MA201	MATHEMATICS– III	BSC	3 - 0 - 0	3 Credits

Pre-requisites: MA151 - Mathematics - II

Course Outcomes: At the end of the course, student will be able to:

CO1	Obtain the Fourier series for a given function
CO2	Find the Fourier transform of a function and Z- transform of a sequence
CO3	Determine the solution of a PDE by variable separable method
CO4	Understand and use of complex variables and evaluation of real integrals

Mapping of course outcomes with program outcomes

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO2	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO3	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO4	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2

Detailed Syllabus

Fourier Series: Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions

Fourier Transforms: Fourier transformation and inverse transforms - sine, cosine transformations and inverse transforms - simple illustrations.

Z-transforms: Z- transform and Inverse Z-transforms – Properties – convolution theorem- simple illustrations.

Partial Differential Equations: Method of separation of variables - Solution of one dimensional wave equation, one dimensional heat conduction equation and two dimensional steady state heat conduction equation with illustrations.

Complex Variables: Analytic function - Cauchy Riemann equations - Harmonic functions - Conjugate functions - complex integration - line integrals in complex plane - Cauchy's theorem (simple proof only), Cauchy's integral formula - Taylor's and Laurent's series expansions - zeros and singularities - Residues - residue theorem, use of residue theorem to evaluate the real integrals of the type $\int_0^{2\pi} f(Cos\theta, Sin\theta)\, d\theta$, $\int_{-\infty}^{\infty} f(x)dx$ without poles on the real axis.

Reading:

1. R.K. Jain and S.R.K. Iyengar, *Advanced Engineering Mathematics,* Narosa Publishing House Pvt. Ltd., 5th Edition, 2016.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2008.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Edition, 2017.

CY201	INDUSTRIAL ORGANIC CHEMISTRY	BSC	3 – 0 – 0	3 Credits

Pre-requisites: CY101-Chemistry

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the reactivity of the intermediates, hydrocarbon chemistry, and importance of functional group transformations.
CO2	Differentiate the structure and properties of biomolecules, polymers and heterocyclic compounds
CO3	Identify the role of chemical engineer in modern drug discovery programs
CO4	Separate the racemic mixtures using resolution methods.
CO5	Elucidate the structure of organic compounds (small molecules) using spectroscopic methods.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	1	1	1	1	1	-	2	3	2	1
CO2	3	3	2	1	2	1	1	1	1	1	-	2	3	2	1
CO3	1	2	1	2	2	3	3	2	1	1	1	2	2	1	1
CO4	2	2	2	1	3	1	1	1	1	1	-	2	3	2	1
CO5	2	2	2	1	3	1	1	1	1	1	-	2	3	2	1

Detailed syllabus

Reactivity of organic compounds: Generation and reactions of: Carbonium ion, carbanion, carbenes, nitrenes and benzyne, Reactions and properties of: Hydrocarbons (Alkane, alkene and alkyne, Alkyl halides, alcohols, ethers, carbonyl compounds, carboxylic acids, nitro compounds and nitriles), Functional group transformations

Chemistry of heterocyclic compounds and drug molecules: Preparation and properties of furan, pyrrole and thiophene, pyridine

Chemistry of biomolecules: Structure and properties of Carbohydrates, Amino acids, Proteins, peptides, purification of proteins, nucleic acids

Application of stereochemistry in pharmaceutical industry: Introduction to stereochemistry, isomerism, D, L and R, S-nomenclature

Conformational analysis of cyclohexane and its derivatives, Racemization, Resolution techniques

Introduction to modern drug discovery: Synthesis of drugs (a) Antipyretics-Paracetamol, (b) Anti-inflammatory drugs-Ibuprofen, (c) Antibiotics-Penicillin, (d) Antimalarial drugs-Quinine, (e) Anticancer drugs and (f) Antihypertensive drugs

Polymer chemistry: Basics of polymerization techniques, Properties and Characterization of polymers

Analysis of organic compounds:

Chromatographic techniques: Column Chromatography, Thin-layer chromatography, Gas chromatography, Liquid Chromatography.

Spectroscopic techniques: Application of UV-Vis, Infra-Red, Nuclear Magnetic Resonance spectroscopic and Mass spectrometric methods for the structural elucidation small molecules

Recent techniques in organic synthesis: Use of alternative reaction media (use of water, ionic liquids), Alternative energy sources (microwave, sonication) for organic reactions, Homogeneous and heterogeneous catalysis, Combinatorial chemistry.

Reading:

1. Francis A. Carey, Organic Chemistry, Tata McGraw Hill Publishing Company Limited, 5th Edition, 2007.
2. Donald L. Pavia, Gary M Lanyman, Introduction to spectroscopy, Thompson publishers, 3rd Edition, 2008.
3. E. Eliel, Stereochemistry of carbon compounds, John Wiley & Sons, Inc., 2009.
4. P. S. Kalsi, Spectroscopy of Organic Compounds, New Age International, 6th Edition, 2006.
5. John W Nicholson, Chemistry of Polymers, Royal Society of Chemistry, 3rd Edition, 2006.
6. Mike Lancaster, Green Chemistry, Royal Society of Chemistry, 2002.

CH201	CHEMICAL PROCESS CALCULATIONS	PCC	3 – 1 – 0	4 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Convert physico-chemical quantities from one system of units to another
CO2	Identify basis and degrees of freedom
CO3	Perform material and energy balances on single units without and with chemical reactions.
CO4	Solve the material and energy balance problems on multi-unit processes with recycle, purge and bypass.
CO5	Analyze the ideal and real behavior of gases, vapors and liquids.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	3	3	2	-	-	-	2	2	1	1	3	3	2
CO2	3	2	3	3	2	-	-	-	2	2	1	1	3	3	2
CO3	3	2	3	3	3	-	-	-	2	2	1	1	3	3	2
CO4	3	2	3	`3	3	-	-	-	2	2	1	1	3	3	2
CO5	3	2	3	3	3	-	-	-	2	2	1	1	3	3	2

Detailed syllabus

Introduction to process calculations: Units and Dimensions - Conversion of Units; Process and process variables – process flow sheet, process unit, process streams, density, specific gravity, specific gravity scales, mass and volumetric flow rates, mole concept, molecular and equivalent weights; Composition of streams; other expressions for concentration; Basic Material Balance Principles.

Material balances on Non-Reactive Systems: Degrees of freedom analysis; Material balance on single unit process– Evaporation, Crystallization, Absorption, Distillation, Drying, Extraction, etc.; Material balance on Multiunit process –Bypass, Recycle, Purge, Makeup;

Material balances on Reactive systems: Stoichiometry basics- excess and limiting reactants conversion, yield; extent of reaction method for a single reaction, element or atomic balance method; molecular or component balance approach; Multiple reactions; Combustion reactions –

Orsat analysis, proximate and ultimate analysis of coal, theoretical and excess air; Multiple unit systems involving reaction, Recycle and Purge.

Single- and Multi-phase systems: Single phase systems; ideal gas equation of state; mixture of ideal gases-Dalton's and Amagat's laws; Properties of real gases – real gases, critical properties, equations of state, compressibility factor, compressibility charts; mixture of real gases; Multiphase systems – phase diagram; vapor-liquid equilibrium curve; Vapor pressure estimation; Ideal solutions and Raoult's law – VLE calculations; Partial saturation & Humidity; Humidity chart.

Energy Balances: Thermophysics -Heat Capacity, Calculation of enthalpy changes without and with phase change, Heat of solution and mixing;Energy balances without chemical reactions;

Thermochemistry - Energy balances with chemical reactions - Standard heat of reaction, formation and combustion, Hess Law, Effect of temperature; Simultaneous material and energy balances - Adiabatic flame temperature.

Reading:

1. Nayef Ghasem, Redhouane Henda, Principles of Chemical Engineering Processes: Material and Energy Balances, 2nd Edition, CRC Press, 2015.
2. Narayanan K.V., Lakshmikutty B., Stoichiometry and Process Calculations, PHI Learning Pvt. Ltd., 7th Edition, 2015.
3. Himmelblau D.H., James B. Riggs, Basic Principles and Calculations in Chemical Engineering, 8th Edition, Prentice Hall, 2012.
4. Hougen O.A., Watson K.M., Ragatz R.A., Chemical Process Principles (Part-I): Material and Energy Balances, 2nd Edition, CBS Publishers, 2004.
5. Bhatt B.I., Thakore S.M., Stoichiometry, 5th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2010.
6. Richard M. Felder, Ronald W. Rousseau, Elementary Principles of Chemical Processes, 3rd Edition, Wiley, 2004.

CH202	FLUID AND PARTICLE MECHANICS	PCC	3 – 1 – 0	4 Credits

Pre-requisites: MA151-Mathematics-II, CE101-Engineering Mechanics.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Derive dimensionless groups by using dimensional analysis.
CO2	Solve problems related to manometers and decanters using the principles of fluid statics.
CO3	Determine the pipe size / flow rate / power requirements under laminar and turbulent flow conditions.
CO4	Solve problems involving motion of particles in fluid, fluid–solid operations in packed beds and fluidized beds.
CO5	Select machinery and measuring devices for fluid flow.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	1	1	-	-	-	-	-	-	-	-	3	0	3
CO2	3	2	2	2	-	-	-	-	-	-	-	-	3	1	0
CO3	3	1	3	3	1	2	-	-	-	-	-	-	3	1	2
CO4	3	3	3	3	1	2	-	-	-	-	-	-	3	1	2
CO5	2	3	2	3	1	-	-	-	-	-	-	-	3	1	0

Detailed syllabus

Unit Systems: Unit systems, Dimensional analysis.

Fluid Statics and Its Applications: Nature of Fluids, Hydrostatic Equilibrium, Applications of Fluid Statics.

Fluid Flow Phenomena: Laminar flow, Shear rate, Shear stress, Rheological properties of fluids, Turbulence, Boundary layers.

Basic Equations of Fluid Flow: Mass balance in a flowing fluid; Continuity, differential momentum balance; equations of motion, Macroscopic momentum balances, Mechanical energy equations.

Incompressible Flow in Pipes and Channels: shear stress and skin friction in pipes, laminar flow in pipes and channels, turbulent flow in pipes and channels, friction from changes in velocity or direction.

Flow of Compressible Fluids: Definitions and basic equations.

Flow Past Immersed Bodies: Friction in flow through beds of solids, Motion of particles through fluids, Fluidization.

Transportation and Metering of Fluids: Pipes, fittings and valves.Pumps - positive displacement pumps and centrifugal pumps, fans, blowers, and compressors, Measurement of flowing fluids - full bore meters, insertion meters.

Introduction to Microfluidics and CFD.

Reading:

1. McCabe W. L., Jullian Smith C. and Peter Harriott - Unit operations of Chemical Engineering, McGraw-Hill international edition, 7th Edition, 2005.
2. Coulson J.M, Richardson. J.F, Chemical Engineering Volume I and II, Elsevier India, 5th Edition, 2006.
3. De Nevers N H- Fluid Mechanics for Chemical Engineers, McGraw Hill, NY, 3rd Edition, 2004.
4. Wilkes James O., Fluid Mechanics for Chemical Engineers, Prentice Hall, 3rd Edition, 2017.

CH203	MECHANICAL OPERATIONS	PCC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the role of mechanical unit operations in chemical industries.
CO2	Select suitable size reduction equipment based on performance and power requirement.
CO3	Analyze particle size distribution of solids
CO4	Evaluate solid-fluid separation equipment.
CO5	Determine the power required for agitation, blending and mixing

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	2	1	-	-	-	-	-	-	-	3	1	-
CO2	3	3	2	2	1	-	1	-	-	-	-	-	3	3	-
CO3	3	3	2	3	1	-	-	-	-	-	-	-	3	3	-
CO4	3	3	3	3	1	-	-	-	-	-	-	-	3	3	-
CO5	3	3	2	2	1	-	1	-	-	-	-	-	3	3	-

Detailed syllabus

Introduction: Unit operations and their role in chemical industries; Types of mechanical operations;

Properties and handling of particulate solids: Characterization of solid particles, Properties of masses of particles, Mixing of solids, Size reduction, Ultrafine grinders.

Screening: Screening equipment, Screen capacity.

Cake filters: Centrifugal filters, Filter media, Principles of cake filtration, Washing filter cakes.

Clarifying filters: Liquid clarification, Gas cleaning, Principles of clarification.

Cross flow filtration: Types of membranes, Permeate flux for ultrafiltration, Concentration polarization, Applications of ultrafiltration, Diafiltration, Microfiltration.

Sedimentation: Gravity sedimentation processes, Centrifugal sedimentation processes.

Agitation and mixing of liquids: Agitated vessels, Blending and mixing, Suspension of solid particles, Dispersion operations, Agitator selection and scaleup, Power Number, Mixing Index.

Reading:

1. McCabe W. L., Jullian Smith C. and Peter Harriott - Unit Operations of Chemical Engineering, 7thEdition, McGraw-Hill international Edition, 2005.
2. Coulson J.M., Richardson J.F, Chemical Engineering, Vol. II, 4th Edition, Elsevier India, 2006.
3. Alan S. Foust, Leonard A. Wenzel, Curtis W. Clump, Louis Maus, L. Bryce Andersen, Principles of Unit Operations, Wiley, 2nd Edition, 2008.
4. Walter L. Badger, Julius T. Banchero, Introduction to Chemical Engineering, Tata McGraw Hill Edition, 2001.
5. Christie John Geankoplis, Transport Processes and Separation Process Principles (Includes Unit Operations), Prentice Hall India Learning Private Limited, 4th Edition, 2004.

CH204	CHEMICAL ENGINEERING THERMODYNAMICS-I	PCC	3 – 0 – 0	3 Credits

Pre-requisites: ME101-Basic Mechanical Engineering

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply the first and second laws of thermodynamics to chemical processes.
CO2	Compute the properties of ideal and real gas mixtures.
CO3	Evaluate the efficiency of expansion and compression flow processes.
CO4	Estimate heat and work requirements for industrial processes.
CO5	Analyze refrigeration and liquefaction processes.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	-	-	-	-	-	-	-	-	-	1	3	3
CO2	2	3	2	2	1	-	-	-	-	-	-	-	2	2	3
CO3	2	2	3	3	2	-	-	-	-	-	-	-	2	1	1
CO4	2	2	2	3	2	-	-	-	-	-	-	-	3	1	2
CO5	2	2	3	2	1	-	-	-	-	-	-	-	3	2	2

Detailed syllabus

Introduction and First Law of Thermodynamics: First Law of Thermodynamics, Energy Balance for Closed Systems, Equilibrium, The Phase Rule, The Reversible Process, Enthalpy, Heat Capacity, Mass and Energy balances for Open Systems.

Volumetric Properties of Pure Fluids: General P-V-T Behaviour of Pure Substances, Virial Equations of State, The Ideal Gas, Application of the Virial Equations, Cubic Equations of State, Generalized Correlations for Gases, Generalized Correlations for Liquids.

The Second Law of Thermodynamics: Statements of the Second Law, Heat Engines, Thermodynamic Temperature Scales, Entropy, Entropy Changes of an Ideal Gas, Mathematical Statement of the Second Law, Entropy Balance for Open Systems, Calculation of Ideal Work, Lost Work, Exergy, The Third Law of Thermodynamics, Entropy from the Microscopic Viewpoint.

Thermodynamic Properties of Fluids: Thermodynamic Property Relations for Single Phase Systems, Residual Property Relations, Residual Property Calculation by Equations of State, Two-

Phase Systems, Thermodynamic Diagrams, Tables of Thermodynamic Properties, Generalized Property Correlations for Gases.

Applications of Thermodynamics to Flow Processes: Duct Flow of Compressible Fluids, Turbines (Expanders), Compression Processes.

Conversion of Heat into Work by Power Cycles: The Steam Power Plant, Internal-Combustion Engines, Jet Engines; Rocket Engines

Refrigeration and Liquefaction: Carnot Refrigerator, Vapor-Compression Cycle, Choice of Refrigerant, Absorption Refrigeration, Heat Pump, Liquefaction Processes.

Reading:

1. Smith J. M, H. C. Van Ness and M. M. Abbott, Introduction to Chemical Engineering Thermodynamics, McGraw-Hill, 7thEdition, 2004.
2. K. V. Narayanan, Chemical Engineering Thermodynamics, Prentice Hall of India Pvt. Ltd., 2009.
3. Michael Modell, Robert C. Reid, Thermodynamics and its Applications, Prentice-Hall International series in Physical and Chemical Engineering Sciences, 2nd Edition, 1983.
4. Milo D. Koretsky, Engineering and Chemical Thermodynamics, Wiley, 2009.

CH205	FLUID AND PARTICLE MECHANICS LABORATORY	PCC	0 – 1 – 2	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Determine viscosity of liquids using Cannon Fenske viscometer and terminal settling velocity.
CO2	Distinguish laminar and turbulent flows.
CO3	Determine the characteristics of flow meters
CO4	Determine the characteristics of packed & fluidized beds and centrifugal pumps.
CO5	Calculate pressure drop across pipe, valves and fittings.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	1	2	3	-	-	-	2	3	3	2	1	1	3	1
CO2	2	1	2	3	-	-	-	2	3	3	2	1	2	3	1
CO3	2	1	2	3	-	-	-	2	3	3	2	1	2	3	1
CO4	2	1	2	3	-	-	-	2	3	3	2	1	2	3	1
CO5	2	1	2	3	-	-	-	2	3	3	2	1	2	3	1

Detailed syllabus (List of Experiments)

1. Determination of viscosity using Cannon Fenske Viscometer.
2. Distinguish between laminar and turbulent flow using Reynolds Experiment.
3. Verification of Bernoulli’s theorem experimentally.
4. Friction in flow through pipes - Friction in pipe fittings and valves.
5. Determination of the viscosity of given solution using Terminal settling velocity data.
6. Study the characteristics of a packed bed with air flow.
7. Study the characteristics of a packed bed with water flow.
8. Study the characteristics of fluidized bed.
9. Determination of Orifice coefficient and Venturi coefficient.
10. Measurement of point velocity and determination of velocity profile using Pitot tube.
11. Determination of pressure drop in flow through non-circular pipes.
12. Study the characteristics of a centrifugal pump.

13. Determination of Efflux time.
14. Determination of pressure drop in flow through helical coil.
15. Demonstration of rheometer.

Reading:

1. Laboratory Manuals.
2. McCabe W. L., Jullian Smith C. and Peter Harriott - Unit operations of Chemical Engineering, 7thEdition, McGraw-Hill International Edition, 2005.
3. Coulson J.M and Richardson. J.F, Chemical Engineering Volume I and II, 5th Edition, Elsevier India, 2006.
4. De Nevers N H- Fluid Mechanics for Chemical Engineers,3rd Edition, McGraw Hill, NY, 2004.

CH206	CHEMICAL PROCESSING LABORATORY	PCC	0 – 1 – 2	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Select suitable methods for size reduction of minerals or other intermediates
CO2	Evaluate suitable mechanical separations of powders, solid-liquid and solid-gas mixtures
CO3	Synthesize products such as soap, formaldehyde and silica colloids
CO4	Determine the VLE of a binary system
CO5	Analyze fuel samples
CO6	Evaluate thermodynamic properties such as specific heat capacity of a liquid and heat of mixing of binary liquids

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	-	3	3	2	3	3	-	1	3	3	-
CO2	3	3	1	1	-	3	3	2	3	3	-	1	3	3	-
CO3	3	3	1	3	-	3	3	2	3	3	-	1	3	3	-
CO4	3	3	1	`3	-	3	3	2	3	3	-	1	3	3	-
CO5	3	3	1	2	-	3	3	2	3	3	-	1	3	3	-
CO6	3	3	1	2	-	3	3	2	3	3	-	1	3	3	-

Detailed syllabus

List of experiments:

1. Analysis of raw materials, intermediates and products such as: Water; Urea; Soda ash;
2. Testing of fuels: Orsat Analysis; Reid's vapor pressure; Smoke point; Aniline point; Photo-colorimeter; Abel's Flash point; Bomb calorimeter
3. Product synthesis: soap, formaldehyde resin, Silica Colloids.
4. Ball Mill
5. Jaw Crusher
6. Sigma Mixer
7. Vibrating Screens

8. Cyclone Separator
9. Filtration
10. Sedimentation
11. Vapor Liquid Equilibrium
12. Bomb Calorimeter
13. Flash& Fire point of fuel samples

Reading: Lab manuals

MA251	MATHEMATICS IV	BSC	3– 0 – 0	3 Credits

Pre-requisites:MA201- Mathematics-III

Course Outcomes: At the end of the course, student will be able to:

CO1	Interpret an experimental data using interpolation / curve fitting
CO2	Solve numerically algebraic/transcendental and ordinary differential equations
CO3	Understand the concepts of probability and statistics
CO4	Obtain the series solutions for ordinary differential equations

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO2	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO3	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2
CO4	3	3	1	2	1	-	-	-	-	-	-	-	-	1	2

Detailed Syllabus

Numerical Methods: Curve fitting by the method of least squares, Fitting of (i) Straight line (ii) Second degree parabola (iii) Exponential curves, Gauss-Seidal iteration method to solve a system of equations, Numerical solution of algebraic and transcendental equations by Regula-Falsi method and Newton-Raphson’s method, Lagrange interpolation, Forward and backward differences, Newton’s forward and backward interpolation formulae, Numerical differentiation with forward and backward differences, Numerical Integration with Trapezoidal rule, Simpson’s 1/3 rule and Simpson’s 3/8 rule, Taylor series method, Euler’s method, modified Euler’s method, 4th order Runge-Kutta method for solving first order ordinary differential equations.

Probability and Statistics: Random variables, discrete and continuous random variables, Mean and variance of Binomial, Poisson and Normal distributions and applications, Testing of Hypothesis –Null and alternate hypothesis, level of significance and critical region-Z-test for single mean and difference of means, single proportion and difference of proportions - t-test for single mean and difference of means - F-test for comparison of variances, Chi-square test for goodness of fit - Karl Pearson coefficient of correlation, lines of regression and examples.

Series Solution: Series solution of Bessel and Legendre’s differential equations, Bessel function of first kind, Recurrence formulae, Generating function, Orthogonality of Bessel functions

- Legendre polynomial, Rodrigue's formula, Generating function, Recurrence formula, Orthogonality of Legendre polynomials.

Reading:

1. M. K. Jain, S.R.K. Iyengarand R.K. Jain, Numerical methods for Scientific and Engineering Computation, New Age International Publications, 2008.
2. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand & Co, 2006.
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2008.
4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2009.

CH251	CHEMICAL ENGINEERING THERMODYNAMICS – II	PCC	3 – 1 – 0	4 Credits

Pre-requisites: CH204-Chemical Engineering Thermodynamics – I

Course Outcomes: At the end of the course, the student will be able to:

CO1	Evaluate heat effects involved in industrial chemical processes
CO2	Determine thermodynamic properties of gaseous mixtures and solutions
CO3	Estimate Bubble-P & T, Dew-P & T for binary and multi-component systems
CO4	Calculate vapor-liquid equilibrium (VLE) composition for ideal and non-ideal systems
CO5	Determine equilibrium constant and composition of product mixture for single and multiple reactions

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	1	1	2	2	-	-	-	-	-	-	-	2	3	1
CO2	1	2	1	2	2	-	-	-	-	-	-	-	1	2	2
CO3	2	2	1	1	2	-	-	-	-	-	-	-	1	2	2
CO4	2	1	1	`2	2	-	-	-	-	-	-	-	2	2	2
CO5	1	1	1	1	2	-	-	-	-	-	-	-	1	2	1

Detailed syllabus

Heat Effects: Sensible heat effects, Temperature dependency of heat capacity, Latent Heat of pure substance, Standard heats of reaction, formation and combustion, Heat effects of industrial reactions.

Solution Thermodynamics: Fundamental property relation, Chemical potential, Partial properties, The ideal gas mixture model, Fugacity and fugacity coefficient, The ideal solution model, Excess properties.

Applications of Solution Thermodynamics: Liquid phase properties from VLE data, Activity coefficient, Excess Gibbs Energy, Models for the excess Gibbs energy, Property changes of mixing, Heat effects of mixing process.

VLE at low to moderate pressures: The nature of equilibrium, Criteria of equilibrium, The phase rule, Duhem's theorem, Raoult's law, Henry's law, Modified Raoults's law, Dew point and bubble point calculations, Relative volatility, Flash calculations.

Thermodynamic properties and VLE from equations of state.

Chemical Reaction Equilibria: The reaction coordinate, Equilibrium criteria to chemical reactions, Gibbs free energy change, Equilibrium constant, Effect of temperature on equilibrium constant, Evaluation of equilibrium constants, Relation of equilibrium constant to composition, Equilibrium conversions for single reactions, Phase rule and Duhem's theorem for reacting systems, Multi-reaction equilibria.

Reading:

1. Smith J.M, Van Ness H.C and Abbott M.M., Introduction to Chemical Engineering Thermodynamics, 7th Edition, McGraw Hill International, 2004.
2. Milo D. Koretsky, Engineering and Chemical Thermodynamics, Wiley, 2009.
3. Hougen O. A, Watson. K. M and Ragatz R. A, Chemical Process Principles (Part-II), 2nd Edition, CBS Publishers, 2004.
4. Narayanan, K.V, Chemical Engineering Thermodynamics, Prentice Hall of India Pvt. Ltd., 2009.

CH252	HEAT TRANSFER	PCC	3 – 1 – 0	4 Credits

Pre-requisites: CH201 Chemical Process Calculations, CH202 Fluid and Particle Mechanics.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the modes of heat transfer.
CO2	Calculate heat transfer coefficients for forced and natural convection.
CO3	Perform heat transfer calculations involving phase changes.
CO4	Analyze the heat exchanger performance for co-current and counter-current flows.
CO5	Design double pipe and shell & tube heat exchangers.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	3	1	1	2	3	-	2	3	1	1	3	3	2
CO2	3	2	3	1	1	2	3	-	2	3	1	1	3	3	2
CO3	3	2	3	1	1	2	3	-	2	3	1	1	3	3	2
CO4	3	2	3	`1	1	2	3	-	2	3	1	1	3	3	2
CO5	3	2	3	1	1	2	3	-	2	3	1	1	3	3	2

Detailed syllabus

Introduction: Modes of heat transfer, material properties of importance in heat transfer.

Heat Transfer by Conduction in Solids & Principles of heat flow in fluids: Steady state heat conduction; Conduction through bodies in series; unsteady state heat conduction; Concept of heat transfer coefficient; Individual and overall heat transfer coefficient; Concept of fins; Critical insulation thickness.

Heat Transfer to fluids without phase change: Principle of convection; Concept of Boundary layers; Heat transfer by forced convection in laminar flow; Turbulent flow and transition region; Heat transfer to liquid metals; Forced convection on outside tubes; Natural convection; Momentum and heat transfer analogies.

Heat Transfer to fluids with phase change: Heat transfer from condensing vapors; Heat transfer to boiling liquids.

Radiation Heat Transfer: Concepts of radiation; Laws of radiation; Radiation between black surfaces; Interchange factor; Exchange of energy between parallel planes and concentric cylinders/spheres.

Heat Exchange equipment: Heat Exchangers; Condensers and Boilers; Shell and Tube Heat Exchangers; Other types of Heat Exchangers; Preliminary Design of Heat Exchangers; Effectiveness-NTU Method.

Evaporation: Basics of evaporation; Performance of tubular evaporators; Capacity & Economy; Multiple effect evaporator; Principles of Crystallization; Crystallization equipment.

Reading:

1. McCabe W. L., Smith J. C., Harriott P., Unit Operations of Chemical Engineering, 7th Edition, McGraw Hill, 2005.
2. Holman J. P, Heat Transfer, 10th Edition, McGraw Hill, New York, 2010.
3. Ozisik N, Heat Transfer: A Basic Approach, Vol. 1, McGraw Hill, 1985.
4. Cengel Y. A, Heat Transfer: A Practical Approach, 2nd Edition, McGraw Hill, 2003.
5. Kern D. Q., Process Heat Transfer, Tata McGraw Hill Education Pvt. Ltd., 2001.
6. Serth R. W, Process Heat Transfer: Principles, Applications and Rules of Thumb, 2nd Edition, Academic Press, 2014.
7. Frank P. Incropera, Theodore L. Bergman, David P. DeWitt, Bergmann, Adrienne S. Lavine, Fundamentals of Heat and Mass Transfer, John Wiley & Sons,7th Edition, 2013.

CH253	Mass Transfer – I	PCC	3-1-0	4 Credits

Pre-requisites: CH201-Chemical Process Calculations, CH202- Fluid and Particle Mechanics

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify diffusion phenomena in various chemical processes.
CO2	Determine diffusivity coefficient in gases and liquids.
CO3	Calculate mass transfer coefficients at interfaces of multiphase mass transfer systems.
CO4	Design equipment for gas-liquid mass transfer operations.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	-	-	-	-	-	-	2	2	2	1
CO2	3	3	2	2	2	-	-	-	-	-	-	2	2	2	2
CO3	3	3	2	2	2	-	-	-	-	-	-	2	2	2	2
CO4	3	3	3	2	2	-	-	-	-	-	-	2	3	2	2

Detailed Syllabus

Introduction: Unit operations with mass transfer phenomena, Introduction to solute transport.

Molecular Diffusion: Stefan tube experiment to determine diffusion coefficient in gases, Fick‘s law of diffusion, Determination of diffusion coefficient in liquids, Diffusion of naphthalene into air – example, Two bulb method to determine diffusion coefficient in gases, Correlations for diffusion coefficient in gases and liquids, Dependence on temperature and pressure, Unsteady state diffusion: semi-infinite slab example, Correlation for diffusion coefficient in multi-component gaseous mixture, Formulation of flux with a reaction occurring on surface, Diffusion in solids.

Inter-Phase Mass Transfer: Pure liquid (stationary) to gas mixture (gently mixed), Concept of mass transfer coefficient and driving force, Pure gas (stationary) to liquid mixture (gently mixed), Pure gas to liquid (laminar falling film), Concept of Sherwood number, Sherwood number correlations for various geometries and flow regimes, Dimensional Analysis: The Route to Correlations, Theories of mass transfer coefficient for gas to turbulent liquid flow, Two film resistance theory, Analogies between heat, mass and momentum transfer.

Equipment for Gas-Liquid Operations: Components of equipment in packed towers, Bubble column, Tray towers, etc. Material balance for packed tower absorption process – Distributed parameter model, Equilibrium curve & Operating line, Concept of HtOG and NtOG - height of transfer unit and number of transfer units, Stage efficiency.

Humidification Operations: Terminology and definitions, Psychrometric charts, Adiabatic operation, Equipment & components, Non-adiabatic operation, Design of cooling tower and domestic air cooler.

Gas Absorption: Equilibrium solubility of gases in liquids, one component transferred - material balances, one component transferred counter-current multistage operation, stage efficiency, continuous contact equipment, multicomponent systems and absorption with chemical reaction.

Reading:

1. Treybal R.E., Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.
2. Geankoplis C.J., Transport processes and Separation Process Principles, 4th Edition, Prentice-Hall India, 2003.
3. Binay K. Dutta, Principles of Mass Transfer and Separation Processes, 2nd Edition, Prentice-Hall India, 2007.
4. E. L. Cussler, Diffusion – Mass transfer in fluid systems, 3rd Edition, Cambridge University Press, 2009.
5. KV Narayanan and B Lakshmikutty, Mass Transfer – Theory and Applications, CBS Publishers & Distributors Pvt. Ltd., 2014.
6. Ernest J. Henley, J.D.Seader, D. Keith Roper, Separation Process Principles, Wiley, 3rd Edition, 2011.

CH254	CHEMICAL REACTION ENGINEERING - I	PCC	3 – 1 – 0	4 Credits

Pre-requisites: CH201-Chemical Process Calculations, CH204-Chemical Engineering Thermodynamics-I

Course Outcomes: At the end of the course, the student will be able to:

CO1	Derive the rate law for non-elementary chemical reactions.
CO2	Determine the kinetics of chemical reaction using integral, differential and fractional life methods.
CO3	Design reactors for homogenous reactions under isothermal conditions.
CO4	Select optimal sequence in multiple reactor systems
CO5	Design adiabatic plug flow reactor.
CO6	Analyze the performance of non-ideal reactors using segregation model, tanks-in series model and dispersion model.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	-	-	-	-	-	-	-	3	3	1
CO2	3	3	3	3	-	-	-	-	-	-	-	-	3	3	2
CO3	3	3	3	3	-	-	-	-	-	-	-	-	3	3	3
CO4	3	3	3	3	-	-	-	-	-	-	-	-	3	3	3
CO5	3	3	3	3	-	-	-	-	-	-	-	-	3	3	1
CO6	3	3	3	3	1	-	3	-	-	-	-	-	3	3	3

Detailed syllabus

Kinetics of Homogeneous Reactions**:** Concentration-Dependent Term of a Rate Equation, Temperature-Dependent Term of a Rate Equation, Searching for a Mechanism, Predictability of Reaction Rate from Theory.

Conversion and Reactor Sizing**:** Definition of Conversion, Batch Reactor Design Equations, Design Equations for Flow Reactors, Applications of the Design Equations for Continuous-Flow Reactors, Reactors in Series.

Analysis of Rate Data: The Algorithm for Data Analysis, Batch Reactor Data, Method of Initial Rates, Method of Half-Lives, Differential Reactors, Experimental Planning, Evaluation of Laboratory Reactors.

Isothermal Reactor Design: Mole Balances in Terms of Conversion- Design Structure for Isothermal Reactors, Scale-Up of Liquid-Phase Batch Reactor Data to the Design of a CSTR, Design of Continuous Stirred Tank Reactors (CSTRs), Tubular Reactors. Mole Balances Written in Terms of Concentration and Molar Flow Rate- Mole Balances on CSTRs, PFRs, and Batch Reactors, recycle reactor.

Non-Isothermal Reactor design: Energy balances, Adiabatic tubular reactor design.

RTD for Chemical Reactors: General Characteristics, Measurement of the RTD, Characteristics of the RTD, RTD in Ideal Reactors, Diagnostics and Troubleshooting, Reactor Modelling Using the RTD, Zero-Parameter Models, RTD and Multiple Reactions.

Analysis of non-ideal reactors**:** One- parameter models, two-parameter models, Tanks-in-Series (T-I-S) Model, Dispersion Model, and Two-Parameter Models-Modelling Real Reactors with Combinations of Ideal Reactors, Other Models of Non-ideal Reactors Using CSTRs and PFRs.

Reading:

1. H. Scott Fogler, Elements of Chemical Reaction Engineering, Prentice Hall India Learning Private Limited, 4th Edition, 2008.
2. O. Levenspiel, Chemical Reaction Engineering,Wiley India, 3rd Edition, 2006.
3. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, Introduction to Chemical Reaction Engineering & Kinetics, Wiley, 1998.
4. E. Bruce Nauman, Chemical Reactor Design, Optimization and Scaleup, Wiley, 2nd Edition, 2008.
5. Mark E. Davis & Robert J. Davis, Fundamentals of Chemical Reaction Engineering, McGraw Hill, 2002.
6. Martin Schmal, Chemical Reaction Engineering: Essentials, Exercises and Examples, CRC Press, 2014
7. S. Suresh and S. Sundaramoorthy, Green Chemical Engineering: An introduction to Catalysis, Kinetics, and Chemical Processes, CRC Press, 2015.

CH255	PROCESS INSTRUMENTATION	PCC	3 – 0 – 0	3 Credits

Pre-requisites: CH202-Fluid and Particle Mechanics.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Characterize the performance of instruments
CO2	Identify the measurement techniques for Pressure and Temperature
CO3	Select instruments for Flow and Level measurement
CO4	Choose recording, indicating and signaling instruments

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	-	1	3	2	-	-	-	-	-	-	1	-	3	1
CO2	3	-	1	3	1	-	-	-	-	-	-	1	-	3	1
CO3	3	-	1	3	1	-	-	-	-	-	-	1	-	3	1
CO4	3	-	1	3`	2	-	-	-	-	-	-	1	-	3	1

Detailed syllabus

Characteristics of Measurement System -Elements of instruments, static and dynamic characteristics, basic concepts of response of first order type instruments, mercury in glass thermometer, bimetallic thermometer, pressure spring thermometer, static accuracy and response of thermometers.

Pressure Measurement- Pressure, vacuum and head manometers, measuring elements for gage pressure and vacuum, measuring pressure in corrosive liquids, measuring of absolute pressure, static accuracy and response of pressure gages.

Temperature Measurement–Industrial thermocouples, thermocouple wires, thermowells and response of thermocouples, Resistance Temperature Detector.

Flow Measurement-open channel meters, flow of dry materials, viscosity measurement.

Level Measurement- direct measurement of liquid level, level measurement in pressure vessels, measurement of interface level, level of dry materials. Differential Pressure Transmitter.

Concentration Measurements – Turbidity meter, Refractometer, colorimeter.

Instruments for Analysis - recording instruments, transducers, indicating and signaling instruments, instrumentation diagram.

Reading:

1. Patranabis D, Principles of Industrial Instrumentation, McGraw Hill Education, 3rd Edition, 2017.
2. Eckman Donald P, Industrial Instrumentation, Wiley Eastern Ltd., 2004.
3. William C. Dunn, Fundamentals of Industrial Instrumentation and Process control, McGraw Hill Education, 2017.
4. V.R. Radhakrishnan, Instrumentation and Control for the Chemical, Mineral and Metallurgical Processes, Allied Publishers Pvt. Limited, 1997.
5. K. Krishna swamy, Industrial Instrumentation, New Age International Publishers, 2003.

CH256	CHEMICAL REACTION ENGINEERING LAB	PCC	0 – 1 – 2	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Determine the kinetics of a reaction in a Batch reactor, Semi batch reactor, CSTR, & PFR
CO2	Determine the kinetics of a variable volume reaction
CO3	Determine the kinetics by fractional conversion method
CO4	Determine the temperature dependency of a reaction
CO5	Evaluate the performance of reactors through RTD studies
CO6	Compare the performance of single reactor with combination of reactors

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	-	1	-	2	-	-	-	2	3	1
CO2	3	2	1	1	1	-	1	-	2	-	-	-	2	3	1
CO3	3	2	1	1	1	-	1	-	2	-	-	-	2	3	1
CO4	3	2	1	`1	1	-	1	-	2	-	--	-	2	3	1
CO5	3	2	1	1	1	-	1	-	2	-	-	-	2	3	1
CO6	3	2	1	1	1	-	1	-	2	-	-	-	2	3	1

Detailed syllabus:

1) Determine the concentration dependency of a reaction in a Batch reactor (BR)
2) Determine the concentration dependency of a reaction in a CSTR
3) Determine the concentration dependency of a reaction in a PFR
4) Determine the concentration dependency of a reaction in a Semi-batch reactor (SBR)
5) Determination of rate constant and temperature dependency of a reaction
6) Determination of rate constant in a combined reactor (PFR followed by CSTR)
7) Determination of rate constant in a Cascade CSTR (or CSTRs in series)
8) Determination of RTD characteristics of a packed bed reactor
9) Determine the kinetics by partial conversion method
10) Determine the kinetics of a variable volume reaction by Dilatometry
11) Determine the kinetics of Polymerization of acrylic acid in a batch reactor.

Reading:

1. Laboratory Manuals
2. Octave Levenspiel, Chemical Reaction Engineering, 2^{nd} Edition, Wiley India, 2006.

CH257	HEAT TRANSFER LABORATORY	PCC	0 – 1 – 2	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Determine thermal conductivity of solids and fluids
CO2	Calculate efficiency of fins
CO3	Verify Newton's law of cooling of hot objects
CO4	Determine efficiency of Double Pipe and Shell & Tube Heat exchangers
CO5	Analyze condensation and boiling phenomena

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	1	2	2	2	-	1	-	3	2	1	2	2	3	1
CO2	2	1	2	2	2	-	1	-	3	2	1	2	2	3	1
CO3	2	1	2	2	2	-	1	-	3	2	1	2	2	3	1
CO4	2	1	2	2	2	-	1	-	3	2	1	2	2	3	1
CO5	2	1	2	2	2	-	1	-	3	2	1	2	2	3	1

Detailed syllabus

List of experiments:

1. Demonstration of the analogue between heat conduction in solids and electric conduction in an L-shaped network of electrical resistances.
2. Determination of overall and individual plate thermal conductivity for a composite wall.
3. Determination of a rod type fin efficiency.
4. Determination of thermal conductivity of metal Rod.
5. Determination of heat transfer coefficient during natural convection from a heated vertical cylinder.
6. Determination of Pin – Fin efficiency.
7. Determination of overall heat transfer coefficient of a double pipe heat exchanger.
8. Determination of overall heat transfer coefficient of a shell and tube heat exchanger.
9. Determination of radiation emissivity of a test plate.
10. Determination of Stefan-Boltzmann constant for radiation.

11. Determination of critical heat flux for a heat wire immersed in water
12. Determination of characteristics of drop-wise and film-wise condensation.

Reading: Lab manuals

CH301	CHEMICAL REACTION ENGINEERING – II	PCC	3 – 0 – 0	3 Credits

Pre-requisites: CH253-Mass Transfer-I, CH254-Chemical Reaction Engineering-I

Course Outcomes: At the end of the course, the student will be able to:

CO1	Derive the rate law for gas-phase reactions catalyzed by solids.
CO2	Design fixed bed reactor in the absence and presence of mass transfer effects
CO3	Analyze the effect of velocity, particle size and fluid properties on rate of reactions controlled by mass transfer.
CO4	Determine internal and overall effectiveness factors.
CO5	Design reactors for fluid-fluid reactions

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	1	-	1	-	-	-	-	-	-	-	3	2	1
CO2	2	2	3	-	-	-	-	-	-	-	-	-	3	3	1
CO3	3	2	2	-	-	-	-	-	-	-	-	-	3	2	1
CO4	3	2	2	1	1	-	-	-	-	-	-	-	2	1	1
CO5	2	2	3	1	1	-	-	-	-	-	-	-	3	2	1

Detailed syllabus

Catalysis and Catalytic Reactors: Catalysts, Steps in a Catalytic Reaction, Synthesizing a Rate Law, Mechanism, and Rate-Limiting Step, Heterogeneous Data Analysis for Reactor Design.

External Diffusion Effects on Heterogeneous Reactions: Diffusion Fundamentals, Binary Diffusion, External Resistance to Mass Transfer, Parameter Sensitivity, the Shrinking Core Model. Rate equation for fluid solid reactions. Design of heterogeneous catalytic reactors.

Diffusion and Reaction: Diffusion and Reaction in Spherical Catalyst Pellets, Internal Effectiveness Factor, Falsified Kinetics, Overall Effectiveness Factor, Estimation of Diffusion- and Reaction-Limited Regimes, Mass Transfer and Reaction in a Packed Bed, Determination of Limiting Situations from Reaction Data, Multiphase Reactors, Fluidized Bed Reactors.

Non-catalytic systems: Fluid-Fluid reactions: Kinetics, Fluid-Fluid Reactors: Design.

Reading:

1. H. Scott Fogler, Elements of Chemical Reaction Engineering, Prentice Hall India Learning Private Limited, 4^{th} Edition, 2008.
2. O. Levenspiel, Chemical Reaction Engineering, Wiley India, 3^{rd} Edition, 2006.
3. J. M. Smith, Chemical Engineering Kinetics, 3^{rd} Edition, McGraw Hill, 1981.
4. T. J. Carberry, Chemical and Catalytic Reaction Engineering, McGraw Hill, 1976.

CH302	MASS TRANSFER – II	PCC	3-1-0	4 Credits

Pre-requisites: CH251-Chemical Engineering Thermodynamics-II, CH253-Mass Transfer-I

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyse VLE, LLE, and SLE data
CO2	Select a suitable mass transfer operation for a given separation
CO3	Determine number of stages in distillation, extraction and adsorption operations
CO4	Estimate the height of packed column in distillation, extraction and adsorption operations
CO5	Calculate drying rates and moisture content for batch and continuous drying operations

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	-	-	-	-	-	-	2	2	2	1
CO2	3	2	2	2	2	-	-	-	-	-	-	2	2	2	1
CO3	3	2	3	2	2	-	-	-	-	-	-	2	3	2	1
CO4	3	2	3	2	2	-	-	-	-	-	-	2	3	2	1
CO5	3	2	2	2	2	-	-	-	-	-	-	2	2	3	1

Detailed syllabus

Distillation: Vapor-Liquid Equilibria, single stage operation - flash vaporization, differential or simple distillation, continuous rectification - binary systems, multistage tray towers: Panchon and Savarit method, McCabe-Thiele method. Steam distillation, Continuous contact equipment (packed towers), multicomponent systems, Extractive distillation, Azeotropic distillation, hybrid distillation.

Liquid-Liquid Extraction: Liquid-Liquid equilibria, Extraction equipments, stage-wise contact, design of stage type extractors and differential (continuous contact) extractors: immiscible and partially miscible systems.

Drying: Equilibrium, drying operations - batch drying, mechanism of batch drying and continuous drying, drying equipment.

Adsorption and Ion exchange: Adsorption equilibria, Batch and continuous adsorption, Selection of adsorbent, Specific surface area of an adsorbent, Adsorption Dynamics, Thermal regeneration of adsorbents, Pressure swing adsorption, ion – exchange processes: Principles, Techniques and applications.

Leaching: Methods of operation and equipment, unsteady state and steady state operation

Reading:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill, 3rd Edition, 1981.
2. Geankoplis C.J., Transport processes and Separation Process Principles, Prentice-Hall India, 4th Edition, 2003.
3. Binay K. Dutta, Principles of Mass Transfer and Separation Processes, Prentice-Hall India, 2nd Edition, 2007.
4. Narayanan, K. V. and Lakshmikutty, B., Mass Transfer – Theory and Applications, CBS Publishers & Distributors Pvt. ltd., 2014.
5. Seader, J. D. and Henley, E. J., Separation Process Principles with application using process simulators, John Wiley & Sons, NY, 4th Edition, 2016.

CH303	ELEMENTS OF TRANSPORT PHENOMENA	PCC	3 – 1 – 0	4 Credits

Pre-requisites:CH202-Fluid and particle mechanics, CH252-Heat Transfer, CH253-Mass Transfer-I, CH254-Chemical Reaction Engineering-I

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the transport properties of solids, liquids and gases
CO2	Formulate a mathematical representation of flow / heat / mass transfer phenomena.
CO3	Solve flow/heat/mass transfer problems either individually or coupled for simple geometries analytically.
CO4	Identify the similarities among the correlations for flow, heat and mass transfer at interfaces.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	2	2	1	2	-	1	-	1	-	-	2	1	3	1
CO2	3	2	2	2	1	-	1	-	1	1	-	2	2	3	2
CO3	3	3	3	2	1	-	1	-	1	1	-	2	2	3	2
CO4	3	2	2	2	1	-	1	-	1	1	-	2	2	3	2

Detailed Syllabus:

Introduction: Properties of solids, liquids and gases; units and non-dimensionalization

Momentum Transfer: Newton’s law of viscosity & mechanism of momentum transport, Continuity equation, Equation of motion, Navier-Stokes Equation, Laminar velocity profiles in simple geometries such as flow between parallel plates, flow in a circular pipe, flow down an inclined plane, Dimensional analysis of equations of change, Time dependent velocity profile, Velocity distributions in turbulent flow, Time-smoothed equations of change for incompressible fluids, Turbulent flow correlations.

Heat Transfer: Fourier’s law of heat conduction & mechanism of heat transport, Heat conduction-convection-generation equation, and Temperature profile for simple geometries with/without heat generation, Temperature profile in laminar flowing fluids with/without heat generation, Equations of change for Non-isothermal systems, Time dependent Temperature profile, and Natural convection.

Mass Transfer: Fick's law of diffusion & mechanism of mass transport, Species balance equation with convection-diffusion and reaction, Diffusion in solids, Dispersion model for laminar flow in tubes, Equations of change for isothermal and Non-isothermal systems, Stefan tube experiment – determination of diffusion constant.

Analogies: Analogies between momentum, heat & mass transfer correlations for friction factor/Nusselt Number/Sherwood Number.

Reading:

1. Bird R.B., Stewart W.E. and Light Foot E.N. Transport Phenomena, John Wiley &Sons, 2nd Edition, 2007.
2. Geankoplis C.J., Transport Processes and Separation Process Principles, 4th Edition, Prentice Hall Inc., 2009.
3. Bodh Raj, Introduction to Transport Phenomena: Momentum, Heat, and Mass, Prentice Hall India Learning Private Limited, 2012.
4. Sunil Kumar Thamida, Transport Phenomena: Chemical Processes, Studium Press (India) Pvt. Ltd. 2016

CH304	CHEMICAL TECHNOLOGY	PCC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Selection of a process for manufacture of chemicals
CO2	Draw process flow diagrams.
CO3	Identify the engineering problems in chemical processes
CO4	List chemical reactions and their mechanism involved.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	1	3	1	2	3	3	-	-	-	-	-	3	2	-
CO2	2	2	2	2	2	-	-	-	-	-	-	-	3	2	-
CO3	3	3	2	1	2	-	-	-	-	-	-	-	3	2	-
CO4	2	2	2	2	-	-	-	-	-	-	-	-	3	2	-

Detailed syllabus

Introduction: Chemical industries-facts and figures, Unit operation and unit process concepts, Chemical processing and role of chemical engineers.

Chloro-Alkali Industries: Soda ash, Solvay process, dual process, Natural soda ash from deposits, Electrolytic process, Caustic soda.

Phosphorus Industries: Phosphoric acid, Wet process, Electric furnace process, Calcium phosphate, Ammonium phosphates, Nitrophosphates, Sodium phosphate.

Potassium Industries: Potassium recovery from sea water.

Nitrogen Industries: Ammonia, Nitric acid, Urea from ammonium carbonate, Ammonium nitrate.

Sulfur and Sulfuric Acid Industries: Elemental sulfur mining by Frasch process, Sulfur production by oxidation-reduction of H_2S, Sulfur and sulfur dioxide from pyrites, Sulfuric acid. Contact process, Chamber process.

Soap and Detergents: Batch saponification production, Continuous hydrolysis and saponification process, Sulfated fatty alcohols, Alkyl-aryl sulfonates.

Sugar and Starch Industries: Sucrose, Extraction of sugar cane to produce crystalline white sugar, Extraction of sugar cane to produce sugar, Starch production from maize, Production of dextrin by starch hydrolysis in a fluidized bed.

Fermentation Industries: Ethyl alcohol by fermentation, Fermentation products from petroleum.

Pulp and Paper Industries: Sulfate pulp process, Chemical recovery from sulfate pulp digestion liquor, Types of paper products, Raw materials, Methods of production.

Plastic Industries: Polymerization fundamentals, Polymer manufacturing processes, Ethenic polymer processes, Polycondensation processes, Polyurethanes.

Rubber: Elastomer polymerization processes, Rubber polymers, Butadiene-Styrene copolymer, Polymer oils and rubbers based on silicon.

Cement Industries: Classification- based on source of cement, based on broad sense cement, based on the application, appearance and constituent of cement. Manufacturing methods- Wet method, Dry method.

Reading:

1. Austin G.T., Shreve's Chemical Process Industries - International Student Edition, McGraw Hill Inc., 5th Edition, 1998.
2. Sittig M. and Gopala Rao M., Dryden's Outlines of Chemical Technology for the 21st Century, 3rd Edition, WEP East West Press, 2010.
3. B.K. Sharma, Industrial chemistry, 15th edition, Goel Publishing House (Krishna Prakashan Media P. LTD.-Meerut), 2016.
4. James A. Kent, Riegel's Hand Book of Industrial Chemistry, Springer Science+Business Media, LLC, 9th Edition, Volume-1, 2013
5. Andreas Jess, Peter Wasserscheid, Chemical Technology, Wiley-VCH, 2013.
6. Smith W. and Chapman R., Chemical Process Industries, Vol 1 & 2, CBS Publishers, 1st Edition, 2016.

CH305	INDUSTRIAL SAFETY AND HAZARD MITIGATION	PCC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze the effects of release of toxic substances.
CO2	Select the methods of prevention of fires and explosions.
CO3	Identify the hazards and preventive measures.
CO4	Assess the risks using fault tree diagram.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	3	-	-	3	3	2	-	-	-	-	2	3	1
CO2	2	2	3	-	-	3	3	2	-	-	-	-	2	3	1
CO3	2	2	3	-	-	3	3	2	-	-	-	-	2	3	1
CO4	2	2	3	-	-	3	3	2	-	-	-	-	2	3	1

Detailed syllabus

Introduction and Industrial Hygiene: Safety Programs, Engineering Ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, Nature of the Accident Process, Inherent Safety, Anticipation and Identification, Hygiene Evaluation, Hygiene Control.

Fires and Explosions and Concepts to Prevent Fires and Explosions: Fire Triangle, Distinction between Fires and Explosions, Flammability Characteristics of Liquids and Vapors, Limiting Oxygen Concentration and Inerting, Flammability Diagram, Inerting, Controlling Static Electricity, Explosion-Proof Equipment and Instruments, Ventilation, Sprinkler Systems.

Introduction to Reliefs: Relief Concepts, Location of Reliefs, Relief Types, Relief Scenarios, Data for Sizing Reliefs, Relief Systems.

Hazards Identification: Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews.

Safety Procedures and Designs: Process Safety Hierarchy, Managing Safety, Best Practices, Procedures—Operating, Procedures—Permits, Procedures—Safety Reviews and Accident Investigations, Designs for Process Safety.

Reading:

1. D.A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 3rd Edition, 2011.
2. John Metcalf Coulson, John Francis Richardson, R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Vol. 6, Butterworth-Heinemann, 1999.
3. Rulph King, Safety in the Process Industries, Butterworth-Heinemann, 1990.
4. K S N Raju, Chemical process Industry Safety, Tata McGraw-Hill Education, 2014.
5. F.P. Lees, Loss Prevention in Process Industries, Elsevier, 1996.

CH306	COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING LAB	PCC	0-1-2	2 Credits

Pre-requisites:MA251-Mathematics-IV

Course Outcomes: At the end of the course, the student will be able to:

CO1	Determine roots of algebraic equations, solution of simultaneous equations, and ordinary differential equations
CO2	Solve problems using regression analysis, interpolation, extrapolation and numerical differentiation and numerical integration
CO3	Solve problems involving material and energy balances, fluid flow operations, heat and mass transfer, evaporation, thermodynamics and mechanical operations.
CO4	Solve initial value problems, boundary value problems, & Initial and boundary value problems

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	2	-	-	1	2	2	1	2	1	2	2
CO2	3	3	1	1	2	-	-	1	2	2	1	2	1	2	2
CO3	3	3	3	2	3	-	-	1	2	2	1	2	2	2	2
CO4	3	3	1	2	3	-	-	1	2	2	1	2	2	2	2

Detailed syllabus:

Numerical Methods: Roots of algebraic equations and solution of simultaneous equations, Regression analysis, Interpolation and Extrapolation, Differentiation and Numerical Integration, Solution of ordinary differential equations, Initial and Boundary Value Problems

Applications of Numerical Methods to Chemical Engineering Problems: Material and Energy Balance, Fluid flow operations, Heat transfer, Mass Transfer, Thermodynamics, Mechanical operations, Prediction of properties.

Reading:

1. Rudra Pratap, Getting started with MATLAB: A quick introduction for scientists & Engineers, Oxford University Press, 2010.

2. Laurene V. Fausett, Applied Numerical Analysis using MATLAB, Pearson, 2nd Edition, 2009.
3. Alkis Constantinides, Navid Moustoufi, Numerical Methods for Chemical Engineers with MATLAB Applications, Prentice Hall, 1999.
4. Niket S. Kaisare, Computational Techniques for Process Simulation and Analysis using MATLAB, Taylor & Francis, CRC press, 2018.
5. Lab Manuals

CH307	MASS TRANSFER LABORATORY	PCC	0 – 1 – 2	2 Credits

Pre-requisites: CH253-Mass Transfer-I

Course Outcomes: At the end of the course, the student will be able to:

CO1	Determine separation performance of batch distillation, steam distillation, sieve plate and packed bed distillation
CO2	Determine the efficiency of liquid-liquid extraction
CO3	Determine the critical moisture content in drying
CO4	Determine the effect of mass transfer with and without chemical reaction
CO5	Estimate the diffusion coefficient of vapour in gas
CO6	Determine the performance of gas-liquid and liquid-solid operations

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	2	1	-	-	-	2	1	2	3	-
CO2	2	2	2	1	1	2	1	-	-	-	2	1	2	3	-
CO3	3	2	2	2	1	2	1	-	-	-	2	1	2	2	-
CO4	2	2	2	1	2	2	1	-	-	-	2	1	2	3	-
CO5	2	2	3	1	1	2	1	-	-	-	2	1	2	3	-
CO6	2	2	2	2	1	2	1	-	-	-	2	1	2	2	-

Detailed Syllabus:

1. Verify the law of steam distillation
2. Verify the Rayleigh’s equation for differential distillation
3. Determine the height equivalent to a theoretical plate (HETP) of a packed bed distillation column for the given system at total reflux
4. Determine the number of theoretical plates of a given sieve plate distillation column for the given system at total reflux
5. Determine the diffusivity of a vapor in air
6. Determine the drying characteristics of a given sample (wet sand) by drying in a force draft tray drier.

7. Find the overall recovery of solute in a single as well as two stage cross current extraction unit
8. Determine distribution coefficient for liquid-liquid extraction
9. Determine the saturation isotherm for the ternary liquid – liquid system
10. Study the absorption of carbon dioxide by aqueous sodium hydroxide solution in a packed bed absorption tower
11. Calculate the theoretical and experimental mass transfer coefficient for vaporization of naphthalene in air using a packed bed of spherical particles of naphthalene
12. Study the dissolution of benzoic acid in water and in aqueous solution of sodium hydroxide
13. Study the adsorption in a packed bed for a solid liquid system.

Reading: Lab Manuals

CH311	PHARMACEUTICALS AND FINE CHEMICALS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: CY201-Industrial Organic Chemistry

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the grades of chemicals.
CO2	State properties, uses and testing of pharmaceuticals and fine chemicals
CO3	Draw flow sheets for manufacture of pharmaceuticals and fine chemicals
CO4	Understand tablet making and coating, preparation of capsules and extraction of crude drugs.
CO5	Understand sterilization.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	3	2	-	2	2	2	-	-	-	-	2	2	-
CO2	3	2	3	2	-	2	2	2	-	-	-	-	2	2	-
CO3	3	2	3	2	-	2	2	2	-	-	-	-	2	2	-
CO4	3	2	3	2	-	2	2	2	-	-	-	-	2	2	-
CO5	3	2	3	2	-	2	2	2	-	-	-	-	2	2	-

Detailed Syllabus:

A brief outline of different grades of chemicals – Reagent grade and Laboratory grade.

Outlines of preparation – Different methods of preparation of Reagent grade and Laboratory grade Chemicals.

Uses and testing of the pharmaceuticals and fine chemicals – Applications of medicinal value Chemicals and their quality testing procedures.

Properties, assays and manufacture of Pharmaceuticals and fine chemicals with flow sheets- Physical and Chemical properties, methods of assessing the quality and industrial methods of formulating the drugs and fine chemicals that have no medicinal value but are used as the intermediates.

Compressed Tablet making and coating – Types of tablets and Methods of compressed tablet making and coating.

Preparation of capsules and extraction of crude drugs – Industrial procedures of capsule formulation and methods of recovering the drugs formulated from the reaction mixture.
Sterilization – Need for sterilization, Sterilization methods, batch and continuous sterilization.

Reading:

1. Remington, Pharmaceutical Sciences, Mak. Publishing Co., 16th Edition, 1980.
2. William Lawrence Faith, Donald B. Keyes and Ronald L. Clark, Industrial Chemicals, 4th Edition, John Wiley & Sons, 1975.

CH312	RENEWABLE ENERGY SOURCES	DEC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the challenges and problems associated with the use of energy sources.
CO2	Illustrate the renewable energy technologies.
CO3	Distinguish conversion technologies for solar, wind, biomass and hydrogen energies
CO4	Evaluate the performance of energy conversion technologies

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	3	1	-	-	1	3	-	-	-	-	-	1	2	-
CO2	2	3	1	2	-	2	3	-	-	-	-	-	3	1	-
CO3	1	2	2	1	-	2	2	-	-	-	-	-	3	2	-
CO4	2	3	2	1	1	2	3	-	-	-	-	-	2	3	-

Detailed syllabus:

Sources of energy: Energy sources and their availability, renewable energy sources. Energy from Biomass: Introduction, Biomass as a source of energy, Biomass conversion technologies, Biogas generation, classification of biogas plants, Biomass gasification. Solar Energy: Sun and solar energy, solar radiation and its measurement, solar energy collectors, solar energy storage, Photovoltaic systems, Application of solar energy Wind Energy: Wind as an Energy source, Basic principles of wind energy conversion, Types of Wind machines, Components of wind energy conversion system, Performance of wind machines, application of wind energy.

Geothermal Energy: Introduction, Origin and distribution of geothermal energy, types of geothermal resources, Hybrid geothermal power plant, Application of geothermal energy Hydrogen energy: Introduction, Hydrogen production, Hydrogen storage, Hydrogen transportation Energy from the Oceans: Introduction, Ocean Thermal Electric Conversion (OTEC), Energy from Tides, Ocean Waves Chemical Energy Sources.

Introduction to Fuel cells, and Batteries

Reading:

1. Rai, G.D, Non-Conventional Energy Sources, Khanna Publishers, New Delhi, 2010.
2. Rajesh Kumar Prasad, T.P. Ojha, Non-Conventional Energy Sources, Jain Brothers, 2012.
3. Sukhatme S.P and J. Nayak, Solar energy – Thermal Collection and storage, 3rd Edition, Tata McGraw Hill Education Pvt. Ltd., 2008.
4. MM. EI Wakil, Power Plant Technology, Tata McGraw Hill, New York, 1999.

CH313	FUEL CELLS AND FLOW BATTERIES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Describe working principles of fuel cells and flow batteries
CO2	Analyze the performance of fuel cell systems.
CO3	Identify intricacies in construction and operation of fuel cell stack and fuel cell system.
CO4	Discuss construction and operation of flow battery cells and stack

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	3	2	1	1	2	-	2	2	-	1	1	3	1
CO2	2	2	3	2	1	1	2	-	2	2	-	1	1	3	1
CO3	2	2	3	2	1	1	2	-	2	2	-	1	1	3	1
CO4	2	2	3	2	1	1	2	-	2	2	-	1	1	3	1

Detailed syllabus

Introduction - Electrochemical Flow Systems - Fuel cells and Flow Batteries.

Overview of Fuel Cells: Introduction, brief history, classification, working principle, applications, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

Fuel cell electrochemistry: electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents.

PEM Fuel cell process design: Main PEM fuel cell components, materials, properties and processes, Fuel cell operating conditions.

Fuels &Fuel processing: Hydrogen, Hydrocarbon fuels, Direct and in-direct internal reforming, Reformation of hydrocarbons by steam, CO_2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal.

Flow batteries: Introduction, Redox flow battery technology - brief history, working principle, redox flow battery components and systems, flow battery testing

Flow Battery Types and Challenges: iron/chromium, Bromine/polysulphide, Vanadium/bromine, Zinc/cerium and All Vanadium flow batteries, current research trends and challenges.

Reading:

1. F. Barbir, PEM Fuel Cells: Theory and Practice, Elsevier/Academic Press, 2nd Edition, 2013.
2. Huamin Zhang, Xianteng Li, Jiujun Zhang,Redox flow batteries: Fundamentals and Applications, CRC Press, 2017.
3. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, New York, 2006.
4. Kirt A. Page, Christopher L. Soles, James Runt, Polymers for Energy storage and Delivery: Polyelectrolytes for Batteries and Fuel cells, OUP USA, 2012.
5. James Larminie, Andrew Dicks, Fuel Cell Systems Explained, Wiley, 2nd Edition, 2003.
6. Hoogers G., Fuel Cell Technology Hand Book, CRC Press, 2003.

CH314	ENERGY MANAGEMENT	DEC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Discuss effective energy management policies, methods and planning
CO2	Carry out energy audit and economic analysis
CO3	Explain energy management control schemes
CO4	Design energy utilization systems for heat recovery
CO5	Select energy security and reliability methods

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	3	-	-	3	3	-	-	1	2	1	1	-	-
CO2	1	1	2	1	1	3	3	-	-	1	2	1	1	2	2
CO3	1	1	2	1	1	3	3	-	-	1	2	1	1	2	-
CO4	2	3	2	1	1	3	3	-	-	1	2	1	1	2	2
CO5	-	-	3	1	1	3	3	-	-	1	2	1	1	2	2

Detailed syllabus:

Introduction: The value of Energy management, suggested principles of energy management

Effective Energy Management: Energy Policy and planning.

Energy auditing and Economic analysis: Energy auditing services, Basic components of an energy audit, Industrial, commercial and residential audits, General characteristics of capital investments, project measures of worth.

Boilers and fired systems, Steam and condensate systems, Cogeneration, Waste heat recovery.

Energy management control systems, energy systems maintenance.

Thermal Energy Storage: Storage system, Storage mediums.

Control systems: The fundamental control loop, sensors, controllers, control strategies, control of Air handling units, control of primary equipment, control of distribution systems, and advanced technology for effective facility control.

Energy security and Reliability: Risk analysis methods, economics of energy security and reliability, links to energy management.

Financing and commissioning energy management projects.

Reading:

1. Murphy W.R and Mckay G., Energy Management, Elsevier, 2007.

2. Wayne C. Turner, Steve Doty, Energy Management Handbook, CRC Press, 6^{th} Edition, 2007.

CH315	CORROSION ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify various forms of corrosion.
CO2	Determine corrosion rates for metals from their polarization curves.
CO3	Analyze corrosion rate characteristics from electrochemical impedance spectroscopy.
CO4	Select suitable corrosion resistant coatings, oxide layers for various applications.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	2	1	2	2	1	2	-	1	-	-	2	1	3	1
CO2	2	2	1	2	2	1	2	-	1	-	-	2	1	3	1
CO3	2	2	1	2	2	1	2	-	1	-	-	2	1	3	1
CO4	1	2	3	2	2	1	2	-	1	-	-	2	1	3	1

Detailed syllabus

Introduction & Corrosion Principles: Definition of corrosion, Impact on economy, electrochemical reactions, Corrosion rate expressions, Polarization, Passivity, Metallurgical aspects.

Eight Forms of Corrosion: Galvanic corrosion, crevice corrosion, pitting, intergranular corrosion, erosion corrosion, stress corrosion, hydrogen damage.

Corrosion testing: Specimen preparation, exposure tests, open corrosion potential, linear polarization, Tafel slopes, corrosion current, stress corrosion cracking, AC impedance/EIS.

Corrosion Prevention: Cathodic protection, sacrificial anode methods of corrosion prevention, Anti-corrosion coatings.

Modern Theory-Principles & Applications: Alloy evaluation, Nobel metal alloying, flow accelerated corrosion, galvanic corrosion as a moving boundary problems.

Introduction to high voltage corrosion.

Reading:

1. Fontana M, Corrosion Engineering, Tata McGraw Hill Education Pvt. Ltd., 3rd Edition, 2010.
2. Pierre Roberge, Corrosion Engineering: Principles and Practice, McGraw Hill, 2008.

3. Denny A. Jones, Principles and Prevention of Corrosion, Pearson-Prentice Hall, 2nd Edition, 2005.
4. Nestor Perez, Electrochemistry and Corrosion Science, Springer, 2nd Edition, 2016.
5. Branko N. Popov, Corrosion Engineering: Principles and Solved Problems, Elsevier, 2015.

CH316	NANOTECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the properties of nanomaterials and their applications
CO2	Apply chemical engineering principles to nanoparticles production and scale-up
CO3	Solve the quantum confinement equations.
CO4	Analyze the nanomaterials characterization.
CO5	State the applications of nanotechnology in electronics and chemical industries.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	1	1	-	-	-	-	-	-	-	-	1	1	1
CO2	3	2	2	1	-	-	-	-	-	-	-	-	3	2	1
CO3	3	3	1	1	-	-	-	-	-	-	-	-	2	-	-
CO4	2	1	1	1	-	-	-	-	-	-	-	-	1	-	-
CO5	1		1	-	-	-	2	-	-	-	-	1	2	-	-

Detailed syllabus

Introduction to Nanotechnology: Introduction to nanotechnology and materials, Nanomaterials, Introduction to nanosizes and properties comparison with the bulk materials, different shapes and sizes and morphology.

Fabrication of Nanomaterials: Top Down Approach, Grinding, Planetary milling and Comparison of particles, Bottom Up Approach, Wet Chemical Synthesis Methods, Microemulsion Approach, Colloidal Nanoparticles Production, Sol Gel Methods, Sonochemical Approach, Microwave and Atomization, Gas phase Production Methods : Chemical Vapour Depositions.

Kinetics at Nanoscale: Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface Charges, Zeta Potential and pH.

Carbon Nanomaterials: Synthesis of carbon buckyballs, List of stable carbon allotropes extended fullerenes, metallofullerenes solid C60, bucky onions nanotubes, nanocones Difference between Chemical Engineering processes and nanosynthesis processes.

Quantum mechanics: Quantum mechanics Quantum dots and its Importance, Pauli exclusion principle Schrödinger's equation, Application of quantum Dots: quantum well, wire, dot, characteristics of quantum dots, Synthesis of quantum dots, Semiconductor quantum dots, Introduction - Nanoclay Synthesis method, Applications of nanoclay.

Nanomaterials characterization: Instrumentation Fractionation principles of Particle size measurements, Particle size and its distribution, XRD, Zeta potential Microscopies SEM, TEM, Atomic Forced Microscopy, Scanning and Tunneling Microscopy

Applications in Chemical Engineering: Self-assembly and molecular manufacturing : Surfactant based system Colloidal system applications, ZnO,TiO_2,Silver Nanoparticles Functional materials Applications, Production Techniques of Nanotubes, Carbon arc, bulk synthesis, commercial processes of synthesis of nanomaterials, Nanoclay, Commercial case study of nano synthesis - applications inchemical engineering, Nanoinorganic materials - $CaCO_3$ synthesis, Hybrid wastewater treatment systems, Electronic Nanodevices, sensor applications,

Nanobiology: biological methods of synthesis. Applicationsin drug delivery, Nanocontainers and Responsive Release of active agents, Layer by Layer assembly for nanospheres, Safety and health Issues of nanomaterials, Environmental Impacts, Case Study for Environmental and Societal Impacts.

Reading:

1. KulkarniSulabha K., Nanotechnology: Principles and Practices, Capital Publishing Company, 2007.
2. Gabor L. Hornyak., Harry F. Tibbals, JoydeepDutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2009.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, 2005.
4. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
5. Davies, J.H. The Physics of Low Dimensional Semiconductors: An Introduction, Cambridge University Press, 1998.
6. B. Viswanathan, Nano Materials, Alpha Science2009.
7. T. Pradeep, Nano - The essentials understanding nanoscience and nanotechnology, The McGraw Hill, 2007.

CH317	POLYMER TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand thermodynamics of polymer structures
CO2	Select polymerization reactor for a polymer product.
CO3	Characterize polymers.
CO4	State polymer additives, blends and composites.
CO5	Understand polymer rheology.
CO6	Identify suitable polymer processing methods

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	1	1	1	-	-	-	-	-	-	-	3	2	1
CO2	2	2	3	1	1	-	-	-	-	-	-	-	2	3	1
CO3	2	1	-	-	-	-	-	-	-	-	-	-	2	-	-
CO4	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO5	2	-	2	-	-	-	-	-	-	-	-	-	2	-	-
CO6	2	2	1	2	-	-	-	-	-	-	-	-	2	2	-

Detailed Syllabus:

Introduction and Classification of Polymers. Thermosets, Factors influencing the polymer properties, Monomers used for polymer synthesis, synthesis procedure for monomers Styrene, ethylene, Vinyl monomers etc., Thermoplastics, Linear Branch, Cross Linked Polymers, Ewart Kinetics for emulsion polymerization.

Addition polymers – kinetics, synthesis and reactions, Condensation polymers, Kinetics reaction and processes, Polymerization Techniques - Emulsion polymerization and Suspension polymerization, Interfacial Polymerization with their merits

Molecular Weights, Polydispersity Index, Different Methods of determination of Molecular weight, Effect of Molecular weight on Engineering Properties of Polymers, Smith Ewart Kinetics for emulsion polymerization, Kinetics of free radical polymerization, Chain transfer agents, Kinetics of Step growth polymerization, Ziegler Natta polymerization Processes, Differentiation based on kinetics of Anionic and cationic polymers.

Polymerization reactors types and mode of operation, Polymerization reactor design, control of polymerization, Post polymerization unit operations and unit processes

High Performance and Specialty Polymers, Polymer additives, compounding. Fillers, plasticizers, lubricants, colorants, UV stabilizers, fire retardants and antioxidants.

Impact, flexural tensile testing methods of polymers, Mechanical Properties of Polymers, Thermodynamics of Polymer Mixtures, ASTM and ISO methods for testing of polymers.

Polymer processing: Extrusion process, Twin and Single Screw extrusion, Blow moulding, injection moulding, Wet and Dry spinning processes, thermo set moulding. Processing of polymer nanocomposites.

Manufacturing of polymers: flow-sheet diagrams, properties & applications of PE, PP, PS, Polyesters, Nylons, ABS and PC.

Reading:

1. Fried J R, Polymer Science and Technology, Prentice Hall of India Pvt. Ltd., New Delhi, Eastern EconomyEdition, 2000.
2. Premamoy Ghosh, Polymer Science and Technology, Tata McGraw Hill Publishing Company, New Delhi, 3rd Edition, 2010.
3. R. Sinha, Outlines of Polymer Technology: Manufacture of Polymers, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
4. George Odian, Principles of Polymerization, John Wiley & Sons, Inc., 2004.

CH318	MATERIAL SCIENCE FOR CHEMICAL ENGINEERS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Select methods of characterization of engineering materials
CO2	Identify materials for applications in chemical process industry
CO3	Assess the life time of materials under different process environments
CO4	Analyze the interactions between materials of construction of equipment and the chemicals processed

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	2	3	1	2	-	1	-	-	2	1	3	1
CO2	1	2	1	2	2	1	2	-	1	-	-	2	1	3	1
CO3	1	2	1	2	2	1	2	1	1	-	-	2	1	3	1
CO4	1	2	1	2	2	1	2	1	1	-	-	2	1	3	1

Detailed Syllabus:

Introduction: Composition of Earth, Natural versus synthetic materials, The Periodic Table, Metals, Ceramics, Refractory materials, Plastics and Polymers

Characterization techniques of metal alloys: Atomic structure, Metal alloy composition, microstructure, Mechanical properties, Corrosion properties, Erosion Properties, Electrical properties, Magnetic properties

Manufacturing Methods: minerals and extraction of iron, aluminium, magnesium copper & gold, Electrometallurgy, surface finishing, semiconductors for electronic chips, polymers & plastics

Selection of MOC: mechanical design – cantilever, pressure vessels, corrosion factor for chemical contact, waste water treatment plants, water pipelines, crude oil pipelines

Reading:

1. Brian S. Mitchell, An Introduction to Materials Engineering and Science: For Chemical and Materials Engineers, John Wiley & Sons, Inc., 2004.
2. Anderson J.C., Leaver K.D., P. Leevers & Rawlings R.D., Material Science for Engineers, CRC Press, 5th Edition, 2003.

3. Subramaniam R., Callister's Material Science and Engineering, Wiley, 2nd Edition, 2014.
4. V. Raghavan, Materials Science and Engineering: A First Course, Prentice Hall India Learning Private Limited, 6th Edition, 2015.
5. O.P. Gupta, Elements of Fuels, Furnaces, & Refractories, Khanna Publishers, 2002.

CH351	PROCESS DYNAMICS AND CONTROL	PCC	3 – 1 – 0	4 Credits

Pre-requisites: MA201-Mathematics-III

Course Outcomes: At the end of the course, the student will be able to:

CO1	Evaluate the dynamic behavior of processes
CO2	Analyze stability of feedback control system
CO3	Design PID controllers
CO4	Determine frequency response for controllers and processes
CO5	Apply advanced control schemes for processes
CO6	Identify the characteristics of control valves

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	-	-	-	-	-	-	1	2	3	3
CO2	3	3	3	2	3	-	-	-	-	-	-	1	2	3	3
CO3	3	2	3	3	3	-	-	-	-	-	1	1	2	3	3
CO4	3	3	2	`3	3	-	-	-	-	-	-	1	1	3	3
CO5	3	3	3	3	3	-	-	-	-	-	1	1	2	3	3
CO6	3	3	3	2	3	-	-	-	-	-	-	1	3	3	2

Detailed Syllabus:

Introduction to process control. Laplace transforms.

Response of first order systems: Transfer Function, Transient Response, Forcing Functions and Responses. Examples of first and second order systems. Linearization, Transportation Lag.

State space models – linear and nonlinear models. Linearization.

Components of a control system, Development of Block Diagrams, Controllers and Final Control Elements. Closed loop Transfer functions: Standard Block-Diagram Symbols, Transfer Functions for Single-Loop Systems and Multi-loop Systems.

Transient response of simple control systems: Servo Problem, Regulatory Problem, Controllers: Proportional, Proportional-Integral, PID Controllers. Ziegler-Nichols and Cohen-Coon Controller Settings. Model based controller design methods: direct synthesis method and IMC method.

Stability: Routh Test and Root Locus Techniques.

Introduction to frequency Response: Substitution Rule, Bode Diagrams. Control system design based on frequency response: Bode and Nyquist Stability Criterion, Gain and Phase Margins.
Advanced Control Strategies: Cascade Control, Feed-forward Control, Ratio Control, Dead-Time Compensation (Smith Predictor), Split Range Control.
Control Valves: Types of Control Vales, Valve Sizing, Valve Characteristics, Valve Positioner.

Reading:

1. Coughanowr D.R., Process System analysis and Control, McGraw Hill, 3rd Edition, 2012.
2. Seborg D.E., Edgar T. E.,Millichamp D.A. and Doyle, F., Process Dynamics and Control, John Wiley & Sons, 3rd Edition, 2010.
3. Stephanopolis G., Chemical Process Control, Prentice Hall India, 2008.
4. B. Wayne Bequette, Process Control: Modeling, Design and Simulation, Prentice Hall India Learning Private Limited, 2003.
5. Romagnoli, J. A. and Palazoglu, A., Introduction to Process Control, CRC Press, 2nd Edition, 2012.
6. Corriou, J.P., Process Control: Theory and Applications, Springer, 2nd Edition, 2018.
7. K. Krishnaswamy, Process Control, New age publishers, 2009.

CH352	PROCESS EQUIPMENT DESIGN	PCC	3-1-0	4 credits

Pre-requisites:CH202-Fluid and Particle Mechanics; CH252-Heat Transfer; CH301-Chemical Reaction Engineering-II; CH302-Mass Transfer-II

Course Outcomes: At the end of the course, the student will be able to:

CO1	Evaluate the process design considerations of separation columns and heat transfer equipment
CO2	Draw process flow diagrams and process instrumentation diagrams
CO3	Apply mechanical design concepts to process equipment
CO4	Design heat exchangers, evaporators, absorbers, distillation columns, reactors

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	2	-	-	1	-	-	-	-	-	2	3	3	-	1
CO2	-	2	-	-	1	-	-	-	-	-	-	-	3	-	1
CO3	2	-	3	3	2	2	-	-	-	-	-	-	3	-	1
CO4	2	-	3	3	2	3	-	-	-	-	-	-	3	-	1

Detailed syllabus:

Introduction to process design of Separation columns (Distillation, Absorption, and Extraction): Design variables, general design considerations, process design methods, Column sizing, Plate and packed column hydraulics design.

Process design of heat-transfer equipment: Types of heat exchanger, Process design of shell and tube heat exchanger, Condenser, and reboilers.

Drawing: Drawing of process equipment symbols for fluid handling, heat transfer, mass transfer, and mechanical operations Detailed drawing of equipment, Drawing of process flow diagram, Piping and instrumentation diagram (P&ID), Vessel and piping layout isometrics.

Mechanical Design of Process Equipment: Introduction to mechanical aspects of chemical equipment design, Design Preliminaries, Design of cylindrical and spherical vessels under internal pressure, external pressure and combined loading, Design of heads and closers, Design of tall vessels. Design of a heat exchanger, Design of an absorber, Design of a distillation column, Design of evaporator, Design of condenser, Design of a chemical reactor.

Reading:

1. R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Volume 06, Elsevier, 3rd Edition, 2005.
2. Robert E. Treybal, Mass Transfer Operations, McGraw Hill Education, 3rd Edition, 1980.
3. Donald Q. Kern, Process Heat Transfer, Tata McGraw-Hill Education, Indian Edition, 1st Edition, 2017.
4. Bhattacharya B.C., Introduction to Chemical Equipment Design- Mechanical Aspects, CBS Publishers and Distributors, 2008.
5. Mahajani V.V. and Umarji S.B., Joshi's process equipment design, Trinity Press, 4th Edition, 2014.
6. Brownell L.E, Process Equipment Design - Vessel Design, Wiley Eastern Ltd., 1986.
7. Towler G. P. and R. K. Sinnott, Chemical Engineering Design, Principles, Practice and Economics of Plant and Process Design, Butterworth Heinemann, 2nd Edition, 2012.
8. Nicholas O Cheremisinoff, Handbook of chemical process equipment, Butterworth-Heinemann, 2000.

CH353	PETROLEUM REFINING PROCESSES	3	1	0	4	PCC

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Characterize the petroleum and petroleum products
CO2	Identify the methods involved in crude preprocessing
CO3	Design the fractionating column for crude
CO4	Differentiate the treatment techniques involved in post processing of crude
CO5	Apply the process flow technologies for crude conversion to fuels

Course Articulation Matrix

PO CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	-	-	2	3	3	-	-	-	-	-	3	3	3
CO2	1	3	-	-	-	-	3	-	-	-	-	-	3	3	3
CO3	3	3	-	-	3	1	3	-	-	-	-	-	3	3	3
CO4	3	3	-	`-	-	1	3	-	-	-	-	-	3	3	3
CO5	3	3	-	-	-	-	3	-	-	-	-	-	3	3	3

Detailed syllabus:

Origin, formation and composition of petroleum: Origin and formation of petroleum, Reserves and deposits of world, Petro Glimpses and petroleum industry in India, Composition of petroleum. Petroleum processing data: Evaluation of Petroleum, Thermal properties of petroleum fractions, important products-properties and test methods

Fractionation of petroleum: Dehydration and desalting of crudes, heating of crudes, Distillation of petroleum, blending of gasoline.

Treatment techniques: Fractions-Impurities, Gasoline treatment, Treatment of kerosene, Treatment of lubes, Wax and purification.

Thermal and catalytic processes: Cracking, Catalytic cracking, Catalytic reforming-introduction and theory, Naptha cracking, Coking, Hydrogen processes, Alkylation, Isomerization processes, Polymer gasoline.

Reading:

1. B.K. Bhaskara Rao, Modern Petroleum Refining Processes, 4th Edition, Oxford& IBH Publishing Co. Pvt. Ltd., 2008.
2. J.G. Speight, and B. Ozum, Petroleum Refining Processes, Marcel Dekker, 2002.
3. Mohamed A. Fahim, Taher A. Al-Sahhaf, Amal Elkilani, Fundamentals of Petroleum Refining, Elsevier Science, 2010
4. R. A. Meyers, Hand Book of Petroleum Refining Processes, McGraw Hill, 3rd Edition, 2003.

CH354	POLLUTION CONTROL IN PROCESS INDUSTRIES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: CH304-Chemical Technology

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze the effects of pollutants on the environment.
CO2	Distinguish air pollution control methods
CO3	Assess treatment technologies for wastewater
CO4	Identify treatment technologies for solid waste

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	2	2	-	1	2	1	1	1	1	1	1	-	-
CO2	3	1	2	2	-	1	2	1	1	1	1	1	1	-	-
CO3	3	2	3	2	2	3	3	1	1	1	1	1	3	3	3
CO4	3	2	3	2	2	3	3	1	1	1	1	1	3	3	3

Detailed Syllabus:

Introduction: Biosphere, Hydrological cycle, Nutrient cycle, Consequences of population growth, Pollution of air, Water and soil.

Air pollution sources & effects: Classification and properties of air pollutants, Emission sources, Behavior and fate of air pollutants, Effect of air pollution.

Meteorological aspects of air pollutant dispersion: Temperature lapse rates and stability, Wind velocity and turbulence, Plume behavior, Dispersion of air pollutants, Estimation of plume rise.

Air pollution sampling and measurement: Types of pollutant sampling and measurement, Ambient air sampling, Stack sampling, Analysis of air pollutants.

Air pollution control methods & equipment: Control methods, Source correction methods, Cleaning of gaseous effluents, Particulate emission control, Selection of a particulate collector, Control of gaseous emissions, Design methods for control equipment.

Control of specific gaseous pollutants: Control of sulphur dioxide emissions, Control of nitrogen oxides, Carbon monoxide control, Control of hydrocarbons and mobile sources.

Water pollution: Water resources, Origin of wastewater, types of water pollutants and their effects.

Waste water sampling, analysis and treatment: Sampling, Methods of analysis, Determination of organic matter, Determination of inorganic substances, Physical characteristics, Bacteriological measurement, Basic processes of water treatment, Primary treatment, Secondary treatment, Advanced wastewater treatment, Recovery of materials from process effluents.

Solid waste management: Sources and classification, Public health aspects, Methods of collection, Disposal Methods, Potential methods of disposal.

Hazardous waste management: Definition and sources, Hazardous waste classification, Treatment methods, Disposal methods.

Reading:

1. Rao C.S., Environmental Pollution Control Engineering, Wiley Eastern Limited, India, 1993.
2. Noel de Nevers, Air Pollution and Control Engineering, McGraw Hill, 2000.
3. Glynn Henry J., Gary W. Heinke, Environmental Science and Engineering, Prentice Hall of India, 2nd Edition, 2004.
4. Rao M.N, Rao H.V.N, Air Pollution, Tata McGraw Hill Publishing Ltd., 1993.
5. De A.K, Environmental Chemistry, Tata McGraw Hill Publishing Ltd., 1999.
6. George Tchobanoglous, Franklin Louis Burton, H. David Stensel, Metcalf & Eddy, Inc., Franklin Burton, waste water engineering: treatment and reuse, McGraw Hill Education; 4th Edition, 2003.
7. E-waste recycling, NPCS Board of consultants and Engineers, Asia Pacific Business Press Inc. 2015
8. Nicholas P. Cheremisinoff, Handbook of Pollution Prevention Practices, CRC press, 2001.

CH355	MINOR RESEARCH PROJECT	PCC	0 – 1 – 2	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Conduct an independent research project involving experimentation/modelling/simulation/optimization in chemical engineering
CO2	Analyze the results
CO3	Communicate the research results orally to an audience
CO4	Present a detailed written report

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	3	3	1	1	2	2	1	2	2	2	3	2
CO2	3	3	3	3	3	1	1	2	2	1	2	2	2	3	2
CO3	-	-	-	-	-	-	-	2	2	3	-	-	2	3	2
CO4	-	-	-	-	-	-	-	2	2	3	-	-	2	3	2

Detailed Syllabus

The student is required to choose any one of the following:

1. Project involving experimentation/modelling/simulation/design/optimization inchemical engineering and allied areas related to research/industry/society
2. Develop prototype/lab experiments.
3. Generation and interpretation of additional experimental data using existing UG/PG lab experimental setups
4. Develop virtual model

The report shall contain: Certificates from the student and the guide / supervisor regarding the bonafide nature of the work.

i. Introduction

ii. Literature review

iii. Problem definition / scope and motivation for the work

iv. Experimental work / mathematical modeling and Analysis / Simulation

v. Results and Discussion

vi. Conclusions

Nomenclature.

References

Minimum number of pages in the report should be 25.

Written report shall adhere to the prescribed format

Reading:

1. Relevant Journals and magazines

CH361	WASTEWATER TREATMENT	PCC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify methods for characterization of wastewater
CO2	Describe stages of treatment methods
CO3	Select advanced methodologies for treating wastewater
CO4	Appraise sustainability and carbon footprint

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	3	2	1	-	-	-	-	-	-	-	-	2	1
CO2	3	1	3	3	1	-	-	-	-	-	-	-	-	2	1
CO3	3	1	3	3	1	-	-	-	-	-	-	-	-	2	1
CO4	3	1	3	2`	1	-	-	-	-	-	-	-	-	2	1

Detailed syllabus

Introduction to Wastewater Treatment.

Biology: Bacteria and Fungi, Protozoa, Viruses, Algae, Waterborne Diseases, Biological Oxygen Demand, Chemical Oxygen Demand, Biological Treatment Systems, Biological Kinetics.

Water Quality: Safe Drinking Water Act, Microbiological Quality of Drinking Water, Chemical Quality of Drinking Water, Clean Water Act, National Pollutant Discharge Elimination System (NPDES), Pollution Effect on Aquatic Life, Groundwater Quality, Seawater Quality.

Wastewater Flows and Characteristics: Domestic Wastewater, Industrial Wastewater, Infiltration and Inflow, Municipal Wastewater, Composite Sampling, Evaluation of Wastewater.

Wastewater Processing: Considerations in Plant Design, Preliminary Treatment, Pumping Stations, Sedimentation, Biological Filtration, Biological Aeration, Mathematical Model for Completely Mixed Aeration, Stabilization Ponds, Effluent Disinfection, Individual Household Disposal Systems, Characteristics and Quantities of Waste Sludge, Sludge Pumps, Sludge Thickening, Regulatory Requirements for Treatment and Disposal of Sewage Sludge, Requirements for Class B Bio-solids, Requirements for Class A Bio-solids, Dewatering, Bio-solids Disposal, Odor Control.

Advanced Wastewater Treatment: Limitations of Conventional Treatment, Suspended solids removal, Pathogen Removal, Toxic substance removal, Phosphorus in Wastewaters, Chemical – Biological Phosphorus removal, Nitrogen in Wastewaters, Biological Nitrification and De-nitrification. Membrane processes: Microfiltration, ultrafiltration, reverse osmosis.

Sustainability and Carbon Footprint: Water and Wastewater Systems, Balance between Sustainability and Advanced Wastewater Treatment.

Reading:

1. Hammer and Hammer, Jr., Water and Wastewater Technology, Pearson Education Inc., 7th Edition, 2012.
2. MetCalf, Eddy, Wastewater Engineering: Treatment and Reuse, Tata McGraw Hill, 2003.
3. Arceivala, S. J. and Asolekar, S. R., Wastewater Treatment for Pollution Control and Reuse, Tata McGraw Hill, 3rd Edition, 2007.
4. Hanley, N. and Bhatia, S. C., Pollution Control in Chemical and Allied Industries, CBS Publishers, 2010.
5. Tchobanoglous G., Burton F. L., Stensel H.D., Wastewater Engineering: Treatment and Reuse, Tata McGraw Hill, 4th Edition, 2002.
6. Nicholas P. Cheremisinoff, Handbook of Water and Wastewater Treatment Technology, CRC Press, 1994.

CH362	FERTILIZER TECHNOLOGY	DEC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Classify fertilizers
CO2	Explain manufacturing processes for production of fertilizers
CO3	Identify the effect of technologies on the health, safety and environment.
CO4	Explain the mechanism of chemical reactions

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	3	-	-	-	-	3	-	-	-	-	-	3	1	-
CO2	1	3	-	-	-	-	3		-	-	-	-	3	1	-
CO3	1	3	-	-	-	-	3	-	-	-	-	-	3	3	-
CO4	1	3	-	-	-	-	3	-	-	-	-	-	3	1	-

Detailed syllabus:

Introduction: Elements required for plants growth, Classification of fertilizers, Compound, Complex and bulk blended fertilizers. N-P-K values and calculations.

Nitrogenous Fertilizers: Manufacturing Processes for Ammonia, Manufacture of ammonium sulphate, ammonium chloride, Ammonium phosphate, Ammonium nitrate, nitric acid, Urea etc. Economics and other strategies, Material of construction and corrosion problem.

Phosphatic fertilizers: Calculation of percentage tricalcium phosphate of lime in phosphatic rock: Manufacture of triple super phosphate and single super phosphate, Nitro phosphate, Sodium phosphate, phosphoric acid and other phosphatic fertilizers.

Potash Fertilizers: Manufacture of potash fertilizers like potassium sulphate, potassium chloride.

Complex Fertilizers: Processes for nitro-phosphates and complex NPK fertilizers liquid fertilizers

Reading:

1. Sittig M and GopalaRao M., Dryden's Outlines of Chemical Technology for the 21st Century, WEP East West Press, 3rd Edition, 2010.
2. Austin G T., Shreve's Chemical Process Industries, McGraw Hill Book Company, New Delhi, 5th Edition, 1986.
3. Handbook on Fertilizer Technology, Fertilizer Association of India, JNU, New Delhi, 2nd Edition, 1977.
4. Shukla S D and Pandey G N, A Text Book of Chemical Technology, Vol I & II, Vikas Publishing House Pvt. Ltd., New Delhi, 2000.
5. Eugene Perry, Fertilizers: Science and Technology, Callisto Reference Publisher, 2018.
6. A.K. Kolay, Manures and Fertilizers, Atlantic, 2008.

CH363	FOOD TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Explain techniques in food processing
CO2	Design process equipment to achieve the desired quality of food.
CO3	Develop novel food processes that have a minimal effect on food quality
CO4	Select control strategies to maintain food quality.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	3	-	-	-	-	3	-	-	-	-	-	3	2	-
CO2	1	3	2	3	-	-	3		-	-	-	-	3	3	-
CO3	1	3	2	2	-	-	3	-	-	-	-	-	3	3	-
CO4	1	3	-	3	-	1	3	-	-	-	-	-	3	3	-

Detailed Syllabus:

Introduction: General aspects of food industry, World food demand and Indian scenario, Constituents of food, Quality and nutritive aspects, Product and Process development, engineering challenges in the Food Processing Industry.

Basic principles: Properties of foods and processing theory, Heat transfer, Effect of heat on micro-organisms, Basic Food Biochemistry and Microbiology: Food Constituents; Food fortification, Water activity, Effects of processing on sensory characteristics of foods, Effects of processing on nutritional properties, Food safety, good manufacturing practice and quality Process Control in Food Processing.

Ambient Temperature Processing: Raw material preparation, Size reduction, Mixing and forming, Separation and concentration of food components, Centrifugation, Membrane concentration, Fermentation and enzyme technology, Irradiation, Effect on micro-organisms, Processing using electric fields, high hydrostatic pressure, light or ultrasound.

Heat processing using steam, water and air: Blanching, Pasteurisation, Heat sterilization, Evaporation and distillation, Extrusion, Dehydration, Baking and roasting.

Heat processing by direct and radiated energy: Dielectric heating, Ohmic heating, Infrared heating, Gamma irradiation.

Post Processing Applications Packaging: Coating or enrobing, Theory and Types of packaging materials, Printing, Interactions between packaging and foods, Environmental considerations.

Reading:

1. Fellows P., Food Processing Technology: Principles and Practice, Woodhead Publishing, 4th Edition, 2016.
2. Toledo R, Fundamentals of Food Process Engineering, Springer, 3rd Edition, 2010.
3. Singh R.P. & Heldman D.R., Introduction to Food Engineering, Academic Press, 3rd Edition, 2001.

CH364	GREEN TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand principles and concepts of green chemistry
CO2	Develop manufacturing processes to reduce wastage and energy consumption.
CO3	Design the technologies to reduce the level of emissions from buildings and core infrastructure
CO4	Analyze the effects of pollutants on the environment

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	2	3	1	-	-	-	-	3	2	1
CO2	3	3	3	1	1	2	3	-	-	-	-	-	3	2	2
CO3	3	3	3	1	1	2	3	-	-	-	-	-	3	2	2
CO4	3	3	2	`2	2	2	3	1	-	-	-	-	3	2	3

Detailed Syllabus:

Principles and concepts of Green Chemistry: Introduction, Sustainable Development and Green Chemistry, Rearrangement Reactions, Addition Reactions, Atom Un-economic Reactions, Substitution Reactions, Elimination Reactions, Wittig Reactions, Toxicity.

Waste- Production, Problems and Prevention: Introduction, Some Problems Caused by Waste, Sources of Waste from the Chemical Industry, the Cost of Waste, Waste Minimization Techniques.

Measuring and controlling environmental performance: The Importance of Measurement, Lactic Acid Production, Safer Gasoline, and Introduction to Life Cycle Assessment, Green Process Metrics, and Environmental Management Systems.

Catalysis and green chemistry: Introduction to Catalysis, Comparison of Catalyst Types, Heterogeneous Catalysts, Basics of Heterogeneous Catalysis and Homogeneous Catalysis.

Organic solvents, Environmentally benign solutions: Organic Solvents and Volatile Organic Compounds, Solvent-free Systems, Supercritical Fluids, Supercritical Carbon Dioxide, Supercritical Water, Water as a Reaction Solvent, Water-based Coatings, Ionic Liquids, Ionic Liquids as Catalysts, Ionic Liquids as Solvents, Fluorous Biphase Solvents.

Renewable Energy as a means of Green energy: Role of Renewable energy sources in promoting Green Technology.

Emerging Greener technologies and Alternative energy solutions: Design for Energy Efficiency, Photochemical Reactions, Advantages of and Challenges Faced by Photochemical, Processes, Examples of Photochemical Reactions, Chemistry Using Microwaves, Microwave Heating, Microwave-assisted Reactions, Sonochemistry, Sonochemistry and Green Chemistry, Electrochemical Synthesis, Examples of Electrochemical Synthesis.

Designing greener processes: Conventional Reactors, Batch Reactors, Continuous Reactors, Inherently Safer Design, Minimization, Simplification, Substitution, Moderation, Limitation, Process Intensification, Some PI Equipment, Examples of Intensified Processes, In-process Monitoring, Near-infrared Spectroscopy.

Inherent safety – safety in design, case studies of major accidents

An integrated approach to a greener chemical industry: Society and Sustainability, Barriers and Drivers, The Role of Legislation, EU White Paper on Chemicals Policy, Green Chemical Supply Strategies.

Reading:

1. Mike Lancaster, Green Chemistry, Royal Society of Chemistry, 2010.
2. Paul T. Anastas, John C. Warner, Green Chemistry: Theory and Practice, Oxford University Press, 2000.
3. Jay Warmke, Annie Warmke, Green Technology, Educational Technologies Group, 2009.
4. James Clark and Duncan Macquarrie, Handbook of Green Chemistry & Technology, Blackwell Publishing, 2002.
5. S. Suresh and S. Sundaramoorthy, Green Chemical Engineering: An introduction to Catalysis, Kinetics, and Chemical Processes, CRC Press, 2015.

CH365	PULP AND PAPER TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Explain process for manufacturing paper.
CO2	Identify harmful impacts of paper and pulp industries on environment.
CO3	Describe mechanical-chemical pulping processes
CO4	Distinguish methods for pulp treatment.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	3	2	2	2	2	2	-	-	2	-	1	3	2	1
CO2	2	3	3	2	2	2	3	-	2	2	-	2	2	2	1
CO3	2	3	2	2	2	2	2	-	-	2	-	1	3	2	1
CO4	2	3	2	-	-	2	2	-	-	2	-	1	3	3	2

Detailed Syllabus:

Introduction and Paper making raw materials: History of Paper Making, Paper making raw materials: Wood anatomy and chemistry, Wood chip preparation and handling at the pulp mill, Solid wood measurement, Properties of selected wood species.

Pulping processes and Pulp treatment: Introduction to pulping, Mechanical pulping, Chemical pulping, Semi-chemical pulping, Soda pulping, Kraft pulping, Sulfite pulping, Other pulping methods, Bleaching mechanical pulps, Measurement of lignin content, Bleaching chemical pulps, Chemical recovery, Refining, Pulp characterization.

Paper making equipment and process: Fiber preparation and approach, Raw materials, Functional additives, Control additives, Wet end chemistry, Paper manufacture, Paper machine, headbox, fourdrinier wet end, Twin wire formers, cylinder machine, press section, dryer section, Post drying operations, Coating.

Environmental protection: Water pollution, Water quality tests, Aqueous effluent treatments, Air pollution, Air quality tests and control, Solid waste disposal.

Properties of paper: General grades of paper, Structure, Mechanical and chemical properties, Basic optical tests of paper.

Reading:

1. J.P. Casey, Pulp and Paper: Chemistry and Chemical Technology, Volumes 1 & 2, Wiley Interscience, 3rd Edition, 1980.
2. G.A. Smook, Handbook for Pulp and Paper Technologists, Angus Wilde Publ, Inc, 3rd Edition, 2002.
3. Christopher J. Biermann, Handbook of Pulping and Paper Making, Academic Press, 1996.
4. Monika EK, Goran Gellerstedt, Gunnar Henrikson, Pulping Chemistry and Technology, Walter De Gruyter & Co, 2009.
5. George T. Austin, Shreve's Chemical Process Industries, McGraw Hill Education, 5th Edition, 2017.

CH366	CATALYSIS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: CH301-Chemical Reaction Engineering-II

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the basic concepts of catalysis
CO2	Analyze the role of heat and mass transfer in the catalytic reactor design
CO3	Describe the methods of preparation and characterization of catalysts
CO4	Distinguish the performance of catalytic reactors
CO5	Identify the role of catalysts in the environmental protection

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	1	-	-	-	-	-	-	-	-	3	2	1
CO2	2	3	2	1	-	-	-	-	-	-	-	-	3	1	1
CO3	2	1	2	1	-	-	-	-	-	-	-	-	1	1	1
CO4	2	3	1	1	-	-	-	-	-	-	-	-	1	1	1
CO5	-	-	-	-	-	-	3	-	-	-	-	-	1	1	1

Detailed syllabus:

Basic concepts in heterogeneous catalysis and green chemistry. Catalyst preparation and characterization, Optimal distribution of catalyst in a pellet. Surface reactivity and kinetics of reaction on surfaces, poisoning and regeneration.

Heat and mass transfer and its role in heterogeneous catalysis. Calculations of effective diffusivity and thermal conductivity of porous catalysts.

Industrially important catalysts and processes such as oxidation, processing of petroleum and hydrocarbons, synthesis gas and related processes, Environmental catalysis. Zeolite catalysts, preparation, characterization and applications.

Commercial Catalytic Reactors (Adiabatic, fluidized bed, trickle bed, slurry etc.). Selection and design and preparation of catalysts.

Reading:

1. John Meurig Thomas, W. J. Thomas, Principles and Practice of Heterogeneous Catalysis, Wiley VCH; 2nd Edition, 2014.
2. James John Carberry, Chemical and Catalytic Reaction Engineering, Dover Publications, INC, 2001.
3. L. K. Doraiswamy, M. M. Sharma, Heterogeneous Reactions: Fluid-fluid-solid Reactions, Wiley, 1984.
4. B. Viswanathan, S. Sivasanker, and A.V. Ramaswamy, Catalysis: Principles and Applications, Narosa Publishing House, 2002.
5. B. Viswanathan, S. Kannan, R.C. Deka, Catalysts and Surfaces: Characterization Techniques, Alpha Science International, 2010.

CH367	EXPERIMENTAL AND ANALYTICAL TECHNIQUES	DEC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Differentiate Microscopy techniques
CO2	Decide the spectroscopy methods
CO3	Select the electro-analytical techniques
CO4	Choose the separation techniques

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	-	3	2	-	-	-	-	3	-	1	-	-	-
CO2	3	3	-	3	2	-	-	-	-	3	-	1	-	-	-
CO3	3	3	-	3	2	-	-	-	-	3	-	1	-	-	-
CO4	3	3	-	3	2	-	-	-	-	3	-	1	-	-	-

Detailed syllabus:

Microscopy Techniques: scanning electron microscopy (SEM); secondary Auger microscopy (SAM); scanning probe microscopy (SPM); scanning tunneling microscopy (STM); transmission electron microscopy (TEM); upright microscope, inverted microscope, image analysis.

Spectroscopy methods: FTIR, AAS, UV-VIS, UV-fluorescent, Wavelength and energy dispersive X-ray fluorescence spectroscopy (WDS and EDS); X-ray absorption spectroscopy (XANES and EXAFS); secondary ion mass spectrometry (SIMS); temperature programmed desorption (TPD); thermal desorption spectroscopy TDS), ICP-OES, XRD.

Atomic absorption spectroscopy (AAS); inductively coupled plasma-atomic emission spectroscopy (ICP-AES).

Electroanalytical Techniques: Voltametry; coulometry; amperometry; potentiometry; polarography; electrolytic conductivity; impedance spectroscopy, rotating disc electrode, rotating ring disc electrode.

Separation Methods: Normal and reversed phase liquid chromatography (NP- & RP-LC); Gas Chromatography (GC); GC-MS; High Performance Liquid Chromatography (HPLC); Size-Exclusion Chromatography (SEC); Ion Chromatography (IC).

Reading:

1. R. Wiesendanger, Scanning Probe Microscopy and Spectroscopy, Cambridge University Press, 1994.
2. Frank A. Settle, Handbook of instrumental techniques for analytical chemistry, Prince Hall, New Jersey, 1997.
3. D. A. Skoog, D. M. West, F. J. Holler and S. R. Couch, Fundamentals of analytical chemistry. Brooks/ColeCengage learning, New Delhi, 2004.
4. P. Atkins and J. de Paula, Atkins' physical chemistry, Oxford University Press, New Delhi, 8th Edition, 2008.
5. K. W. Kolasinski, Surface Science: Foundations of Catalysis and Nanoscience, John Wiley and Sons, 2002.
6. Gregory S. Patience, Experimental Methods and Instrumentation for Chemical Engineers, Elsevier, 2nd Edition, 2018.

CH368	COMPLEX FLUIDS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Distinguish the complex fluids from classical fluids
CO2	Understand the macroscopic behavior of the complex fluids.
CO3	Identify forces involved in complex fluids.
CO4	Analyze rheology of polymers, glassy liquids and gels
CO5	Understand rheology of suspensions, surfactant solutions and block copolymers

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	2	1	-	-	-	2	2	-	1	2	1	2
CO2	2	2	1	2	1	-	-	-	2	2	-	1	2	1	2
CO3	2	2	1	2	1	-	-	-	2	2	-	1	2	1	2
CO4	2	2	1	2	1	-	-	-	2	2	-	1	2	1	2
CO5	2	2	1	2	1	-	-	-	2	2	-	1	2	1	2

Detailed Syllabus:

Introduction to Complex fluids: Complex fluids vs. classical solids and liquids; Examples; Rheological measurements and properties; Kinematics and Stress; Structural probes of complex fluids; Computational methods; Stress tensor

Basic forces: Excluded volume interactions; Vander Waals interactions; Electrostatic interactions; Hydrogen bonding; hydrophilic and other interactions.

Rheology of Polymers, glassy liquids and polymer gels: Polymers –Theory and Rheology of polymers; Glassy liquids – Theory and rheology of glassy liquids; Polymer gels – Theory and rheology of gels.

Suspensions: Particulate gels – particle interactions, Rheology of particulate gels; Foams, Emulsions and Blends – Emulsion preparation, Rheology of emulsions, immiscible blends and foams;

Rheology of surfactant solutions and block copolymers

Reading:

1. Larson RG, The Structure and Rheology of Complex Fluids, Oxford University Press, 1999.
2. Chhabra RP, Richardson JF, Non-Newtonian Flow and Applied Rheology: Engineering Applications, Butterworth-Heinemann, 2nd Edition, 2008.
3. Abhijit PD, Murali Krishna J, Sunil Kumar PB, Rheology of Complex Fluids, Springer, 2010.
4. Christopher W. Macosko, Rheology: Principles, Measurements and Applications, Wiley - VCH, 1994.
5. Alexander Ya. Malkin, Rheology Fundamentals, Chem Tech Publishing, 1994.

CH369	NATURAL GAS ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Describe the properties, phase behavior of natural gas.
CO2	Evaluate oil and gas reserve estimations, and bottom hole pressure calculations.
CO3	Select the compressors used in the natural gas industry.
CO4	Illustrate the production economics and production trends of natural gas.
CO5	Discuss LNG production and treatment technologies

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO 1	PSO 2	PSO 3
CO1	3	3	1	1	-	2	1	-	-	-	-	-	-	1	-
CO2	2	3	3	3	1	2	1	-	-	-	1	-	-	1	1
CO3	2	2	3	3	-	-	-	-	-	-	-	-	1	2	-
CO4	2	3	1	2	1	1	1	1	-	-	2	2	1	1	-
CO5	3	3	2	3	-	3	3	-	-	-	-	2	2	2	-

Detailed Syllabus:

Basics of natural gas reservoir: Composition of associated and non-associated gas, retrograde condensate wells, Physical properties of natural gas and associated liquid.

Phase Behavior: Physical properties of natural gas, Phase behavior of two-phase hydrocarbon systems, vapor liquid equilibria (VLE), pressure gradient in gas column, well head and bottom hole pressure.

Compression and Compressor: Various types of compressors, multi-phase compression; Liquefied natural gas (LNG).

Flow measurement: orifice meter, flow formula, critical flow meter, flow prover.

Field separation of oil from gas: Type of separators and Sizing, Oil absorption, low temperature separation

Natural gas and LNG treatment; world market implications and future trends, safety measures.

Reading:

1. Chi U. Ikoku, Natural Gas Production Engineering, John Wiley & Sons.1992.
2. Sanjay Kumar, Gas Production Engineering, Gulf Publishing Company, Volume 4, 1987.
3. Donald La Verne Katz, Robert L. Lee, Natural Gas Engineering: Production and Storage, McGraw Hill Inc., 1990.
4. Donald La Verne Katz, Hand Book of Natural Gas Engineering, McGraw Hill, 1959.
5. Hussain K. Abdel-Aal, Mohammed Aggour, M.A. Fahim, Petroleum and Gas field Processing, Marcel Dekker, 2003.
6. Saed Mokhatab, John Y. Mak, Jaleel V. Valappil, David A. Wood, Handbook of Liquefied Natural Gas, Elsevier Inc., 2014.
7. B. Guo, A. Ghalambor, Natural Gas Engineering Handbook, Gulf Publishing Company, Houston, 2005.
8. Alireza Bahadori, Natural Gas Processing: Technology and Engineering Design, Gulf Professional Publishing, 2014

CH401	PLANT DESIGN AND PROCESS ECONOMICS	PCC	3 – 1 – 0	4 Credits

Pre-requisites:CH303-Elements of Transport Phenomena

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze alternative processes and equipment for manufacturing a product.
CO2	Determine costs involved in process plants.
CO3	Perform economic analysis and optimum design of processes.
CO4	Evaluate project profitability.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	3	2	-	-	2	2		2	3	3	-	2	3	-
CO2	2	-	-	2	2	-	-	-	2	2	3	-	1	3	-
CO3	3	2	2		2	-	-	-	2	2	3	-	-	3	3
CO4	2	3	3	1`	2	-	-	-	2	3	3	-	2	3	2

Detailed Syllabus:

Introduction: Chemical Engineering plant design, Overall design consideration, Practical considerations in design, engineering ethics in design.

General Design Considerations: Health and Safety hazards, Loss prevention, Environmental Protection, Plant Location, Plant Layout, Plant Operation and Control.

Process Design Development: Development of design database, Process creation, Process design criteria, Process flow diagram (PFD), Equipment design specifications.

Flow sheet synthesis and development: General procedure, Process information, Functions diagram, Flow sheet synthesis, Software use in process design.

Cost and asset accounting: General accounting procedure, Balance sheet and Income statements.

Analysis of Cost Estimation: Cash flow for industrial operations, Factors affecting investment and production costs, Capital investments, Fixed capital and working capital, Estimation of capital investment, Cost indices, Estimation of total cost, Gross profit, Net profit and cash flow, Cost scaling factors, Net present value analysis.

Interest and Insurance: Interest, Simple interest, Compound interest, Nominal and effective interest rates, Continuous interest, Costs of capital, Time value of money, Annuity, Cash flow patterns, Income taxes, Present worth, Future worth, Taxes and Insurance.

Depreciation: Depreciable investments, Methods for calculating Depreciation.

Profitability Analysis: Profitability standards, Costs of capital, Minimum acceptable rate of return, Methods of calculating profitability, Rate of return on investment, Payback period, Net return, discounted cash flow rate of return, Net present worth, Pay-out period, Alternative investments, Replacements.

Optimum design and design strategy: Defining the optimization problem, Selecting an objective function, Structural optimization, parametric optimization, Variable screening and selection, Optimization Applications. Design Report.

Reading:

1. Peters M.S., K.D. Timmerhaus and R.E. West, Plant Design and Economics for Chemical Engineers, McGraw Hill, 5th Edition, 2011.
2. Turton R., R.C. Baile, W.B. Whiting, J. A. Shaeiwitz. Analysis, Synthesis and Design of Chemical Processes, PHI, New Delhi, 3rd Edition, 2011.
3. Seider W.D., J.D. Seader, D.R. Lewin, Product and Process Design Principles: Synthesis, Analysis, and Evaluation, Wiley, 2nd Edition, 2004.
4. James R. Couper, W. Roy Penny, James R. fair, Stanley M. Walas, Chemical Process Equipment: Selection and Design, Elsevier Butterworth-Heinemann, 2012.
5. R. Panneerselvam, Engineering Economics, Prentice Hall India, 2013.

CH402	DESIGN AND SIMULATION LABORATORY	PCC	0 – 1 – 4	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Carry out thermodynamic property estimations using Aspen
CO2	Simulate Mixer, splitter, pumps, compressors and flash units
CO3	Apply sensitivity, design specification and case study tools in Aspen
CO4	Design heat exchangers, reactors and distillation columns
CO5	Optimize process flow sheets using sequential modular and equation oriented approaches.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	-	-	-	-	-	-	3	3	3
CO2	3	3	3	3	3	1	-	-	-	-	-	-	3	3	3
CO3	3	3	3	3	3	3	-	-	-	-	-	-	3	3	3
CO4	3	3	3	3	3	2	-	-	-	-	-	-	3	3	3
CO5	3	3	3	3	3	2	-	-	-	-	-	-	3	3	3

Detailed syllabus

Solve the following steady state simulation exercises using **Aspen:**

1. Physical property estimations.
2. Simulation of individual units like, mixers, splitters, heat exchangers, flash columns and reactors
3. Design and rating of heat exchangers
4. Design and rating of distillation columns.
5. Mass and Energy balances.
6. Handling user specifications on output streams – Sensitivity and design Spec tools.
7. Simulation of a flow sheet
8. Simulation exercises using calculator block
9. Optimization Exercises
10. Simulation using equation oriented approach

Reading:

1. Lab manuals / Exercise sheets
2. A.K.Jana, Chemical Process Modelling and Computer Simulation, Prentice Hall India, 3rd Edition, 2018.

CH403	PROCESS INSTRUMENTATION AND CONTROL LABORATORY	PCC	0 – 1 – 2	2 Credits

Pre-requisites: CH255 - Process Instrumentation, CH351 - Process Dynamics and Control.

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify the dynamics of first order, second order, interacting and non-interacting processes
CO2	Implement PID controller on a level control process
CO3	Evaluate the characteristics of I-P and P-I converters
CO4	Apply cascade and ratio control schemes
CO5	Determine control valve characteristics

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	2	3	1	-	-	-	-	-	-	-	3	3	2
CO2	3	1	2	3	3	-	-	-	-	-	-	-	1	3	2
CO3	3	1	1	3	3	-	-	-	-	-	-	-	1	3	2
CO4	3	1	2	`3	3	-	-	-	-	-	-	-	1	3	2
CO5	3	1	2	3	2	-	-	-	-	-	-	-	1	3	2

Detailed Syllabus:

List of experiments:

1. Dynamics of non-interacting process
2. Dynamics of interacting process
3. Dynamics of first and second order processes
4. Flapper nozzle system
5. Measurement of liquid level using DPT
6. Characteristics of I&P and P&I converters
7. Control valve characteristics
8. Control of liquid level in a cylindrical tank process
9. Cascade control
10. Ratio control

Reading:

1. Lab manuals

CH449	PROJECT WORK - PART A	PRC	0 – 0 – 3	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Carry out literature review
CO2	Formulate the problem involving manufacture of a chemical product/ experimentation/ modelling/simulation/optimization/design
CO3	Analyze the results
CO4	Communicate the results orally to an audience
CO5	Present a written report

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	3	1	2	1	1	1	-	-	2	-	-	2	2	-
CO2	3	3	1	1	1	1	2	-	-	2	-	-	3	2	
CO3	3	3	3	3	2	1	1	1	2	1	-	-	3	3	3
CO4	3	3	3	`3	2	1	1	1	2	3	-	-	3	3	3
CO5	3	1	-	-	-	1	1		2	3	-	-	2	1	1

Detailed Syllabus

The student is required to choose any one of the following:

1. Project involving experimentation/modelling/simulation/Design/optimization in chemical engineering related to research/industry/society

   At the end of the semester, the student is required to present (i) Literature survey, (ii) Problem formulation, (iii) Methodology, (iv) Preliminary results, (v) Proposed work for the next semester, (vi) References

2. Project involving manufacture of any chemical product on industrial scale

   At the end of the semester, the student is required to present (i) market survey, (ii) Properties and Applications (iii) different processes for production, (iv) selection of process, (v) detained process description (vi) material balance, and (vii) References

Minimum number of pages in the report should be 30.

Written report shall adhere to the prescribed format.

Reading

1. Handbooks,
2. Journals and magazines
3. Martyn S. Ray and Martin G. Sneesby, Chemical Engineering Design Project: A Case Study Approach, Gordon and Breach Science Publishers, Second Edition, 1989.

CH411	BIOCHEMICAL ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand cell and enzyme kinetics
CO2	Discuss methods of immobilization.
CO3	Calculate volume of a bioreactor
CO4	State sterilization methods
CO5	Select downstream process to separate the products

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	1	-	1	2	1	-	-	-	-	3	3	
CO2	3	3	2	1	-	1	2	1	-	-	-	-	3	3	
CO3	3	3	2	1	-	1	2	1	-	-	-	-	3	3	
CO4	3	3	2	1	-	1	2	1	-	-	-	-	3	3	
CO5	3	3	2	1	-	1	2	1	-	-	-	-	3	3	

Detailed Syllabus:

Introduction: Biotechnology, Biochemical Engineering, Biological Process, Definition of Fermentation.

Enzyme Kinetics: Introduction, Simple Enzyme Kinetics, Enzyme Reactor with Simple Kinetics, Inhibition of Enzyme Reactions, and Other Influences on Enzyme Activity.

Immobilized Enzyme: Immobilization techniques and effect of mass transfer resistance.

Industrial application of enzymes: Carbohydrates, starch conversion and cellulose conversion.

Cell Cultivation: Microbial cell cultivation, animal cell cultivation, plant cell cultivation, cell growth measurement and cell immobilization.

Cell Kinetics and Fermenter Design: Introduction, growth cycle for batch cultivation, stirred tank fermenters, multiple fermenters connected series, cell recycling, alternate fermenters and structured model.

Sterilization: Sterilization methods, thermal death kinetics, design criterion, batch sterilization, continuous sterilization and air sterilization.

Agitation and Aeration: Introduction, basic mass transfer concepts, correlation for mass transfer co-efficient, measurement of interfacial area, correlations for ‘a’ and D_{32}, gas-holdup, power consumption, determination of oxygen absorption rate, correlation for k_{La}, scale-up and shear sensitivity.

Downstream Processing: introduction, solid-liquid separation, cell rupture, recovery and purification.

Reading:

1. James M. Lee, Biochemical Engineering, Prentice Hall, 1992.
2. James E. Bailey and David F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill International, 2nd Edition, 1986.
3. Michael L. Shuler and Fikret Kargi, Bioprocess Engineering – Basic Concepts, Prentice Hall of India, 2nd Edition, 2002.

CH412	INTERFACIAL SCIENCE	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the interfacial phenomena occurring at macro scale and quantify the effect owing to interfacial properties.
CO2	Analyze ab-initio calculations for inter-colloidal forces.
CO3	Identify equipment and sensors for characterizing various interfaces.
CO4	Design processes that utilize interfacial phenomena to achieve a desired effect.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	3	1	1	-	-	-	-	-	-	-	-	-	-	-
CO3	1	3	1	1	-	-	-	-	-	-	-	-	-	-	-
CO4	3	3	3	3	-	-	-	-	-	-	-	-	-	-	-

Detailed Syllabus:

Introduction to types of interfaces: The importance of interfaces, Surfaces and interfaces, Stable interfaces.

Capillarity and surface tension: Surface tension and work, Measurement of surface tension, The Laplace equation, The Kelvin equation, The surface tension of pure liquids.

Adsorption and thermodynamics of surfaces: Introduction, Models of the interface, Adsorption, Thermodynamic properties of interfaces, Surface excess quantities, Measurement of Adsorption, Adsorption form solution, Kinetics of Adsorption.

Surfactants & Micelles, Films and foams: Introduction, Application of surfactants, Adsorption of surfactants, Micelles, films and foams, Aerosols.

Monolayers formation: Introduction, Formation of floating monolayers, Surface pressure-area relationships, Deposition of Langmuir Blodgett (LB) films, The study of film structure, the structure and properties of floating monolayers, Interactions in monolayers, the structures of LB films, characterization and application.

The liquid-liquid interface: Emulsions, Colloids, Membranes: Introduction, Emulsions, Emulsion stability and selection of the emulsion, Micro-emulsion, Emulsion polymerization, Liquid-liquid extraction, Membranes.

The liquid-solid interface: Introduction, Colloidal dispersions, The properties of colloidal dispersions, Coagulation of lyophobic colloids by electrolytes, solvent effects in colloidal interactions, Nanoparticles.

Reading:

1. Geoffrey Barnes and Ian Gentle, Interfacial Science: An Introduction, Oxford University Press, 2nd Edition, 2011.
2. Jacob N. Israelachvili, Intermolecular and Surface Forces, Academic Press, 3rd Edition, 2011.
3. John B. Hudson, Surface Science: An Introduction, John Wiley & Sons, 1998.
4. Paul C. Hiemenz and Raj Rajagopalan, Principles of Colloids and Surface Chemistry, Taylor and Francis, 3rdEdition, 1997.

CH413	STATISTICAL THERMODYNAMICS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the molecular level properties influencing the macroscopic thermodynamic properties.
CO2	Develop models for simulating real gases, liquids and solids using ensemble methods to estimate thermodynamic properties
CO3	Design molecular level architecture to enhance macroscopic properties.
CO4	Estimate macroscopic properties based on molecular level interactions.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	2	1	2	2	1	2	-	1	-	-	2	1	3	1
CO2	2	2	2	2	3	-	-	-	1	-	-	2	1	3	2
CO3	1	2	1	2	2	1	2	-	1	-	-	2	1	3	1
CO4	1	2	1	2	2	1	2	-	1	-	-	2	1	3	1

Detailed Syllabus:

Basics of Statistical Thermodynamics: The Statistical Foundation of Classical Thermodynamics, Classification Scheme for Statistical Thermodynamics, Importance of Statistical Thermodynamics.

Ensembles: Ensembles and Postulates, Canonical Ensemble, Canonical Ensemble and Thermodynamics, Grand Canonical Ensemble, Micro Canonical Ensemble, Thermodynamic Equivalence of Ensembles.

Evaluation of Probabilities: Probability- Definitions and Basic Concepts, Permutations and Combinations, Distribution Functions: Discrete and Continuous, Binomial Distribution, Poisson distribution, Gaussian Distribution, Combinatorial Analysis for Statistical Thermodynamics.

Criteriafor Equilibrium: Equilibrium Principles, States of Equilibrium: Neutral, Metastable, and Unstable equilibrium, Maximizing Multiplicity.

Modelfor Mono-atomic Ideal Gas and Polyatomic Ideal Gases: Energy Levels and Canonical Ensemble, Partition Function, Thermodynamic Functions for Mono-atomic Ideal Gases, Grand Ensemble, Internal Degrees of Freedom, Independence of Degrees of Freedom, Potential Energy

Surface, Vibration, Rotation, Thermodynamic Functions for Poly-atomic Ideal Gases, Hindered Internal Rotation in Ethane, Hindered Translation on a Surface.
Einstein's and Debye's Model of the Solid, Simple Liquids, Phase Equilibrium, Models for Multi-Component Systems: Ideal Lattice Gas, Lattice Gas with Interactions, Solutions (Bragg-William Model and Regular Solutions, Quasi-Chemical Model), Chemical Equilibrium.

Reading:

1. Leonard K. Nash, Elements of Statistical Thermodynamics, Dover Publications, 2^{nd} Edition, 2006.
2. Normand M. Laurendeau, Statistical Thermodynamics: Fundamentals and Applications, Cambridge University Press, 2005.
3. Stanley I. Sandler, An Introduction to Applied Statistical Thermodynamics, John Wiley &Sons, 2010.
4. Herbert B. Callen, Thermodynamics and Introduction to Thermo-statistics, Wiley, 2^{nd}Edition, 1985.

CH414	PETROCHEMICAL TECHNOLOGIES	DEC	3 - 0 - 0	3 credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Differentiate process technologies associated with methane, ethane, ethylene, acetylene as feedstock
CO2	Discuss process technologies in manufacture of chemicals from synthesis gas and olefins by various routes
CO3	Identify production technologies of Petroleum aromatics, synthetic fibers, and synthetic rubber
CO4	Describe classification of plastics and learn various process technologies in manufacture of various plastics

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	2	2	2	2	1	-	-	-	-	-	2	-	-
CO2	3	1	2	2	2	2	1	-	-	-	-	-	2	-	-
CO3	3	1	2	2	2	2	1	-	-	-	-	-	2	-	-
CO4	3	1	2	2	2	2	1	-	-	-	-	-	2	-	-

Detailed syllabus:

Petrochemical Industry – Feed stocks.

Chemicals from methane: Introduction, production of Methanol, Formaldehyde, Ethylene glycol, PTFE, Methylamines.

Chemicals from Ethane-Ethylene-Acetylene: Oxidation of ethane, production of Ethylene, Manufacture of Vinyl Chloride monomer, vinyl Acetate manufacture, Ethanol from Ethylene, Acetylene manufacture, Acetaldehyde from Acetylene.

Chemicals from Synthesis gas, Polymers of Olefins: Polyethylene, Poly Propylene, Polyvinyl Chloride, Copolymers of Ethylene-Propylene, Liquid crystals.

Petroleum Aromatics: Production of BTX

Synthetic Fibers and Synthetic Rubber: Production techniques, Polyesteres, Acrylic fibers, Polypropylene, synthetic paper, optical fibers, Natural rubber Latex, Butadiene Rubber, Chloroprene rubber, Trans polypentamer rubber, Ethylene-propylene rubber, Polyurethanes
Plastics: Engineering Plastics, Resins, Poly carbonates, Polyamides, Poly Acetals.

Reading:

1. B.K. BhaskaraRao, A Text Book of Petrochemicals, Khanna Publications, 2nd Edition, 2002.
2. Robert A. Meyers, Robert A. Meyers, Handbook of Petrochemicals Production Processes, McGraw-Hill Inc., 2005.
3. Mall I.D., Petrochemical Process Technology, Macmillan India, 2015

CH415	SCALE-UP METHODS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand principles of scale up.
CO2	Apply dimensional analysis technique for scale up problems.
CO3	Carry out scale up of mixers, heat exchangers and chemical reactors
CO4	Scale up distillation columns and packed towers.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	-	1	-	2	2	-	1	3	3	1
CO2	3	2	2	1	1	-	1	-	2	2	-	1	3	3	1
CO3	3	2	2	1	1	-	1	-	2	2	-	1	3	3	1
CO4	3	2	2	1	1	-	1	-	2	2	-	1	3	3	1

Detailed Syllabus:

Principals of Similarity, Pilot Plants & Models: Introduction to scale-up methods, pilot plants, models and principles of similarity, Industrial applications.

Dimensional Analysis and Scale-Up Criterion: Dimensional analysis, regime concept, similarity criterion and scale up methods used in chemical engineering, experimental techniques for scale-up.

Scale-Up of Mixing and Heat Transfer Equipment: Typical problems in scale up of mixing equipment and heat transfer equipment.

Scale-Up of Chemical Reactors: Kinetics, reactor development & scale-up techniques for chemical reactors.

Scale-Up of Distillation Column & Packed Towers: Scale-up of distillation columns and packed towers for continuous and batch processes.

Reading:

1. Marko Zlokamik, Scale-up in Chemical Engineering, Wiley-VCH, 2nd Edition, 2006.
2. Johnstone, Thring, Pilot Plants Models and Scale-up methods in Chemical Engineering, McGraw Hill, New York, 1962.

3. Hoyle W, Pilot Plants and Scale-Up, Royal Society of Chemistry, 1999.
4. Bruce Nauman E, Chemical Reactor Design, Optimization and Scale-up, McGraw Hill Handbooks, New York, 2002.

CH416	CO_2 CAPTURE AND UTILIZATION	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the necessity of CO_2 capture, storage and utilization
CO2	Distinguish the CO_2capture techniques
CO3	Evaluate CO_2 Storage and sequestration methods
CO4	Assess Environmental impact of CO_2 capture and utilization

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	3	1	2	3	3	-	2	2	-	1	2	2	1
CO2	3	2	3	1	2	3	3	-	2	2	-	1	2	2	1
CO3	3	2	3	1	2	3	3	-	2	2	-	1	2	2	1
CO4	3	2	3	1	2	3	3	-	2	2	-	1	2	2	1

Detailed syllabus

Introduction: Global status of CO_2 emission trends, Policy and Regulatory interventions in abatement of carbon footprint, carbon capture, storage and utilization (CCS&U)

CO_2 capture technologies from power plants: Post-combustion capture, Pre-combustion capture, Oxy-fuel combustion, chemical looping combustion, calcium looping combustion

CO_2 capture agents and processes: Capture processes, CO_2 capture agents, adsorption, ionic liquids, metal organic frameworks

CO_2 storage and sequestration: Geological sequestration methods, Biomimetic carbon sequestration

CO_2 Utilization: CO_2 derived fuels for energy storage, polymers from CO_2, CO_2 based solvents, CO2 to oxygenated organics, Conversion into higher carbon fuels, High temperature catalysis

Environmental assessment of CO_2 capture and utilization: Need for assessment, Green chemistry and environmental assessment tools, Life cycle assessment (LCA), ISO standardization of LCA, Method of conducting an LCA for CO_2 capture and Utilization.

Reading:

1. Peter Styring, Elsje Alessandra Quadrelli, Katy Armstrong, Carbon dioxide utilization: Closing the Carbon Cycle, Elsevier, 2015.
2. Goel M, Sudhakar M, Shahi RV, Carbon Capture, Storage and, Utilization: A Possible Climate Change Solution for Energy Industry, TERI, Energy and Resources Institute, 2015.
3. Amitava Bandyopadhyay, Carbon Capture and Storage, CO_2 Management Technologies, CRC Press, 2014.
4. Fennell P, Anthony B, Calcium and Chemical Looping Technology for Power Generation and Carbon Dioxide (CO_2) Capture, Woodhead Publishing Series in Energy: No. 82, 2015.
5. Mercedes Maroto-Valer M, Developments in Innovation in Carbon Dioxide Capture and Storage Technology: Carbon Dioxide Storage and Utilization, Vol 2, Woodhead Publishing Series in Energy, 2014.

CH417	NATURAL GAS PROCESSES, MODELING AND SIMULATION	DEC	3 – 0 – 0	3 CREDITS

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze the properties of natural gas, Dehydration process plant in detail.
CO2	Design gas dehydration contactor using graphical and analytical methods.
CO3	Illustrate the importance of sulfur recovery in natural gas processing
CO4	Discuss the technology for Natural gas storage
CO5	Perform modelling of process & sweetening units using software tools

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	1	-	-	-	-	1	3	2	-
CO2	3	3	2	2	2	1	1	-	-	-	-	1	3	3	3
CO3	2	2	3	2	1	1	1	-	-	-	-	1	3	3	-
CO4	2	3	3	2	1	1	-	-	-	-	-	1	2	1	-
CO5	3	3	3	2	3	1	-	-	-	-	-	-	2	2	3

Detailed Syllabus:

Gas Dehydration: Glycol Process: Operation, System Parameters, Contactor Sizing and Stage Calculations, Graphical and Analytical Methods. Regeneration.

Solid Bed Absorption: Types of solid desiccants, System Parameters, Operation and Design

Sweetening: Acid Gases Toxicity, Solid Bed Process , Absorbent Selection, Selection Variables and Design , Physical & Chemical absorption Processes, Sulphur Recovery

Storage of Natural Gas: Pipeline Storage, Underground Storage, Mined Caverns

Modeling and Simulation: Introduction, Absorber, Distillation Column, Heat Exchanger, Regeneration unit, Simulation by software (Matlab and Aspen Plus, etc.)

Reading:

1. Chi U.Ikoku, Natural Gas Production Engineering, John Wiley & Sons.1992.
2. James G Speight, Natural Gas –A Basic Hand Book, Gulf Publishing Company, 2007.

3. Sanjay Kumar, Gas Production Engineering, Gulf Publishing Company, Volume 4, 1987.
4. John M Campbell, Gas Conditioning & Processing Volume 2, Volume 3, Volume 4 Campbell Petroleum Series.
5. Donald Katz, Hand Book of Natural Gas engineering, McGraw Hill, 1959.
6. LP Dake, Fundamentals of Reservoir Engineering, Elsevier, 1978.
7. Hussain K. Abdel-Aal, Mohammed Aggour, M.A. Fahim, Petroleum and Gas field Processing, Marcel Dekker, 2003.

CH418	INTRODUCTION TO TRIBOLOGY	DEC	3 – 0 – 0	3 CREDITS

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the theories associated with evaluation and causes of friction
CO2	Understand type and mechanism of wear
CO3	Differentiate lubrication types and additives
CO4	Apply tribology to various bearings

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	1	-	-	-	-	1	3	2	-
CO2	3	3	2	2	2	1	1	-	-	-	-	1	3	3	3
CO3	2	2	3	2	1	1	1	-	-	-	-	1	3	3	-
CO4	2	3	3	2	1	1	-	-	-	-	-	1	2	1	-

Detailed Syllabus:

Introduction: Introduction to tribology; History of tribology; Interdisciplinary Approach; Economic Benefits.

Friction: Causes of Friction; Adhesion Theory; Abrasive Theory; Junction Growth Theory; Laws of Rolling Friction; Friction Instability.

Wear: Wear Mechanisms; Adhesive Wear; Abrasive Wear; Corrosive Wear; Fretting Wear; Wear Analysis

Lubrication and Lubricants; Importance of Lubrication; Boundary Lubrication; Mixed Lubrication; Full Fluid Film Lubrication ; Hydrodynamic; Elastohydrodynamic lubrication; Types & Properties of Lubricants; Lubricants Additives.

Fluid film lubrication: Fluid mechanics concepts; Equation of Continuity & Motion; Generalised Reynolds Equation with Compressible & Incompressible Lubricants.

Application of Tribology: Introduction; Rolling Contact Bearings; Gears; Journal Bearings - Finite Bearings.

Reading:

1. Dowson D, History of Tribology, Longman London, 1979.
2. Stachowiak G N, Batchelor A W and Stachowick G B "Experimental methods in Tribology", Tribology Series 44, Editor D Dowson, 2004.
3. Michael M Khonsari, Applied Tribology (Bearing Design and Lubrication), John Wiley & Sons, 2001.
4. Jost H P, Lubrication (Tribology): A Report on the present position and industry`s needs, Her Majesty`s Stationary Office, London, 1966.
5. J Halling, Principles of Tribology, The Macmillan Press Ltd, London, 1975.
6. Archard J F and Hirst W, The Wear of Metals under Unlubricated Conditions, Proc. R. Soc., London, A 236, 397-410, 1956.

CH5111	PROCESS MODELING AND ANALYSIS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand model building techniques
CO2	Develop first principles, grey box and empirical models for systems.
CO3	Develop mathematical models for engineering processes
CO4	Model discrete time systems

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	2	1	-	-	-	-	-	-	-	3	3	3
CO2	3	3	3	3	2	-	-	-	-	-	-	-	3	3	3
CO3	3	3	2	2	1	-	-	-	-	-	-	-	3	3	3
CO4	3	2	2	2	1	-	-	-	-	-	-	-	3	3	3

Detailed syllabus

Introduction to modeling, a systematic approach to model building, classification of models.

Development of steady state and dynamic lumped and distributed parameter models based on conservation principles. The transport phenomena models: Momentum, energy and mass transport models. Analysis of ill-conditioned systems.

Classification of systems, system's abstraction and modeling, types of systems and examples, system variables, input-output system description, system response, analysis of system behavior, linear system, superposition principle, linearization, non-linear system analysis, system performance and performance targets.

Development of grey box models. Empirical model building. Statistical model calibration and validation. Population balance models. Examples.

Mathematical model development for electromagnetic forces in high field magnet coils, free and forced vibration of an automobile, cantilever beam subjected to an end load. Mathematical model development for different chemical engineering processes – distillation columns, reactors, heat exchangers.

Discrete systems: difference equations, state-transition diagrams, cohort simulation of Markov models, random processes, descriptive statistics, hypothesis testing, probabilistic distributions, pseudo-random numbers, Monte Carlo methods, numerical simulation of continuous-time dynamics, discrete-event systems, cellular automata, Moore machines, real-world system examples: Mechanical, Electrical, Electro-Mechanical, Chemical Systems.

Reading:

1. Ashok Kumar Verma, Process Modeling and Simulation in Chemical, Biochemical and Environmental Engineering, CRC Press, 2014.
2. Amiya K. Jana, Chemical Process Modeling and Computer Simulation, Prentice Hall, 2nd Edition, 2011.
3. Jim Caldwell, Douglas K. S. Ng, Mathematical Modeling: Case Studies, Kluwer Academic Publishers, 2004.
4. K. M. Hangos and I. T. Cameron, Process Modelling and Model Analysis, Academic Press, 2001.
5. M. Chidambaram, Mathematical Modelling and Simulation in Chemical Engineering, Cambridge University Press, 2018.
6. Sandip Benerjee, Mathematical Modeling: Models, Analysis and Applications, CRC Press, 2014.
7. Ancheyta, J. Modelling and Simulation of Catalytic Reactors for Petroleum Refining. Wiley, 2011.
8. Pota, G. Mathematical problems for chemistry students, Oxford: Elsevier, 2006.

CH5114	STATISTICAL DESIGN OF EXPERIMENTS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Plan experiments for a critical comparison of outputs
CO2	Include statistical approach to propose hypothesis from experimental data
CO3	Implement factorial and randomized sampling from experiments
CO4	Estimate parameters by multi-dimensional optimization

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	-	-	-	-	-	-	-	2	2	3
CO2	3	3	3	3	2	-	-	-	-	-	-	-	2	2	3
CO3	3	3	3	3	2	-	-	-	-	-	-	-	2	2	3
CO4	3	3	3	3	2	-	-	-	-	-	-	-	2	2	3

Detailed syllabus

Introduction: Strategy of experimentation, basic principles, guidelines for designing experiments.

Simple Comparative Experiments: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means: Hypothesis testing, Choice of samples size, Confidence intervals, Randomized and paired comparison design.

Experiments with Single Factor; An example, The analysis of variance, Analysis of the fixed effect model, Model adequacy checking, Practical interpretation of results, Sample computer output, Determining sample size, Discovering dispersion effect, The regression approach to the analysis of variance, Nonparameteric methods in the analysis of variance, Problems.

Design of Experiments: Introduction, Basic principles: Randomization, Replication, Blocking, Degrees of freedom, Confounding, Design resolution, Metrology considerations for industrial designed experiments, Selection of quality characteristics for industrial experiments.

Parameter Estimation.

Response Surface Methods: Introduction, The methods of steepest ascent, Analysis of a second-order response surface, Experimental designs for fitting response surfaces: Designs for fitting the first-order model, Designs for fitting the second-order model, Blocking in response surface designs, Computer-generated (Optimal) designs, Mixture experiments, Evolutionary operation, Robust design, Problems.

Design and Analysis: Introduction, Preliminary examination of subject of research, Screening experiments: Preliminary ranking of the factors, active screening experiment-method of random balance, active screening experiment Plackett-Burman designs, Completely randomized block design, Latin squares, Graeco-Latin Square, Youdens Squares, Basic experiment-mathematical modeling, Statistical Analysis, Experimental optimization of research subject: Problem of optimization, Gradient optimization methods, Nongradient methods of optimization, Simplex sum rotatable design, Canonical analysis of the response surface, Examples of complex optimizations.

Reading:

1. Lazic Z. R., Design of Experiments in Chemical Engineering, A Practical Guide, Wiley, 2005.
2. Antony J., Design of Experiments for Engineers and Scientists, Butterworth Heinemann, 2004.
3. Montgomery D. C., Design and Analysis of Experiments, Wiley, 5th Edition, 2010.
4. Doebelin E. O., Engineering Experimentation: Planning, Execution, Reporting, McGraw-Hill, 1995.

CH5115	CHEMICAL PROCESS SYNTHESIS	PCC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze alternative processes and equipment
CO2	Synthesize a chemical process flow sheet that would approximate the real process
CO3	Design best process flow sheet for a given product
CO4	Perform economic analysis related to process design and evaluate project profitability

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	3	2	1	-	1	1	-	-	-	-	-	2	3	-
CO2	3	2	2	-	-	1	1	-	-	-	-	-	3	2	-
CO3	2	2	3	-	-	1	-	-	-	-	3	-	3	2	-
CO4	2	3	1	-	-	-	-	-	-	-	-	-	1	3	-

Detailed syllabus

Synthesis of steady state flow sheet: Introduction, Flow sheets, The problem of steady state flow sheeting, General semantic equation of equipment, Generalization of the method of synthesis of process flow sheet, Recycle structure of the flow sheet, separation systems.

Heuristics for process synthesis:

Raw materials and Chemical reactions, Distribution of chemicals, Separations, Heat exchangers and furnaces, pumping pressure reduction and conveying of solids

Algorithmic methods for process synthesis: Reactor design and reactor network synthesis, Synthesis of separation trains, sequencing of ordinary distillation columns

Optimization of flow sheet with respect to heat exchanger network: Introduction, Network of heat exchanger, Some necessary conditions for the existence of an optimal exchanger network, Maximum heat transfer in a single exchanger (rule 1), Hot and cold utilities (rule2), Condition of optimality for the minimum area network, Three special situations in energy transfer, Heat content diagram representation of the network problem, Matching of heat content diagram for minimum network area, Rules of adjustment of the minimum heat exchanger network to find the optimal solution.

Safety in Chemical plant design: Introduction, Reliability of equipment, prevention of accidents, Flammability of chemicals, Safety considerations in plant layout, Classification of chemicals and handling problem, Venting of tanks and vessels, Design of safety valves, Safety consideration in reactor design, Leakages, Handling of fluids, Trouble-shooting analysis of equipment and chemical plants, Fault tree analysis of accidents. Reliability consideration in maintenance policies of a chemical plant

Economic evaluation: Time value of money, Methods for Profitability evaluation, Rate of return, Net Present Worth, Capitalised cost , Discounted Cash flow analysis.

Reading:

1. Seider W. D., Seader J.D. and Lewin D. R., Product and Process Design Principles: Synthesis, Wiley, 2005.
2. Robin Smith, Chemical Process Design and Integration, John Wiley & Sons Ltd., 2005.
3. Bieglar L.T, Grossman E.I and Westerberg A.W., Systematic Methods of Chemical Process Design, Prentice Hall Inc.,1997
4. Douglas J. M., Conceptual Design of Chemical Processes, McGraw Hill International, 1988.

CH5117	NUCLEAR POWER TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:.

CO1	Understand radioactivity, nuclear fission and fusion, interaction of particles with matter
CO2	Design and operate nuclear power plants
CO3	Select materials for nuclear reactor systems
CO4	Design and operate plants for the nuclear fuel cycle with emphasis on environmental and ethical aspects.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	2	1	2	1	-	-	-	-	-	3	2	1
CO2	3	3	3	2	2	1	1	-	-	-	-	-	3	3	2
CO3	2	2	3	1	1	1	1	-	-	-	-	-	1	2	1
CO4	3	2	3	2	1	2	3	2	-	-	-	-	2	2	1

Detailed syllabus

Nuclear Reactions and radiations: Atomic structure, Radioactivity and Radio isotopes, interaction of alpha and beta particles with matter, decay chains, neutron reactions, fission process, growth and decay of fission products in a reactor with neutron burnout and continuous processing. Nuclear fission and fusion, types and classification of nuclear reactors, nuclear fuels, other reactor materials.

Nuclear Reactor theory: The neutron cycle, critical mass, neutron diffusion, the diffusion equation, slowing down of neutrons, reactor period, transient conditions and reflectors. Introduction to nuclear power systems, Thermal-hydraulics: Thermal parameters: definitions and uses. Sources and distribution of thermal loads in nuclear power reactors. Thermal analysis of nuclear fuel, Single-phase flow and heat transfer, Two-phase flow and heat transfer.

Nuclear reactor materials: General requirements (neutronic and physical) of nuclear materials: Core, structural, moderator, coolant and control rod, properties of moderator and coolant materials: graphite, beryllium, Boron, water, heavy water, liquid metals. Brief description of different systems. Selection Criteria of Materials for different systems. Materials behavior under extreme environments, radiation, high temperature, corrosion. Zr alloys and Austenitic stainless steels.

Nuclear fuel cycle: Uranium mining, milling and enrichment. Fuel reprocessing, PUREX flow sheet, Solvent extraction, Selection of solvents, Non aqueous reprocessing. Waste management, classification of wastes, treatment of radioactive wastes, partitioning and transmutation. deep geological disposal.

Environmental effects of nuclear Power generation. Ethical aspects of nuclear power production.

Reading:

1. Glasstone S and Alexender Seasonske, Nuclear Reactor Engineering, CBS Publisher, USA, 3rd Edition, 1994.
2. W Marshall, Nuclear Power Technology, Vol I, II, and III, Oxford University Press, New York, 1983.
3. G. Vaidyanathan, Nuclear Reactor Engineering (Principles and Concepts), S. Chand Publishers, 2013.
4. J.R. Lamarsh and A.J. Baratta, Introduction to Nuclear engineering, 3rd Edition, 2001.
5. K.D. Kok, Nuclear Engineering Handbook, CRC Press, 2009.
6. Manson Benedict, Thomas H. Pigford, Dr. Hans Wolfgang Levi: Nuclear Chemical Engineering, McGraw-Hill Professional, 2nd Edition, 1981.

CH5119	PIPING ENGINEERING	DEC	3– 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the key steps in a pipeline's lifecycle: design, construction, installation and maintenance.
CO2	Draw piping and instrumentation diagrams (P&ID).
CO3	Understand codes, standards and statutory regulations.
CO4	Select pipe and pipe fittings.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	2	-	-	1	-	-	-	1	1	2	1	-
CO2	2	3	2	1	-	-	-	-	-	-	-	-	-	-	1
CO3	2	2	-	-	1	2	2	-	-	-	-	-	-	2	-
CO4	2	2	2	3	1	-	-	-	-	-	-	-	2	-	-

Detailed Syllabus:

Introduction to piping: piping classification, other pipe ratings, and definitions of forces, moments, equilibrium, work, power, and energy.

Piping components: pipe and tube products, traps, strainers, expansion joints, threaded joints, bolted flange joints, welded and brazed joints.

Piping materials: material properties of piping materials, metallic materials, degradation of materials in service.

Piping codes and standards: ASME, BIS, ISO standards relevant to chemical engineering.

Piping layout: Line diagram, process flow diagram, piping and instrumentation diagram, codes and standards.

Application of computer-aided design to piping layout.

Fabrication and installation of piping systems: introduction, fabrication, installation, Selection and application of valves, Pressure and leak testing.

Flow of fluids and calculations: introduction, theoretical background, steady single-phase incompressible flow in piping, steady single-phase compressible flow in piping, single-phase flow in nozzles, venturi tubes, and orifices, steady two-phase flow.

Reading:

1. McAllister E.W., Pipeline Rules of Thumb Handbook, Gulf Publication, 7th Edition, 2009.
2. Kellogg, Design of Piping System, M.W. Kellogg Co., 2nd Edition, 2009.
3. Weaver R., Process Piping Design Vol.1 and 2, Gulf Publication, 1989.
4. Nayyar M. L., Piping Handbook, McGraw Hill, 7th Edition, 2000.

CH5212	DATA ANALYTICS	DEC	3– 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply the concepts of probability, statistics, linear algebra, and calculus for data analysis
CO2	Understand Machine learning and graph structure learning concepts
CO3	Analyze data using Regression and Classification techniques
CO4	Apply Learning techniques and Dimensionality reduction techniques

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	-	-	-	-	-	-	1	1	3	3
CO2	3	3	3	3	3	-	-	-	-	-	-	1	1	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	1	1	3	3
CO4	3	3	3	3`	3	-	-	-	-	-	-	1	1	3	3

Detailed Syllabus:

Review of basics basic concepts on probability, statistic, linear algebra, and calculus.

Descriptive Statistics, Distributions. Inferential Statistics through hypothesis tests, Permutation & Randomization Test. Regression & ANOVA (Analysis of Variance).

Machine Learning: Introduction and Concepts Differentiating algorithmic and model based frameworks Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbors Regression & Classification.

Graph structure learning: Traditional structure learning techniques – constraint based and score-based algorithms, L1-based structure learning algorithm, Structure learning with priors and applications.

Supervised Learning with Regression and Classification techniques-1: Bias-Variance Dichotomy, Model Validation Approaches Logistic Regression, Linear Discriminant Analysis Quadratic Discriminant Analysis Regression and Classification Trees Support Vector Machines

Supervised Learning with Regression and Classification techniques-2: Ensemble Methods: Random Forest, Neural Networks, Deep learning. Unsupervised Learning and Challenges for Big Data Analytics Clustering Associative Rule Mining Challenges for big data analytics Prescriptive analytics Creating data for analytics through designed experiments Creating data for analytics through Active learning Creating data for analytics through Reinforcement learning. Dimensionality reduction techniques - PCA, KPCA, PCR. Data collection and pre-processing.

Reading:

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman,The Elements of Statistical Learning, Springer, 2009.
2. Montgomery, Douglas C., and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley & Sons, 2010.
3. David J. Hand, Statistics, Sterling Press, 2008.
4. J. Han, M. Kamber, J. Pei, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2012.
5. I.H. Witten, E. Frank, M. A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Morgan Kaufmann, 2011.
6. N. Matloff, The Art of R Programming, No Starch Press, 2011.
7. Denis Constales Gregory S. Yablonsky, Dagmar R. D'hooge,Joris W. Thybaut, and Guy B. Maric, Advanced Data Analysis and Modelling in Chemical Engineering, Elsevier, 2017.

SM701	INDUSTRIAL MANAGEMENT	HSC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Explain the four evolutionary phases of the organizational theories their circumstances and the consequences.
CO2	Examine organizational systems, inventory and quality for productivity improvements.
CO3	Understand the marketing management process to discuss marketing mix in formulation of marketing strategies
CO4	Calculate project schedule along with the interdependencies using PERT/CPM techniques.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	-	-	1	1	-	-	3	1	3	-	-	-	-
CO2	-	-	-	-	1	1	-	-	3	1	3	-	-	-	-
CO3	-	-	-	-	1	1	-	-	3	1	3	-	-	-	-
CO4	-	-	-	-	1	1	-	-	3	1	3	-	-	-	-

Detailed syllabus

Introduction - Overview of organizational theory and theoretical perspectives

Rational and natural systems-The evolution of organizational theory - rational systems and Natural systems, Quality management: Dimensions of quality; Process control charts both attributes and variables. Sampling Plan - LTPD and AOQL concepts. Taguchi's Quality Philosophy; Quality function deployment; Introduction to TQM, Inventory Management: Purpose of inventories; Inventory costs; ABC classification; Economic Order Quantity (EOQ); P and Q systems of inventory control.

Organizational behavior – I and II-The individual, The Group, Organization system (structure and culture), Organization its environment, design, and change

Open systems and behavioral decision-making

Other management topics-Marketing management process; 4P's of marketing mix; Target marketing; Product life cycle and marketing strategies, Project Management: Project activities;

Network diagrams; Critical path method (CPM); Program Evaluation and Review Technique (PERT). Project crashing. Slack computations, Resource leveling

Reading:

1) Robbins, S. P. and Judge, T. A., Organizational Behavior, Pearson, 2001.
2) Jones, G. R and Jones, G. R. Organizational theory, design, and change. Upper Saddle River, NJ: Pearson, 2013.
3) Taylor F.W Principles of Scientific Management, 30-144, 2017.
4) Besterfield, Total Quality Management. Pearson Education India; 4th Edition, 2015.
5) Khanna O. P., Industrial engineering and management, Dhanpat Rai, 1980.
6) Kottler P and Keller, K. L., Marketing Management 14e Global Edition, 2011.
7) Weber M. Economy and Society 1978 pp.212-254, 956-975

CH499	PROJECT WORK - PART B	PRC	0 – 0 – 6	4 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Carry out the project involving manufacture of a chemical product/ experimentation/ modelling/simulation/optimization/design
CO2	Discuss the results
CO3	Communicate the results orally to an audience
CO4	Present a detailed written report

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	3	1	2	1	1	1	-	-	2	-	-	2	2	-
CO2	3	3	1	1	1	1	2	-	3	2	-	-	3	2	-
CO3	3	3	3	3	2	1	1	1	3	3	-	-	3	3	3
CO4	3	3	3	`3	2	1	1	1	2	3	-	-	3	3	3

Detailed syllabus

The student is required to choose any one of the following:

1. Project involving experimentation/modelling/simulation/Design/optimization in chemical engineering related to research/industry/society

   At the end of the semester, the student is required to present (i) Literature survey, (ii) Problem formulation, (iii) Methodology, (iv) Results and Discussion, (v) Conclusions (vi) Future work (vii) References

2. Project involving manufacture of any chemical product on industrial scale

At the end of the semester, the student is required to present (i) market survey, (ii) Properties and Applications (iii) different processes for production, (iv) selection of process, (v) detained process description (vi) material and Energy balance, (vii) design of equipment, (viii) cost and profitability analysis, (ix) plant layout and location, (x) environmental considerations and safety and (xi) References

Minimum number of pages in the report should be 50.

Written report shall adhere to the prescribed format

Reading

1. Handbooks,
2. Journals and magazines
3. Martyn S. Ray and Martin G. Sneesby, Chemical Engineering Design Project: A Case Study Approach, Gordon and Breach Science Publishers, Second Edition, 1989.

CH461	MICROSCALE UNIT OPERATIONS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the micro-scale phenomena in various miniaturized equipment like MEMS.
CO2	Solve fluid flow phenomena for single and two immiscible liquids in micro-channels.
CO3	Design architectures of micro-fluidic devices for chemical & medical applications
CO4	Integrate theoretically the modular components for assembling of Lab-on-a-chip devices.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	2	1	2	2	-	-	-	-	-	1	2	2	2	1
CO2	2	3	3	2	2	-	-	-	-	-	1	2	3	2	2
CO3	2	3	3	2	2	-	-	-	-	-	1	2	2	3	3
CO4	2	2	2	2	2	-	-	-	-	-	1	2	2	2	2

Detailed Syllabus:

Physics and Chemistry at microscale: Introduction, Ranges of forces of microscopic origin, Microscopic length scales intervening in liquids and gases, Micromanipulation of molecules and cells in Microsystems, The physics of miniaturization, miniaturization of electrostatic systems, miniaturization of electromagnetic systems, miniaturization of mechanical systems, miniaturization of thermal systems, miniaturization of systems for chemical analysis.

Fluid dynamics in micro channels: Introduction, hypotheses of hydrodynamics, Hydrodynamics of gases in Microchannels, Flow of liquids with slip at the surface, Microhydrodynamics, Microfluidics involving inertial effects.

Interfacial phenomena: a few ideas about capillarity, Microfluidics of drops and bubbles, two-phase flows, emulsion in Microsystems.

Reaction, Mixing and separation in micro chambers: Introduction, The microscopic origin of diffusion process, Advection-diffusion equation and its properties, Analysis of dispersion phenomena, chaotic mixing, mixing in Microsystems, Adsorption phenomena, Dispersion with chemical kinetics, Chromatography.

Instruments for micro devices: Introduction, Examples of microfluidic structures, connectors, Examples of micro-fabricated valves and pumps.

Fabrication methods of micro devices, Applications of micro devices: Introduction, Current situation of micro-technologies, The environment of micro-fabrication, Photolithography, Micro-fabrication methods for silicon and glass MEMS, Methods of Fabrication for plastic MEMS.

Reading:

1. Tabeling P, Introduction to Microfluidics, Oxford University Press, 2010.
2. N.T. Nguyen, Steven Wereley, Fundamentals and Applications of Microfluidics, Artech House Inc., 2nd Edition, 2002.
3. Ronald F. Probstein, Physicochemical Hydrodynamics: An Introduction, Wiley-Interscience, 2nd Edition, 2003.

CH462	PROCESS AND PRODUCT DESIGN	DEC	3 – 0 – 0	3 CREDITS

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand Chemical product design principles
CO2	Select processes and flowsheets
CO3	Assess energy requirements and safety/sustainability indicators of processes
CO4	Execute computer aided molecular and mixture design
CO5	Design chemical devices

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	-	-	-	-	-	-	-	1	1	2
CO2	3	3	3	2	1	-	-	-	-	-	-	-	2	2	2
CO3	2	3	3	2	1	2	2	-	-	-	-	-	3	3	3
CO4	3	3	3	2`	3	-	-	-	-	-	-	-	2	3	3
CO5	3	3	3	2	1	-	-	-	-	-	-	-	2	3	3

Detailed Syllabus

Introduction to Chemical Product Design : Introduction, The Diversity of Chemical Products, The Chain of Chemical Products, Companies Engaging in Production of Chemical Products, B2B and B2C Chemical Products, Market Sectors and Classes of Chemical Products, Product Design and Development, Tasks and Phases in Product Design and Development Project Management, Market Study, Product Design, Feasibility Study, Prototyping

Introduction to Process Design : Objectives, Introduction, Information Gathering, Environmental and Safety Data, Chemical Prices, Experiments, Preliminary Process Synthesis, Chemical State, Process Operations, Synthesis Steps, Continuous or Batch Processing, Next Process Design Tasks, Flowsheet Mass Balances, Process Stream Conditions, Flowsheet Material and Energy Balances, Equipment Sizing and Costing, Economic Evaluation, Heat and Mass Integration, Environment, Sustainability, and Safety, Controllability Assessment, Optimization, Preliminary Flowsheet Mass Balances, Flow Diagrams.

Design Literature, Stimulating Innovation, Energy, Environment, Sustainability, Safety, Engineering Ethics : Objectives, Design Literature, Information Resources, General Search Engines and Information Resources, Stimulating Invention and Innovation, Energy Sources - Coal, Oil, and Natural Gas, Shale Oil, Shale Gas, Hydrogen, Hydrogen Production, Fuel Cell Energy Source, Hydrogen Adsorption, Biofuels, Solar Collectors, Wind Farms, Hydraulic Power, Geothermal Power, Nuclear Power, Selection of Energy Sources in Design, Environmental Protection, Environmental Issues, Environmental Factors in Product and Process Design, Sustainability—Key Issues, Sustainability Indicators, Life-Cycle Analysis, Safety Considerations, Safety Issues, Design Approaches Toward Safe Chemical Plants, Engineering Ethics

Molecular and mixture design: Framework for Computer-Aided Molecular-Mixture Design, Molecular Structure Representation, Generation of Molecule-Mixture Candidates, Mathematical Formulations of Molecular and/or Mixture Design Problems, Solution Approaches, Case Studies - Refrigerant Design, Large Molecule (Surfactant) Design, Active Ingredient Design/Selection, Polymer Design, Dichloromethane (DCM) Replacement in Organic Synthesis, Azeotrope Formation, Solvent Substitution, Mixture Design

Design of Chemical Devices, Functional Products, and Formulated Products: Objectives, Design of Chemical Devices and Functional Products, The Use of Models in Design of Devices and Functional Products, Design of Formulated Products, Design of Processes for B2C Products

Reading:

1. Warren D. Seider, Daniel R. Lewin, J. D. Seader, S. Widagdo, R. Gani, K.A. Ming Ng, Product and Process design principles, Synthesis, Analysis and Evaluation, Wiley,4th Edition,1999.
2. E. L. Cussler and G. D. Moggridge, Chemical Product Design (Cambridge Series in Chemical Engineering), Cambridge University Press, 2nd Edition, 2011.

CH463	MATHEMATICAL METHODS IN CHEMICAL ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None.

Course Outcomes: At the end of the course the student will be able to:

CO1	Formulate lumped and distributed parameter mathematical models for chemical processes
CO2	Evaluate degrees of freedom for the developed mathematical models
CO3	Solve the model equations describing chemical processes and equipment
CO4	Analyze the results of the solution methods.
CO5	Perform nonlinear analysis

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	3	3	-	3	-	-	-	-	-	-	3	3	3
CO2	3	2	3	3	-	-	-	-	-	-	-	-	3	3	3
CO3	3	3	3	3	-	-	-	-	-	-	-	-	3	3	3
CO4	3	3	3	3	-	-	-	-	-	-	-	-	3	3	3
CO5	3	-	-	3	3	-	-	-	-	-	-	-	3	-	3

Detailed Syllabus:

Mathematical Formulation of the Physical Problems- Introduction, Representation of the problem, blending process, continuous stirred tank reactor, unsteady state operation, heat exchangers, distillation columns, biochemical reactors.

Analytical (explicit) Solution of Ordinary Differential Equations encountered in Chemical Engineering Problems-Introduction, Order and degree, first order differential equations, second order differential equations, Linear differential equations, Simultaneous differential equations. Differential algebraic equations.

Non-linear analysis: Phase plane analysis, Bifurcation behavior

Formulation of partial differential equations- Introduction, Interpretation of partial derivatives, Formulation partial differential equations, particular solutions of partial differential equations, Orthogonal functions, Method of separation of variables, The Laplace Transform method, Other transforms.

Unsteady state heat conduction in one dimension - Mass transfer with axial symmetry - Continuity equations; Boundary conditions - Iterative solution of algebraic equations- The difference operator - Properties of the difference operator- Linear finite difference equations- Non-linear finite difference equations- Simultaneous linear differential equations - analytical solutions - Application of Statistical Methods.

Reading:

1. B. A. Finlayson, Introduction to Chemical Engineering Computing, Wiley India Edition, 2010.
2. Singaresu S. Rao, Applied Numerical Methods for Engineers and Scientists, Prentice Hall, 2002.
3. Amiya K. Jana, Chemical Process Modelling and Computer Simulation, Prentice Hall India, 2nd Edition, 2011.
4. Norman W. Loney, Applied Mathematical Methods for Chemical Engineers, CRC Press, 3rdEdition, 2015.
5. B.W. Bequette -Process Dynamics- Modelling, Analysis and Simulation, Prentice Hall, 1998.
6. S.K.Gupta, Numerical Methods for Engineers, New Age International Publishers, 2015.
7. M. Chidambaram, Mathematical Modelling and Simulation in Chemical Engineering, Cambridge University Press, 2018.

CH464	INTRODUCTION TO MACROMOLECULES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Describe macromolecules based on chemical constitution and architecture of chains.
CO2	Correlate macroscopic properties of polymer using microscopic chemical structure.
CO3	Predict the thermodynamic behavior of polymer mixtures by using Flory-Huggins theory.
CO4	Characterize polymeric materials using mechanical or electrical response.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	2	-	-	-	-	-	-	-	-	-	-	-
CO2	3	3	2	2	-	-	-	-	-	-	-	-	-	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-	-	-	-
CO4	3	3	3	3	-	-	-	-	-	-	-	-	-	-	-

Detailed syllabus

Introduction: Concepts, nomenclature and synthesis of polymers; Origins of polymer science and the polymer industry, basic definitions and nomenclature, molar mass and degree of polymerization.

Single chain conformations: Conformations of a single macromolecule, ideal chain, expanded chain, persistent chain.

Polymer solutions: Dilute and semi-dilute solutions, excluded volume interaction, polyelectrolyte solutions.

Polymer blends and copolymers: Flory-Huggins theory, phase separation mechanisms and critical fluctuations and spinodal decomposition.

Mechanical and Electrical response: Types of response and response functions.

Reading:

1. Gert Strobl, The physics of polymers: Concepts for Understanding Their Structures and Behavior, Springer,3rd Edition, 2007.
2. Robert J. Young, Peter A. Lovell, Introduction to polymers, CRC Press, 3rd Edition, 2011.
3. Michael Rubinstein, Ralph H. Colby, Polymer Physics, OUP Oxford, 2003.
4. L. Mandelkern, An introduction to Macromolecules, Springer-Verlag, 2nd Edition, 2012.

CH5161	OPTIMIZATION TECHNIQUES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Formulate objective function for a given problem
CO2	Understand unconstrained single variable optimization and unconstrained multi variable optimization
CO3	Understand linear programming and nonlinear programming techniques
CO4	Use dynamic programming and semi definite programming for optimization

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	-	2	1	2	-	-	1	-	-	1	1	3
CO2	3	3	3	-	-	1	2	-	-	1	-	-	-	1	3
CO3	3	3	3	-	-	1	2	-	-	1	2	-	1	1	3
CO4	3	3	3	`	-	1	2	-	-	1	2	-	2	1	3

Detailed syllabus

The Nature and Organization of Optimization Problems: What Optimization is all about, Why Optimize?, Scope and Hierarchy of Optimization, Examples of applications of Optimization, The Essential Features of Optimization Problems, General Procedure for Solving Optimization Problems, Obstacles to Optimization.

Basic Concepts of Optimization: Continuity of Functions, Unimodal vs. multimodal functions, Convex and concave functions, convex region, Necessary and Sufficient Conditions for an Extremum of an Unconstrained Function, Interpretation of the Objective Function in terms of its Quadratic Approximation.

Optimization of Unconstrained Functions: One Dimensional search Numerical Methods for Optimizing a Function of One Variable, Scanning and Bracketing Procedures, Newton and Quasi-Newton Methods of Uni-dimensional Search, Polynomial approximation methods, How One-Dimensional Search is applied in a Multidimensional Problem, Evaluation of Uni-dimensional Search Methods.

Unconstrained Multivariable Optimization: Direct methods, indirect methods – first order, indirect methods – second order.

Linear Programming and Applications: Basic concepts in linear programming, Degenerate LP's – Graphical Solution, Natural occurrence of Linear constraints, The Simplex methods of solving linear programming problems, standard LP form, Obtaining a first feasible solution, Sensitivity analysis, Duality in linear programming

Nonlinear programming with constraints The Lagrange multiplier method, Necessary and sufficient conditions for a local minimum, introduction to quadratic programming.

Optimization of Stage and Discrete Processes: Dynamic programming, Introduction to integer and mixed integer programming.

Applications to different processes.

Reading:

1. Thonas F. Edgar, D.M. Himmelblau and Leon S. Lasdon, Optimization of Chemical Processes, McGraw Hill, 2nd Edition, 2001.
2. Stoecker W. F, Design of Thermal Systems, McGraw-Hill, 3rd Edition, 2011.
3. Singiresu S Rao, Engineering Optimization: Theory and Practice, John Wiley & Sons Ltd., 4th Edition, 2009.
4. Mohan C. Joshi and Kannan M. Moudgalya, Optimization: Theory and Practice, Alpha Science International Limited, 2004.
5. Stephen Boyd, Lieven Vandenberghe, Convex optimization, Cambridge University Press, 2004.
6. P. Venkataraman, Applied Optimization with MATLAB Programming, Wiley, 2nd Edition, 2009.
7. Suman Dutta, Optimization in Chemical Engineering, Cambridge University Press, 2016.

CH5162	PROCESS SCHEDULING AND UTILITY INTEGRATION	DEC	3 – 0 – 0	3 Credits

Prerequisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify the objectives of scheduling problem
CO2	Develop a model for batch process scheduling
CO3	Integrate process scheduling and resource conservation
CO4	Design and synthesize batch plants

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3		3	2		3			1	3				
CO2	1	2	3		2					1					
CO3	1	1	3		3		2			1	3				
CO4		1	3	2`	3					1	2				

Detailed Syllabus:

Introduction to Batch Chemical Processes: Definition of a batch process, Operational philosophies, Types of batch plants, Recipe representations, Batch chemical process integration.

Short-Term Scheduling: Effective technique for scheduling of multipurpose and multi-product batch plants, Different storage policies for intermediate and final products, Evolution of multiple time grid models in batch process scheduling, Short-term scheduling of multipurpose pipeless plants, Planning and scheduling in biopharmaceutical industry.

Resource Conservation: Integration of batch process schedules and water allocation network, Water conservation in fixed scheduled batch processes, Wastewater minimization in multiproduct batch plants: single contaminants, Storage design for maximum wastewater reuse in batch plants, Wastewater minimization in multipurpose batch plants: multiple contaminants, Wastewater minimization using multiple storage vessels, Wastewater minimization using inherent storage, Zero effluent methodologies,

Heat integration in multipurpose batch plants: direct and indirect heat integration, Simultaneous optimization of energy and water use in multipurpose batch plants, Flexibility analyses and their applications in solar-driven membrane distillation desalination system designs, Automated targeting model for batch process integration.

Design and Synthesis: Design and synthesis of multipurpose batch plants, Process synthesis approaches for enhancing sustainability of batch process plants, Scheduling and design of multipurpose batch facilities: Periodic versus non periodic operation mode through a multi objective approach, Mixed-integer linear programming model for optimal synthesis of polygeneration systems with material and energy storage for cyclic loads.

Reading:

1. Thokozani Majozi, Esmael Reshid Seid, Jui-Yuan Lee, Synthesis, Design, and Resource Optimization in Batch Chemical Plants, CRC Press Taylor & Francis, 2015.
2. Thokozani Majozi, Batch Chemical Process Integration - Analysis, Synthesis and Optimization, Springer, 2010.
3. Gintaras V. Reklaitis, Aydin K. Sunol, David W. T. Rippin, Oner Hortacsu, Batch Processing Systems Engineering, Springer, 1996.
4. Mariano Martin, Introduction to Software for Chemical Engineers, CRC Press, 2015.
5. Amir Shafeeq, Multiproduct Batch Process Scheduling, VDM Verlag, 2011.

CH5164	ADVANCED MASS TRANSFER	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the concept of separation factor and separating agent.
CO2	Classify the separation processes based on the energy requirements.
CO3	Determine the degrees of freedom using phase rule and description rule.
CO4	Compare multi-stage operations.
CO5	Design binary distillation column using McCabe Thiele and Ponchon-Savarit methods.
CO6	Design multi-component distillation columns using short cut and rigorous calculation methods.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	-	-	-	-	-	-	2	2	2	1
CO2	3	2	2	1	2	-	-	-	-	-	-	2	2	2	1
CO3	3	2	2	1	2	-	-	-	-	-	-	2	2	2	1
CO4	3	2	2	1	2	-	-	-	-	-	-	2	2	2	1
CO5	3	2	3	1	2	-	-	-	-	-	-	2	3	2	1
CO6	3	2	3	1	2	-	-	-	-	-	-	2	3	2	1

Detailed syllabus

Characterization of Separation processes: Inherent Separation Factors: Equilibration Processes, Inherent Separation Factors: Rate-governed Processes.

Simple equilibrium processes: Equilibrium Calculations, Checking Phase Conditions for a Mixture.

Multistage separation processes: Increasing Product Purity, Reducing Consumption of Separating Agent, Co-current, Crosscurrent, and Counter current Flow.

Binary multistage separation: Binary Systems, Equilibrium Stages, McCabe-Thiele Diagram, The Design Problem, Choice of Column Pressure.

Binary multistage separations-general graphical approach: Straight Operating Lines, Curved Operating Lines, Extraction, Absorption, Processes without Discrete Stages, Packed tower distillation, General Properties of the yx Diagram.

Energy requirements of a separation process: Minimum Work of Separation, Net Work Consumption, Thermodynamic Efficiency, network of potentially reversible process, partially reversible process and irreversible processes.

Multi-component system fractionation: preliminary calculations, feed condition, column pressure, design procedure, number of equilibrium stages, feed location, estimation of number of theoretical plates – shortcut methods and rigorous calculation methods.

Reading:

1. King C. J., Separation Processes, Tata McGraw Hill Book Company, 2nd Edition, 1983.
2. Vanwinkle M, Distillation, McGraw Hill Chemical Engineering Series, New York, 1967.
3. Holland C. D., Multi-component Distillation, Prentice Hall of India Pvt. Ltd., 1981.
4. Geankoplis C. J., Transport Processes and Unit Operations, Prentice Hall of India Pvt. Ltd.,4thEdition, New Delhi, 2004.
5. Nakajima H. Mass Transfer: Advanced Aspects, Intech Publishers, 2014.

CH5165	COMPUTATIONAL FLUID DYNAMICS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to

CO1	Derive governing equations of fluid flow and heat transfer and classify them
CO2	Discretize the equations using Finite difference and volume formulation
CO3	Solve the discretized equations using different techniques
CO4	Implement pressure velocity coupling algorithms
CO5	Understand grid generation techniques

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	-	-	-	2	2	-	1	-	1	3
CO2	3	2	2	2	3	-	-	-	2	2	-	1	-	1	3
CO3	3	2	2	2	3	-	-	-	2	2	-	1	-	1	3
CO4	3	2	2	2	3	-	-	-	2	2	-	1	-	1	3
CO5	3	2	2	2	3	-	-	-	2	2	-	1	-	1	3

Detailed syllabus

Introduction – CFD approach, Need for CFD.

Governing equations of fluid flow and heat transfer - Laws of conservation: Mass – Momentum - Energy, Initial and boundary conditions - Conservative form – Differential and Integral forms of general transport equations – Classification of physical behaviours – Classification of fluid flow equations.

Discretization of equations – Finite difference / volume methods – 1D, 2D and 3D Diffusion problems - Convection and diffusion problems - Properties of discretization schemes- Central, upwind, hybrid and higher order differencing schemes.

Solution methods of discretized equations- Tridiagonal matrix algorithm (TDMA)-Application of TDMA for 2D and 3D problems – Iterative methods – Multigrid techniques.

Pressure – velocity coupling algorithms in steady flows – Staggered grid – SIMPLE, SIMPLEC and PISO - Unsteady flows- Explicit scheme, Crank Nicholson scheme, fully implicit scheme

Turbulence modelling - Prantl mixing length mode - One equation model, k - ε model, RSM equation model - Applications.

Structured and unstructured grids – Grid generation methods

Reading:

1. H. K. Versteeg, W. Malalasekera, An Introduction to Computational Fluid Dynamics - The finite volume method, Pearson Education Limited,2ndEdition, 2007.
2. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2nd Edition, 2010.
3. C. Hirch, Numerical Computation of internal and external flows, Wiley, 2nd Edition, 2007.
4. J. D. Anderson Jr., Computational Fluid Dynamics - The basics with Applications, McGraw Hill, 1995.
5. J. H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, Springer, 2002.
6. Gautam Biswas and Somenath Mukherjee, Computational Fluid Dynamics, Alpha Science International Limited, 2014.
7. Sreenivas Jayanti, Computatinal Fluid Dynamics for Engineers and Scientists, Springer, 2018.

CH5166	PROCESS INTENSIFICATION	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the scope for process intensification in chemical processes.
CO2	Implement methodologies for process intensification
CO3	Understand scale up issues in the chemical process.
CO4	Solve process challenges using intensification technologies.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	-	-	-	-	-	-	-	2	3	1
CO2	3	2	2	1	1	-	-	-	-	-	-	-	1	2	3
CO3	2	1	3	1	1	-	-	-	-	-	-	-	2	3	1
CO4	3	3	2	2`	1	-	-	-	-	-	-	-	2	1	1

Detailed syllabus

Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, Process-Intensifying Equipment, Process intensification toolbox, Techniques for PI application.

Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Microreaction Technology, from basic Properties to Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

Scales of mixing, Flow patterns in reactors, mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors.

Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification.

Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sonocrystallization, Reactive separations, Super critical fluids.

Reading:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.
2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.
3. Kamelia Boodhoo (Editor), Adam Harvey (Editor), Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013.
4. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián (Eds.), Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016.
5. Reay, Ramshaw, Harvey, Process Intensification, Engineering for Efficiency, Sustainability and Flexibility, Butterworth-Heinemann, 2013.

CH5262	SOFT COMPUTING TECHNIQUES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the concept of neural networks
CO2	Use neural networks to control the process plants
CO3	Develop fuzzy logic based controllers for different processes
CO4	Combine fuzzy logic with neural networks for plant control

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	3	2	1	-	-	-	-	-	-	-	-	2	1
CO2	3	1	3	2	1	-	-	-	-	-	-	-	-	2	1
CO3	3	1	3	2	1	-	-	-	-	-	-	-	-	2	1
CO4	3	1	3	2`	1	-	-	-	-	-	-	-	-	2	1

Detailed syllabus

Introduction to Neural Networks: Artificial Neural Networks: Basic properties of Neurons, Neuron Models, and Feed forward networks. Computational complexity of ANNs.

Neural Networks Based Control: ANN based control: Introduction: Representation and identification, modeling the plant, control structures – supervised control, Model reference control, Internal model control, Predictive control: Examples – Inferential estimation of viscosity an chemical process, Auto – turning feedback control, industrial distillation tower.

Introduction to Fuzzy Logic: Fuzzy Controllers: Preliminaries – Fuzzy sets and Basic notions – Fuzzy relation calculations – Fuzzy members – Indices of Fuzziness – comparison of Fuzzy quantities – Methods of determination of membership functions.

Fuzzy Logic Based Control: Fuzzy Controllers: Preliminaries – Fuzzy sets in commercial products – basic construction of fuzzy controller – Analysis of static properties of fuzzy controller – Analysis of dynamic properties of fuzzy controller – simulation studies – case studies – fuzzy control for smart cars.

Neuro – Fuzzy and Fuzzy – Neural Controllers: Neuro – fuzzy systems: A unified approximate reasoning approach – Construction of role bases by self-learning: System structure and learning. Introduction to Genetic algorithms. Controller design using genetic algorithms.

Reading:

1. Bose and Liang, Artificial Neural Networks, Tata McGraw Hill, 1996.
2. Huaguang Zhang, Derong Liu, Fuzzy Modeling and Fuzzy Control, Birkhauser Publishers, 2006.
3. Kosco B, Neural Networks and Fuzzy Systems: A Dynamic Approach to Machine Intelligence, Prentice Hall of India, 1992.
4. Lakshmi C. Jain, N. M. Martin, Fusion of Neural Networks, Fuzzy Systems and Genetic Algorithms: Industrial Applications, CRC Press, 1998.
5. MuhammetÜnal, AyçaAk, Vedat Topuz, Hasan Erdal, Optimization of PID Controllers using Ant colony and Genetic Algorithms, Springer, 2013.
6. S.N. Sivanandam, S.N. Deepa, Principles of Soft Computing, John Wiley & Sons, 2007.

OPEN ELECTIVES

CE390	ENVIRONMENTAL IMPACT ANALYSIS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Identify the environmental attributes to be considered for the EIA study.
CO2	Formulate objectives of the EIA studies.
CO3	Identify the suitable methodology and prepare Rapid EIA.
CO4	Prepare EIA reports and environmental management plans.
CO5	Plan the methodology to monitor and review the relief and rehabilitation works.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	1	2	-	-	3	3	1	-	2	1	-	-	-	-
CO2	2	1	2	-	-	3	3	1	-	2	1	-	-	-	-
CO3	2	1	2	-	-	3	3	1	-	2	1	-	-	-	-
CO4	2	1	2	-	-	3	3	1	-	2	1	-	-	-	-
CO5	2	1	2	-	-	3	3	1	-	2	1	-	-	-	-

Detailed Syllabus:

Introduction: The Need for EIA, Indian Policies Requiring EIA , The EIA Cycle and Procedures, Screening, Scoping, Baseline Data, Impact Prediction, Assessment of Alternatives, Delineation of Mitigation Measure and EIA Report, Public Hearing, Decision Making, Monitoring the Clearance Conditions, Components of EIA, Roles in the EIA Process. Government of India Ministry of Environment and Forest Notification (2000), List of projects requiring Environmental clearance, Application form, Composition of Expert Committee, Ecological sensitive places, International agreements.

Identifying the Key Issues: Key Elements of an Initial Project Description and Scoping, Project Location(s), Land Use Impacts, Consideration of Alternatives, Process selection: Construction Phase, Input Requirements, Wastes and Emissions, Air Emissions, Liquid Effluents, Solid Wastes, Risks to Environment and Human, Health, Socio-Economic Impacts, Ecological Impacts, Global Environmental Issues.

EIA Methodologies**:** Criteria for the selection of EIA methodology, impact identification, impact measurement, impact interpretation & Evaluation, impact communication, Methods-Adhoc methods, Checklists methods, Matrices methods, Networks methods, Overlays methods, Environmental index using factor analysis, Cost/benefit analysis, Predictive or Simulation methods. Rapid assessment of Pollution sources method, predictive models for impact assessment, Applications for RS and GIS.

Reviewing the EIA Report: Scope, Baseline Conditions, Site and Process alternatives, Public hearing. Construction Stage Impacts, Project Resource Requirements and Related Impacts, Prediction of Environmental Media Quality, Socio-economic Impacts, Ecological Impacts, Occupational Health Impact, Major Hazard/ Risk Assessment, Impact on Transport System,Integrated Impact Assessment.

Review of EMP and Monitoring: Environmental Management Plan, Identification of Significant or Unacceptable Impacts Requiring Mitigation, Mitigation Plans and Relief & Rehabilitation, Stipulating the Conditions, What should be monitored? Monitoring Methods, Who should monitor? Pre-Appraisal and Appraisal.

Case Studies: Preparation of EIA for developmental projects- Factors to be considered in making assessment decisions, Water Resources Project, Pharmaceutical industry, thermal plant, Nuclear fuel complex, Highway project, Sewage treatment plant, Municipal Solid waste processing plant, Tannery industry.

Reading:

1. Jain R.K., Urban L.V., Stracy G.S., *Environmental Impact Analysis*, Van Nostrand Reinhold Co., New York, 1991.
2. Barthwal R. R., *Environmental Impact Assessment*, New Age International Publishers, 2002
3. Rau J.G. and Wooten D.C., *Environmental Impact Assessment,* McGraw Hill Pub. Co., New York, 1996.
4. Anjaneyulu Y., and Manickam V., Environmental Impact Assessment Methodologies, B.S. Publications, Hyderabad, 2007.
5. Wathern P., Environmental Impact Assessment- Theory and Practice, Routledge Publishers, London, 2004.

EE390	LINEAR CONTROL SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Analyze electromechanical systems using mathematical modelling
CO2	Determine Transient and Steady State behavior of systems using standard test signals
CO3	Analyze linear systems for steady state errors, absolute stability and relative stability
CO4	Design a stable control system satisfying requirements of stability and reduced steady state error

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	-	-	1	-	-	-	-	-	-	1	3	2
CO2	3	3	2	-	-	1	-	-	-	-	-	-	1	3	2
CO3	3	3	2	-	-	1	-	-	-	-	-	-	1	3	2
CO4	3	3	2	-	-	1	-	-	-	-	-	-	1	3	2

Detailed syllabus:

Introduction: Control system, types, feedback and its effects-linearization

Mathematical Modeling of Physical Systems: Block diagram Concept and use of Transfer function. Signal Flow Graphs, Mason's gain formula.

Time Domain Analysis of Control Systems - BIBO stability, absolute stability, Routh-Hurwitz Criterion.

P, PI and PID controllers. Root Locus Techniques - Root loci theory,Application to system stability studies.

Introduction to state variables technique, Analysis of R-L, R-L-C networks.

Frequency Domain Analysis of Control Systems - polar plots, Nyquist stability criterion, Bode plots, application of Bode plots.

Reading:

1. B.C.Kuo, Automatic Control Systems, 7th Edition, Prentice Hall of India, 2009.
2. I.J. Nagarath and M. Gopal: Control Systems Engineering, 2nd Edition, New Age Pub. Co.2008.

EE391	SOFT COMPUTING TECHNIQUES	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand the concepts of population based optimization techniques
CO2	Examine the importance of exploration and exploitation in heuristic optimization techniques to attain near-global optimal solution
CO3	Evaluate the importance of parameters in heuristic optimization techniques
CO4	Apply for the solution of multi-objective optimization

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	-	-	-	-	-	-	-	1	1	3
CO2	3	3	1	2	2	-	-	-	-	-	-	-	1	1	3
CO3	3	3	1	2	2	-	-	-	-	-	-	-	1	1	3
CO4	3	3	1	2	2	-	-	-	-	-	-	-	1	1	3

Detailed syllabus:

Fundamentals Of Soft Computing Techniques: Definition-Classification of optimization problems-Unconstrained and Constrained optimization Optimality conditions- Introduction to intelligent systems- Soft computing techniques- Classification of meta-heuristic techniques - Single solution based and population based algorithms – Exploitation and exploration in population based algorithms - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.

Genetic Algorithm And Particle Swarm Optimization: Genetic algorithms- Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions - PSO topologies - control parameters. Application to SINX maximization problem.

Ant Colony Optimization And Artificial Bee Colony Algorithms: Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating- local-global - Pheromone evaporation - ant colony system- ACO models-Touring ant colony system-max

min ant system - Concept of elistic ants-Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms-binary ABC algorithms.
Shuffled Frog-Leaping Algorithm and Bat Optimization Algorithm: Bat Algorithm- Echolocation of bats- Behavior of microbats- Acoustics of Echolocation- Movement of Virtual Bats- Loudness and Pulse Emission- Shuffled frog algorithm-virtual population of frogs-comparison of memes and genes -memeplex formation- memeplex updation. Application to multi-modal function optimization Introduction to Multi- Objetive optimization-Concept of Pareto optimality.

Reading:

1. Xin-She Yang, "Recent Advances in Swarm Intelligence and Evolutionary Computation, Springer International Publishing, Switzerland, 2015.
2. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, John Wiley & Sons, 2001.
3. James Kennedy and Russel E Eberheart, Swarm Intelligence, The Morgan Kaufmann Series in Evolutionary Computation, 2001.
4. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, Swarm Intelligence-From natural to Artificial Systems, Oxford university Press, 1999.
5. David Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Pearson Education, 2007.
6. Konstantinos E. Parsopoulos and Michael N. Vrahatis, Particle Swarm Optimization and Intelligence: Advances and Applications, Information science reference, IGI Global, 2010.
7. N P Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press, 2005.

ME390	AUTOMOTIVE MECHANICS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Analyze operation and performance indicators of transmission systems, internal combustion engines and after treatment devices.
CO2	Understand operation of engine cooling system, lubrication system, electrical system and ignition system.
CO3	Understand fuel supply systems in an diesel and petrol vehicles
CO4	Analyze current and projected future environmental legislation and its impact on design, operation and performance of automotive power train systems.
CO5	Understand operation and performance of suspension, steering and braking system.
CO6	Understand layout of automotive electrical and electronics systems.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-
CO2	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-
CO3	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-
CO4	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-
CO5	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-
CO6	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-

Detailed syllabus

Introduction: Layout of an automotive chassis, engine classification.

Cooling Systems: Air cooling, air cleaners, Water cooling: Thermosyphon and pump circulation systems, Components of water cooling systems- Radiator, thermostat etc.

Engine Lubrication: Petroils system, Splash system, Pressure lubrication and dry sump system

Ignition System: Battery, Magneto and Electronic, Engine Starting drives

Fuel supply system: Components in fuel supply system, types of feed pumps, air cleaners, fuel and oil filters, pressure and dry sump systems.

Engine testing and Performance: Performance parameters, constant and variable speed test, heat balance test, performance characteristics. Engine Emissions: SI and CI engine emissions, emission control methods

Automotive electrical and electronics: Electrical layout of an automobile, ECU, sensors, windscreen wiper, Electric horn.

Transmission: Clutch- Single and multiplate clutch, semi & centrifugal clutch and fluid flywheel, Gear box: Sliding mesh, constant mesh and synchromesh gear box, selector mechanism, over drive, Propeller shaft and Differential.

Suspension System: Front and rear suspension, shock absorbers, Rear Axles mountings, Front Axle. Steering Mechanism: Manual and power steering systems, Braking System: Mechanical, Hydraulic and Air braking systems.

Engine service: Engine service procedure.

Reading:

1. S. Srinivasan, Automotive Mechanics, Tata McGraw-Hill, 2004.
2. K.M. Gupta, Automobile Engineering, Vol.1 and Vol.2, Umesh Publications, 2002
3. Kirpal Singh, Automobile Engineering, Vol.1 and Vol.2, Standard Publishers, 2003.
4. William H. Crouse and Donald L. Anglin, Automotive Mechanics, Tata McGraw-Hill, 2004
5. Joseph Heitner, Automotive Mechanics, East-West Press, 2000.

ME391	ENTREPRENEURSHIP DEVELOPMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand entrepreneurship and entrepreneurial process and its significance in economic development.
CO2	Develop an idea of the support structure and promotional agencies assisting ethical entrepreneurship.
CO3	Identify entrepreneurial opportunities, support and resource requirements to launch a new venture within legal and formal frame work.
CO4	Develop a framework for technical, economic and financial feasibility.
CO5	Evaluate an opportunity and prepare a written business plan to communicate business ideas effectively.
CO6	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization and growth.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO2	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO3	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO4	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO5	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO6	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-

Detailed syllabus

Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

Establishing Small Scale Enterprise: Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site.

Planning a Small Scale Enterprises**:** Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business organization/ownership.

Operational Issues in SSE**:** Financial management issues; Operational/project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws.

Performance appraisal and growth strategies**:** Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

Reading:

1. G.G. Meredith, R.E. Nelson and P.A. Neek, The Practice of Entrepreneurship, ILO, 1982.
2. Dr. Vasant Desai, Management of Small Scale Enterprises, Himalaya Publishing House, 2004.
3. A Handbook for New Entrepreneurs, Entrepreneurship Development Institute of India, Ahmedabad, 1988.
4. Bruce R Barringer and R Duane Ireland, Entrepreneurship: Successfully Launching New Ventures, 3rd Edition, Pearson Edu., 2013.

EC390	COMMUNICATION SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand different modulation and demodulation schemes for analog communications.
CO2	Design analog communication systems to meet desired application requirements
CO3	Evaluate fundamental communication system parameters, such as bandwidth, power, signal to quantization noise ratio etc.
CO4	Elucidate design tradeoffs and performance of communications systems.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	1	-	-	1	1	-	-	-	-	-	-	-	1	-
CO2	1	1	-	-	1	1	-	-	-	-	-	-	-	1	-
CO3	1	1	-	-	1	1	-	-	-	-	-	-	-	1	-
CO4	1	1	-	-	1	1	-	-	-	-	-	-	-	1	-

Detailed syllabus

Signal Analysis**:** Communication Process, Sources of Information, Communication Channels, Modulation Process, Types of Communication, Random Process, Gaussian Process, Correlation Function, Power Spectral Density, Transmission of Random Process through an LTI Filter.

Noise Analysis: External Noise, Internal Noise, White Noise, Narrow Band Noise, Representation of Narrow Band noise In phase and Quadrature Components, Noise Figure, Noise Bandwidth, Noise Temperature.

Amplitude (Linear) Modulation: Linear Modulation Schemes, Generation of AM, Envelope Detector, DSB-SC Product Modulator, Switching Modulator, Ring Modulator, Coherent Detection, Costas receiver, SSB Signal Representation, Filtering Method, Phase Shift Method, Coherent Demodulation, VSB Modulator and Demodulator, Carrier Acquisition using Squaring Loop and Costas Loop, Receiver Model, SNR, Noise in SSB and DSB receivers using coherent detection, Noise in AM Receiver using Envelope detection, Threshold Effect.

Angle (Exponential) Modulation: Types of Angle Modulation, Relation between FM and PM, Narrow Band FM, Wideband FM, Transmission Bandwidth of FM Signals, Generation of FM using Direct and Indirect methods, FM Demodulation using Slope Circuit, Frequency Discriminator, Interference in Angle Modulation, Noise in FM Receiver, FM Threshold Effect, Pre-emphasis and De-emphasis in FM, Model of PLL for FM Demodulation.

Pulse Modulation: Sampling Process, PAM, PWM, PPM, Quantization, PCM, TDM, Digital Multiplexer Hierarchy, DM, DSM, Linear Prediction, DPCM, ADPCM, Noise in PCM System, Companding, Comparison of the Noise Performance of AM,FM,PCM and DM.

Information Theory: Uncertainty, Information, Entropy, Source Coding Theorem, Data Compaction, Mutual information, Channel Capacity, BSC Channel, Information Capacity Theorem, Bandwidth - Power Tradeoff, Huffman Coding.

Reading:

1. S. Haykin, Communication Systems, 4thEdn, John Wiley & Sons, Singapore, 2001.
2. B.P. Lathi, Modern Digital & Analog Communication Systems, 3rdEdition, Oxford University Press, Chennai, 1998.
3. Leon W. Couch II, Digital and Analog Communication Systems, 6thEdition, Pearson Education Inc., New Delhi, 2001.
4. A Bruce Carlson, PB Crilly, JC Rutledge, Communication Systems, 4thEdition, MGH, New York, 2002.

EC391	MICROPROCESSOR SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Develop basic understanding of microprocessor architecture.
CO2	Design Microprocessor and Microcontroller based systems.
CO3	Understand C, C++ and assembly language programming
CO4	Understand concept of interfacing of peripheral devices and their applications

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	1	1	-	2	-	-	-	-	-	-	-	-	1	-
CO2	1	1	1	-	2	-	-	-	-	-	-	-	-	1	-
CO3	1	1	1	-	2	-	-	-	-	-	-	-	-	1	-
CO4	1	1	1	-	2	-	-	-	-	-	-	-	-	1	-

Detailed syllabus

Microcomputer Organization: CPU, Memory, I/O, Operating System, Multiprogramming, Multithreading, MS Windows

80386 Micro Processors : Review of 8086,salient features of 80386,Architecture and Signal Description of 80386,Register Organization of 80386,Addressing Modes,80386 Memory management, Protected mode, Segmentation, Paging, Virtual 8086 Mode, Enhanced Instruction set of 80386, the Co- Processor 80387

Pentium & Pentium-pro Microprocessor: Salient features of Pentium microprocessor, Pentium architecture, Special Pentium registers, Instruction Translation look aside buffer and branch Prediction, Rapid Execution module, Memory management, hyper-threading technology, Extended Instruction set in advanced Pentium Processors

Microcontrollers: Overview of micro controllers-8051 family microcontrollers, 80196 microcontrollers family architecture, instruction set, pin out, memory interfacing.

ARM Processor Fundamentals: Registers, current Program Status Registers, Pipeline Exceptions, Interrupts and Vector Table, Architecture Revisions, ARM Processor families, ARM

instruction set, Thumb Instruction set-Exceptions Handing, Interrupts, Interrupt Handling schemes, firmware, Embedded operating systems, Caches-cache architecture, Cache policy, Introduction to DSP on the ARM, DSP on the ARM7TDMI,ARM9TDMI.
Case study-Industry Application of Microcontrollers

Reading:

1. Barry B. Brey, Intel Microprocessor Architecture, Programming and Interfacing-8086/8088, 80186, 80286, 80386 and 80486, PHI, 1995.
2. Muhammad Ali Mazidi and Mazidi, The 8051 Microcontrollers and Embedded systems,PHI,2008
3. Intel and ARM Data Books on Microcontrollers.

MM364	FUNDAMENTALS OF MATERIALS PROCESSING TECHNOLOGY	OPC	3 – 0 –0	03 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Describe engineering materials.
CO2	Appreciate material processing techniques.
CO3	Select material processing technique for a given material and application.
CO4	Explain surface engineering techniques and their engineering significance.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	-	-	1	1	-	-	-	-	-	1	1	-
CO2	3	3	2	-	-	1	1	-	-	-	-	-	1	1	-
CO3	3	3	2	-	-	1	1	-	-	-	-	-	1	1	-
CO4	3	3	2	-	-	1	1	-	-	-	-	-	1	1	-

Detailed syllabus

Introduction to engineering materials: Metals, alloys and phase diagrams, ferrous metals, non-ferrous metals, superalloys, guide to processing of metals; ceramics-structure and properties of ceramics, traditional ceramics, new ceramics, glass, some important elements related to ceramics; polymers-fundamentals of polymer science and technology, thermoplastic and thermosetting polymers, elastomers; composite materials-classification of composite materials, metal matrix, polymer matrix and ceramic matrix composites.

Fundamental properties of materials: mechanical properties-stress-strain relationships, hardness, tensile properties, effect of temperature on properties, visco-elastic behaviour of polymers, thermal properties and electrical properties of metals, polymers, ceramics and composites.

Metal casting fundamentals and metal casting processes: Overview of casting technology, melting and pouring, solidification and casting, sand casting, other expendable-mold casting processes, permanent-mold casting processes, casting quality, metals for casting.

Particulate processing of metals and ceramics: Powder metallurgy-characterization of engineering powders, production of metallic powders, conventional processing and sintering, alternative processing and sintering techniques, materials and products for powder metallurgy, design considerations in powder metallurgy, processing of traditional ceramics, processing of new ceramics, cermets and their processing.

Fundamentals of metal forming and shaping processes, such as rolling, forging, extrusion, drawing, sheet metal forming: Overview of metal forming, friction and lubrication in metal forming; bulk deformation processes in metal forming-rolling, other deformation processes related to rolling, forging, other deformation processes related to forging, extrusion, wire and bar drawing; cutting and bending operations, sheet-metal drawing, other sheet metal forming operations, dies and presses for sheet-metal processes, sheet-metal operations not performed in presses.

Fundamentals welding: Overview of welding technology, the weld joint, physics of welding, features of a fusion-welded joint; Welding processes-arc welding, resistance welding, oxy-fuel gas welding, other fusion welding processes, solid-state welding, weld quality, weldability; brazing, soldering and adhesive bonding.

Surface engineering and tribology: Importance of surface engineering, classification of surface engineering processes, introduction to thermal, mechanical, thermo-chemical and electro-chemical surface engineering processes with their advantages, limitations and applications.

Reading:

1. Kalpakjian and Schmid, Manufacturing Engineering and Technology, Prentice Hall, New Jersey, 2013.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing, John Wiley & Sons, Inc., New Jersey, 2010.
3. DeGarmo, Black, and Kohser, Materials and Processes in Manufacturing, John Wiley & Sons, Inc, New York, 2011.
4. R. S. Parmar, Welding processes and Technology, Khanna Publishers, 2010.
5. H.S. Bawa, Manufacturing Technology-I, Tata McGraw Hill Publishers New Delhi, 2007.
6. Serope Kalpakjian, Manufacturing processes for Engineering Materials, Addison Wesley, 2001.

CH390	**NANOTECHNOLOGY AND APPLICATIONS**	**OPC**	**3 – 0 – 0**	**3 Credits**

(Not offered to Chemical Engineering Students)

Prerequisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the properties of nanomaterials
CO2	Synthesize nanoparticles
CO3	Characterize nanomaterials.
CO4	Scale up the production of nanoparticles
CO5	Evaluate safety and health related issues of nanoparticles

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											
CO5															

Detailed Syllabus:

Introduction to Nanotechnology: Introduction to nanotechnology and materials, Nanomaterials, Introduction to nanosizes and properties comparison with the bulk materials, Different shapes and sizes and morphology.

Fabrication of Nanomaterials: Top Down Approach Grinding, Planetary milling and Comparison of particles, Bottom Up Approach, Wet Chemical Synthesis Methods, Microemulsion Approach, Colloidal Nanoparticles Production, Sol Gel Methods, Sonochemical Approach, Microwave and Atomization, Gas phase Production Methods : Chemical Vapour Depositions.

Kinetics at Nanoscale: Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface charges, Zeta Potential and pH.

Carbon Nanomaterials: Synthesis of carbon bucky-balls, List of stable carbon allotropes extended, fullerenes, metallofullerenes, solid C_{60}, bucky onions, nanotubes, nanocones.

Quantum mechanics: Quantum dots and its Importance, Pauli exclusion principle, Schrödinger's equation, Application of quantum Dots: quantum well, wire, dot, characteristics of quantum dots, Synthesis of quantum dots Semi-conductor quantum dots

Nanomaterials characterization: Fractionation principles of Particle size measurements, Particle size and its distribution, XRD, Zeta potential, Electronic band structure Electron statistics Application: Optical transitions in solids, photonic crystals, Microscopies SEM, TEM, Atomic Forced Microscopy, Scanning and Tunneling Microscopy.

Applications: Self-assembly and molecular manufacturing, Surfactant based system Colloidal system applications, Functional materials Applications, commercial processes of synthesis of nanomaterials.

Nanoinroganic materials of $CaCO_3$ synthesis, Hybrid Waste Water Treatments systems, Electronic Nanodevices,

Nanobiology: Biological synthesis of nanoparticles and applications in drug delivery, Nanocontainers and Responsive Release of active agents, Layer by Layer assembly for nanospheres, Safety and health Issues of nano materials, Environmental Impacts, Case Study for Environmental and Societal Impacts

Reading:

1. Kulkarni Sulabha K, Nanotechnology: Principles and Practices, Capital Publishing Company, 2007
2. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, 2005.
4. Gabor L. Hornyak, H.F. Tibbals, JoydeepDutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2008.
5. Davies, J.H., The Physics of Low Dimensional Semiconductors: An Introduction, Cambridge University Press, 1998.

CH391	INDUSTRIAL SAFETY MANAGEMENT	OPC	3 – 0 – 0	3 Credits

(Not offered to Chemical Engineering Students)

Prerequisites: None.

Course Outcomes: At the end of the course the student will be able to:

CO1	Analyze the effects of release of toxic substances.
CO2	Select the methods of prevention of fires and explosions.
CO3	Understand the methods of hazard identification and prevention.
CO4	Assess the risks using fault tree diagram.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											
CO5															
CO6															

Detailed syllabus:

Introduction-Safety Programs, Engineering Ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, The Nature of the Accident Process, Inherent Safety.

Industrial Hygiene-Anticipation and Identification, Hygiene Evaluation, Hygiene Control.

Toxic Release and Dispersion Models-Parameters Affecting Dispersion, Neutrally Buoyant Dispersion Models, Dense Gas Dispersion, Toxic Effect Criteria, Effect of Release Momentum and Buoyancy, Release Mitigation.

Fires and Explosions-The Fire Triangle, Distinction between Fires and Explosions, Flammability Characteristics of Liquids and Vapors, Limiting Oxygen Concentration and Inerting, Flammability Diagram

Hazards Identification- Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews.

Risk Assessment- Review of Probability Theory, Event Trees, Fault Trees.

Safety Procedures: Process Safety Hierarchy, Managing Safety, Best Practices, Procedures-Operating, Procedures-Permits, Procedures-Safety Reviews and Accident Investigations.

Reading:

1. D. A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 2011.
2. R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Elsevier India, Volume 6, 2006.

CH392	**INDUSTRIAL POLLUTION CONTROL**	**OPC**	**3 – 0 – 0**	**3 Credits**

(Not offered to Chemical Engineering Students)

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze the effects of pollutants on the environment.
CO2	Distinguish air pollution control methods
CO3	Assess treatment technologies for wastewater
CO4	Identify treatment technologies for solid waste
CO5	Select treatment methodologies for hazardous and E-waste

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											
CO5															

Detailed Syllabus:

Introduction: Biosphere, Hydrological cycle, Nutrient cycle, Consequences of population growth, Pollution of air, Water and soil.

Air pollution sources & effects: Classification and properties of air pollutants, Emission sources, Behavior and fate of air pollutants, Effect of air pollution.

Meteorological aspects of air pollutant dispersion: Temperature lapse rates and stability, Wind velocity and turbulence, Plume behavior, Dispersion of air pollutants, Estimation of plume rise.

Air pollution sampling and measurement: Types of pollutant sampling and measurement, Ambient air sampling, Stack sampling, Analysis of air pollutants.

Air pollution control methods & equipment: Control methods, Source correction methods, Cleaning of gaseous effluents, Particulate emission control, Selection of a particulate collector, Control of gaseous emissions, Design methods for control equipment.Control of specific gaseous pollutants: Control of NOx emissions, Control of hydrocarbons and mobile sources.

Water pollution: Water resources, Origin of wastewater, types of water pollutants and their effects. Waste water sampling, analysis and treatment: Sampling, Methods of analysis, Determination of organic matter, Determination of inorganic substances, Physical characteristics, Bacteriological measurement, Basic processes of water treatment, Primary treatment, Secondary treatment, Advanced wastewater treatment, Recovery of materials from process effluents.

Solid waste management: Sources and classification, Public health aspects, Methods of collection, Disposal Methods, Potential methods of disposal.

Hazardous waste management: Definition and sources, Hazardous waste classification, Treatment methods, Disposal methods.

E-waste: Sources, environmental and social issues, management practices

Reading:

1. Rao C.S., Environmental Pollution Control Engineering, Wiley Eastern Limited, India, 1993.
2. Noel de Nevers, Air Pollution and Control Engineering, McGraw Hill, 2000.
3. Glynn Henry J. and Gary W. Heinke, Environmental Science and Engineering, Prentice Hall of India, 2nd Edition, 2004.
4. Rao M.N., Rao H.V.N, Air Pollution, Tata McGraw Hill Publishing Ltd., 1993.
5. De A.K., Environmental Chemistry, Tata McGraw Hill Publishing Ltd., 1999.
6. George Tchobanoglous, Franklin Louis Burton, H. David Stensel, Metcalf & Eddy, Inc., Franklin Burton, Waste Water Engineering: Treatment and Reuse, McGraw Hill Education; 4th Edition, 2003.
7. E-waste recycling, NPCS Board of consultants and Engineers, Asia pacific business press Inc. 2015

CH393	**SOFT-COMPUTING METHODS FOR CONTROL**	**OPC**	**3 – 0 – 0**	**3 Credits**

(Not offered to Chemical Engineering Students)

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO2	Use neural networks to control the process plants
CO3	Develop fuzzy logic based controllers for different processes
CO4	Combine fuzzy logic with neural networks for plant control
CO5	Design controllers using genetic algorithms

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											
CO5															

Detailed syllabus

Introduction to Artificial Neural Networks: Basic properties, Neuron Models, Feed forward networks.

Neural Networks Based Control: Representation and identification, modeling the plant, control structures – supervised control, Model reference control, Internal model control, Predictive control: Examples – Inferential estimation of viscosity an chemical process, Auto – turning feedback control.

Introduction to Fuzzy Logic: Fuzzy Controllers, Fuzzy sets and Basic notions – Fuzzy relation calculations – Fuzzy members – Indices of Fuzziness – comparison of Fuzzy quantities – Methods of determination of membership functions.

Fuzzy Logic Based Control: Fuzzy sets in commercial products – basic construction of fuzzy controller – Analysis of static properties of fuzzy controller – Analysis of dynamic properties of fuzzy controller – simulation studies – case studies – fuzzy control for smart cars.

Neuro – Fuzzy and Fuzzy – Neural Controllers: Neuro – fuzzy systems: A unified approximate reasoning approach – Construction of role bases by self-learning: System structure and learning. Introduction to Genetic algorithms. Controller design using genetic algorithms.

Reading:

1. S. N. Sivanandam and S. N. Deepa, Principles of Soft Computing, John Wiley & Sons, 2007.
2. Bose and Liang, Artificial Neural Networks, Tata McGraw Hill, 1996.
3. Huaguang Zhang, Derong Liu, Fuzzy Modeling and Fuzzy Control, Birkhauser Publishers, 2006.
4. Kosco B, Neural Networks and Fuzzy Systems: A Dynamic Approach to Machine Intelligence, Prentice Hall of India, 1992.
5. Lakshmi C. Jain, N. M. Martin, Fusion of Neural Networks, Fuzzy Systems and Genetic Algorithms: Industrial Applications, CRC Press, 1998.
6. MuhammetÜnal, AyçaAk, VedatTopuz, Hasan Erdal, Optimization of PID Controllers using Ant Colony and Genetic Algorithms, Springer, 2013.

CS390	OBJECT ORIENTED PROGRAMMING	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand fundamental concepts in object oriented approach.
CO2	Analyze design issues in developing OOP applications.
CO3	Write computer programs to solve real world problems in Java.
CO4	Analyze source code API documentations.
CO5	Create GUI based applications.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	-	-	2	-	-	-	-	-	-	-	-	-	1
CO2	3	3	-	-	2	-	-	-	-	-	-	-	-	-	1
CO3	3	3	-	-	2	-	-	-	-	-	-	-	-	-	1
CO4	3	3	-	-	2	-	-	-	-	-	-	-	-	-	1
CO5	3	3	-	-	2	-	-	-	-	-	-	-	-	-	1

Detailed Syllabus:

Object- oriented thinking, History of object-oriented programming, overview of java, Object-oriented design, Structure of java program. Types and modifiers, Classes, declaring objects in classes, Methods, constructors, garbage collection, Method overloading, passing objects as parameters, Inheritance, various forms and types of inheritance, Multilevel hierarchy, use of super, method overriding, Applications of method overriding, abstract classes, Packages with examples

Interfaces and implementation, Exception handling, types, throwing, creating own exceptions, Multithreading and concepts, its usage and examples, Input/output streams, String operations and examples, Collection classes-array, stack collection, bitset collection, Utility classes-string tokenizer, bitset, date, Applets- methods, creation, designing and examples, Event handling-event classes, Event listener interfaces, AWT classes, working with frames, AWT controls-layout manager, user interface components, Graphics programming

Reading:

1. Timothy Budd, Understanding object-oriented programming with Java, Pearson, 2000.
2. Herbert Schildt, The complete reference Java 2, TMH, 2017.

BT390	GREEN TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Address smart energy and green infrastructure
CO2	Build models that simulate sustainable and renewable green technology systems
CO3	Understand the history, global, environmental and economical impacts of green technology
CO4	Address non-renewable energy challenges

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	2	3	1	-	-	-	-	3	2	1
CO2	3	3	3	1	1	2	3	-	-	-	-	-	3	2	2
CO3	3	3	3	1	1	2	3	-	-	-	-	-	3	2	2
CO4	3	3	2	2	2	2	3	1	-	-	-	-	3	2	3

Detailed Syllabus:

Biomass Energy, basic concepts, sources of biomass energy, uses of biomass energy, science and engineering aspects of biomass energy, production of biomass electricity, transmission of biomass electricity, storage of biomass electricity.

Energy transformation from source to services; Energy sources, sun as the source of energy; biological processes; photosynthesis; food chains, classification of energy sources, quality and concentration of energy sources; fossil fuel reserves - estimates, duration; theory of renewability, renewable resources; overview of global/ India's energy scenario.

Environmental effects of energy extraction, conversion and use; sources of pollution from energy technologies, Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends-process/product innovation-, technological/ environmental leap-frogging; Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity.

First and second laws of thermodynamics and their applications – Thermodynamic processes - Irreversibility of energy – Entropy. Properties of steam and classification of steam engines. Carnot cycle - Rankine cycle, Current energy requirements, growth in future energy requirements, Review of conventional energy resources- Coal, gas and oil reserves and resources, Tar sands and Oil, Shale, Nuclear energy Option.

Biomass fuels, market barriers of biomass fuels, biomass fuel standardization, biomass fuel life cycle, Sustainability of biomass fuels, economics of biomass fuels, Fuel stoichiometry and analysis: Fuel stoichiometry relations; Estimation of air required for complete combustion; Estimation of minimum amount of air required for a fuel of known composition; Estimation of dry flue gases for known fuel composition; Calculation of the composition of fuel & excess air supplied, from exhaust gas analysis; Dew point of products; Flue gas analysis (O_2, CO_2, CO, NOx, SOx).

Biomass as a major source of energy in India: Fuel-wood use in rural households. Consequences for ecosystems. Future energy scenario in rural areas. Utilization of biomass in industrial and semi-industrial settings. Future utilization of biomass in India. Future of landscape management: optimal management.

Reading:

1. Ayhan Demirbas, Green Energy and Technology, Biofuels, Securing the Planet's Future Energy Needs, Springer, 2009.
2. Jay Cheng, Biomass to Renewable Energy Processes, CRC press, 2009.
3. Samir K. Khanal, Rao Y. Surampally, American Society of Civil Engineers, 2010.

SM390	MARKETING MANAGEMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand concepts and scope of marketing and market oriented strategic planning
CO2	Analyze macro level environment
CO3	Identify factors influencing consumer behavior in competitive global business environment
CO4	Identify tools and techniques for marketing management through integrated marketing communication systems.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-
CO2	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-
CO3	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-
CO4	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-

Detailed Syllabus:

Importance of Marketing, Scope of Marketing, Core Marketing concepts company orientation towards market place-production concept, Product concept, selling concept and Marketing concept.

Market oriented Strategic planning – Defining corporate Mission and Vision Statement at Corporate level and at Business unit level. Assigning resources to Strategic Business units through B.C.G Matrix and G.E Model.

Analyzing Macro environment-Demographic environment. Economic Environment, Technical Environment, Social-Cultural Environment and political – Legal Environment.

Components of Marketing information systems- Internal Records, Marketing intelligence, Marketing research and Marketing Decision support system.

Consumer Behavior- Buying Decision process and the factors influencing consumer Behavior-Psychological factors, social factors, cultural factors and personal factors.

Importance of Market segmentation, Target market selection and positioning.

Importance of new product development process and the various stages involved.

The concept of product lifecycle and the various strategies used by the marketer in each stage.

Product characteristics and classification, Product mix and product line decisions Branding Decisions, Building Brand Equity.

Importance of Pricing, Factors influencing pricing decisions. Various pricing methods-cost based and demand based methods.

Role of Marketing channels-Channel functions and channel levels channel Design and channel Management Decisions, Managing Retailing. Wholesaling and logistics. Importance of Electronic channels.

Importance of integrated Marketing communication. Advantages and Disadvantages of Various promotional tools- Advertising, Sales promotion, personal selling, publicity and public Relations and Direct marketing.

Reading:

1. Philip Kotler, Marketing Management, PHI, 14th Edition, 2013.
2. William Stonton & Etzel, Marketing Management, TMH, 13th Edition, 2013.
3. Rama Swamy & Namakumari, Marketing Management, McMillan, 2013.

MA390	NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Solve nonlinear differential equations by numerical methods.
CO2	Determine the convergence region for a finite difference method.
CO3	Solve elliptic PDE by finite difference method
CO4	Solve a parabolic PDE by finite difference method
CO5	Solve a hyperbolic PDE by finite difference method

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	-	-	-	-	-	-	-	-	1	2
CO2	3	3	1	1	1	-	-	-	-	-	-	-	-	1	2
CO3	3	3	1	1	1	-	-	-	-	-	-	-	-	1	2
CO4	3	3	1	1	1	-	-	-	-	-	-	-	-	1	2
CO5	3	3	1	1	1	-	-	-	-	-	-	-	-	1	2

Detailed Syllabus:

Ordinary Differential Equations: Multistep (explicit and implicit) methods for initial value problems, Stability and Convergence analysis, Linear and nonlinear boundary value problems, Quasi-linearization, Shooting methods

Finite difference methods: Finite difference approximations for derivatives, boundary value problems with explicit boundary conditions, implicit boundary conditions, error analysis, stability analysis, convergence analysis.

Partial Differential Equations: Classification of partial differential equations, finite difference approximations for partial derivatives and finite difference schemes for Parabolic equations, Schmidt's two level, multilevel explicit methods, Crank-Nicolson's two level, multilevel implicit methods, Dirichlet's problem, Neumann problem, mixed boundary value problem, stability analysis.

Hyperbolic Equations: Explicit methods, implicit methods, one space dimension, two space dimensions, ADI methods.

Elliptic equations: Laplace equation, Poisson equation, iterative schemes, Dirichlet's problem, Neumann problem, mixed boundary value problem, ADI methods.

Reading:

1. M.K. Jain, Numerical Solution of Differential Equations, Wiley Eastern, 1984.
2. G.D. Smith, Numerical Solution of Partial Differential Equations, Oxford Univ. Press, 2004.
3. M.K.Jain, S.R.K. Iyengar and R.K. Jain, Computational Methods for Partial Differential Equations, Wiley Eastern, 2005.

MA391	FUZZY MATHEMATICS AND APPLICATIONS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply operations on Fuzzy sets
CO2	Solve problems related to Propositional Logic.
CO3	Apply Fuzzy relations to cylindric extensions.
CO4	Apply logic of Boolean Algebra to switching circuits.
CO5	Develop Fuzzy logic controllers

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	2	1	-	-	-	-	-	-	-	1	2
CO2	3	3	1	1	2	1	-	-	-	-	-	-	-	1	2
CO3	3	3	1	1	2	1	-	-	-	-	-	-	-	1	2
CO4	3	3	1	1	2	1	-	-	-	-	-	-	-	1	2
CO5	3	3	1	1	2	1	-	-	-	-	-	-	-	1	2

Detailed Syllabus:

Crisp set theory (CST): Introduction, Relations between sets, Operations on sets, Characteristic functions, Cartesian products of crisp sets, crisp relations on sets.

Fuzzy set theory (FST): Introduction, concept of fuzzy set (FS), Relation between FS, operations on FS, properties of standard operations, certain numbers associated with a FS, certain crisp sets associated with FS, Certain FS associated with given FS, Extension principle.

Propositional Logic (PL1): Introduction, Syntax of PL1, Semantics of PL1, certain properties satisfied by connectives, inference rules, Derivation, Resolution.

Predicate Logic (PL2): Introduction, Syntax of PL2, Semantics of PL2, certain properties satisfied by connectives and quantifiers, inference rules, Derivation, Resolution

-cuts of FR, Composition of FR, Projections of FR, Cylindric extensions, Cylindric closure, FR on a domain.

Fuzzy Logic (FL): Introduction, Three-valued logics, N-valued logics and infinite valued logics, Fuzzy logics, Fuzzy propositions and their interpretations in terms of fuzzy sets, Fuzzy rules and their interpretations in terms of FR, fuzzy inference, More on fuzzy inference, Generalizations of FL.

Switching functions (SF) and Switching circuits (SC): Introduction, SF, Disjunctive normal form, SC, Relation between SF and SC, Equivalence and simplification of circuits, Introduction of Boolean Algebra BA, Identification, Complete Disjunctive normal form.

Applications: Introduction to fuzzy logic controller (FLC), Fuzzy expert systems, classical control theory versus fuzzy control, examples, working of FLC through examples, Details of FLC, Mathematical formulation of FLC, Introduction of fuzzy methods in decision making.

Reading:

1. M. Ganesh, Introduction to Fuzzy Sets and Fuzzy Logic, PHI, 2001.
2. G.J. Klir and B.Yuan, Fuzzy sets and Fuzzy Logic–Theory and Applications, PHI, 1997.
3. T. J. Ross, Fuzzy Logic with Engineering Applications, McGraw-Hill, 1995.

PH390	MEDICAL INSTRUMENTATION	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the origin of bio-potentials and their physical significance.
CO2	Understand anatomy and functioning of human heart and its common problems.
CO3	Analyze ECG, ENG and EMG signals and instrumentation.
CO4	Compare different techniques of measuring blood pressure, blood flow and volume.
CO5	Interpret the principle and operation of therapeutic and prosthetic devices.
CO6	Differentiate between the various techniques for measurement of parameters.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO2	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO3	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO4	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO5	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO6	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-

Detailed Syllabus:

General Introduction: The cell, body fluids, Musculoskeletal system, respiratory system, gastrointestinal system, Nervous system, endocrine system and circulatory system.

Origin of Bio potentials: electrical activity of Excitable cells: the resting state, The active state, Volume conductor fields, Functional organization of the peripheral nervous system: Reflex are & Junctional transmission.

The Electroneurogram (ENG): The H-Reflex, The Electromyogram (EMG), The Electrocardiogram (ECG), heart and the circulatory system, Electro conduction system of the heart and heart problems, ECG waveform and Physical significance of its wave features, Electrical behavior of cardiac cells, The standard lead system, The ECG preamplifier, DC ECG Amplier, Defibrillator protection circuit, Electro surgery Unit filtering, Functional blocks of ECG system, Multichannel physiological monitoring system, Common problems encountered and remedial techniques.

Blood Pressure: indirect measurement of blood pressure, korotkoff sounds, auscultatory method using sphygmo manometer, Oscillometric and ultrasonic noninvasive pressure measurement, Direct measurement of blood pressure H2O manometers, electronic manometry, Pressure transducers,. Pressure amplifier designs, Systolic, diastolic mean detector circuits

Blood flow and Volume Measurement: indicator dilution methods, Transit time flow meter, DC flow meter, Electromagnetic flow meter AC electromagnetic flow meter, Quadrature suppression flow meter, Ultrasonic flow meter, Continuous-wave Doppler flow meter, Electric impedance plethysmography, chamber plethysmography, Photo plethysmography.

Pulse Oximetr: Principles of Operation, Absorption Spectrum, Sensor design, Pulse oximeter, Therapeutic and Prosthetic Devices.

Cardiac Pacemakers: Lead wires and electrodes, Synchronous Pacemakers, rate responsive pacemaking, Defibrillators, cardioverters, electrosurgical unit, Therapeutic applications of laser, Lithotripsy Haemodialysis.

Reading:

1. John G Webster, Medical Instrumentation: Application and Design, John Wiley, 3rd Edition, 2012.
2. Joseph J. Carr & John M. Brown , Introduction to biomedical Equipment Technology, 4th Edition, Prentice Hall India, 2001

PH391	ADVANCED MATERIALS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the synthesis and properties of nanomaterials
CO2	Evaluate the usefulness of nanomaterials in medicine, biology and sensing
CO3	Understand modeling of composite materials by finite element analysis
CO4	Differentiate superconducting materials
CO5	Understand the characteristics and uses of functional materials

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	-	-	1	-	-	-	-	-	-	-	1	-
CO2	3	3	3	-	-	1	-	-	-	-	-	-	-	1	-
CO3	3	3	3	-	-	1	-	-	-	-	-	-	-	1	-
CO4	3	3	3	-	-	1	-	-	-	-	-	-	-	1	-
CO5	3	3	3	-	-	1	-	-	-	-	-	-	-	1	-

Detailed Syllabus:

Nano Materials: Origin of nanotechnology, Classification of nanomaterials, Physical, chemical, electrical, mechanical properties of nanomaterials. Preparation of nanomaterials by plasma arcing, physical vapour deposition, chemical vapour deposition (CVD), Sol-Gel, electro deposition, ball milling, carbon nanotubes (CNT). Synthesis, preparation of nanotubes, nanosensors, Quantum dots, nanowires, nanobiology, nanomedicines.

Biomaterials: Overview of biomaterials. Biomaterials, bioceramics, biopolymers, tissue grafts, soft tissue applications, cardiovascular implants, biomaterials in ophthalmology, orthopedic implants, dental materials.

Composites: General characteristics of composites, composites classes, PMCs, MMCs, CMCs, CCCs, IMCs, hybrid composites, fibers and matrices, different types of fibers, whiskers, different matrices materials, polymers, metal, ceramic matrices, toughening mechanism, interfaces, blending and adhesion, composite modeling, finite element analysis and design.

Optical materials: Mechanisms of optical absorption in metals, semiconductors and insulators. Nonlinear optical materials, optical modulators, optical fibers. Display devices and materials photo-emissive, photovoltaic cells, charge coupled devices (CCD), laser materials.

Super conducting materials: Types of super conductors, an account of mechanism of superconductors, effects of magnetic field currents, thermal energy, energy gap, acoustic attenuation, penetration depth, BCS theory, DC and AC Josephson effects, high Tc superconductors, potential applications of superconductivity, electrical switching element, superconductor power transmission and transformers, magnetic mirror, bearings, superconductor motors, generators, SQUIDS etc.

Smart materials: An introduction, principles of smart materials, input – output decision ability, devices based on conductivity changes, devices based on changes in optical response, biological systems smart materials. Devices based on magnetization, artificial structures, surfaces, hetero structures, polycrystalline, amorphous, liquid crystalline materials.

Surface Acoustic Wave (SAW) Materials and Electrets: Delay lines, frequency filters, resonators, and Pressure and temperature sensors, Sonar transducers. Comparison of electrets with permanent magnets, Preparation of electrets, Application of electrets.

Reading:

1. T. Pradeep, Nano: The Essentials; TATA McGraw-Hill, 2008.
2. B.S. Murthy et al., Textbook of Nano science and Nanotechnology, University press, 2012.
3. Krishan K Chawla, Composite Materials; 2nd Edition, Springer 2006.

CY390	INSTRUMENTAL METHODS IN CHEMICAL ANALYSIS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the concepts of ultraviolet and visible absorption and fluorescence techniques for material characterization.
CO2	Understand the various liquid, gas and size-exclusion chromatographic techniques the automated continuous analysis of environmental, industrial, production-line materials
CO3	Understand the concepts of various electro analytical techniques for characterization of interfaces and traces of surface adsorbed-materials.
CO4	Understands the principles of thermogravimetry and differential thermal analyses (TGA and DTA) for applications into pharmaceuticals, drugs, polymers, minerals, toxins and in Finger Print Analysis
CO5	Identification of suitable analytical technique for characterization of chemical, inorganic and engineering materials

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	-	3	1	1	1	-	-	-	-	-	1	2	-
CO2	3	3	-	3	1	1	1	-	-	-	-	-	1	2	-
CO3	3	3	-	3	1	1	1	-	-	-	-	-	1	2	-
CO4	3	3	-	3	1	1	1	-	-	-	-	-	1	2	-
CO5	3	3	-	3	1	1	1	-	-	-	-	-	1	2	-

Detailed Syllabus:

UV-Visible Spectrophotometry and Fluorescence: Beer-Lambert’s law, limitations, Molecular fluorescence, influencing factors, basic instruments, standardization, quantitative methods, applications.

Atomic spectrometry, atomic absorption, X-ray fluorescence methods: Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, quantitative aspects, X-ray fluorescence principle, instrumentation, quantitative analysis.

Chromatorgraphy methods: Gas chromatography, High performance liquid chromatography, size exclusion chromatography, Principle, Basic instrumentation, terminology, NPC, RPC, Qualitative and Quantitative applications. Capillary Electrophoresis: Principle and application.

Thermoanalytical methods: Thermogravimetry, Differential thermal analysis, differential scanning calorimetry, Principle, Block diagram, Applications, Quantitative determinations

Electroanalytical methods: Coulometric methods, Polarography, Pulse voltammetric methods, Amperometry, Principles, Applications, Electrochemical sensors, Ion selective, Potentiometric and amperometric Sensors, Applications.

Spectroscopic methods: Molecular absorption, Woodward rules, applications, Infrared absorption, functional group analysis, qualitative analysis, 1H- and 13C-NMR spectroscopy, Principle, Basic instrumentation, terminology, Interpretation of data, Quantitative applications

Mass spectrometry: Principles, Instrumentation, Ionization techniques, Characterization and applications.

Reading:

1. Gurdeep Chatwal and Sham Anand, Instrumental Methods of Chemical Analysis, Himalaya Publishing House, 1986.
2. Skoog, Holler and Kouch, Instrumental methods of analysis, Thomson, 2007.
3. Mendham, Denny, Barnes and Thomas, Vogel: Text book of quantitative chemical analysis, Pearson, 6Edotion, 2007.
4. William Kemp, Organic spectroscopy, McMillan Education, UK, 1991.
5. Instrumental methods of analysis – Willard, Meritt and Dean, PHI, 2005.

HS390	SOFT SKILLS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand corporate communication culture
CO2	Prepare business reports and proposals expected of a corporate professional
CO3	Employ appropriate speech in formal business situations
CO4	Exhibit corporate social responsibility and ethics
CO5	Acquire corporate email, mobile and telephone etiquette

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO2	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO3	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO4	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO5	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-

Detailed Syllabus:

English Language Enhancement: Verbs and tenses, Phrasal verbs, Synonyms, Antonyms, Homonyms - Descriptive Words, Combining Sentences, Business Idioms, Indianisms in English.

Art of Communication, Communication process- Non-verbal Communication- Effective Listening.

Interpersonal and Intra Personal Communication Skills- Self-Awareness- Self-Esteem and Confidence- Assertiveness and Confidence- Dealing with Emotions-Team Concept- Elements of Teamwork- Stages of Team Formation- Effective Team-Team Player Styles-Leadership.

Campus to Company- Dressing and Grooming- The Corporate Fit- Business Etiquette- Communication; media etiquette- Group Discussions, Interviews, and Presentation Skills.

Interview handling skills- Effective Resume-- Common Interview Mistakes- Body-language- Content Aid, Visual Aids- Entrepreneurial Skills Development.

Reading:

1. Robert M. Sherfield, Developing Soft Skills, Montgomery and Moody 4th Edition, Pearson, 2009.
2. K. Alex, Soft Skills: Know Yourself & Know The world, S. Chand; 2009.
3. Robert Bramson, Coping with Difficult People, Dell, 2009.

CE440	BUILDING TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

Course Outcomes: At the end of the course the student will be able to:

CO1	Apply basic principles to develop stable, sustainable and cost-effective building plans
CO2	Identify different materials, quality and methods of fabrication & construction.
CO3	Adopt standard building provisions for natural ventilation and lighting.
CO4	Identify effective measures for fire proofing, damp proofing, and thermal insulation.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	-	-	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	-	-	1	1	-	-	-	-	-	-	-	-
CO3	2	2	1	-	-	1	1	-	-	-	-	-	-	-	-
CO4	2	2	1	-	-	1	1	-	-	-	-	-	-	-	-

Detailed Syllabus:

Overview of the course, basic definitions, Buildings – Types, components, economy and design, Principles of planning of buildings and their importance. Definitions and importance of Grouping and circulation; Lighting and ventilation; How to consider these aspects during planning of building.

Termite proofing: Inspection, control measures and precautions, Lightning protection of buildings: General principles of design of openings, various types of fire protection measures to be considered while planning a building.

General requirements and extra requirements for safety against fire, special precautions, Vertical transportation in building – types of vertical transportation, Stairs, different forms of stairs, planning of stair cases, Other modes of vertical transportation – lifts, ramps, escalators.

Prefabrication systems in residential buildings – walls, openings, cupboards, shelves etc., planning and modules and sizes of components in prefabrication. Planning and designing of residential buildings against the earthquake forces, Principles, Seismic forces and their effect on buildings.

Air conditioning – process and classification of air conditioning, Dehumidification. Systems of air-conditioning, ventilation, functional requirements of ventilation.

Acoustics, effect of noise, properties of noise and its measurements, Principles of acoustics of building. Sound insulation – importance and measures.

Plumbing services – water supply system, maintenance of building pipe line, sanitary fittings, principles governing design of building drainage.

Reading:

1. Building Construction - Varghese, PHI Learning Private Limited, 2008.
2. Building Construction - Punmia, B C, Jain, A J and Jain A J, Laxmi Publications, 2005.
3. Building Construction by S.P. Arora and S.P. Bindra – Dhanpatrai and Sons, New Delhi, 1996.
4. Building Construction – Technical Teachers Training Institute, Madras, Tata McGraw Hill, 1992.
5. National Building code of India, Bureau of Indian Standards, 2005.

EE440	NEW VENTURE CREATION	OPC	3–0– 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the process and practice of entrepreneurship and new venture creation
CO2	Identify entrepreneurial opportunities, preparation of a business plan for launching a new venture
CO3	Explore the opportunities in the domain of respective engineering disciplines for launching a new venture
CO4	Expose the students with the functional management issues of running a new venture

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO2	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO3	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO4	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-

Detailed syllabus:

Entrepreneur and entrepreneurship: Entrepreneurship and Small Scale Enterprises (SSE), Role in Economic Development, Entrepreneurial Competencies, and Institutional Interface for SSE.

Establishing The Small Scale Enterprise: Opportunity Scanning and Identification,Market Assessment for SSE, Choice of Technology and Selection of Site, Financing the New/Small Enterprises, Preparation of the Business Plan, Ownership Structures and Organizational Framework.

Operating the Small Scale Enterprises: Financial Management Issues in SSE, Operational Management Issues in SSE, Marketing Management Issues in SSE, and Organizational Relations in SSE.

Reading:

1. Holt, Entrepreneurship: New Venture Creation, PHI (P), Ltd., 2001.
2. Madhulika Kaushik: Management of New & Small Enterprises, IGNOU course material, 1995

3. B S Rathore S Saini: Entrepreneurship Development Training Material, TTTI, Chandigarh, 1988.
4. P.C. Jain: A Hand Book for New Entrepreneurs, EDI-Faculty & External Experts, EDII, Ahmedabad, 1986.
5. J.B. Patel, D.G Allampalli: A Manual on How to Prepare a Project Report, EDII, Ahmedabad, 1991.
6. J B Patel, S S Modi, A Manual on Business Opportunity Identification and Selection, EDII, Ahmedabad, 1995.

EE441	PRINCIPLES OF ELECTRIC POWER CONVERSION	OPC	3–0– 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the basics in the electric power conversion using power switching devices
CO2	Evaluate the conversion for range of renewable energy sources with the help of available electrical machines drives
CO3	Analyze the different energy storage systems
CO4	Identify the various Industrial and domestic applications

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	2	1	1	1	1	1	-	-	-	-	-	1	2	-
CO2	1	2	1	1	1	1	1	-	-	-	-	-	1	2	-
CO3	1	2	1	1	1	1	1	-	-	-	-	-	1	2	-
CO4	1	2	1	1	1	1	1	-	-	-	-	-	1	2	-

Detailed syllabus:

Power Electronic Devices and Converters: V-I characteristics of SCR, MOSFET and IGBT. Phase controlled rectifiers, DC-DC converters and Inverters.

Applications to Electric Drives: Speed control of DC motor, Induction motors, PMSM and BLDC drives

Applications to Renewable Energy: Introduction to solar cell, solar panels, MPPT, wind and other renewable energy sources, Integration of renewable energy sources to the grid.

Energy Storage Systems: Study of automotive batteries, SMF, pumped storage systems, super-capacitors, fly wheels - applications, Li-ion batteries and applications to electric vehicles.

Domestic And Industrial Applications: Induction heating, melting, hardening, lighting applications and their control, UPS, battery chargers

Reading:

1. M.H.Rashid: Power Electronics-circuits, Devices and applications, Prentice Hall India, New Delhi, 2009.
2. P.S.Bhimbra: Power Electronics, Khanna publishers, New Delhi, 2012.
3. Ned Mohan, Undeland and Robbin: Power electronics converters, applications and design, John Willey & Sons, New York, 2006.

ME440	ALTERNATIVE SOURCES OF ENERGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify renewable energy sources and their utilization.
CO2	Understand basic concepts of solar radiation and analyze solar thermal systems for its utilization.
CO3	Understand working of solar cells and its modern manufacturing technologies.
CO4	Understand concepts of Fuel cells and their applications
CO5	Identify methods of energy storage.
CO6	Compare energy utilization from wind energy, geothermal energy, biomass, biogas and hydrogen.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2
CO2	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2
CO3	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2
CO4	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2
CO5	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2
CO6	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2

Detailed Syllabus:

Introduction: Overview of the course; Examination and Evaluation patterns; Global warming; Introduction to Renewable Energy Technologies

Energy Storage: Introduction; Necessity of Energy Storage; Energy Storage Methods

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Measurement of solar radiation data

Solar Thermal systems: Introduction; Basics of thermodynamics and heat transfer; Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems

Solar Photovoltaic systems: Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction; Photovoltaic thermal systems.

Wind Energy: Introduction; Origin and nature of winds; Wind turbine siting; Basics of fluid mechanics; Wind turbine aerodynamics; wind turbine types and their construction; Wind energy conversion systems

Fuel cells: Overview; Classification of fuel cells; operating principles; Fuel cell thermodynamics

Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies; Urban waste to energy conversion; Biomass gasification.

Other forms of Energy: Introduction: Nuclear, ocean and geothermal energy applications; Origin and their types; Working principles

Reading:

1. Sukhatme S.P. and J.K. Nayak, Solar Energy - Principles of Thermal Collection and Storage, Tata McGraw Hill, New Delhi, 2008.
2. Khan B.H., Non-Conventional Energy Resources, Tata McGraw Hill, New Delhi, 2006.
3. J.A. Duffie and W.A. Beckman, Solar Energy - Thermal Processes, John Wiley, 2001.

ME441	ROBUST DESIGN	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand stages in engineering design and concept of robust design.
CO2	Develop quality loss functions and S/N ratios for S, N and L type objective functions.
CO3	Identify control and noise factors for a given product or process.
CO4	Conduct experiments using DOE concepts to decide the optimal setting of parameters
CO5	Apply quality loss function approach for fixing the component tolerances.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	1	3	2	1	-	2	-	-	-	-	-	-	1	1
CO2	1	1	3	2	1	-	2	-	-	-	-	-	-	1	1
CO3	1	1	3	2	1	-	2	-	-	-	-	-	-	1	1
CO4	1	1	3	2	1	-	2	-	-	-	-	-	-	1	1
CO5	1	1	3	2	1	-	2	-	-	-	-	-	-	1	1

Detailed syllabus

Introduction: Taguchi's quality philosophy, causes of performance variation, concept of robust design, stages in product/process design, need for experimentation, QFD, process flow analysis, cause and effect diagram.

Design of Experiments**:** Principles of experimentation, Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA, Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.

Parameter Design**:** Loss function, average quality loss, S/N ratios, objective functions, selection of control & noise factors and their levels, strategy for systematic sampling of noise, classification of control factors, inner-array and outer-array design, data analysis, selection of optimum levels/values for parameters.

Tolerance Design: Experiments, selection of tolerances to be tightened, fixing the final tolerances.

Reading:

1. Taguchi G, Chowdhury S and Taguchi S, Robust Engineering, TMH, 2000.
2. Ross PJ, Taguchi Techniques for Quality Engineering, TMH, 2005.

EC440	ELECTRONIC MEASUREMENTS AND INSTRUMENTATION	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Apply knowledge of instruments for effective use
CO2	Select suitable instruments for typical measurements.
CO3	Identify various transducers to measure strain, temperature and displacement.
CO4	Understand data acquisition system and general purpose interfacing bus.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	-	1	1	1	-	-	-	-	-	1	2	-
CO2	2	2	1	-	1	1	1	-	-	-	-	-	1	2	-
CO3	2	2	1	-	1	1	1	-	-	-	-	-	1	2	-
CO4	2	2	1	-	1	1	1	-	-	-	-	-	1	2	-

Detailed syllabus

Measurement And Error: Sensitivity, Resolution, Accuracy and precision, absolute and Relative types of errors, Statistical analysis, Probability of and Limiting errors, Linearity.

Instruments: D'Arsonval movement and basic principles of Measurement of Voltage, Current and Resistance in instruments. Analog and Digital Multimeters, Measurement of time and Frequency – Digital Frequency Meter and applications.

Impedance Measurement: Kelvin Bridge; Megger; Maxwell, Hay and Shering Bridges. Q-meter; Noise and Interference reduction techniques in Measurement Systems.

Oscilloscopes: Block diagram, probes, Deflection amplifier and delay line, Trigger Generator, Coupling, Automatic Time Base and Dual Trace Oscilloscopes, Pulse Measurements, Delayed Time Base, Analog Storage, Sampling and Digital Storage Oscilloscopes.

Special instruments: Wave Analyzer, Harmonic Distortion Analyzer, Spectrum Analyzer, FFT Analyzer.

Transducers (Qualitative Treatment Only): Classification and selection of Transducers, Introduction to strain, Load, force, Displacement, Velocity, Acceleration, Pressure and Temperature Measurements.

Introduction to Data Acquisition Systems (DAS): Block Diagram, Specifications and various components of DAS.

General purpose Instrumentation Bus (GP-IB): Protocol, SCPI Commands and Applications to DSO and DMM.

Reading:

1. Oliver and Cage, Electronic Measurements and Instrumentation, McGraw Hill, 2009
2. Helfrick Albert D. and Cooper William D., Electronic Instrumentation & Measurement Techniques, PHI, 2008.
3. D.A. Bell, Electronic Instrumentation and Measurements, 3rd Edition, Oxford, 2013.

MM499	METALLURGY FOR NON-METALLURGISTS	OPC	3-0-0	03 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Discuss the characteristics and applications of metals and alloys.
CO2	Explain different fabrication techniques.
CO3	Correlate the microstructure, properties, processing and performance of materials.
CO4	Select metal/alloy for engineering applications.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	-	1	1	1	-	-	-	-	-	1	1	-
CO2	2	2	1	-	1	1	1	-	-	-	-	-	1	1	-
CO3	2	2	1	-	1	1	1	-	-	-	-	-	1	1	-
CO4	2	2	1	-	1	1	1	-	-	-	-	-	1	1	-

Detailed syllabus

Introduction to Metallurgy: Metals and Alloys classification, engineering applications of metals/alloys.

Structure of Metals and Alloys: Nature of Metallic Bonding, Crystal Structures of Metals, Structure of Alloys, Imperfections in Crystals.

Mechanical Properties: Plastic Deformation Mechanisms, Tensile, Creep, Fatigue, Fracture

Strengthening Mechanisms: Strain Hardening, Grain Size Refinement, Solid Solution Strengthening, Precipitation Hardening

Fabrication and Finishing of metal products: Metal Working and Machining

Testing of Metals: Destructive and Non-Destructive Testing, Inspection and Quality Control of Metals.

Engineering Alloys: Steel Products and Properties, Cast Irons, Tool Steels and High Speed Steels, Stainless Steels, selective non-ferrous metals and alloys.

Heat Treatment: Annealing, Normalizing, Hardening and Tempering.

Material selection processes: Case studies

Reading:

1. M. F. Ashby, Engineering Metals, 4^{th} Edition, Elsevier, 2005.
2. R. Balasubramaniam (Adapted): Calister's Materials Science and Engineering, 7^{th} Edition, Wiley India (P) Ltd, 2007.
3. R. Abbaschian, L. Abbaschian, R.E. Reed-Hill, Physical Metallurgy Principles, East-West Press, 2009.
4. V Raghavan, Elements of Materials Science and Engineering- A First Course, 5^{th} Edition, PHI Publications, 2011

CH440	DATA DRIVEN MODELLING	OPC	3 – 0 – 0	3 Credits

(Not offered to Chemical Engineering Students)

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify disturbance models
CO2	Estimate parametric and non-parametric models
CO3	Determine the model structure
CO4	Validate the developed models

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	2	2	-	-	-	-	-	-	1	-	-	3
CO2	2	2	1	2	2	-	-	-	-	-	-	1	-	-	3
CO3	2	2	1	2	2	-	-	-	-	-	-	1	-	-	3
CO4	2	2	1	2	2	-	-	-	-	-	-	1	-	-	3

Detailed syllabus

System Identification - Motivation and Overview. Models of Discrete-Time LTI Systems – Convolution equation. Difference equations, Transfer functions, State-space models, Discretization, Sampling and Hold operations, sampling theorem.

Disturbance models - random processes, representation of stationary processes, white-noise process, auto-covariance function (ACF), ARMA models. Parametric model structures - ARX, ARMAX, OE, BJ and PEM – structures and their applicability in real-time.

Linear Regression - Least Squares estimates, Statistical properties of LS Estimates. Weighted Least Squares, Recursive Least Squares, Maximum Likelihood Estimation and properties.

Estimation of non-parametric models - impulse / step response coefficients, frequency response models.

Estimation of parametric models - notions of prediction and simulation, predictors for parametric models, prediction-error methods, Instrumental Variable method.

Model Structure Selection and Diagnostics -estimation of delay and order, residual checks, properties of parameter estimates, model comparison and selection, model validation.

Reading:

1. Arun K. Tangirala. System Identification: Theory and Practice, CRC Press, 2014.
2. Karel J. Keesman, System Identification – An Introduction, Springer, 2011.
3. Nelles, O. Nonlinear System Identification, Springer-Verlag, Berlin, 2001.
4. Zhu, Y. Multivariable System Identification for Process Control, Pergamon, 2001.
5. Ljung, L. System Identification: Theory for the User, Prentice-Hall, 2nd Edition, 1999.
6. J. R. Raol, G. Girija, J. Singh, Modeling and Parameter Estimation of Dynamic Systems, The Institution of Electrical Engineers, 2004.
7. Rolf Johansson, System Modeling and Identification, Prentice Hall, 1993.

CH441	**FUEL CELL TECHNOLOGY**	**OPC**	**3 – 0 – 0**	**3 Credits**

(Not offered to Chemical Engineering Students)

Pre-requisites: None.

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand fuel cell fundamentals.
CO2	Analyze the performance of fuel cell systems.
CO3	Demonstrate the operation of fuel cell stack and fuel cell system.
CO4	Apply the modeling techniques for fuel cell systems

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											
CO5															
CO6															

Detailed syllabus

Overview of Fuel Cells: What is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

Fuels for Fuel Cells: Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others.

Fuel cell electrochemistry: electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents.

Fuel cell process design: Main PEM fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, Fuel cell operating conditions: pressure, temperature, flow rates, humidity.

Main components of solid-oxide fuel cells, Cell stack and designs, Electrode polarization, testing of electrodes, cells and short stacks, Cell, stack and system modeling

Fuel processing: Direct and in-direct internal reforming, Reformation of hydrocarbons by steam, CO_2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal , Using renewable fuels for SOFCs

Reading:

1. Hoogers G, Fuel Cell Technology Hand Book, CRC Press, 2003.
2. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, 2006.
3. F. Barbir, PEM Fuel Cells: Theory and Practice, Elsevier/Academic Press, 2nd Edition, 2013.
4. Subhash C. Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications
5. Laminie J, Dicks A, Fuel Cell Systems Explained, 2nd Edition, John Wiley, New York, 2003.

CH442	**DESIGN OF EXPERIMENTS**	**OPC**	**3 – 0 – 0**	**3 Credits**

(Not offered to Chemical Engineering Students)

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Design experiments for a critical comparison of outputs
CO2	Propose hypothesis from experimental data
CO3	Implement factorial and randomized sampling from experiments
CO4	Estimate parameters by multi-dimensional optimization

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											

Detailed syllabus

Introduction: Strategy of experimentation, basic principles, guidelines for designing experiments.

Simple Comparative Experiments: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means: Hypothesis testing, Choice of samples size, Confidence intervals, Randomized and paired comparison design.

Experiments with Single Factor; An example, The analysis of variance, Analysis of the fixed effect model, Model adequacy checking, Practical interpretation of results, Sample computer output, Determining sample size, Discovering dispersion effect, The regression approach to the analysis of variance, Nonparameteric methods in the analysis of variance, Problems.

Design of Experiments: Introduction, Basic principles: Randomization, Replication, Blocking, Degrees of freedom, Confounding, Design resolution, Metrology considerations for industrial designed experiments, Selection of quality characteristics for industrial experiments.

Parameter Estimation.

Response Surface Methods: Introduction, The methods of steepest ascent, Analysis of a second-order response surface, Experimental designs for fitting response surfaces: Designs for fitting the first-order model, Designs for fitting the second-order model, Blocking in response surface designs, Computer-generated (Optimal) designs, Mixture experiments, Evolutionary operation, Robust design, Problems.

Design and Analysis: Introduction, Preliminary examination of subject of research, Screening experiments: Preliminary ranking of the factors, active screening experiment-method of random balance, active screening experiment Plackett-Burman designs, Completely randomized block design, Latin squares, Graeco-Latin Square, Youdens Squares, Basic experiment-mathematical modeling, Statistical Analysis, Experimental optimization of research subject: Problem of optimization, Gradient optimization methods, Nongradient methods of optimization, Simplex sum rotatable design, Canonical analysis of the response surface, Examples of complex optimizations.

Reading:

1. Lazic Z. R., Design of Experiments in Chemical Engineering, A Practical Guide, Wiley, 2005.
2. Antony J., Design of Experiments for Engineers and Scientists, Butterworth Heinemann, 2004.
3. Montgomery D. C., Design and Analysis of Experiments, Wiley, 5thEdition, 2010.
4. Doebelin E. O., Engineering Experimentation: Planning, Execution, Reporting, McGraw-Hill, 1995.

CH443	**CARBON CAPTURE, SEQUESTRATION AND UTILIZATION**	**OPC**	**3 – 0 – 0**	**3 Credits**

(Not offered to Chemical Engineering Students)

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the necessity of CO_2 capture, storage and utilization
CO2	Distinguish the CO_2capture techniques
CO3	Evaluate CO_2 Storage and sequestration methods
CO4	Assess Environmental impact of CO_2 capture and utilization

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											

Detailed syllabus

Introduction: Global status of CO_2 emission trends, Policy and Regulatory interventions in abatement of carbon footprint, carbon capture, storage and utilization (CCS&U)

CO_2 capture technologies from power plants: Post-combustion capture, Pre-combustion capture, Oxy-fuel combustion, chemical looping combustion, calcium looping combustion

CO_2 capture agents and processes: Capture processes, CO_2 capture agents, adsorption, ionic liquids, metal organic frameworks

CO_2 storage and sequestration: Geological sequestration methods, Biomimetic carbon sequestration

CO_2 Utilization: CO_2 derived fuels for energy storage, polymers from CO_2, CO_2 based solvents, CO_2 to oxygenated organics, Conversion into higher carbon fuels, High temperature catalysis

Environmental assessment of CO_2 capture and utilization: Need for assessment, Green chemistry and environmental assessment tools, Life cycle assessment (LCA), ISO standardization of LCA, Method of conducting an LCA for CO_2 capture and Utilization.

Reading:

1. Peter Styring, Elsje Alessandra Quadrelli, Katy Armstrong, Carbon dioxide utilization: Closing the Carbon Cycle, Elsevier, 2015.
2. Goel M, Sudhakar M, Shahi RV, Carbon Capture, Storage and, Utilization: A Possible Climate Change Solution for Energy Industry, TERI, Energy and Resources Institute, 2015.
3. Amitava Bandyopadhyay, Carbon Capture and Storage, CO_2 Management Technologies, CRC Press, 2014.
4. Fennell P, Anthony B, Calcium and Chemical Looping Technology for Power Generation and Carbon Dioxide (CO_2) Capture, Woodhead Publishing Series in Energy: No. 82, 2015.
5. Mercedes Maroto-Valer M, Developments in Innovation in Carbon Dioxide Capture and Storage Technology: Carbon Dioxide Storage and Utilization, Vol 2, Woodhead Publishing Series in Energy, 2014.

CS440	MANAGEMENT INFORMATION SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Determine key terminologies and concepts including IT, marketing, management, economics, accounting, finance in the major areas of business.
CO2	Design, develop and implement Information Technology solutions for business problems.
CO3	Analysis of computing systems and telecommunication networks for business information systems.
CO4	Understand ethical issues that occur in business, evaluate alternative courses of actions and evaluate the implications of those actions.
CO5	Plan projects, work in team settings and deliver project outcomes in time.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	1		3	-	-	2	-	-	2	-	1	-	-
CO2	-	-	1		3	-	-	2	-	-	2	-	1	-	-
CO3	-	-	1		3	-	-	2	-	-	2	-	1	-	-
CO4	-	-	1		3	-	-	3	-	-	2	-	1	-	-
CO5	-	-	1		3	-	-	2	-	-	3	-	1	-	-

Detailed syllabus

Organization and Information Systems, Foundation Concepts, Information Systems in Business, the Components of Information Systems, Competing with Information Technology, Fundamentals of Strategic Advantage, Using Information Technology for Strategic Advantage. Changing Environment and its impact on Business, Kinds of Information Systems.

Computer Fundamentals, Computer Hardware, and Computer Systems: End User and Enterprise Computing, Computer Peripherals: Input, Output, and Storage Technologies, Computer Software, Application Software, System Software, Computer System Management, Data Resource Management, Technical Foundations of Database Management, Managing Data Resources

Telecommunication and Networks, Telecommunications and Networks, the Networked Enterprise, Telecommunications Network Alternatives System Analysis and Development and Models, Developing Business/IT Strategies, Planning Fundamentals, Implementation Challenges, Developing Business/IT Solutions, Developing Business Systems, Implementing Business Systems Manufacturing and Service Systems Information systems for Accounting, Finance, Production and Manufacturing, Marketing and HRM functions, Enterprise Resources Planning (ERP), Choice of IT, Nature of IT decision, Managing Information Technology, Managing Global IT, Security and Ethical Challenges, Security and Ethical Challenges, Security and Ethical, and Societal Challenges of IT, Security Management of Information Technology, Enterprise and Global Management of Information Technology.

Reading:

1. Kenneth J Laudon, Jane P. Laudon, Management Information Systems, 10th Edition, Pearson/PHI, 2007.
2. W. S. Jawadekar, Management Information Systems, 3rd Edition, TMH, 2004.

BT440	BIOSENSORS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand biosensing and transducing techniques
CO2	Understand principles of linking cell components and biological pathways with energy transduction, sensing and detection
CO3	Demonstrate appreciation for the technical limits of performance of biosensor
CO4	Apply principles of engineering to develop bioanalytical devices and design of biosensors

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO2	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO3	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO4	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-

Detailed Syllabus:

General principles: A historical perspective; Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies, Definitions and Concepts Terminology and working vocabulary; Main technical definitions: calibration, selectivity, sensitivity, reproducibility, detection limits, response time.

Physico-chemical transducers: Electrochemical transducers (amperometric, potentiometric, conductimetric); optical transducers (absorption, fluorescence, SPR); Thermal transducers; piezoelectric transducers.

Biorecognition systems: Enzymes; Oligonucleotides and Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Tissue and organelles (animal and plant tissue); Cell culture; Immunoreceptors; Chemoreceptors; Limitations & problems. Immobilization of biomolecules.

Biosensor Engineering: Methods for biosensors fabrication: self-assembled monolayers, screen printing, photolithography, micro-contact printing, MEMS. Engineering concepts for mass production.

Application of modern sensor technologies: Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable sensors for long-term monitoring; Environmental monitoring; Technological process control; Food quality control; Forensic science benefits; Problems & limitations.

Reading:

1. Donald G. Buerk, Biosensors: Theory and Applications, CRC Press, 2009.
2. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley& Sons, 1998.
3. Brian R. Eggins, Chemical Sensors and Biosensors, John Wiley& Sons, 2003.

SM440	HUMAN RESOURCE MANAGEMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand principles, processes and practices of human resource management.
CO2	Apply HR concepts and techniques in strategic planning to improve organizational performance.
CO3	Understand tools to manage HR systems and procedures.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-
CO2	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-
CO3	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-

Detailed Syllabus:

Introduction to Human Resource Management, Objectives, Scope and Significance of HRM, Functions of HRM, Problems and Prospects in HRM, Environmental scanning.

Human Resource Planning, Demand Forecasting Techniques, Supply Forecasting Techniques, Analyzing work and designing jobs, Recruitment and Selection, Interviewing Candidates.

Human Resource Development, Orientation, Training and Development, Management, Development, Performance Appraisal and Employee Compensation, Factors Influencing, Employee Remuneration and Challenges of Remuneration.

Industrial Relations, Industrial Disputes and Discipline, Managing Ethical Issues in Human Resource Management, Workers Participation in Management, Employee safety and health, Managing Global Human Resources and Trade Unions

International HRM, Future of HRM and Human Resource Information Systems

Reading:

1. Aswathappa, Human Resource Management –– TMH, 2010.
2. Garry Dessler and BijuVarkkey, Human Resource Management, PEA, 2011.
3. Noe & Raymond, HRM: Gaining a Competitive Advantage, TMH, 2008.
4. Bohlander George W, Snell Scott A,Human Resource Management, Cengage Learning, 2009.

MA440	OPTIMIZATION TECHNIQUES	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Formulate and solve linear Programming Problems
CO2	Determine the optimum solution to constrained and unconstrained
CO3	Apply dynamic programming principle to Linear programming problems.
CO4	Determine the integer solutions to Linear Programming Problems.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO2	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO3	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO4	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3

Detailed Syllabus:

Linear Programming: Introduction and formulation of models, Convexity, Simplex method, Big-M method, Two-phase method, Degeneracy, non-existent and unbounded solutions, revised simplex method, duality in LPP, dual simplex method, sensitivity analysis, transportation and assignment problems, traveling salesman problem .

Nonlinear Programming: Introduction and formulation of models, Classical optimization methods, equality and inequality constraints, Lagrange multipliers and Kuhn-Tucker conditions, quadratic forms, quadratic programming problem, Wolfe's method.

Dynamic Programming: Principle of optimality, recursive relations, solution of LPP.

Integer Linear Programming: Gomory's cutting plane method, Branch and bound algorithm, Knapsack problem, linear 0-1 problem.

Reading:

1. Kanti Swarup, Man Mohan and P.K. Gupta, Introduction to Operations Research, S. Chand & Co., 2006
2. J.C.Pant, Introduction to Operations Research, Jain Brothers, New Delhi, 2008.
3. N.S. Kambo, Mathematical Programming Techniques, East-West Pub., Delhi, 1991.

MA441	OPERATIONS RESEARCH	OPC	3 – 0 – 0	3 Credits

Prerequisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Formulate and solve linear programming problems
CO2	Determine optimum solution to transportation problem
CO3	Determine average queue length and waiting times of queuing models.
CO4	Determine optimum inventory and cost in inventory models.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO2	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO3	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO4	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3

Detailed Syllabus:

Linear Programming: Formulation and graphical solution of LPP's. The general LPP, slack, surplus and artificial variables. Reduction of a LPP to the standard form. Simplex computational procedure, Big-M method, Two-phase method. Solution in case of unrestricted variables. Dual linear programming problem. Solution of the primal problem from the solution of the dual problems.

Transportation Problems: Balanced and unbalanced Transportation problems. Initial basic feasible solution using N-W corner rule, row minimum method, column minimum, least cost entry method and Vogel's approximation method. Optimal solutions.Degenracy in Transportation problems. Queueing Theory: Poisson process and exponential distribution. Poisson queues - Model (M/M/1):(∞/FIFO) and its characteristics.

Elements of Inventory Control: Economic lot size problems - Fundamental problems of EOQ. The problem of EOQ with finite rate of replenishment. Problems of EOQ with shortages - production instantaneous, replenishment of the inventory with finite rate. Stochastic problems with uniform demand (discrete case only).

Reading:

1. K. Swarup, Manmohan & P.K. Gupta, Introduction to Operations Research, S. Chand & Co., 2006
2. J.C. Pant, Introduction to Operations Research, Jain Brothers, New Delhi, 2008.
3. N.S. Kambo: Mathematical Programming Techniques, East-West Pub., Delhi, 1991.

PH440	NANOMATERIALS AND TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Prerequisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand synthesis and properties of nanostructured materials.
CO2	Analyze magnetic and electronic properties of quantum dots
CO3	Understand structure, properties and applications of Fullerenes and Carbon nanotubes.
CO4	Understand applications of nanoparticles in nanobiology and nanomedicine

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	1	1	-	-	-	-	-	-	-	-	1	1	-
CO2	3	1	1	1	-	-	-	-	-	-	-	-	1	1	-
CO3	3	1	1	1	-	-	-	-	-	-	-	-	1	1	-
CO4	3	1	1	1	-	-	-	-	-	-	-	-	1	1	-

Detailed Syllabus:

General properties of Nano materials: Origin of nanotechnology. Classification of nanomaterials. Fullerene,carbon nanotubes (CNT's), Nanoparticles. Physical, Chemical, Electrical, Optical, Magnetic and mechanical properties of nanomaterials.

Fullerenes and Carbon Nanotubes (CNT's): Introduction: Synthesis and purification. Preparation of fullerenes in the condensed phase, Transport, mechanical, physical properties of CNT's.

Investigation and manipulating materials in the Nanoscale: Electron microscope, scanning probe microscopes, optical microscopes for Nanoscience and Technology, X-Ray Diffraction.

SAMs and clusters: Growth process. Patterning monolayers. Types of clusters. Bonding and properties of clusters.

Semi conducting Quantum Dots: Introduction: Synthesis of Quantum Dots. Electronic structure of Nanocrystals, properties.

Nanobiology: Interaction between Biomolecules and Nanoparticle surgaces. Different types of Inorganic materials used for the synthesis of Hybrid Nano-bio assemblies. Nanoprobes for Analytical Applications.

Nanosensors: Nanosensors based on optical properties. Nanosensors based on quantum size effects. Nanobiosensors.

Nanomedicines: Developments of nanomedicines. Nanotechnology in Diagnostic Applications, materials for use in Diagnostic and therapeutic Applications.

Reading:

1. T. Pradeep, Nano: The Essentials; Tata McGraw-Hill, 2008.
2. W.R. Fahrner, Nanotechnology and Nanoelectronics; Springer, 2006.
3. Rechard Booker and Earl Boysen, Nanotechnology, Willey, 2006.

PH441	BIOMATERIALS AND TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Prerequisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the structure and properties of biomaterials
CO2	Classify implant biomaterials
CO3	Evaluate biocompatibility of implants
CO4	Identify appropriate biomaterials for specific medical applications

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	-	1	2	1	-	-	-	-	1	1	-
CO2	3	3	1	1	-	1	2	1	-	-	-	-	1	1	-
CO3	3	3	1	1	-	1	2	1	-	-	-	-	1	1	-
CO4	3	3	1	1	-	1	2	1	-	-	-	-	1	1	-

Detailed Syllabus:

Overview of biomaterials: Historical developments, impact of biomaterials, interfacial phenomena, tissue responses to implants.

Structure and properties of biomaterials: Crystal structure of solids, phase changes, imperfections in solids, non-crystalline solids, surface properties of solids, mechanical properties, surface improvements.

Types of biomaterials: Metallic implant materials, ceramic implant materials, polymeric implant materials composites as biomaterials.

Characterization of materials: Electric properties, optical properties, X-ray absorption, acoustic and ultrasonic properties.

Bio implantation materials: Materials in ophthalmology, orthopedic implants, dental materials and cardiovascular implant materials.

Tissue response to implants: Normal wound healing processes, body response to implants, blood compatibility, and structure – property relationship of tissues.

Reading:

1. Joon Park, R.S. Lakes, Biomaterials an introduction; 3rd Edition, Springer, 2007
2. Sujatha V Bhat, Biomaterials; 2nd Edition, Narosa Publishing House, 2006.

CY441	CHEMISTRY OF NANOMATERIALS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Demonstrate a systematic knowledge of the range and breadth of application of nanomaterials.
CO2	Review critically the potential impact, in all classes of materials, of the control of nanostructure
CO3	Describe the methods for the synthesis and nanostructural characterisation of such materials.
CO4	Identify the possible opportunities for nanomaterials in society development and enhancement.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	1	1	-	2	2	-	-	-	-	-	1	-	-
CO2	3	1	1	1	-	2	2	-	-	-	-	-	1	-	-
CO3	3	1	1	1	-	2	2	-	-	-	-	-	1	-	-
CO4	3	1	1	1	-	2	2	-	-	-	-	-	1	-	-

Detailed Syllabus:

Introduction: Review the scope of nanoscience and nanotecnology, understand the nanoscience in nature, classification of nanostructured materials and importance of nanomaterials.

Synthetic Methods: Teach the basic principles for the synthesis of Nanostructure materials by Chemical Routes (Bottom-Up approach):-Sol-gel synthesis, microemulsions or reverse micelles, solvothermal synthesis, microwave heating synthesis and sonochemical synthesis and Physical methods (Top-Down approach):- Inert gas condensation, plasma arc technique, ion sputtering, Laser ablation, laser pyrolysis, and chemical vapour deposition method.

Techniques for characterization: Learning of characterization method by various techniques like, Diffraction Technique:-Powder X-ray diffraction for particle size analysis, Spectroscopy Techniques:-Operational principle and applications of spectroscopy techniques for the analysis of nanomaterials, UV-VIS spectrophotometers and its application for band gap measurement, Electron Microscopy Techniques:-Scanning electron microscopy (SEM)and EDAX analysis, transmission electron microscopy (TEM), scanning probe microscopy (SPM)BET method for surface area determination and Dynamic light scattering technique for particle size analysis.

Studies of nano-structured Materials:Synthesis, properties and applications of the following nanomaterials: fullerenes, carbon nanotubes, core-shell nanoparticles, nanoshells, self-assembled monolayers, and monolayer protected metal nanoparticles, nanocrystalline materials.

Reading:

1. T Pradeep, NANO: The Essentials, MaGraw Hill, 2007.
2. B S Murty, P Shankar, BaldevRai, BB Rath and James Murday, Textbook of Nanoscience and nanotechnology, Univ. Press, 2012.
3. Guozhong Cao, Nanostructures & Nanomaterials; Synthesis, Properties & Applications, Imperial College Press, 2007.
4. M.A. Shah and Tokeer Ahmad, Principles of Nanoscience and Nanotechnology, Narosa Pub., 2010.
5. Manasi Karkare, Nanotechnology: Fundamentals and Applications, IK International, 2008.
6. C. N. R. Rao, Achim Muller, K. Cheetham, Nanomaterials Chemistry, Wiley-VCH, 2007.

HS440	CORPORATE COMMUNICATION	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand corporate communication culture
CO2	Prepare business letters, memos and reports
CO3	Communicate effectively in formal business situations
CO4	Exhibit corporate social responsibility and ethics
CO5	Practice corporate email, mobile and telephone etiquette
CO6	Develop good listening skills and leadership qualities

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO2	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO3	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO4	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO5	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO6	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-

Detailed Syllabus:

Importance of Corporate communication: Introduction to and definition of corporates – Communication, process, patterns and channels of communication- Barriers to communication and strategies to overcome them- Evolution of corporate culture- Role and contribution of individual group and organization - Role of psychology in communication.

Oral Communication: Techniques for improving oral fluency-Speech mechanics-Group Dynamics and Group Discussion – Debate and oral presentations.

Written Communication: Types and purposes- Writing business reports, and business proposals- Memos, minutes of meetings- Circulars, persuasive letters- Letters of complaint- ; language and formats used for drafting different forms of communication. Internal and external communication.

Corporate responsibility: Circulating to employees vision and mission statements- ethical practices- Human rights -Labour rights-Environment- governance- Moral and ethical debates surrounding -Public Relations - Building trust with stakeholders.

Corporate Ethics and Business Etiquette: Integrity in communication-Harmful practices and communication breakdown- Teaching how to deal with tough clients through soft skills. Body language- Grooming- Introducing oneself- Use of polite language- Avoiding grapevine and card pushing – Etiquette in e-mail, mobile and telephone.

Listening Skills: Listening- for information and content- Kinds of listening- Factors affecting listening and techniques to overcome them- retention of facts, data and figures- Role of speaker in listening.

Leadership Communication Styles: Business leadership -Aspects of leadership-qualities of leader- training for leadership-delegation of powers and ways to do it-humour-commitment.

Reading:

1. Raymond V. Lesikar, John D. Pettit, Marie E. FlatleyLesikar's Basic Business Communication - 7th Edition: Irwin, 1993
2. Krishna Mohanand Meera Banerji, Developing Communication Skills: Macmillan Publishers India, 2000
3. R.C. Sharma & Krishna Mohan Business Correspondence and Report Writing: – 3rd Edition Tata McGraw-Hill, 2008
4. Antony Jay & Ross Jay, Effective Presentation, University Press, 1999.
5. Shirley Taylor, Communication for Business, Longman, 1999.