VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF CHEMICAL ENGINEERING (SCHEME)

B. Tech Chemical Engineering (BCM)

Curriculum and Syllabus

[2018-2019 admitted students]

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VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

World class Education: Excellence in education, grounded in ethics and critical thinking, for improvement of life.

Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.

Impactful People: Happy, accountable, caring and effective workforce and students.

Rewarding Co-creations: Active collaboration with national & international industries & universities for productivity and economic development.

Service to Society: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF SCHOOL OF CHEMICAL ENGINEERING

To improve the quality of life through innovations in Chemical Engineering

MISSION STATEMENT OF SCHOOL OF CHEMICAL ENGINEERING

To prepare the graduates for a rewarding career by providing quality education in Chemical Engineering in tune with evolving requirements of the society.

To impart knowledge and develop technology through quality research in frontier areas of chemical and inter-disciplinary fields.

To produce practicing engineers with professional ethics to cater the contemporary needs of the society and environment.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.

3. Graduates will function in their profession with social awareness and responsibility.

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.

5. Graduates will be successful in pursuing higher studies in engineering or management.

6. Graduates will pursue career paths in teaching or research.

PROGRAMME OUTCOMES (POs)

PO_01: Having an ability to apply mathematics and science in engineering applications.

PO_02: Having a clear understanding of the subject related concepts and of contemporary issues and apply them to identify, formulate and analyse complex engineering problems.

PO_03: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints, including public health, safety, culture, society and environment

PO_04: Having an ability to design and conduct experiments, as well as to analyse and interpret data, and synthesis of information

PO_05: Having an ability to use techniques, skills, resources and modern engineering and IT tools necessary for engineering practice

PO_06: Having problem solving ability- to assess social issues (societal, health, safety, legal and cultural) and engineering problems

PO_07: Having adaptive thinking and adaptability in relation to environmental context and sustainable development

PO_08: Having a clear understanding of professional and ethical responsibility

PO_09: Having cross cultural competency exhibited by working as a member or in teams

PO_10: Having a good working knowledge of communicating in English – communication with engineering community and society

PO_11: Having a good cognitive load management skills related to project management and finance

PO_12: Having interest and recognise the need for independent and lifelong learning

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of B. Tech. (Chemical Engineering) programme, graduates will be able to:

1. Analyse and solve complex problems in process and allied Industries by applying core and multidisciplinary competencies.
2. Design and develop efficient chemical processes/products considering economic, safety and environmental aspects.
3. Implement the modern practices in industrial/research settings to serve as practicing engineers with professional ethics.

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SCHOOL OF CHEMICAL ENGINEERING

B. Tech Chemical Engineering

CREDIT STRUCTURE

Category-wise Credit distribution

Category	Credits
University core (UC)	**70**
Programme core (PC)	**60**
Programme elective (PE)	**38**
University elective (UE)	**12**
Bridge Course (BC)	**-**
Total credits	**180**

B. Tech Chemical Engineering

CURRICULUM

University Core

S.No	Course Code	Course Title	Course Type	L	T	P	J	C
1	CHE3099	Industrial Internship	PJT	0	0	0	0	2
2	CHE3999	Technical Answers for Real World Problems (TARP)	ETP	1	0	0	8	3
3	CHE4098	Comprehensive Examination	PJT	0	0	0	0	2
4	CHE4099	Capstone Project	PJT	0	0	0	0	20
5	CHY1002	Environmental Sciences	TH	3	0	0	0	3
6	CHY1701	Engineering Chemistry	ET	3	0	2	0	4
7	CSE1001	Problem Solving and Programming	LO	0	0	6	0	3
8	CSE1002	Problem Solving and Object Oriented Programming	LO	0	0	6	0	3
9	ENG1011	English for Engineers	LO	0	0	4	0	2
10	EXC4097	Co-Extra Curricular Basket	CDB	0	0	0	0	2
11	FLC4097	Foreign Language Course Basket	CDB	0	0	0	0	2
12	HUM1021	Ethics and Values	TH	2	0	0	0	2
13	MAT1011	Calculus for Engineers	ET	3	0	2	0	4
14	MAT2001	Statistics for Engineers	ET	2	1	2	0	4
15	MGT1022	Lean Start-up Management	ETP	1	0	0	4	2
16	PHY1701	Engineering Physics	ET	3	0	2	0	4
17	PHY1999	Introduction to Innovative Projects	ETP	1	0	0	4	2
18	STS4097	Soft Skills Course Basket	CDB	0	0	0	0	6

B. Tech Chemical Engineering

Programme Core

S.No	Course Code	Course Title	Course Type	L	T	P	J	C
1	CHE1001	Materials Science and Strength of Materials	TH	3	0	0	0	3
2	CHE1002	Process Calculations	TH	4	0	0	0	4
3	CHE1003	Process Engineering Thermodynamics	ETP	3	0	0	4	4
4	CHE1004	Chemical Technology	TH	3	0	0	0	3
5	CHE1005	Momentum Transfer	ETL	3	0	2	0	4
6	CHE1006	Heat Transfer	ETLP	2	0	2	4	4
7	CHE1022	Mechanical Operations	ETL	3	0	2	0	4
8	CHE2001	Chemical Reaction Engineering	ETL	3	0	2	0	4
9	CHE2002	Process Equipment Design and Economics	ETLP	2	0	2	4	4
10	CHE3001	Computational Methods in Process Engineering	ETL	3	0	2	0	4
11	CHE3002	Process Instrumentation and Control	ETLP	2	0	2	4	4
12	CHE3003	Mass Transfer	TH	3	0	0	0	3
13	CHE4001	Equilibrium Staged Operations	ETLP	2	0	2	4	4
14	MAT2002	Applications of Differential and Difference Equations	ETL	3	0	2	0	4
15	MAT3003	Complex Variables and Partial Differential Equations	TH	3	1	0	0	4
16	MEE1001	Engineering Drawing	ETL	1	0	4	0	3

B. Tech Chemical Engineering

Programme Elective

S.No	Course Code	Course Title	Course Type	L	T	P	J	C
1	CHE1007	Safety and Hazard Analysis	ETP	2	0	0	4	3
2	CHE1008	Unit Processes in Organic Synthesis	ETL	3	0	2	0	4
3	CHE1009	Biochemical Engineering	TH	3	0	0	0	3
4	CHE1010	Process Plant Utilities	TH	3	0	0	0	3
5	CHE1011	Optimization of Chemical Processes	TH	3	0	0	0	3
6	CHE1013	Natural Gas Engineering	TH	3	0	0	0	3

7	CHE1014	Petroleum Technology	TH	3	0	0	0	3
8	CHE1015	Petrochemical Technology	TH	3	0	0	0	3
9	CHE1016	Fermentation Technology	TH	3	0	0	0	3
10	CHE1017	Food Process Engineering	ETP	2	0	0	4	3
11	CHE1018	Membrane Separations Technology	TH	3	0	0	0	3
12	CHE1019	Polymer Technology	TH	3	0	0	0	3
13	CHE1020	Fertilizer Technology	TH	3	0	0	0	3
14	CHE1023	Production and Operations Management	TH	3	0	0	0	3
15	CHE2003	Chemical Product Design	TH	3	0	0	0	3
16	CHE2006	Fuels and Combustion	TH	3	0	0	0	3
17	CHE3004	Heterogeneous Reaction Engineering	ETP	2	0	0	4	3
19	CHE3005	Chemical Process Integration	TH	3	0	0	0	3
19	CHE3006	Process Plant Simulation	ETP	3	0	0	4	4
20	CHE3007	Multiphase Flow	TH	3	0	0	0	3
21	CHE3008	Industrial Pollution Engineering	TH	3	0	0	0	3
22	CHE4002	Transport Phenomena	TH	3	0	0	0	3
23	CHE4003	Modelling and Simulation in Process Engineering	ETL	2	0	2	0	3
24	CHE4005	Fluidization Engineering	TH	3	0	0	0	3
25	CHY1704	Materials and Instrumental Techniques	ETL	3	0	2	0	4
26	EEE1001	Basic Electrical and Electronics Engineering	ETL	2	0	2	0	3
27	MEE1011	Renewable Energy Sources	ETLP	2	2	2	0	4
28	MEE4006	Computational Fluid Dynamics	ETL	2	1	2	0	4

UNIVERSITY CORE

CHE3099	Industrial Internship	L	T	P	J	C
		0	0	0	0	2
Pre-requisite	Completion of minimum of Two semesters					

Course Objectives:

The course is designed so as to expose the students to industry environment and to take up on-site assignment as trainees or interns.

Course Outcomes:

1. Have an exposure to industrial practices and to work in teams
2. Communicate effectively
3. Understand the impact of engineering solutions in a global, economic, environmental and societal context
4. Develop the ability to engage in research and to involve in life-long learning
5. Comprehend contemporary issues
6. Engage in establishing his/her digital footprint

Contents	**4**	**Weeks**

Four weeks of work at industry site.

Supervised by an expert at the industry.

Mode of Evaluation: Internship Report, Presentation and Project Review

Recommended by Board of Studies	28-02-2016		
Approved by Academic Council	No. 37	Date	16-06-2015

Course code	Technical Answers for Real World Problems (TARP)	L	T	P	J	C
CHE3999		1	0	0	8	3
Pre-requisite	PHY1999 and 115 Credits Earned	Syllabus version				
		v. 1.0				

Course Objectives:

1. To help students to identify the need for developing newer technologies for industrial / societal Needs
2. To train students to propose and implement relevant technology for the development of the prototypes / products
3. To make the students learn to the use the methodologies available to assess the developed prototypes / products

Course Outcomes:

1. Identify real life problems related to society.
2. Apply appropriate technology(ies) to address the identified problems using engineering principles and arrive at innovative solutions

Module:1		15 hours

1. Identification of real life problems
2. Field visits can be arranged by the faculty concerned
3. 6 – 10 students can form a team (within the same / different discipline)
4. Minimum of eight hours on self-managed team activity
5. Appropriate scientific methodologies to be utilized to solve the identified issue
6. Solution should be in the form of fabrication/coding/modeling/product design/process design/relevant scientific methodology(ies)
7. Consolidated report to be submitted for assessment
8. Participation, involvement and contribution in group discussions during the contact hours will be used as the modalities for the continuous assessment of the theory component
9. Project outcome to be evaluated in terms of technical, economical, social, environmental, political and demographic feasibility
10. Contribution of each group member to be assessed
11. The project component to have three reviews with the weightage of 20:30:50

Mode of Evaluation: (No FAT) Continuous Assessment the project done – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews

Recommended by Board of Studies	04.03.2016		
Approved by Academic Council	No. 47	Date	05.10.2017

Course code	Comprehensive Examination	L	T	P	J	C
CHE4098		0	0	0	0	2
Pre-requisite	Minimum of 115 Credits Earned or at the end of the 7th semester	Syllabus version				
		v. 1.0				

Course Objectives:

1. To measure student's competency and mastery of concepts in the field of chemical Engineering.
2. To evaluate the ability of students to move into the dissertation phase of their degree.

Course Outcomes:

1. Define, explain and summarize the basic principles of chemical engineering.
2. Use the principles of science and mathematics to identify, formulate and solve advanced engineering problems.
3. Evaluate the hypotheses, methods, results and conclusions of published scientific literature and apply conclusions to their own work.

Contents

Process Calculations and Thermodynamics: Steady and unsteady state mass and energy balances including multiphase, multi-component, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis. First and Second laws of thermodynamics. Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium

Momentum Transfer: Fluid statics, Newtonian and non-Newtonian fluids, shell-balances including differential form of Bernoulli equation and energy balance, Macroscopic friction factors, dimensional analysis, flow through pipeline systems, flow meters, pumps and compressors, flow past immersed bodies including packed and fluidized beds, Turbulent flow: fluctuating velocity, universal velocity profile and pressure drop.

Mechanical Operations: Particle size and shape, particle size distribution, size reduction and classification of solid particles; free and hindered settling; centrifuge and cyd0nes-; thickening and classification, flotation, filtration, agitation and mixing; conveying of solids.

Heat Transfer: Steady and unsteady heat conduction, convection and radiation, Heat Transfer through fins, thermal boundary layer and heat transfer coefficients, boiling, condensation and evaporation; types of heat exchangers and evaporators and their process calculations. Design of double pipe, shell and tube heat exchangers, and single and multiple effect evaporators.

Mass Transfer: Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; analogies; stage-wise and continuous contacting and stage efficiencies; HTU & NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification adsorption and crystallization.

Chemical Reaction Engineering: Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, non-ideal reactors; residence time distribution, single parameter model; non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis.

Instrumentation and Process Control: Measurement of process variables; sensors, transducers and their dynamics, process modeling and linearization, transfer functions and dynamic responses of various systems, systems with inverse response, process reaction curve, controller modes (P, Pl, and PIO); control valves; analysis of closed loop systems including stability, frequency response, controller tuning, cascade and feed forward control.

Chemical Technology: Inorganic chemical industries (sulfuric acid, phosphoric acid, chlor alkali industry, cement, paint, glass industry), fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); petroleum refining and petrochemicals; Fermentation products: Ethanol, citric acid, antibiotics, penicillin polymerization industries (polyethylene, polypropylene, PVC and polyester synthetic fibers).

Plant Design and Economics: Principles of process economics and cost estimation including depreciation and total annualized cost, cost indices, rate of return, payback period, discounted cash flow, optimization in process design and sizing of chemical engineering equipment such as compressors, heat exchangers, multistage contactors.

Assessment / Criteria: Computer based on line Examination

Mode of Evaluation: Computer based Evaluation

Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	No. 47	Date	05.10.2017

Course Code	Course Title	L	T	P	J	C
CHE4099	Capstone Project	0	0	0	0	20
Pre-requisite	As per the academic regulations	Syllabus version				
		v. 1.0				

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

Course Outcomes:

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing
5. Synthesise the results and arrive at scientific conclusions / products / solution
6. Document the results in the form of technical report / presentation

Contents

1. Capstone Project may be a theoretical analysis, modeling & simulation, experimentation &analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.

2. Project can be for one or two semesters based on the completion of required number of credits as per the academic regulations.

3. Can be individual work or a group project, with a maximum of 3 students.

4. In case of group projects, the individual project report of each student should specify the individual's contribution to the group project.

5. Carried out inside or outside the university, in any relevant industry or research institution.

6. Publications in the peer reviewed journals / International Conferences will be an added advantage

Mode of Evaluation: Periodic reviews, Presentation, Final oral viva, Poster submission

Recommended by Board of Studies	10.06.2015		
Approved by Academic Council	37th AC	Date	16.06.2015

Course code	Environmental Sciences	L	T	P	J	C
CHY1002		3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		V:1.1				

Course Objectives:

1. To make students understand and appreciate the unity of life in all its forms, the implications of life style on the environment.
2. To understand the various causes for environmental degradation.
3. To understand individuals contribution in the environmental pollution.
4. To understand the impact of pollution at the global level and also in the local environment.

Module:1	Environment and Ecosystem	7 hours

Key environmental problems, their basic causes and sustainable solutions. IPAT equation. Ecosystem, earth – life support system and ecosystem components; Food chain, food web, Energy flow in ecosystem; Ecological succession- stages involved, Primary and secondary succession, Hydrarch, mesarch, xerarch; Nutrient, water, carbon, nitrogen, cycles; Effect of human activities on these cycles.

Module:2	Biodiversity	6 hours

Importance, types, mega-biodiversity; Species interaction - Extinct, endemic, endangered and rare species; Hot-spots; GM crops- Advantages and disadvantages; Terrestrial biodiversity and Aquatic biodiversity – Significance, Threats due to natural and anthropogenic activities and Conservation methods.

Module:3	Sustaining Natural Resources and Environmental Quality	7 hours

Environmental hazards – causes and solutions. Biological hazards – AIDS, Malaria, Chemical hazards- BPA, PCB, Phthalates, Mercury, Nuclear hazards- Risk and evaluation of hazards. Water footprint; virtual water, blue revolution. Water quality management and its conservation. Solid and hazardous waste – types and waste management methods.

Module:4	Energy Resources	6 hours

Renewable - Non renewable energy resources- Advantages and disadvantages - oil, Natural gas, Coal, Nuclear energy. Energy efficiency and renewable energy. Solar energy, Hydroelectric power, Ocean thermal energy, Wind and geothermal energy. Energy from biomass, solar-Hydrogen revolution.

Module:5	Environmental Impact Assessment	6 hours

Introduction to environmental impact analysis. EIA guidelines, Notification of Government of India (Environmental Protection Act – Air, water, forest and wild life). Impact assessment methodologies. Public awareness. Environmental priorities in India.

Module:6	**Human Population Change and Environment**	**6 hours**
Urban environmental problems; Consumerism and waste products; Promotion of economic development – Impact of population age structure – Women and child welfare, Women empowerment. Sustaining human societies: Economics, environment, policies and education.		
Module:7	**Global Climatic Change and Mitigation**	**5 hours**
Climate disruption, Green house effect, Ozone layer depletion and Acid rain. Kyoto protocol, Carbon credits, Carbon sequestration methods and Montreal Protocol. Role of Information technology in environment-Case Studies.		
Module:8	**Contemporary issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Books

1. G. Tyler Miller and Scott E. Spoolman (2016), Environmental Science, 15th Edition, Cengage learning.
2. George Tyler Miller, Jr. and Scott Spoolman (2012), Living in the Environment – Principles, Connections and Solutions, 17th Edition, Brooks/Cole, USA.

Reference Books

1. David M.Hassenzahl, Mary Catherine Hager, Linda R.Berg (2011), Visualizing Environmental Science, 4thEdition, John Wiley & Sons, USA.

Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & FAT

Recommended by Board of Studies	12.08.2017		
Approved by Academic Council	No. 46	Date	24.08.2017

Course code	Engineering Chemistry (UC)	L	T	P	J	C
CHY1701		3	0	2	0	4
Pre-requisite	NIL	Syllabus version				
		1.1				

Course Objectives:

1. To impart technological aspects of applied chemistry
2. To lay foundation for practical application of chemistry in engineering aspects

Course Outcomes:

1. Recall and analyze the issues related to impurities in water and their removal methods and apply recent methodologies in water treatment for domestic and industrial usage
2. Evaluate the causes of metallic corrosion and apply the methods for corrosion protection of metals
3. Evaluate the electrochemical energy storage systems such as lithium batteries, fuel cells and solar cells, and design for usage in electrical and electronic applications
4. Assess the quality of different fossil fuels and create an awareness to develop the alternative fuels
5. Analyze the properties of different polymers and distinguish the polymers which can be degraded and demonstrate their usefulness
6. Apply the theoretical aspects: (a) in assessing the water quality; (b) understanding the construction and working of electrochemical cells; (c) analyzing metals, alloys and soil using instrumental methods; (d) evaluating the viscosity and water absorbing properties of polymeric materials

Module:1	Water Technology	5 hours

Characteristics of hard water - hardness, DO, TDS in water and their determination – numerical problems in hardness determination by EDTA; Modern techniques of water analysis for industrial use - Disadvantages of hard water in industries.

Module:2	Water Treatment	8 hours

Water softening methods: - Lime-soda, Zeolite and ion exchange processes and their applications. Specifications of water for domestic use (ICMR and WHO); Unit processes involved in water treatment for municipal supply - Sedimentation with coagulant- Sand Filtration - chlorination; Domestic water purification – Candle filtration- activated carbon filtration; Disinfection methods- Ultrafiltration, UV treatment, Ozonolysis, Reverse Osmosis; Electro dialysis.

Module:3	Corrosion	6 hours

Dry and wet corrosion - detrimental effects to buildings, machines, devices & decorative art forms, emphasizing Differential aeration, Pitting, Galvanic and Stress corrosion cracking; Factors that enhance corrosion and choice of parameters to mitigate corrosion.

Module:4	Corrosion Control	4 hours

Corrosion protection - cathodic protection – sacrificial anodic and impressed current protection methods; Advanced protective coatings: electroplating and electroless plating, PVD and CVD.

Alloying for corrosion protection – Basic concepts of Eutectic composition and Eutectic mixtures - Selected examples – Ferrous and non-ferrous alloys.

Module:5	Electrochemical Energy Systems	6 hours

Brief introduction to conventional primary and secondary batteries; High energy electrochemical energy systems: Lithium batteries – Primary and secondary, its Chemistry, advantages and applications. Fuel cells – Polymer membrane fuel cells, Solid-oxide fuel cells- working principles, advantages, applications. Solar cells – Types – Importance of silicon single crystal, polycrystalline and amorphous silicon solar cells, dye sensitized solar cells - working principles, characteristics and applications.		
Module:6	**Fuels and Combustion**	**8 hours**
Calorific value - Definition of LCV, HCV. Measurement of calorific value using bomb calorimeter and Boy's calorimeter including numerical problems. Controlled combustion of fuels - Air fuel ratio – minimum quantity of air by volume and by weight-Numerical problems-three way catalytic converter- selective catalytic reduction of NO_X; Knocking in IC engines-Octane and Cetane number - Antiknocking agents.		
Module:7	**Polymers**	**6 hours**
Difference between thermoplastics and thermosetting plastics; Engineering application of plastics - ABS, PVC, PTFE and Bakelite; Compounding of plastics: moulding of plastics for Car parts, bottle caps (Injection moulding), Pipes, Hoses (Extrusion moulding), Mobile Phone Cases, Battery Trays, (Compression moulding), Fibre reinforced polymers, Composites (Transfer moulding), PET bottles (blow moulding); Conducting polymers- Polyacetylene- Mechanism of conduction – applications (polymers in sensors, self-cleaning windows)		
Module:8	**Contemporary issues:**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	1. Sashi Chawla, A Text book of Engineering Chemistry, Dhanpat Rai Publishing Co., Pvt. Ltd., Educational and Technical Publishers, New Delhi, 3rd Edition, 2015. 2. O.G. Palanna, McGraw Hill Education (India) Private Limited, 9th Reprint, 2015. 3. B. Sivasankar, Engineering Chemistry 1st Edition, Mc Graw Hill Education (India), 2008 4. Photovoltaic solar energy : From fundamentals to Applications", AngÃ le Reinders, Pierre Verlinden, Wilfried van Sark, Alexandre Freundlich, Wiley publishers, 2017.
Reference Books	
2	1. O.V. Roussak and H.D. Gesser, ***Applied Chemistry-A Text Book for Engineers and Technologists***, Springer Science Business Media, New York, 2nd Edition, 2013. 2. S. S. Dara, ***A Text book of Engineering Chemistry,*** S. Chand & Co Ltd., New Delhi, 20th Edition, 2013.
Mode of Evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & FAT	
List of Experiments	

	Experiment title	Hours
1.	Water Purification: Estimation of water hardness by EDTA method and its removal by ion-exchange resin	1 h 30 min

2. 3.	Water Quality Monitoring: Assessment of total dissolved oxygen in different water samples by Winkler's method Estimation of sulphate/chloride in drinking water by conductivity method	3h
4/5	Material Analysis: Quantitative colorimetric determination of divalent	3h
	metal ions of Ni/Fe/Cu using conventional and smart phone digital-imaging methods	
6.	Analysis of Iron in carbon steel by potentiometry	1 h 30 min
7.	Construction and working of an Zn-Cu electrochemical cell	1 h 30 min
8.	Determination of viscosity-average molecular weight of different natural/synthetic polymers	1 h 30 min
9.	Arduino microcontroller based sensor for monitoring pH/temperature/conductivity in samples.	1 h 30 min
	Total Laboratory Hours	17 hours
Mode of Evaluation: Viva-voce and Lab performance & FAT		
Recommended by Board of Studies	31-05-2019	
Approved by Academic Council	54th ACM	Date 13-06-2019

Course code	PROBLEM SOLVING AND PROGRAMMING	L	T	P	J	C
CSE1001		0	0	6	0	3
Pre-requisite	NIL	Syllabus version				
		v1.0				

Course Objectives:

1. To develop broad understanding of computers, programming languages and their generations
2. Introduce the essential skills for a logical thinking for problem solving
3. To gain expertise in essential skills in programming for problem solving using computer

Course Outcomes:

1. Understand the working principle of a computer and identify the purpose of a computer programming language.
2. Learn various problem solving approaches and ability to identify an appropriate approach to solve the problem
3. Differentiate the programming Language constructs appropriately to solve any problem
4. Solve various engineering problems using different data structures
5. Able to modulate the given problem using structural approach of programming
6. Efficiently handle data using flat files to process and store data for the given problem

List of Challenging Experiments (Indicative)

1. Steps in Problem Solving Drawing flowchart using yEd tool/Raptor Tool	3 Hours
2. Introduction to Python, Demo on IDE, Keywords, Identifiers, I/O Statements.	4 Hours
3. Simple Program to display Hello world in Python.	
4. Operators and Expressions in Python	4 Hours
5. Algorithmic Approach 1: Sequential	2 Hours
6. Algorithmic Approach 2: Selection (if, elif, if.. else, nested if else	2 Hours
7. Algorithmic Approach 3: Iteration (while and for)	4 Hours
8. Strings and its Operations	2 Hours
9. Regular Expressions	2 Hours
10. List and its operations.	2 Hours
11. Dictionaries: operations	2 Hours
12. Tuples and its operations	2 Hours
13. Set and its operations	2 Hours
14. Functions, Recursions	2 Hours
15. Sorting Techniques (Bubble/Selection/Insertion)	4 Hours

16. Searching Techniques : Sequential Search and Binary Search	3 Hours
17. Files and its Operations	4 Hours
Total Lecture hours:	**45 hours**

Text Book(s)	
1.	John V. Guttag., 2016. Introduction to computation and programming using python: with applications to understanding data. PHI Publisher.

Reference Books	
1.	Charles Severance.2016.Python for everybody: exploring data in Python 3, Charles Severance.
2.	Charles Dierbach.2013.Introduction to computer science using python: a computational problem-solving focus. Wiley Publishers.

Mode of Evaluation: P**AT / CAT / FAT**
Recommended by Board of Studies Date: 04-04-2014
Approved by 38th Academic Council Date: 23-10-2015

CSE1002	Problem Solving and Object Oriented Programming	L	T	P	J	C
		0	0	6	0	3
Pre-requisite	NIL	Syllabus version				
		v1.0				

Course Objectives:

1. To emphasize the benefits of object oriented concepts
2. To enable the students to solve the real time applications using object oriented programming features.
3. To improve the skills of a logical thinking and to solve the problems using any processing elements

Course Outcomes:

1. Recall the basics of procedural programming and to represent the real world entities as programming constructs
2. Enumerate object oriented concepts and translate real-world applications into graphical representations
3. Demonstrate the usage of classes and objects of the real world entities in applications
4. Discriminate the reusability and multiple interfaces with same functionality based features to solve complex computing problems
5. Propose possible error-handling constructs for unanticipated states/inputs and to use generic programming constructs to accommodate different datatypes
6. Validate the program against file inputs towards solving the problem

Module:1	Structured Programming	12 hours

Structured Programming conditional and looping statements-arrays – functions - pointers – dynamic memory allocation - structure

Module:2	Introduction to object oriented approach	10 hours

Introduction to object oriented approach: Why object oriented programming?- Characteristics of object oriented language: classes and objects - encapsulation-data abstraction- inheritance - polymorphism - Merits and Demerits of object oriented programming. UML- class diagram of OOP - Inline function – default argument function- Exception handling (Standard) - reference: independent reference – function returning reference – pass by reference.

Module:3	Classes and objects	14 hours

Classes and objects: Definition of classes – access specifier – class versus structure – constructor – destructor – copy constructor and its importance – array of objects – dynamic objects- friend function-friend class

Module:4	Polymorphism and Inheritance	26 hours

Polymorphism and Inheritance: Polymorphism-compile time polymorphism – function

overloading – operator overloading - . Inheritance-types of inheritance- constructors and destructors in inheritance – constraints of multiple inheritance-virtual base class - run time polymorphism-function overriding.		
Module:5	**Exception handling and Templates**	**18 hours**
Exception handling and Templates Exception handling(user-defined exception)- Function template , Class template – Template with inheritance , STL – Container, Algorithm, Iterator - vector, list, stack, map.		
Module:6	**IO Streams and Fi les**	**10 hours**
IOstreams and Files IOstreams, Manipulators- overloading Inserters(<<) and Extractors(>>)Sequential and Random files – writing and reading objects into/from files		
	Total Lab hours:	**90 hours**

Text Book(s)	
1.	Stanley B Lippman, Josee Lajoie, Barbara E, Moo, "C++ primer", Fifth edition, Addison-Wesley, 2012.
2.	Ali Bahrami, Object oriented Systems development, Tata McGraw - Hill Education, 1999
3.	Brian W. Kernighan, Dennis M. Ritchie , The „C" programming Language, 2nd edition, Prentice Hall Inc., 1988.
Reference Books	
1.	Bjarne stroustrup, The C++ programming Language, Addison Wesley, 4th edition, 2013
2.	Harvey M. Deitel and Paul J. Deitel, C++ How to Program, 7th edition, Prentice Hall, 2010.
3.	Maureen Sprankle and Jim Hubbard, Problem solving and Programming concepts, 9th edition, Pearson Eduction, 2014
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	
List of Challenging Experiments (Indicative)	
1.	**Postman Problem** A postman needs to walk down every street in his area in order to deliver the mail. Assume that the distances between the streets along the roads are given. The postman starts at the post office and returns back to the post office after delivering all the mails. Implement an algorithm to help the post man to walk minimum distance for the purpose.
2.	**Budget Allocation for Marketing Campaign** A mobile manufacturing company has got several marketing options such as Radio advertisement campaign, TV non peak hours campaign, City top paper network, Viral marketing campaign, Web advertising. From their previous experience, they have got a statistics about paybacks for each marketing option. Given the marketing budget (rupees in crores) for the current year and details of paybacks for each option, implement an algorithm to determine the amount that shall spent on each marketing option so that the company attains the maximum profit.
3.	**Missionaries and Cannibals** Three missionaries and three cannibals are on one side of a river, along with a boat that can hold one or two people. Implement an algorithm to find a way to get everyone to the other side of the river, without ever leaving a group of missionaries in one place outnumbered by

	the cannibals in that place.
4.	**Register Allocation Problem** A register is a component of a computer processor that can hold any type of data and can be accessed faster. As registers are faster to access, it is desirable to use them to the maximum so that the code execution is faster. For each code submitted to the processor, a register interference graph (RIG) is constructed. In a RIG, a node represents a temporary variable and an edge is added between two nodes (variables) t1 and t2 if they are live simultaneously at some point in the program. During register allocation, two temporaries can be allocated to the same register if there is no edge connecting them. Given a RIG representing the dependencies between variables in a code, implement an algorithm to determine the number of registers required to store the variables and speed up the code execution.
5.	**Selective Job Scheduling Problem** A server is a machine that waits for requests from other machines and responds to them. The purpose of a server is to share hardware and software resources among clients. All the clients submit the jobs to the server for execution and the server may get multiple requests at a time. In such a situation, the server schedule the jobs submitted to it based on some criteria and logic. Each job contains two values namely time and memory required for execution. Assume that there are two servers that schedules jobs based on time and memory. The servers are named as Time_Schedule_Server and memory_Schedule_Server respectively. Design a OOP model and implement the time_Schedule_Server and memory_Schedule_Server. The Time_Schedule_Server arranges jobs based on time required for execution in ascending order whereas memory_Schedule_Server arranges jobs based on memory required for execution in ascending order.
6.	**Fragment Assembly in DNA Sequencing** DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. The information in DNA is stored as a code made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T). In DNA sequencing, each DNA is sheared into millions of small fragments (reads) which assemble to form a single genomic sequence ("superstring"). Each read is a small string. In such a fragment assembly, given a set of reads, the objective is to determine the shortest superstring that contains all the reads. For example, given a set of strings, {000, 001, 010, 011, 100, 101, 110, 111} the shortest superstring is 0001110100. Given a set of reads, implement an algorithm to find the shortest superstring that contains all the given reads.
7.	**House Wiring** An electrician is wiring a house which has many rooms. Each room has many power points in different locations. Given a set of power points and the distances between them, implement an algorithm to find the minimum cable required.

Total Laboratory Hours	90 hours
Recommended by Board of Studies	Date: 29-10-2015
Approved by 39th Academic Council	Date: 17-12-2015

Course code	Course title	L	T	P	J	C
ENG1011	English for Engineers	0	0	4	0	2
Pre-requisite	Cleared EPT / Effective English				Syllabus version	
						v. 2.2

Course Objectives:

1. To facilitate effective language skills for academic purposes and real-life situations.
2. To enhance students' language and communication with focus on placement skills development.
3. To aid students apply language and communication skills in professional reading and reporting.

Course Outcomes:

1. Apply language skills with ease in academic and real-life situations.
2. Build up a job winning digital foot print and learn to face interviews confidently.
3. Develop good interpreting and reporting skills to aid them in research.
4. Comprehend language and communication skills in academic and social contexts.
5. Acquire vocabulary and learn strategies for error-free communication.

Module:1	**Listening**	**4 hours**
Casual and Academic		
Module:2	**Speaking**	**4 hours**
Socializing Skills - Introducing Oneself- His / Her Goals & SWOT		
Module:3	**Reading**	**2 hours**
Skimming and Scanning		
Module:4	**Writing**	**2 hours**
Error-free sentences, Paragraphs		
Module:5	**Listening**	**4 hours**
News (Authentic Material): Analyzing General and Domain Specific Information		
Module:6	**Speaking**	**4 hours**
Group Discussion on factual, controversial and abstract issues		
Module:7	**Reading:**	**2 hours**
Extensive Reading		
Module:8	**Writing**	**2 hours**
Email Etiquette with focus on Content and Audience		
Module:9	**Listening**	**4 hours**

Speeches : General and Domain Specific Information		
Module:10	**Speaking**	**4 hours**
Developing Persuasive Skills - Turncoat and Debate		
Module:11	**Reading**	**2 hours**
Intensive Reading		
Module:12	**Writing**	**2 hours**
Data Transcoding		
Module:13	**Cross Cultural Communication**	**4 hours**
Understanding Inter and Cross-Cultural Communication Nuances		
Module:14	**Speaking**	**4 hours**
Public Speaking/Extempore /Monologues		
Module:15	**Reading for research**	**2 hours**
Reading Scientific/Technical Articles		
Module:16	**Writing**	**2 hours**
Creating a Digital/Online Profile – LinkedIn (Résumé/Video Profile)		
Module:17	**Speaking:**	**4 hours**
Mock Job/Placement Interviews		
Module:18	**Writing**	**2 hours**
Report Writing		
Module:19	**Speaking**	**4 hours**
Presentation using Digital Tools		
Module:20	**Vocabulary**	**2 hours**
Crossword Puzzles/Word games		
	Total Lecture hours:	**60 hours**
Text Book (s)		
1.	Clive Oxenden and Christina Latham-Koenig, New English File: Advanced: Teacher's Book with Test and Assessment CD-ROM: Six-level general English course for adults Paperback – Feb 2013, Oxford University Press, UK	

2	Clive Oxenden and Christina Latham-Koenig,New English File: Advanced Students Book Paperback – Feb 2012, Oxford University Press, UK
3	Michael Vince,Language Practicefor Advanced - Students Book, Feb. 2014, 4th Edition, Macmillan Education, Oxford, UnitedKingdom
Reference Books	
1.	Steven Brown, Dorolyn Smith, Active Listening 3, 2011, 3rd Edition, Cambridge University Press, UK
2.	Tony Lynch, Study Listening, 2013, 2nd Edition, Cambridge University Press, UK
3.	Liz Hamp-Lyons, Ben Heasley, Study Writing, 2010, 2nd Edition, Cambridge University Press, UK
4.	Kenneth Anderson, Joan Maclean, Tony Lynch, Study Speaking, 2013, 2nd Edition, Cambridge University Press, UK
5.	Eric H. Glendinning, Beverly Holmstrom, Study Reading, 2012, 2nd Edition Cambridge University Press, UK
6.	Michael Swan, Practical English Usage (Practical English Usage), Jun 2017, 4th edition, Oxford , University Press, UK
7.	Michael McCarthy, Felicity O'Dell, English Vocabulary in Use Advanced (South Asian Edition), May 2015, Cambridge University Press, UK
8.	Michael Swan, Catherine Walter, Oxford English Grammar Course Advanced, Feb 2012, 4th Edition, Oxford University Press, UK
9.	Heather Silyn-Roberts, Writing for Science and Engineering: Papers, Presentations and Reports, Jun 2016, 2nd Edition, Butterworth-Heinemann, UK

Mode of Evaluation: Assignment and FAT- Mini Project, Flipped Class Room, Lecture, PPT's, Role play, Assignments Class/Virtual Presentations, Report and beyond the classroom activities

List of Challenging Experiments (Indicative)		
1.	Create a Digital or Online Profile or a Digital Footprint	6 hours
2.	Prepare a video resume	8 hours
3.	Analyse a documentary critically	4 hours
4.	Turn Coat- Speaking for and against the topic / Activities through VIT Community Radio	6 hours
5	Present a topic using 'Prezi'	6 hours
6	Analyse a case on cross cultural communication critically	6 hours
7	Create a list of words relating to your domain	4 hours
8	Listen to a conversation of native speakers of English and answer the following questions	6 hours

9	Read an article and critically analyse the text in about 150 words	6 hours
10	Read an autobiography and role play the character in class by taking an excerpt from the book	8 hours
Total Practical Hours		**60 hours**

Mode of evaluation: Mini Project, Flipped Class Room, Lecture, PPT's, Role play, Assignments Class/Virtual Presentations, Report and beyond the classroom activities

Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 47	Date	24.08.2017

Course code	Course title	L	T	P	J	C
HUM1021	ETHICS AND VALUES	2	0	0	0	2
Pre-requisite	Nil	Syllabus version				
		1.1				

Course Objectives:

1. To understand and appreciate the ethical issues faced by an individual in profession, society and polity
2. To understand the negative health impacts of certain unhealthy behaviors
3. To appreciate the need and importance of physical, emotional health and social health

Course Outcomes:

1. Follow sound morals and ethical values scrupulously to prove as good citizens
2. Understand various social problems and learn to act ethically
3. Understand the concept of addiction and how it will affect the physical and mental health
4. Identify ethical concerns in research and intellectual contexts, including academic integrity, use and citation of sources, the objective presentation of data, and the treatment of human subjects
5. Identify the main typologies, characteristics, activities, actors and forms of cybercrime

Module:1	Being Good and Responsible	5 hours

Gandhian values such as truth and non-violence – Comparative analysis on leaders of past and present – Society's interests versus self-interests - Personal Social Responsibility: Helping the needy, charity and serving the society

Module:2	Social Issues 1	4 hours

Harassment – Types - Prevention of harassment, Violence and Terrorism

Module:3	Social Issues 2	4 hours

Corruption: Ethical values, causes, impact, laws, prevention – Electoral malpractices;
White collar crimes - Tax evasions – Unfair trade practices

Module:4	Addiction and Health	5 hours

Peer pressure - Alcoholism: Ethical values, causes, impact, laws, prevention – Ill effects of smoking - Prevention of Suicides;
Sexual Health: Prevention and impact of pre-marital pregnancy and Sexually Transmitted Diseases

Module:5	Drug Abuse	3 hours

Abuse of different types of legal and illegal drugs: Ethical values, causes, impact, laws and prevention

Module:6	Personal and Professional Ethics	4 hours

Dishonesty - Stealing - Malpractices in Examinations – Plagiarism

Module:7	**Abuse of Technologies**		**3 hours**
Hacking and other cyber crimes, Addiction to mobile phone usage, Video games and Social networking websites			
Module:8	**Contemporary issues:**		**2 hours**
Guest lectures by Experts			
	Total Lecture hours:	**30 hours**	
Reference Books			
1.	Dhaliwal, K.K , "Gandhian Philosophy of Ethics: A Study of Relationship between his Presupposition and Precepts,2016, Writers Choice, New Delhi, India.		
2.	Vittal, N, "Ending Corruption? - How to Clean up India?", 2012, Penguin Publishers, UK.		
3.	Pagliaro, L.A. and Pagliaro, A.M, "Handbook of Child and Adolescent Drug and Substance Abuse: Pharmacological , Developmental and Clinical Considerations", 2012Wiley Publishers, U.S.A.		
4.	Pandey, P. K (2012), "Sexual Harassment and Law in India", 2012, Lambert Publishers, Germany.		
Mode of Evaluation: CAT, Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies	26-07-2017		
Approved by Academic Council	No. 46	Date	24-08-2017

Course Code	Course Title	L	T	P	J	C
MAT-1011	**Calculus for Engineers**	3	0	2	0	4
Pre-requisite	**10+2 Mathematics or MAT1001**	**Syllabus Version**				
		1.0				

Course Objectives:

1. To provide the requisite and relevant background necessary to understand the other important engineering mathematics courses offered for Engineers and Scientists.
2. To introduce important topics of applied mathematics, namely Single and Multivariable Calculus and Vector Calculus etc.
3. To impart the knowledge of Laplace transform, an important transform technique for Engineers which requires knowledge of integration

Course Outcomes:

1. A pply single variable differentiation and integration to solve applied problems in engineering and find the maxima and minima of functions
2. Understand basic concepts of Laplace Transforms and solve problems with periodic functions, step functions, impulse functions and convolution
3. Evaluate partial derivatives, limits, total differentials, Jacobians, Taylor series and optimization problems involving several variables with or without constraints
4. Evaluate multiple integrals in Cartesian, Polar, Cylindrical and Spherical coordinates.
5. Understand gradient, directio nal derivatives, divergence, curl and Greens', Stokes, Gauss theorems

Module:1	**Application of Single Variable Calculus**	**9 hours**

Differentiation- Extrema on an Interval-Rolle's Theorem and the Mean Value Theorem-Increasing and Decreasing functions and First derivative test-Second derivative test- Maxima and Minima-Concavity. Integration-Average function value - Area between curves - Volumes of solids of revolution - Beta and Gamma functions–interrelation

Module:2	**Laplace transforms**	**7 hours**

Definition of Laplace transform-Properties-Laplace transform of periodic functions-Laplace transform of unit step function, Impulse function-Inverse Laplace transform-Convolution.

Module:3	**Multivariable Calculus**	**4 hours**

Functions of two variables-limits and continuity-partial derivatives –total differential- Jacobian and its properties.

Module:4	**Application of Multivariable Calculus**	**5 hours**

Taylor's expansion for two variables–maxima and minima–constrained maxima and minima-Lagrange's multiplier method.

Module:5	**Multiple integrals**	**8 hours**
Evaluation of double integrals–change of order of integration–change of variables between Cartesian and polar co-ordinates - Evaluation of triple integrals-change of variables between Cartesian and cylindrical and spherical co-ordinates- evaluation of multiple integrals using gamma and beta functions.		
Module:6	**Vector Differentiation**	**5 hours**
Scalar and vector valued functions – gradient, tangent plane–directional derivative- divergence and curl–scalar and vector potentials–Statement of vector identities-Simple problems		
Module:7	**Vector Integration**	**5 hours**
line, surface and volume integrals - Statement of Green's, Stoke's and Gauss divergence theorems -verification and evaluation of vector integrals using them.		
Module:8	**Contemporary Issues:**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**45 hours**

Text Book(s)

[1] Thomas' Calculus, George B.Thomas, D.Weir and J. Hass, 13th edition, Pearson,2014.
[2] Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, Wiley India, 2015.

Reference Books

1. Higher Engineering Mathematics, B.S. Grewal, 43rd Edition ,Khanna Publishers, 2015
2. Higher Engineering Mathematics, John Bird, 6th Edition, Elsevier Limited, 2017.
3. Calculus: Early Transcendentals, James Stewart, 8th edition, Cengage Learning, 2017.
4. Engineering Mathematics, K.A.Stroud and Dexter J. Booth, 7th Edition, Palgrave Macmillan (2013)

Mode of Evaluation

Digital Assignments, Quiz, Continuous Assessments, Final Assessment Test

List of Challenging Experiments (Indicative)		
1.	Introduction to MATLAB through matrices, and general Syntax	2 hours
2	Plotting and visualizing curves and surfaces in MATLAB – Symbolic computations using MATLAB	2 hours
3.	Evaluating Extremum of a single variable function	2 hours
4.	Understanding integration as Area under the curve	2 hours
5.	Evaluation of Volume by Integrals (Solids of Revolution)	2 hours
6.	Evaluating maxima and minima of functions of several variables	2 hours
7.	Applying Lagrange multiplier optimization method	2 hours
8.	Evaluating Volume under surfaces	2 hours

9.	Evaluating triple integrals			2 hours
10.	Evaluating gradient, curl and divergence			2 hours
11.	Evaluating line integrals in vectors			2 hours
12.	Applying Green's theorem to real world problems			2 hours
		Total Laboratory Hours		**24 hours**
Mode of Assessment:				
Weekly assessment, Final Assessment Test				
Recommended by Board of Studies	12-06-2015			
Approved by Academic Council	No. 37	Date	16-06-2015	

Course Code	Course title	L	T	P	J	C
MAT2001	Statistics for Engineers	3	0	2	0	4
Prerequisites	MAT1011 – Calculus for Engineers	Syllabus Version:				1.0

Course Objectives :

1. To provide students with a framework that will help them choose the appropriate descriptive methods in various data analysis situations.
2. To analyse distributions and relationship of real-time data.
3. To apply estimation and testing methods to make inference and modelling techniques for decision making.

Course Outcomes:

1. Compute and interpret descriptive statistics using numerical and graphical techniques.
2. Understand the basic concepts of random variables and find an appropriate distribution for analysing data specific to an experiment.
3. Apply statistical methods like correlation, regression analysis in analysing, interpreting experimental data.
4. Make appropriate decisions using statistical inference that is the central to xperimental research.
5. Use statistical methodology and tools in reliability engineering problems.
6. Demonstrate R programming for statistical data

Module: 1	Introduction to Statistics	6 hours

Introduction to statistics and data analysis-Measures of central tendency –Measures of variability-[Moments-Skewness-Kurtosis (Concepts only)].

Module: 2	Random variables	8 hours

Introduction -random variables-Probability mass Function, distribution and density functions - joint Probability distribution and joint density functions- Marginal, conditional distribution and density functions- Mathematical expectation, and its properties Covariance , moment generating function – characteristic function.

Module: 3	Correlation and regression	4 hours

Correlation and Regression – Rank Correlation- Partial and Multiple correlation- Multiple regression.

Module: 4	Probability Distributions	7 hours

Binomial and Poisson distributions – Normal distribution – Gamma distribution – Exponential distribution – Weibull distribution.

Module: 5	Hypothesis Testing I	4 hours

Testing of hypothesis – Introduction-Types of errors, critical region, procedure of testing hypothesis-Large sample tests- Z test for Single Proportion, Difference of Proportion, mean and difference of means.

Module: 6	Hypothesis Testing II	9 hours

Small sample tests- Student's t-test, F-test- chi-square test- goodness of fit - independence of attributes- Design of Experiments - Analysis of variance – one and two way classifications - CRD-RBD- LSD.

Module: 7	**Reliability**	**5 hours**

Basic concepts- Hazard function-Reliabilities of series and parallel systems- System Reliability - Maintainability-Preventive and repair maintenance- Availability.

Module: 8	**Contemporary Issues**	**2 hours**

Industry Expert Lecture

	Total Lecture hours	**45 hours**

Text book(s)

- Probability and Statistics for engineers and scientists, R.E.Walpole, R.H.Myers, S.L.Mayers and K.Ye, 9th Edition, Pearson Education (2012).
- Applied Statistics and Probability for Engineers, Douglas C. Montgomery, George C. Runger, 6th Edition, John Wiley & Sons (2016).

Reference books

- Reliability Engineering, E.Balagurusamy, Tata McGraw Hill, Tenth reprint 2017.
- Probability and Statistics, J.L.Devore, 8th Edition, Brooks/Cole, Cengage Learning (2012).
- Probability and Statistics for Engineers, R.A.Johnson, Miller Freund's, 8th edition, Prentice Hall India (2011).
- Probability, Statistics and Reliability for Engineers and Scientists, Bilal M. Ayyub and Richard H. McCuen, 3rd edition, CRC press (2011).

Mode of Evaluation

Digital Assignments, Continuous Assessment Tests, Quiz, Final Assessment Test.

List of Experiments (Indicative)			
1	Introduction: Understanding Data types; importing/exporting data.	2 hours	
2	Computing Summary Statistics /plotting and visualizing data using Tabulation and Graphical Representations.	2 hours	
3	Applying correlation and simple linear regression model to real dataset; computing and interpreting the coefficient of determination.	2 hours	
4	Applying multiple linear regression model to real dataset; computing and interpreting the multiple coefficient of determination.	2 hours	
5	Fitting the following probability distributions: Binomial distribution	2 hours	
6	Normal distribution, Poisson distribution	2 hours	

7	Testing of hypothesis for One sample mean and proportion from real-time problems.	2 hours	
8	Testing of hypothesis for Two sample means and proportion from real-time problems	2 hours	
9	Applying the t test for independent and dependent samples	2 hours	
10	Applying Chi-square test for goodness of fit test and Contingency test to real dataset	2 hours	
11	Performing ANOVA for real dataset for Completely randomized design, Randomized Block design ,Latin square Design	2 hours	
	Total laboratory hours	**22 hours**	

Mode of Evaluation			
Weekly Assessment, Final Assessment Test			
Recommended by Board of Studies	25-02-2017		
Approved by Academic Council	47	Date:	05-10-2017

Course code	Course title	L	T	P	J	C
MGT1022	Lean Start up Management	1	0	0	4	2
Pre-requisite	Nil	Syllabus version				
		v.1.0				

Course Objectives:

1. Learn methods of company formation and management.
2. Gain practical skills in and experience of stating of business using pre-set collection of business ideas.
3. Learn basics of entrepreneurial skills.

Course Outcomes:

1. Understand developing business models and growth drivers
2. Use the business model canvas to map out key components of enterprise
3. Analyze market size, cost structure, revenue streams, and value chain
4. Understand build-measure-learn principles
5. Foreseeing and quantifying business and financial risks

Module:1		**2 Hours**
Creativity and Design Thinking (identify the vertical for business opportunity, understand your customers, accurately assess market opportunity)		
Module:2		**3 Hours**
Minimum Viable Product (Value Proposition, Customer Segments, Build- measure-learn process)		
Module:3		**3 Hours**
Business Model Development(Channels and Partners, Revenue Model and streams, Key Resources, Activities and Costs, Customer Relationships and Customer Development Processes, Business model canvas –the lean model- templates)		
Module:4		**3 Hours**
Business Plan and Access to Funding(visioning your venture, taking the product/ service to market, Market plan including Digital & Viral Marketing, start-up finance - Costs/Profits & Losses/cash flow, Angel/VC,/Bank Loans and Key elements of raising money)		
Module:5		**3 Hours**
Legal, Regulatory, CSR, Standards, Taxes		
Module:6		**2 Hours**
Lectures by Entrepreneurs		
	Total Lecture	**15 hours**

Text Book(s)	
1.	The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company, Steve Blank, K & S Ranch; 1st edition (March 1, 2012)
2	The Four Steps to the Epiphany, Steve Blank, K&S Ranch; 2nd edition (July 17, 2013)
3	The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, Eric Ries, Crown Business; (13 September 2011)
Reference Books	
1.	Holding a Cat by the Tail, Steve Blank, K&S Ranch Publishing LLC (August 14, 2014)
2	Product Design and Development, Karal T Ulrich, SD Eppinger, McGraw Hill
3	Zero to One: Notes on Startups, or How to Build the Future, Peter Thiel, Crown Business(2014)
4	Lean Analytics: Use Data to Build a Better Startup Faster (Lean Series), Alistair Croll & Benjamin Yoskovitz, O'Reilly Media; 1st Edition (March 21, 2013)
5	Inspired: How To Create Products Customers Love, Marty Cagan, SVPG Press; 1st edition (June 18, 2008)
6	**Website References:** 1. http://theleanstartup.com/ 2. https://www.kickstarter.com/projects/881308232/only-on-kickstarter-the-leaders-guide-by-eric-ries 3. http://businessmodelgeneration.com/ 4. https://www.leanstartupmachine.com/ 5. https://www.youtube.com/watch?v=fEvKo90qBns 6. http://thenextweb.com/entrepreneur/2015/07/05/whats-wrong-with-the-lean-startup-methodology/#gref 7. http://www.businessinsider.in/Whats-Lean-about-Lean-Startup/articleshow/53615661.cms 8. https://steveblank.com/tools-and-blogs-for-entrepreneurs/ 9. https://hbr.org/2013/05/why-the-lean-start-up-changes-everything 10. chventures.blogspot.in/ platformsandnetworks.blogspot.in/p/saas-model.html
Mode of Evaluation: Assignments; Field Trips, Case Studies; e-learning; Learning through research, TED Talks	
Project	
1.	Project — 60 hours
	Total Project — 60 hours

Recommended by Board of Studies	08-06-2015		
Approved by Academic Council	37	Date	16-06-2015

Course code	Course title	L	T	P	J	C
PHY1701	ENGINEERING PHYSICS	3	0	2	0	4
Pre-requisite	Physics of 12th standard or equivalent			Syllabus version		
				V.2.1		

Course Objectives:

To enable the students to understand the basics of the latest advancements in Physics viz., Quantum Mechanics, Nanotechnology, Lasers, Electro Magnetic Theory and Fiber Optics.

Course Outcomes:

1. Understand the dual nature of radiation and matter.
2. Apply Schrodinger's equations to solve finite and infinite potential problems.
3. Apply quantum ideas at the nanoscale.
4. Apply quantum ideas for understanding the operation and working principle of optoelectronic devices.
5. Analyze the Maxwell's equations in differential and integral form.
6. Classify the optical fiber for different Engineering applications.
7. Apply concept of Lorentz Transformation for Engineering applications.
8. Demonstrate the quantum mechanical ideas – LAB

Module:1	Introduction to Modern Physics	6 hours

Planck's concept (hypothesis), Compton Effect, Particle properties of wave: Matter Waves, Davisson Germer Experiment, Heisenberg Uncertainty Principle, Wave function, and Schrodinger equation (time dependent & independent).

Module:2	Applications of Quantum Physics	5 hours

Particle in a 1-D box (Eigen Value and Eigen Function), 3-D Analysis (Qualitative), Tunneling Effect (Qualitative) (AB 205), Scanning Tunneling Microscope (STM).

Module:3	Nanophysics	5 hours

Introduction to Nano-materials, Moore's law, Properties of Nano-materials, Quantum confinement, Quantum well, wire & dot, Carbon Nano-tubes (CNT), Applications of nanotechnology in industry.

Module:4	Laser Principles and Engineering Application	6 hours

Laser Characteristics, Spatial and Temporal Coherence, Einstein Coefficient & its significance, Population inversion, Two, three & four level systems, Pumping schemes, Threshold gain coefficient, Components of laser, Nd-YAG, He-Ne, CO2 and Dye laser and their engineering applications.

Module:5	Electromagnetic Theory and its application	6 hours

Physics of Divergence, Gradient and Curl, Qualitative understanding of surface and volume integral, Maxwell Equations (Qualitative), Wave Equation (Derivation), EM Waves, Phase velocity, Group velocity, Group index , Wave guide (Qualitative)

Module:6	Propagation of EM waves in Optical fibers and Optoelectronic Devices	10 hours

Light propagation through fibers, Acceptance angle, Numerical Aperture, Types of fibers - step index, graded index, single mode & multimode, Attenuation, Dispersion-intermodal and intramodal. Sources-LED & Laser Diode, Detectors-Photodetectors- PN & PIN - Applications of fiber optics in communication- Endoscopy.

Module:7	**Special Theory of Relativity**	**5 hours**
Frame of reference, Galilean relativity, Postulate of special theory of relativity, Simultaneity, length contraction and time dilation.		
Module:8	**Contemporary issues:**	**2 hours**
	Lecture by Industry Experts	
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Arthur Beiser et al., Concepts of Modern Physics, 2013, Sixth Edition, Tata McGraw Hill. William Silfvast,
2. Laser Fundamentals, 2008, Cambridge University Press.
3. D. J. Griffith, Introduction to Electrodynamics, 2014, 4th Edition, Pearson.
4. Djafar K. Mynbaev and Lowell L.Scheiner, Fiber Optic Communication Technology, 2011, Pearson

Reference Books

1. Raymond A. Serway, Clement J. Mosses, Curt A. Moyer Modern Physics, 2010, 3rd Indian Edition Cengage learning.
2. John R. Taylor, Chris D. Zafiratos and Michael A. Dubson, Modern Physics for Scientists and Engineers, 2011, PHI Learning Private Ltd.
3. Kenneth Krane Modern Physics, 2010, Wiley Indian Edition.
4. Nityanand Choudhary and Richa Verma, Laser Systems and Applications, 2011, PHI Learning Private Ltd.
5. S. Nagabhushana and B. Sathyanarayana, Lasers and Optical Instrumentation, 2010, I.K. International Publishing House Pvt. Ltd.,
6. R. Shevgaonkar, Electromagnetic Waves, 2005, 1st Edition, Tata McGraw Hill
7. Principles of Electromagnetics, Matthew N.O. Sadiku, 2010, Fourth Edition, Oxford.
8. Ajoy Ghatak and K. Thyagarajan, Introduction to Fiber Optics, 2010, Cambridge University Press.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Experiments

1.	Determination of Planck's constant using electroluminescence process	2 hrs
2.	Electron diffraction	2 hrs
3.	Determination of wavelength of laser source (He -Ne laser and diode lasers of different wavelengths) using diffraction technique	2 hrs
4.	Determination of size of fine particle using laser diffraction	2 hrs
5.	Determination of the track width (periodicity) in a written CD	2 hrs
6.	Optical Fiber communication (source + optical fiber + detector)	2 hrs
7.	Analysis of crystallite size and strain in a nano -crystalline film using X-ray diffraction	2 hrs
8.	Numerical solutions of Schrödinger equation (e.g. particle in a box problem) (can be given as an assignment)	2 hrs
9.	Laser coherence length measurement	2 hrs
10.	Proof for transverse nature of E.M. waves	2 hrs
11.	Quantum confinement and Heisenberg's uncertainty principle	2 hrs
12.	Determination of angle of prism and refractive index for various colour –Spectrometer	2 hrs
13.	Determination of divergence of a laser beam	2 hrs
14.	Determination of crystalline size for nanomaterial (Computer simulation)	2 hrs

15.	Demonstration of phase velocity and group velocity (Computer simulation)			2 hrs
			Total Laboratory Hours	30 hrs
Mode of evaluation: CAT / FAT				
Recommended by Board of Studies	04-06-2019			
Approved by Academic Council	No. 55	Date	13-06-2019	

Course code	Course title	L	T	P	J	C
PHY1999	Introduction to Innovative Projects	1	0	0	4	2
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

1. To make students confident enough to handle the day to day issues.
2. To develop the "Thinking Skill" of the students, especially Creative Thinking Skills
3. To train the students to be innovative in all their activities
4. To prepare a project report on a socially relevant theme as a solution to the existing issues

Course Outcomes:

1. Understand the various types of thinking skills.
2. Enhance the innovative and creative ideas.
3. Find out a suitable solution for socially relevant issues- J component

Module:1 A	Self Confidence	1 hour

Understanding self – Johari Window –SWOT Analysis – Self Esteem – Being a contributor – Case Study

Project : Exploring self, understanding surrounding, thinking about how s(he) can be a contributor for the society, Creating a big picture of being an innovator – writing a 1000 words imaginary autobiography of self – Topic "Mr X – the great innovator of 2015" and upload. **(4 non- contact hours)**

Module:1 B	Thinking Skill	1 hour

Thinking and Behaviour – Types of thinking– Concrete – Abstract, Convergent, Divergent, Creative,
Analytical, Sequential and Holistic thinking – Chunking Triangle – Context Grid – Examples – Case
Study.

Project : Meeting at least 50 people belonging to various strata of life and talk to them / make field visits to identify a min of100 society related issues, problems for which they need solutions

Module:1 C	Lateral Thinking Skill	1 hour

Blooms Taxonomy – HOTS – Outof the box thinking – deBono lateral thinking model – Examples

Project : Last weeks - incomplete portion to be done and uploaded

Module:2 A	**Creativity**	**1 hour**
Creativity Models – Walla – Barrons – Koberg & Begnall – Examples **Project:** Selecting 5 out of 100 issues identified for future work. Criteria based approach for prioritisation, use of statistical tools & upload. **(4 non- contact hours)**		
Module:2 B	**Brainstorming**	**1 hour**
25 brainstorming techniques and examples **Project:** Brainstorm and come out with as many solutions as possible for the top 5 issues identified & upload. **(4 non- contact hours)**		
Module:3	**Mind Mapping**	**1 hour**
Mind Mapping techniques and guidelines. Drawing a mind map **Project :** Using Mind Maps get another set of solutions forthe next 5 issues (issue 6 – 10) . **(4 non- contact hours)**		
Module:4 A	**Systems thinking**	**1 hour**
Systems Thinking essentials – examples – Counter Intuitive condemns **Project:** Select 1 issue / problem for which the possible solutions are available with you. Apply Systems Thinking process and pick up one solution [explanation should be given why the other possible solutions have been left out]. Go back to the customer and assess the acceptability and upload. . **(4 non- contact hours)**		
Module:4 B	**Design Thinking**	**1 hour**
Design thinking process – Human element of design thinking – case study **Project :** Apply design thinking to the selected solution, apply the engineering & scientific tinge to it. Participate in "design week" celebrations upload the weeks learning out come.		
Module:5 A	**Innovation**	**1 hour**
Difference between Creativity and Innovation – Examples of innovation –Being innovative. **Project:** A literature searches on prototyping of your solution finalized. Prepare a prototype model or process and upload. . **(4 non- contact hours)**		
Module:5 B	**Blocks for Innovation**	**1 hour**
Identify Blocks for creativity and innovation – overcoming obstacles – Case Study **Project :** Project presentation on problem identification, solution, innovations-expected results – Interim review with PPT presentation. . **(4 non- contact hours)**		
Module:5 C	**Innovation Process**	**1 hour**
Steps for Innovation – right climate for innovation **Project:** Refining the project, based on the review report and uploading the text. . **(4 non-contact hours)**		
Module:6 A	**Innovation in India**	**1 hour**
Stories of 10 Indian innovations **Project:** Making the project better with add ons. . **(4 non- contact hours)**		
Module:6 B	**JUGAAD Innovation**	**1 hour**
Frugal and flexible approach to innovation - doing more with less Indian Examples **Project:** Fine tuning the innovation project with JUGAAD principles and uploading (Credit for JUGAAD implementation) . **(4 non- contact hours)**		
Module:7 A	**Innovation Project Proposal Presentation**	**1 hour**
Project proposal contents, economic input, ROI – Template **Project:** Presentation of the innovative project proposal and upload . **(4 non- contact hours)**		
Module:8 A	Contemporary issue in Innovation	**1 hour**
Contemporary issue in Innovation		

Project: Final project Presentation , Viva voce Exam (**4 non- contact hours)**			
	Total Lecture hours:	**15 hours**	
Text Book(s)			
1.	How to have Creative Ideas, Edward debone, Vermilon publication, UK, 2007		
2.	The Art of Innovation, Tom Kelley & Jonathan Littman, Profile Books Ltd, UK, 2008		
Reference Books			
1.	Creating Confidence, Meribeth Bonct, Kogan Page India Ltd, New Delhi, 2000		
2.	Lateral Thinking Skills, Paul Sloane, Keogan Page India Ltd, New Delhi, 2008		
3.	Indian Innovators, Akhat Agrawal, Jaico Books, Mumbai, 2015		
4.	JUGAAD Innovation, Navi Radjou, Jaideep Prabhu, Simone Ahuja Random house India, Noida, 2012.		
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar Three reviews with weightage of 25 : 25 : 50 along with reports			
Recommended by Board of Studies	15-12-2015		
Approved by Academic Council	No. 39	Date	17-12-2015

Soft Skill Course Basket

Course code	Course title	L	T	P	J	C
STS 1201	Introduction to problem solving	3	0	0	0	1
Pre-requisite	None	Syllabus version				
		1				

Course Objectives:

1. To enhance the logical reasoning skills of the students and improve the problem-solving abilities
2. To strengthen the ability to solve quantitative aptitude problems
3. To enrich the verbal ability of the students for academic purpose

Course Outcomes:

1. Students will be introduced to basic concepts of Quantitative Aptitude, Logical reasoning and Verbal ability
2. Students will be able to read and demonstrate good comprehension of text in areas of the student's interest
3. Students will be able to demonstrate the ability to resolve problems that occur in their field.

Module:1	Lessons on excellence	2hours

Skill introspection, Skill acquisition, consistent practice

Module:2	Logical Reasoning	18 hours

Thinking Skill

- Problem Solving
- Critical Thinking
- Lateral Thinking

Taught through thought-provoking word and rebus puzzles, and word-link builder questions

Coding & decoding, Series, Analogy, Odd man out and Visual reasoning

- Coding and Decoding
- Series
- Analogy
- Odd Man Out

- Visual Reasoning

Sudoku puzzles
Solving introductory to moderate level sudoku puzzles to boost logical thinking and comfort with numbers

Attention to detail
Picture and word driven Qs to develop attention to detail as a skill

Module:3	**Quantitative Aptitude**	**14 hours**

Speed Maths

- Addition and Subtraction of bigger numbers
- Square and square roots
- Cubes and cube roots
- Vedic maths techniques
- Multiplication Shortcuts
- Multiplication of 3 and higher digit numbers
- Simplifications
- Comparing fractions
- Shortcuts to find HCF and LCM
- Divisibility tests shortcuts

Algebra and functions

Module:4	**Recruitment Essentials**	**5hours**

Looking at an engineering career through the prism of an effective resume

- Importance of a resume - the footprint of a person's career achievements
- How a resume looks like?
- An effective resume vs. a poor resume: what skills you must build starting today and how?

Impression Management
Getting it right for the interview:

- Grooming, dressing
- Body Language and other non-verbal signs
- Displaying the right behaviour

Module:5	**Verbal Ability**	**6hours**

Grammar challenge
A practice paper with sentence based and passage-based questions on grammar discussed. Topics covered in questions are Nouns and Pronouns, Verbs, Subject-Verb Agreement, Pronoun-Antecedent Agreement, Punctuations

Verbal reasoning

	Total Lecture hours:	**45 hours**

Mode of Evaluation: FAT, Assignments, 3 Assessments with Term End FAT (Computer Based Test)

Text Book(s):

1. FACE, Aptipedia Aptitude Encyclopedia, 2016, 1st Edition, Wiley Publications, Delhi.
2. ETHNUS, Aptimithra, 2013, 1st Edition, McGraw-Hill Education Pvt.Ltd.
3. SMART, PlaceMentor, 2018, 1st Edition, Oxford University Press.
4. R S Aggarwal, Quantitative Aptitude For Competitive Examinations, 2017, 3rd Edition, S. Chand Publishing, Delhi.

Reference Book(s):

Arun Sharma, Quantitative Aptitude, 2016, 7th Edition, McGraw Hill Education Pvt. Ltd.

Course code	Course title	L	T	P	J	C
STS 1202	Introduction to quantitative, logical and verbal ability	3	0	0	0	1
Pre-requisite	None	Syllabus version				
Cleared the cut-off in end-of-sem 1 assessment		1				

Course Objectives:

1. To enhance the logical reasoning skills of the students and improve the problem-solving abilities
2. To strengthen the ability to solve quantitative aptitude problems
3. To enrich the verbal ability of the students for academic purpose

Course Outcomes:

1. Students will be able to show more confidence in solving problems of Quantitative Aptitude
2. Students will be able to show more confidence in solving problems of Logical Reasoning
3. Students will be able to show more confidence in understanding the questions of Verbal Ability

Module:1	Logical Reasoning	12 hours

Word group categorization questions

Puzzle type class involving students grouping words into right group orders of logical sense

Cryptarithmetic

Data arrangements and Blood relations

- Linear Arrangement
- Circular Arrangement
- Multi-dimensional Arrangement
- Blood Relations

Module:2	Quantitative Aptitude	20 hours

Ratio and Proportion

- Ratio
- Proportion
- Variation
- Simple equations
- Problems on Ages
- Mixtures and alligations: Problems involving multiple iterations of mixtures

Percentages, Simple and Compound Interest

- Percentages as Fractions and Decimals
- Percentage Increase / Decrease
- Simple Interest
- Compound Interest
- Relation Between Simple and Compound Interest

Number System

- Number system
- Power cycle
- Remainder cycle
- Factors, Multiples
- HCF and LCM

Module:3	Verbal Ability	13hours

Reading Comprehension – Advanced

Grammar - application and discussion

A practice paper with sentence based and passage-based questions on grammar discussed. Topics covered in questions are Prepositions, Adjectives and Adverbs, Tenses, Forms and Speech and Voice, Idioms and Phrasal Verbs, Collocations, Gerund and Infinitives

Articles, Prepositions and Interrogatives

- Definite and Indefinite Articles
- Omission of Articles
- Prepositions
- Compound Prepositions and Prepositional Phrases
- Interrogatives

Vocabulary – Advanced

Exposure to challenging placement questions on vocabulary

	Total Lecture hours:	45 hours

Mode of Evaluation: FAT, Assignments, 3 Assessments with Term End FAT (Computer Based Test)

Text Book(s):

1. FACE, Aptipedia Aptitude Encyclopedia, 2016, 1st Edition, Wiley Publications, Delhi.
2. ETHNUS, Aptimithra, 2013, 1st Edition, McGraw-Hill Education Pvt.Ltd.
3. SMART, PlaceMentor, 2018, 1st Edition, Oxford University Press**.**
4. R S Aggarwal, Quantitative Aptitude For Competitive Examinations, 2017, 3rd Edition, S. Chand Publishing, Delhi.

Reference Book(s):

Arun Sharma, Quantitative Aptitude, 2016, 7th Edition, McGraw Hill Education Pvt. Ltd.

Course code	Course title	L	T	P	J	C
STS 2201	Numerical ability and cognitive intelligence	3	0	0	0	1
Pre-requisite	None	Syllabus version				
		1				

Course Objectives:

1. To develop the students' logical thinking skills and apply it in the real-life scenarios
2. To learn the strategies of solving quantitative ability problems
3. To enrich the verbal ability of the students

Course Outcomes:

1. Students will be able to demonstrate critical thinking skills, such as problem solving related to their subject matters
2. Students will be able to demonstrate competency in verbal, quantitative and reasoning aptitude
3. Students will be able to perform good written communication skills

Module:1	Logical Reasoning	10 hours

Clocks, calendars, Direction sense and Cubes

- Clocks
- Calendars
- Direction Sense
- Cubes

Practice on advanced problems

Data interpretation and Data sufficiency - Advanced

- Advanced Data Interpretation and Data Sufficiency questions of CAT level
- Multiple chart problems
- Caselet problems

Module:2	Quantitative Aptitude	19 hours

Time and work – Advanced

- Work with different efficiencies
- Pipes and cisterns: Multiple pipe problems
- Work equivalence
- Division of wages

- Advanced application problems with complexity in calculating total work

Time, Speed and Distance - Advanced

- Relative speed
- Advanced Problems based on trains
- Advanced Problems based on boats and streams
- Advanced Problems based on races

Profit and loss, Partnerships and averages - Advanced

- Partnership
- Averages
- Weighted average

Advanced problems discussed

Number system - Advanced

Advanced application problems on Numbers involving HCF, LCM, divisibility tests, remainder and power cycles.

Module:3	**Verbal Ability**	**13hours**

Sentence Correction - Advanced

- Subject-Verb Agreement
- Modifiers
- Parallelism
- Pronoun-Antecedent Agreement
- Verb Time Sequences
- Comparisons
- Prepositions
- Determiners

Quick introduction to 8 types of errors followed by exposure to GMAT level questions

Sentence Completion and Para-jumbles - Advanced

- Pro-active thinking
- Reactive thinking (signpost words, root words, prefix suffix, sentence structure clues)
- Fixed jumbles
- Anchored jumbles

Practice on advanced GRE/ GMAT level questions

Reading Comprehension – Advanced

Exposure to difficult foreign subject-based RCs of the level of GRE/ GMAT

Module:4	**Writing skills for placements**	**3 hours**	

Essay writing

• Idea generation for topics • Best practices • Practice and feedback		
	Total Lecture hours:	**45 hours**
Mode of Evaluation: FAT, Assignments, 3 Assessments with Term End FAT (Computer Based Test)		
Text Book(s): **1.** FACE, Aptipedia Aptitude Encyclopedia, 2016, 1st Edition, Wiley Publications, Delhi. **2.** ETHNUS, Aptimithra, 2013, 1st Edition, McGraw-Hill Education Pvt.Ltd. **3.** SMART, PlaceMentor, 2018, 1st Edition, Oxford University Press. **4.** R S Aggarwal, Quantitative Aptitude For Competitive Examinations, 2017, 3rd Edition, S. Chand Publishing, Delhi.		
Reference Book(s): Arun Sharma, Quantitative Aptitude, 2016, 7th Edition, McGraw Hill Education Pvt. Ltd.		

Course code	Course title	L	T	P	J	C
STS 2202	Advanced aptitude and reasoning skills	3	0	0	0	1
Pre-requisite	None	Syllabus version				
		1				

Course Objectives:

1. To develop the students' logical thinking skills and apply it in the real-life scenarios
2. To learn the strategies of solving quantitative ability problems
3. To enrich the verbal ability of the students
4. To strengthen the basic programming skills for placements

Course Outcomes:

1. The students will be able to interact confidently and use decision making models effectively
2. The students will be able to deliver impactful presentations
3. The students will be able to be proficient in solving quantitative aptitude and verbal ability questions effortlessly

Module:1	Logical Reasoning	4 hours

Logical Reasoning puzzles - Advanced

Advanced puzzles:

- Sudoku
- Mind-bender style word statement puzzles
- Anagrams
- Rebus puzzles

Logical connectives, Syllogism and Venn diagrams

1. Logical Connectives
2. Advanced Syllogisms - 4, 5, 6 and other multiple statement problems
3. Challenging Venn Diagram questions: Set theory

Module:2	Quantitative Aptitude	10 hours

Logarithms, Progressions, Geometry and Quadratic equations - Advanced

1. Logarithm
2. Arithmetic Progression
3. Geometric Progression
4. Geometry
5. Mensuration
6. Coded inequalities
7. Quadratic Equations

Concepts followed by advanced questions of CAT level

Permutation, Combination and Probability - Advanced

- Fundamental Counting Principle
- Permutation and Combination
- Computation of Permutation - Advanced problems
- Circular Permutations
- Computation of Combination - Advanced problems
- Advanced probability

Module:3	Verbal Ability	5hours

Image interpretation

1. Image interpretation: Methods
2. Exposure to image interpretation questions through brainstorming and practice

Critical Reasoning - Advanced

1. Concepts of Critical Reasoning
2. Exposure to advanced questions of GMAT level

Module:4	Recruitment Essentials	8 hours

Mock interviews

Cracking other kinds of interviews

Skype/ Telephonic interviews
Panel interviews
Stress interviews

Guesstimation

1. Best methods to approach guesstimation questions
2. Practice with impromptu interview on guesstimation questions

Case studies/ situational interview

1. Scientific strategies to answer case study and situational interview questions
2. Best ways to present cases
3. Practice on presenting cases and answering situational interviews asked in

recruitment rounds		
Module:5	**Problem solving and Algorithmic skills**	**18 hours**
1. Logical methods to solve problem statements in Programming 2. Basic algorithms introduced		
	Total Lecture hours:	**45 hours**
Mode of Evaluation: FAT, Assignments, Mock interviews, 3 Assessments with Term End FAT (Computer Based Test)		
Text Book(s): **1.** FACE, Aptipedia Aptitude Encyclopedia, 2016, 1st Edition, Wiley Publications, Delhi. **2.** ETHNUS, Aptimithra, 2013, 1st Edition, McGraw-Hill Education Pvt.Ltd. **3.** SMART, PlaceMentor, 2018, 1st Edition, Oxford University Press**.** **4.** R S Aggarwal, Quantitative Aptitude For Competitive Examinations, 2017, 3rd Edition, S. Chand Publishing, Delhi.		
Reference Book(s): Arun Sharma, Quantitative Aptitude, 2016, 7th Edition, McGraw Hill Education Pvt. Ltd.		

Course code	Course title	L	T	P	J	C
STS 3201	Programming skills for employment	3	0	0	0	1
Pre-requisite	None	Syllabus version				
		1				

Course Objectives:

1. Ability to translate vast data into abstract concepts and to understand JAVA concepts
2. To have a clear understanding of subject related concepts
3. To develop computational ability in Java programming language

Course Outcomes:

1. Clear Knowledge about problem solving skills in JAVA concepts
2. Students will be able to write codes in Java

Module:1	Object and Class, Data types, Basic I / O	8 hours

Types of programming
Disadvantages of functional programming
Class & Objects
Attributes
Methods
Objects
Solving MCQs based on Objects and Classes
Solving tricky questions based on encapsulation
Solving frequently asked object based questions

Data types
Data
Why data type
Variables
Available data types
Numeric – int, float, double
Character – char, string
Solving MCQs based on type casting, data types
Solving debugging based MCQs

Printing
Getting input from user during run time
Command line arguments

Solving programming questions based on CLA
Solving MCQs questions based on CLA

Module:2	Decision Making, Loop Control, String, Date, Array	10 hours

Need for control statement
if..else
if..else if..else
Nested if..else
Switch case
Common mistakes with control statements (like using = instead of ==)
Solving frequently asked questions on decision making

Types of looping statements
Entry Controlled
For
While
Exit Controlled
do while
break and continue
Demo on looping
Common mistakes with looping statements (like using ; at the end of the loop)
Solving pattern programming problems, series problems
Solving predict the output questions

String handling, date handling
Solving problems based on arrays like searching, sorting, rearranging, iteration)
Multi-dimensional arrays
Solving pattern problems using 2D arrays
Real time application based on 2D arrays

Module:3	Inheritance, Aggregation & Associations	10 hours

Need
Is A – Inheritance
Types of inheritance supported
Diagrammatic representation
Demo on inheritance
Has A – Aggregation
Diagrammatic representation
Demo on aggregation
Uses A - Association
Diagrammatic representation
Demo on association
Assignment on relationships
Solving MCQs based on relationships between classes

Module:4	Modifiers, Interface & Abstract classes (Java specific), Packages	7 hours
Types of access specifiers Demo on access specifiers Assignment on access modifiers Instance Members Solving MCQs based on modifiers Abstract Classes Need Abstract Classes Abstract Methods Interfaces Assignment on abstract classes and interface Need for packages Access specifiers & packages Import classes from other packages		
Module:5	**Collections**	**10 hours**
ArrayList, LinkedList, List Interface, HashSet, Map Interface, HashMap, Set Programming questions based on collections Real world problems based on data structure		
	Total Lecture hours:	**45 hours**

Reference Books	
1.	Java The Complete Reference, 2014, 9th Edition by By Herbert Schildt, McGraw-Hill Education Pvt Ltd
2.	Introduction to Programming with Java: A Problem-Solving Approach by John Dean

Mode of Evaluation: FAT, Assignments, 3 Assessments with Term End FAT (Computer Based Test)

Course code	Course title	L	T	P	J	C
STS3204	JAVA programming and software engineering fundamentals	3	0	0	0	1
Pre-requisite	None	Syllabus version				
		1				

Course Objectives:

1. Ability to translate vast data into abstract concepts and to understand JAVA concepts
2. To have a clear understanding of subject related concepts
3. To develop computational ability in Java programming language

Course Outcomes:

1. Clear Knowledge about problem solving skills in JAVA concepts
2. Students will be able to write codes in Java

Module:1	Threads, Exceptions, LinkedList, Arrays, Stack and Queue	8 hours

Need of threads
Creating threads
Wait
Sleep
Thread execution

Need for exception handling
try, catch, throw, throws
Creating own exception (Java, Python)
Handling own exceptions

Solving programming questions based on linked list and arrays

Solving programming questions based on stacks and queues
How to implement a stack using queue?
How to implement a queue using stack?

Module:2	Trees, JDBC Connectivity	7 hours

Solving programming questions based on trees, binary trees, binary search trees
JDBC Overview
Database Setup
Install the MySQL Database
Create New Database User in MySQL Workbench

Module:3	**JDBC Data**	**6 hours**
Selecting data from tables Inserting Data into the Database Updating Data in the Database Deleting Data from the Database Creating Prepared Statements		
Module:4	**Networking with Java**	**12 hours**
Working with URLs Sending HTTP Requests Processing JSON data using Java Processing XML data using Java		
Module:5	**Advanced programming**	**12 hours**
File Operations CSV Operations Encoder & Decoders Encryption & Decryption Hashes Loggers		
	Total Lecture hours:	**45 hours**

Reference Books	
1.	Java The Complete Reference, 2014, 9th Edition by By Herbert Schildt, McGraw-Hill Education Pvt Ltd
2.	Introduction to Programming with Java: A Problem-Solving Approach by John Dean

Mode of Evaluation: FAT, Assignments, 3 Assessments with Term End FAT (Computer Based Test)

Course code	Course title	L	T	P	J	C
STS 3205	Advanced JAVA Programming	3	0	0	0	1
Pre-requisite	None	Syllabus version				
		1				

Course Objectives:

1. Ability to translate vast data into abstract concepts and to understand JAVA concepts
2. To have a clear understanding of subject related concepts
3. To develop computational ability in Java programming language

Course Outcomes:

1. Clear Knowledge about problem solving skills in JAVA concepts
2. Students will be able to write codes in Java

Module:1	Associations, Modifiers	9 hours

Uses A - Association
Diagrammatic representation
Demo on association
Assignment on relationships
Solving MCQs based on relationships between classes

Types of access specifiers Demo
on access specifiers Assignment
on access modifiers Instance
Members
Solving MCQs based on modifiers

Module:2	Interface & Abstract classes (Java specific), Packages	10 hours

Abstract Classes
Need
Abstract Classes
Abstract Methods
Interfaces
Assignment on abstract classes and interface

Need for packages
Access specifiers & packages

Import classes from other packages		
Module:3	**Exceptions**	**7 hours**
Need for exception handling try, catch, throw, throws Creating own exception (Java, Python) Handling own exceptions		
Module:4	**Collections**	**15 hours**
ArrayList, LinkedList, List Interface, HashSet, Map Interface, HashMap, Set Programming questions based on collections Real world problems based on data structure		
Module:5	**LinkedList, Arrays**	**4 hours**
Solving programming questions based on linked list and arrays		
	Total Lecture hours:	**45 hours**

Reference Books	
1.	Java The Complete Reference, 2014, 9th Edition by By Herbert Schildt, McGraw-Hill Education Pvt Ltd
2.	Introduction to Programming with Java: A Problem-Solving Approach by John Dean

Mode of Evaluation: FAT, Assignments, 3 Assessments with Term End FAT (Computer Based Test)

Course code	Course title	L	T	P	J	C
STS 3401	Foundation to programming skills	3	0	0	0	1
Pre-requisite	None	Syllabus version				
		1				

Course Objectives:

1. Ability to translate vast data into abstract concepts and to understand JAVA concepts
2. To have a clear understanding of subject related concepts
3. To develop computational ability in Java programming language

Course Outcomes:

1. Clear Knowledge about problem solving skills in JAVA concepts
2. Students will be able to write codes in Java

Module:1	Object and Class	8 hours

Types of programming
Disadvantages of functional programming
Class & Objects
Attributes
Methods
Objects
Solving MCQs based on Objects and Classes
Solving tricky questions based on encapsulation
Solving frequently asked object based questions

Module:2	Data types, Basic I / O	8 hours

Data types
Data
Why data type
Variables
Available data types
Numeric – int, float, double
Character – char, string
Solving MCQs based on type casting, data types
Solving debugging based MCQs
Printing
Getting input from user during run time
Command line arguments
Solving programming questions based on CLA Solving MCQs questions based on CLA

Module:3	Decision Making, Loop Control	9 hours
Need for control statement if..else if..else if..else Nested if..else Switch case Common mistakes with control statements (like using = instead of ==) Solving frequently asked questions on decision making Types of looping statements Entry Controlled For While Exit Controlled do while break and continue Demo on looping Common mistakes with looping statements (like using ; at the end of the loop) Solving pattern programming problems, series problems Solving predict the output questions		
Module:4	**String, Date, Array**	**10 hours**
String handling, date handling Solving problems based on arrays like searching, sorting, rearranging, iteration) Multi-dimensional arrays Solving pattern problems using 2D arrays Real time application based on 2D arrays		
Module:5	**Inheritance, Aggregation**	**10 hours**
Need Is A – Inheritance Types of inheritance supported Diagrammatic representation Demo on inheritance Has A – Aggregation Diagrammatic representation Demo on aggregation Solving MCQs based on relationships between classes		
	Total Lecture hours:	**45 hours**
Reference Books		

1.	Java The Complete Reference, 2014, 9th Edition by By Herbert Schildt, McGraw-Hill Education Pvt Ltd
2.	Introduction to Programming with Java: A Problem-Solving Approach by John Dean
Mode of Evaluation: FAT, Assignments, 3 Assessments with Term End FAT (Computer Based Test)	

BRIDGE COURSES

Course code	Course title	L	T	P	J	C
ENG1002	Effective English	0	0	4	0	2
Pre-requisite	Not cleared English Proficiency Test (EPT)	Syllabus version				
		v.2.0				

Course Objectives:

1. To enable students develop basic proficiency in Language Skills
2. To help students overcome communication barriers
3. To facilitate students communicate effectively in academic and social contexts

Expected Course Outcome:

1. Speak fluently in academic and social contexts
2. Listen for global and specific comprehension to improve study skills like note taking, summarizing, etc.
3. Read and comprehend technical and general texts
4. Write grammatically correct creative and descriptive sentences and paragraphs in specific contexts
5. Enact on social contexts with a message, and communicate clearly and effectively in formal and informal contexts

Module:1	Speaking	**4hours**	**CO:01**
Introduce yourself using Temperament Sorter			
Module:2	Listening	**4 hours**	**CO: 02**
Listen to songs – Gap-fill Exercise			
Module:3	Reading	**2 hours**	**CO: 03**
Loud Reading with focus on pronunciation			
Module:4	Writing	**2 hours**	**CO: 04**
Make sentences using jumbled words			
Module:5	Listening	**4 hours**	**CO:02**
Listen to Motivational Speeches – Note taking			
Module:6	Speaking	**4 hours**	**CO:05**
Situational Dialogues			
Module:7	Reading	**2hours**	**CO:03**
Reading for vocabulary development			
Module:8	Writing	**2hours**	**CO:04**
Descriptive Writing – Process			
Compare & Contrast – Product description			
Module:9	Listening	**4hours**	**CO:02**

Minimal Pairs- Difficult Sounds for Indian Speakers			
Module:10	Speaking	**4hours**	**CO:01**
Just a Minute			
Module:11	Reading	**2hours**	**CO:03**
Global Comprehension			
Module:12	Writing	**2hours**	**CO:04**
Travelogue Writing - 25+ FAQs (Wh-questions) on a place they have visited – Pair work			
Module:13	Listening	**4hours**	**CO:02**
Listen to a Documentary/Talk show and summarize			
Module:14	Speaking	**4 hours**	**CO:01**
Discuss facts and opinions using question tags			
Module:15	Speaking**:**	**4hours**	**CO:05**
Role Play with a Message			
Module:16	Writing	**2hours**	**CO:04**
Formal Letter Writing focusing on Content			
Module:17	Vocabulary	**2hours**	**CO:04**
Correct spelling errors			
Module:18	Speaking	**4 hours**	**CO:05**
Asking for and giving Directions/Instructions			
Module:19	Reading	**2hours**	**CO:03**
Factual Comprehension			
Module:20	Writing	**2 hours**	**CO:04**
Story writing using prompts/pictures			
	Total Practical hours:	**60hours**	

Text Books

1. Lewis Lansford and Peter Astley. Oxford English for Careers: Engineering 1: Student's Book. 2013. USA: Oxford University Press.
2. Jaimie Scanlon. Q: Skills for Success 1 Listening & Speaking. 2015. [Second Revised Edition]. Oxford: Oxford University Press.

Reference Books

1. Sanjay Kumar and Puspalata. Communication Skills. 2015. [Second Edition] Print. New Delhi: Oxford University Press.

2.	John Seely. Oxford Guide to Effective Writing and Speaking. 2013. [Third Edition].New Delhi: Oxford University Press.
3.	Meenakshi Raman. Communication Skills. 2011. [Second Edition]. New Delhi: Oxford University Press.
4.	Terry O'Brien. Effective Speaking Skills. 2011. New Delhi: Rupa Publishers.
5.	BarunMitra. Effective Technical Communication: AGuide for Scientists and Engineers. 2015. New Delhi: Oxford University Press.

Mode of Evaluation: Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini project.

List of Challenging Experiments (Indicative)		**CO:1,2,3,4,5**
1.	Speaking: Introduce yourself using Temperament Sorter	8 hours
2.	Reading: Loud Reading with focus on pronunciation	4 hours
3.	Writing: Descriptive Writing – Process Compare & Contrast – Product description	6 hours
4.	Speaking: Just a Minute / Activities through VIT Community Radio	6 hours
5.	Writing: Travelogue Writing - 25+ FAQs (Wh-questions) on a place they have visited – Pair work	10 hours
6.	Speaking: Discuss facts and opinions using question tags	6 hours
7.	Writing: Formal Letter Writing focusing on Content	6 hours
8.	Vocabulary: Correct spelling errors	4 hours
9.	Speaking: Asking for and giving Directions/Instructions	6 hours
10.	Writing: Story writing using prompts/pictures	4 hours
	Total Laboratory Hours	60 hours

Mode of evaluation: Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini project.

Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 46	Date	24-08-2017

PROGRAMME CORE

JULY 2019

Course code	CHE1001	L	T	P	J	C
Course title	MATERIAL SCIENCE AND STRENGTH OF MATERIALS	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. To understand the concept of mechanical behaviour of materials, stress - strain and their use in analysis and design of machine members and structures.
2. To learn the distributed force systems, centroid/centre of gravity and method of finding centroids of composite figures and bodies
3. To study the moment of inertia and method of finding moment of inertia of areas and bodies, bending of beams under different loading conditions

Course Outcomes (CO):

1. Understand concept of mechanical behavior of materials and calculations of same using appropriate equations
2. Analyse the behaviour of structural and machine components subjected to various loading and support conditions based on principles of equilibrium.
3. Identify the significance of centroid/ center of gravity and find centroids of composite figures and bodies.
4. Understand the concept of moment of inertia and method of finding moment of inertia of areas and bodies.
5. Apply the concept of stress and strain to analyse structural members and machine parts under axial load, shear load, and bending moment.
6. Analyze the stresses developed in cylindrical and spherical shell.

Module:1	Engineering Metallurgy	6 hours

Properties of materials: Mechanical, Physical & Chemical properties, Industrial Engineering Materials – Ferrous & Non Ferrous metals & alloys; Introduction to various heat treatment processes & Mechanical tests.

Module:2	Response of materials (Regular Geometry)	6 hours

Introduction to elasticity – Stress & Strain – Types of stresses & strain – Stress strain curve and relationship – Hooke's law – Modulus of Elasticity & Modulus of Rigidity – Deformation of a body due to force acting on it – Deformation of a body due to self-weight.

Module:3	Response of materials (Irregular Geometry)	8 hours

Principle of Superposition – Stress & Strain analysis in bars of varying sections – Stresses in bars of uniformly tapering section.

Module:4	Centroid	6 hours

Introduction to Centroid & Centre of Gravity – Methods of Centroid – Centroid of plane figures by geometrical consideration. Centre of Gravity (real bodies): Centre of gravity by method of moments for symmetrical & unsymmetrical lamina – Centre of gravity for solids and cut sections.		
Module:5	**Moment of Inertia**	**6 hours**
Concept of Moment of Inertia & Methods for Moment of Inertia – Moment of Inertia for Rectangular sections – Theory of Parallel axis – Moment of Inertia for Triangular, Circular and Semi-circular sections.		
Module:6	**Transverse loading on Beams**	**6 hours**
Introduction to Beams – Types of Loading – Shear force and Bending Moments – Sign conventions – SFD & BMD for Cantilever beams and Simply supported beams with point loads, UDL and UVL.		
Module:7	**Thin and Thick Pressure vessels**	**5 hours**
Introduction – Pressure vessels; Stresses in thin and thick cylindrical shell due to internal pressure – Circumferential and longitudinal stresses – Spherical shells subjected to internal pressure.		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**
Text Books		
1.	M. F. Ashby, D. R. H. Jones, Engineering Materials - An Introduction to their Properties and Applications. 2nd ed., Butterworth Heinemann, 2011	
2.	S. Timoshenko, D.H. Young (Author), Strength of Materials: Advanced theory and problems, 4th ed., CBS Publishers & Distributors, 2013	
Reference Books		
1.	N.M. Belayavev, Problems in Strength of Materials, Pergamon Press, 2013.	
2.	W. A. Nash, Strength of Materials, Schaum's Outline Series, Revised 4th ed., McGraw Hill, 2010.	
3.	Beer, Johnsto & Dewolf, Mechanics Of Materials (in SI Units), Tata McGraw Hill Publications, 2004	
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test		
Recommended by Board of Studies	04-03-2016	
Approved by Academic Council	40th	18-03-2016

Course code	CHE1002	L	T	P	J	C
Course title	PROCESS CALCULATIONS	4	0	0	0	4
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Formulate material balances to solve for compositions and flow rates of process streams
2. Incorporate single and multiple reactions into unit operations within chemical processes
3. Perform material and energy balance calculations in various systems

Course Outcomes (CO):

1.Apply mole concept and ideal gas equation to express the composition of mixtures
2.Understand the concept of humidity and usage of psychrometric chart
3.Understand the method of solving steady state material balances without chemical reactions
4.Estimate the extent of reaction in material balances for systems involving chemical reactions
5.Analyze the processes involving recycling and bypass involving chemical reactions
6.Apply simultaneous material & energy balances to industrial processes

Module:1	Basic Chemical Calculations	8 hours

Units and dimensions – Conversion factors – Mole concept – Concept of normality, molarity, and molality – Density and specific gravity – Methods of expressing composition of mixtures and solutions – Weight fraction – Mole fraction –Volumetric composition – Ideal gas law – Dalton's law – Amagat's law

Module:2	Vapor pressure and Humidity calculations	6 hours

Vapor pressure and liquids – Antoine equation, Vapor pressure of immiscible liquids and ideal solutions – Raoult's law – Humidity and Saturation – Relative and percentage saturation, Wet bulb and dry bulb temperature, Dew point – Use of humidity chart for engineering calculations

Module:3	Material Balance without Chemical Reaction	12 hours

Law of conservation of mass – Process flow sheet – Material balance calculations involving drying, dissolution, distillation, crystallization, evaporation, absorption and extraction

Module:4	Material balance with Chemical Reaction	7 hours

Stoichiometric equation – stoichiometric ratio – limiting reactant – excess reactant – percent excess – conversion – yield

Module:5	Recycle and Bypass Operation	7 hours

Recycle, Purge, Bypass calculations in operations such as evaporation, distillation, and drying

Module:6	Combustion calculations	10 hours

Calorific value of fuels, Flue gas analysis, Orsat analysis, theoretical and excess air requirement for solid, liquid and gaseous fuels

Module:7	**Energy balance**			**8 hours**
Standard heat of formation – Standard heat of combustion – Standard Heat of reaction – Hess's law – Determination of heat of reaction at temperatures other than standard temperature using specific heat relationships – Calculation of theoretical flame temperature				
Module:8	**Contemporary issues**			**2 hours**
Total Lecture hours				**60 hours**
Text Books				
1.	Himmelblau D.M., Basic Principles and Calculations in Chemical Engineering, 8th ed., Prentice Hall, India, 2012.			
2.	Bhatt B.I., Thakore S. B., Stoichiometry, 5th ed., Tata McGraw – Hill Book Company, New Delhi, 2011.			
Reference Books				
1.	Felder R, Rousseau R, Elementary Principles of Chemical Processes, 3rd ed., John Wiley & Sons, 2000.			
2.	Narayanan K.V., Lakshmikutty B, Stoichiometry and Process calculations, Prentice Hall India Limited, New Delhi, 2006.			
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test				
Recommended by Board of Studies		04-03-2016		
Approved by Academic Council		40th	Date	18-03-2016

JULY 2019

Course code	CHE1003	L	T	P	J	C
Course title	PROCESS ENGINEERING THERMODYNAMICS	3	0	0	4	4
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Enhance the basic knowledge and intuitive understanding of thermodynamics on the physical and chemical system
2. Introduce the concepts of partial molar properties, fugacity, activity, vapour-liquid equilibrium for ideal and real substances existing in more than one phases under equilibrium
3. Generalize the design thinking skills on property estimation to chemical industries

Course Outcomes (CO):

1. Define and illustrate thermodynamic equilibrium state system, ideal and non-ideal relations
2. Relate properties such as change in enthalpy, entropy, free energy, heat and work requirement for any batch and flow process happens in chemical industries
3. Make use of thermodynamic relations to interpret the partial molar properties of pure gases and liquids, and their mixtures
4. Construct and analysis the phase equilibrium data, P-x-y, T-x-y diagram for ideal binary miscible vapour-liquid systems
5. Device methodologies for qualitative and quantitative analysis of VLE for non-ideal binary miscible systems using van Laar, Margules, property estimation models
6. Estimate the feasibilities of any reaction, and to determine the equilibrium rate constant for chemical reactions

Module:1	Fundamental concepts and definitions	5 hours

Introduction - Definition and Basic Concepts - classical and statistical thermodynamics - Concept of Continuum - Thermodynamic steady state - equilibrium state process , Volumetric properties of pure fluids: PVT Relations - Ideal gas- Real gas- Law of corresponding states

Module:2	Laws of thermodynamics	6 hours

First law analysis – Closed non-flow system - Steady state flow systems and their analysis; Second law of thermodynamics - change in internal energy - enthalpy - entropy calculation for process - phase change; Heat effects - standard heat of reaction

Module:3	Thermodynamic properties of pure fluids	7 hours

Gibbs free energy- Helmholtz free energy- exact differential equation - thermodynamic property relations- Maxwell's relations and applications - fugacity -activity of pure substances- determination of fugacity of pure gases, solids and liquids

Module:4	Thermodynamic properties of solution	7 hours

Mixture of pure fluids - Partial molar properties - Chemical potential - fugacities in solution; Ideal solutions - Lewis Randal rule - Raoult' s law - Henry's law; Gibbs- Duhem equation; Residual properties - Property changes of mixing for ideal - non-ideal solutions - Excess properties relations and Gibbs free energy calculation		
Module:5	**Phase equilibria**	**6 hours**
Phase rule - criteria of phase equilibrium - single component - multiple components; Vapor Liquid Equilibria for ideal solutions - Phase diagram for binary systems using ASPEN PLUS - constant temperature equilibria- constant pressure equilibria - phase equilibrium curves.		
Module:6	**Vapor liquid equilibria - non-ideal solutions**	**7 hours**
Non ideal solution – Azeotropes systems - minimum boiling – maximum boiling – VLE – P-x-y diagram and T-x-y diagram using ASPEN PLUS; Bubble point – Dew Point – calculation methods – Van Laar equation - Margules equation - Wilson equation. Multicomponent Systems – flash vaporization; Consistency Test for VLE Data		
Module:7	**Chemical reaction equilibria**	**5 hours**
Chemical reaction equilibria - Reaction coordinates - criteria for chemical equilibrium, equilibrium constant - Gibbs Free Energy of the reaction - effect of temperature on equilibrium constant - equilibrium constant of homogeneous gas and liquid phase reactions		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**
Text Books		
1.	Narayanan K.V., A Textbook of Chemical Engineering Thermodynamics, 2nd ed., Prentice Hall India, New Delhi, 2012	
2.	Ahuja P, Chemical Engineering Thermodynamics, 2nd ed., PHI Learning Pvt. Ltd., New Delhi, 2012.	
Reference Books		
1.	Smith J.M., Van Ness H.C., Abbott M.M., Introduction to Chemical Engineering Thermodynamics, 8th ed., McGraw-Hill, New York, 2018.	
2.	Rao Y.V.C., Chemical Engineering Thermodynamics, 1st ed., University Press, New Delhi, 2005.	
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test		
Recommended by Board of Studies	04-03-2016	
Approved by Academic Council	40th	Date 18-03-2016

Course code	CHE 1004	L	T	P	J	C
Course title	CHEMICAL TECHNOLOGY	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Introduce the basic information and the systematic diagrams of Unit operations involved in chemical industries.
2. Familiarize the concepts of design, operation details and schematic of industrial equipment.
3. Ascertain the right separation technology for easy separation of chemical components

Course Outcomes (CO):

1. Classify the major unit operations and processes involved in manufacturing industries
2. Illustrate the manufacturing processes of organic and inorganic chemical industries
3. Understand the different industrial gases involved in chemical industries
4. Demonstrate the manufacturing processes for fertilizers industries
5. Explain the process flow sheet and end uses of cellulosic material in different application
6. Discuss the manufacturing processes of petroleum refinery and petrochemical products

Module:1	Chloro-alkali and Cement Industries	6 hours

Manufacture of soda ash; caustic soda–manufacture of calcium hypochlorite; manufacture of sulphur and sulphuric acid; manufacture of Portland cement; manufacture of glass

Module:2	Industrial Gases	5 hours

Manufacture of carbon-di-oxide; hydrogen; oxygen and nitrogen; acetylene; water gas; producer gas and manufacture of natural gas

Module:3	Fertilizer Industries	8 hours

Manufacture of nitric acid and urea; manufacture of phosphorus and phosphoric acid; manufacture of super phosphate and triple super phosphate; manufacture of potassium chloride

Module:4	Cellulose, Sugar and Oil Production Industries	7 hours

Production of pulp–manufacture of paper and manufacture of viscous rayon; manufacture of sugar and starch; refining of edible oils and fats; manufacture of soaps and detergents; bio-degradability of surfactants

Module:5	Petroleum Industries	6 hours

Petroleum refining processes; reforming; cracking; secondary refining processes

Module:6	Petrochemical Industries	6 hours

Introduction to Petrochemical processes; Manufacture of C_2, C_3,C_4 chemical compounds

Module:7	Polymer Industries	5 hours

Introduction; manufacture of nylon 6; nylon 6,6; manufacture of silicones; manufacture of urea formaldehyde; manufacture of phenol formaldehyde				
Module:8	**Contemporary issues**			**2 hours**
Total Lecture hours				**45 hours**
Text Books				
1	Rao G., Sittig M., Dryden's Outlines of Chemical Technology, 3rd ed., East West Press, India, 2010.			
2	Austin G.T., Shreve's Chemical Process Industries, 5th ed., McGraw Hill, USA, 2012.			
Reference Books				
1	Matar S., Hatch L.F., Chemistry of Petrochemical Processes, 4th ed., Gulf Publishing, USA, 2005.			
2	Nelson W.L., Petroleum Refinery Engineering, 4th ed., McGraw Hill, USA, 2005.			
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test				
Recommended by Board of Studies		04-03-2016		
Approved by Academic Council		40th	Date	18-03-2016

Course code	CHE1005	L	T	P	J	C
Course title	MOMENTUM TRANSFER	3	0	2	0	4
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Understand the fluid properties, the fundamental principles and theorem related to momentum transfer
2. Apply the physical and mathematical models to analyse the fluid flow phenomena in engineering applications
3. Solve the steady state and un-steady state momentum transfer problems

Course Outcomes (CO):

1. Explain the properties of Newtonian and Non-Newtonian fluid and basic principles of momentum transfer
2. Classify the governing equations related to the momentum transfer phenomena
3. Summarize the different types of flow measuring devices related to the momentum transfer
4. Solve the problems related to the losses incurred during the flow of fluid
5. Analyze the different non-dimensional numbers based on the theorems
6. Evaluate the fluid flow phenomena through packed and fluidized bed

Module:1	Basic Concept of Momentum Transfer	5 hours

Introduction and Significance of Momentum Transfer in Chemical Engineering. Definition of fluid - Classification of fluids – Newtonian fluid – Characteristic properties of fluids – Non - Newtonian Fluids and their classification. Fluid statics: Pascal's law and Hydrostatic law of equilibrium; Pressure and its measurement- Manometers

Module:2	Concept of Fluid Flow Phenomena	7 hours

Kinematics of fluid flow, Dynamics of fluid flow – Basic equations governing fluid flow – types of fluid flow. Equation of Continuity and its application, Equation of motion – Derivation of Euler's equation, Bernoulli's equation and its application in fluid flow

Module:3	Flow Measuring Devices	5 hours

Importance of metering – Classification flow measuring devices, Principle and working of Orifice meter, Venturi meter, Pitot tube, Variable area meters: Rotameter

Module:4	Flow through Circular Pipes	8 hours

Flow of fluids in Laminar regime – Velocity Profile, Shear Stress Distribution – Hagen–Poiseuille equation - Concept of average velocity – Concept of Kinetic energy correction factor, Concept of Fluid friction – Skin friction – Form friction – Factors affecting friction – Friction factor – Application of Moody's diagram, Minor losses and major losses during flow

Module:5	Dimensional Analysis	4 hours

Dimensional homogeneity – Raleigh and Buckingham π theorems – Non-dimensional numbers, model laws		
Module:6	**Fluid Flow through Packed and Fluidized Bed**	**7 hours**
Flow past immersed bodies – Significance of form friction - Concept of Drag, Drag Coefficients and Particle Reynolds number - Drag Coefficient vs. Particle Reynolds number curves for regular and irregular shaped solid particles. Flow of fluids through packed beds – Packing and types of packing -Pressure drop across packed beds –Kozeny Carman equation – Ergun's equation - Loading and Flooding Packed Beds. Concept of Fluidization – Condition for Solid particles to be in a suspended condition in a flowing fluid – minimum fluidization velocity		
Module:7	**Transportation of Fluids**	**7 hours**
Transportation Components -Pipe, Fittings and Valves, Types of Fittings, valves -Stuffing Boxes, Mechanical Seals – Estimation of head loss from fittings and valves, Concept of minor losses-types of minor losses. Fluid Moving Machinery: Pumps – Classification and working of Centrifugal Pumps and Positive Displacement Pumps Basic Principles of Centrifugal Pumps – Pump Characteristics – Concept of Specific Speed, Net Positive Suction Head - Factors influencing selection of pump		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Fox R.W., McDonald A.T., Pirtchard P.J., Mitchell J. W., Introduction to Fluid Mechanics, 9th ed., Wiley Publications, 2015.
2.	Cengel Y.A., Cimbala J.M., Fluid Mechanics (SIE): Fundamentals and Applications, 3rd ed., Mcgraw Hill, New York, 2014.
Reference Books	
1.	Mc Cabe, Smith, Harriott, Unit Operations of Chemical Engineering 7th ed., McGraw Hill, USA, 2014.
2.	Som S.K., Biswas G., Chakraborty S., Introduction to Fluid Mechanics and Fluid Machines, 3rd ed., Tata McGraw Hill, India, 2011.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Laboratory Experiments

1.	Determination of coefficient of discharge of venturimeter	2 hours
2.	Calibration of an orifice meter	2 hours
3.	Determination of friction factor for flow through circular pipe	2 hours
4.	Determination of loss of coefficient due to sudden enlargement, sudden contraction, bend and elbow	2 hours
5.	Determination of Reynolds apparatus	2 hours

6.	Verification of Bernoulli's theorem	2 hours
7.	Performance characteristics of centrifugal pump at rated speed	2 hours
8.	Determination of pressure drop per unit length as a function of superficial velocity of fluidization medium	2 hours
9.	Verification of relationship between fluid flow and pressure drop per unit length of packing	2 hours
10.	Determination of friction factor for flow through noncircular pipe	2 hours
	Total Laboratory Hours	20 hours

Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1006	L	T	P	J	C
Course title	HEAT TRANSFER	2	0	2	4	4
Pre-requisite	MAT2002	Syllabus version				
		1.2				

Course Objectives:

1. Explain the fundamental principles of heat transfer and various modes of heat transfer
2. Solve heat transfer problems using the principles of heat transfer in different modes
3. Design and estimate heat loads for heat transfer equipments such as heat exchangers and evaporators

Course Outcomes (CO):

1. Classify the different modes of heat transfer with their significance
2. Model and solve steady/unsteady state heat transfer problems
3. Analyze the heat transfer phenomena in fluids involving phase and no phase changes
4. Examine radiative heat transfer with and without radiation shields through shape factor concept
5. Determine the performance of various heat types of heat exchangers
6. Estimate the heat transfer rate and surface area of evaporators/condensers

Module:1	Conduction	5 hours

Basic concepts – Conduction – Fourier's Law of Heat conduction – Concept of Thermal Conductivity – Generalized conduction equation in cartesian, cylindrical and spherical systems; Steady State Conduction –Heat transfer composite systems – Critical thickness of insulation – Conduction with heat Generation

Module:2	Extended Surfaces and Unsteady state conduction	3 hours

Extended surfaces – types and applications of fins – Fin efficiency and effectiveness – Fin performance; Unsteady state heat conduction – Lumped parameter system – Conduction through Semi Infinite Solids

Module:3	Convection (without phase change)	5 hours

Fundamentals of Convection – Thermal boundary layer & Convective heat transfer coefficients – Convection correlations through Dimensional analysis; Laminar flow over a flat plate – Turbulent flow over a flat plate – Flow over cylinders – Internal flow through pipes – annular spaces – Natural convection in vertical - inclined and horizontal surfaces.

Module:4	Convection (with phase change)	3 hours

Condensation and Boiling – Drop wise and Film type Condensation – Film condensation on a vertical plate; Boiling – Nucleate boiling and film boiling correlations – Critical flux

Module:5	**Radiation**	**3 hours**
Radiation heat transfer – Thermal radiation – Laws of radiation – Black body concepts– Emissive power – Radiation shape factor – Gray bodies – Radiation shields		
Module:6	**Heat Exchangers**	**5 hours**
Heat exchangers – Types and practical application –Concept of LMTD & Overall heat transfer coefficient; Effectiveness – NTU method for heat exchanger design; Fouling factor and estimation of Overall heat transfer coefficient; Special type of heat exchangers		
Module:7	**Evaporators**	**4 hours**
Introduction – Types of Evaporators – Capacity – Steam economy – Boiling point elevation (Duhring rule); Material and energy balance of single effect evaporator; Theory of multiple effect evaporators; Design of single and multiple effect evaporators, Vapor recompression method		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**30 hours**

Text Books	
1.	Ghajar A.J., Cengel Y.A., Heat and Mass Transfer: A Practical Approach, 5th ed., McGraw-Hill, USA, 2014.
2.	Holman J.P, Heat Transfer, 10th ed., McGraw-Hill Series, USA, 2010.
Reference Books	
1.	Frank Kreith, Raj M Manglik, Principles of Heat Transfer, 8th ed., Cengage Learning, USA, 2016.
2.	Frank. P. Incropera, David P. Dewitt, Fundamentals of Heat & Mass Transfer, 6th ed., John Wiley & Sons, USA, 2010.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Laboratory Experiments

1.	Measurement of thermal conductivity of Metals & insulators	2 hours
2.	Analysis of Transient Heat Conduction	2 hours
3.	Performance of Natural Convection	2 hours
4.	Analysis of Fin efficiency & effectiveness	2 hours
5.	Emissivity measurement	2 hours
6.	Performance of Double Pipe Heat Exchanger	2 hours
7.	Performance of Agitated Vessel	2 hours
8.	Performance of Plate type Heat Exchanger	2 hours

9.	Performance of Heat Transfer in packed bed	2 hours
10.	Performance of Cooling tower	2 hours
	Total Laboratory Hours	20 hours

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1022	L	T	P	J	C
Course title	MECHANICAL OPERATIONS	3	0	2	0	4
Pre-requisite	Nil	Syllabus version				
		1.2				

Course Objectives:

1. Introduce the basic information and the systematic diagrams of Unit operations involved in chemical industries
2. Learn the concepts of design, operation details and schematic of industrial equipment
3. Choose the right separation technology for easy separation of chemical components

Course Outcomes (CO):

1. Understand the basic principles in unit operations
2. Calculate the size distribution of average particles
3. Describe various size reduction equipment
4. Identify the suitable separation technique based on particle characteristics
5. Estimate the filtration parameters
6. Design agitation vessel based on standard design criterion

Module:1	Introduction to Particulate Solids	4 hours

Particle Shape, Size, Mixed Particle Sizes and Size Analysis – Cumulative and Differential Analysis –Various Mean Diameters – Screen Analysis Standard Screens – Various Industrial Screens

Module:2	Particle Separation	3 hours

Introduction to Particle Separation – Electrostatic Precipitation and Magnetic Separation - Storage of Solids

Module:3	Size Reduction	8 hours

Size Reduction – Principles of Comminution - Energy and Power Requirements in Comminution - Mechanical Efficiency-Laws of Crushing-Size Reduction Equipment – Crushers- Grinders-Cutting Machines – Open and Closed Circuit Operation

Module:4	Particulate Solids Flow	5 hours

Motion of a Particle through a Fluid – Terminal Velocity–Free and Hindered Settling. Classification: Separations Ratio – Classification Equipment – Gravity Settling Tank –Elutriator – Cone Classifiers – Bowl Classifier – Centrifugal Classifier – Cyclone Separator-Wet Scrubber

Module:5	Hydro-Mechanical Separations	7 hours

Sedimentation: Gravity Sedimentation – Mechanism – Continuous Sedimentation – Thickener – Design of thickener – Classifier and Clarifier – Settling Area – Centrifugal Sedimentation-Centrifuges - Hydro clones. Floatation: Equipment – Modifiers – Collectors - Frothing Agents

Module:6	Filtration	8 hours
Filtration– Filter Media – Filter Aids – Principles of Cake Filtration – Constant Pressure Filtration – Constant Rate Filtration - Pressure Drop Through Filter Cake –Compressible and Incompressible Filter Cakes - Specific Cake Resistance - Filter Medium Resistance. Filtration Equipment – Filter Presses – Leaf Filter - Rotary Continuous Filters. Principles of Centrifugal Filtration-Washing of Filter Cakes		
Module:7	**Agitation and Mixing**	**8 hours**
Agitation and Mixing of Liquids – Principles of Agitation – Agitation Equipment –Impellers – Flow Pattern in Agitated Vessel - Power Consumption in Agitated vessel. Flow number – Power Correlation - Calculation of power consumption. Blending and mixing - Jet mixers – Motionless Mixers. Mixing of Solids: Mixtures for Cohesive solids – Power requirements Criteria for mixer effectiveness. Mixers for free flowing granular solids - Rate of mixing		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books

1.	McCabe W., Smith J., Harriott P., Unit Operations of Chemical Engineering, 7th ed., McGraw Hill Education; USA, 2014.

Reference Books

1.	Coulson J.M., Richardson J.F., Chemical Engineering, Volume 2 (Particle Technology & Separation Processes), 5th ed., Butterworth – Heinemann Publishing Ltd., USA, 2001.
2.	Narayanan C.M., Bhattacharya B.C., Mechanical Operations for Chemical Engineers, 3rd ed., Khanna Publishers, India, 2011.
3.	Patil K.D., Mechanical Operations (Fundamental Principles and Applications), 3rd ed., Nirali Prakasam, India, 2012.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Laboratory Experiments

1.	Performance of Plate and Frame filter press	2 hours
2.	Performance of Rotary Drum Filter	2 hours
3.	Performance of Leaf Filter	2 hours
4.	Analysis of Jaw crusher parameters	2 hours
5.	Analysis of Roll crusher parameters	2 hours
6.	Analysis of Ball mill parameters	2 hours
7.	Sieve analysis	2 hours
8.	Measurement of Drag	2 hours

9.	Batch sedimentation performance	2 hours
10.	Beaker decantation analysis	2 hours
	Total Laboratory Hours	20 hours

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE2001	L	T	P	J	C
Course title	CHEMICAL REACTION ENGINEERING	3	0	2	0	4
Pre-requisite	CHE1003	Syllabus version				
		1.2				

Course Objectives:

1. Impart the knowledge of calculus, differential equations, thermodynamics, general chemistry, and material and energy balances to solve reactor design problems.
2. Simulate several types of reactors in order to choose the most appropriate reactor for a given need
3. Examine the problems related to multiple reactions and evaluate the selectivity, reactivity and yield

Course Outcomes (CO):

1. Classify various reaction types and their applications
2. Apply the principles of reaction kinetics, formulate rate equations and analyze the batch reactor data
3. Design ideal reactors (Batch, CSTR, PFR, recycle and autocatalytic) for simple chemical reaction schemes
4. Evaluate the choice of right reactor among single, multiple, recycle reactor, etc. with or without multiple reactions
5. Design non-isothermal reactors and the heat exchange equipment required
6. Design non-ideal reactors using tracer information

Module:1	Fundamental Concepts and Definitions	5 hours

Classification of reactions- Rate and stoichiometry-rate law- rate equation-rate constant-variables affecting the rate of reaction-activation energy-reactions at equilibrium

Module:2	Chemical Kinetics	6 hours

Interpretation of Batch Reactor Data-Constant Volume Batch Reactor and variable volume batch reactor; Integral method-Differential method of analysis for reactions-reaction mechanism; Method of half-life; Analysis of data for Reversible and Irreversible Reactions

Module:3	Isothermal Ideal Reactor Design of Single and Multiple reactions	7 hours

Ideal Batch Reactor-space time-holding time and space velocity; Ideal Mixed Flow Reactor-Ideal Plug Flow Reactor for single reactions-Size comparison of single Reactors for single reactions-Semi batch reactor - Recycle reactor-Auto catalytic reactor

Module:4	Multiple Reactors	6 hours

Multiple Reactor Systems-equal size mixed flow reactors in series-plug flow reactors in series and

or in parallel-mixed flow reactors of different sizes in series-reactors of different types in series		
Module:5	**Design for Multiple Reactions**	**6 hours**
Reactions in parallel (simultaneous reactions) for CSTR-PFR-reactions in series (Consecutive Reactions) for CSTR-PFR-Combined series and parallel reactions		
Module:6	**Non-isothermal Reactors**	**6 hours**
Steady state non-isothermal reactors-CSTR-PFR-Mole balance-Energy balance-Adiabatic reactors -CSTR-PFR-Batch reactor-Multiple steady states-Multiple chemical reactions		
Module:7	**Non Ideal Reactors**	**7 hours**
Basics of non-ideal flow - Measurement of residence time distribution (RTD) - Relationship between C, E and F curves - Modelling of non-ideal reactors - one parameter and two parameter models - Conversion in real reactor systems		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books

1.	Levenspiel O., Chemical Reaction Engineering, 3rd ed., Wiley Publications, USA, 2006
2.	Fogler H.S., Elements of Chemical Reaction Engineering, 5th ed., Prentice Hall India Pvt. Ltd., India, 2016

Reference Books

1.	Froment G. F, Bischoff K.B, Wilde J.D., Chemical Reactor Analysis and Design, 1st ed., Wiley Publications, USA, 2010
2.	Smith J.M., Chemical Engineering Kinetics, 8th ed., McGraw-Hill, USA, 2008

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Laboratory Experiments

1.	Analysis of Batch reactor – equimolar constant volume system	2 hours
2.	Analysis of Temperature dependency of reaction rate	2 hours
3.	Analysis of Semi batch reactor	2 hours
4.	Assessment of Adiabatic batch reactor performance	2 hours
5.	Analysis of Mixed flow reactor	2 hours

6.	Analysis of Plug flow reactor analysis	2 hours
7.	Analysis of combined reactor system	2 hours
8.	Analysis of Packed bed reactor	2 hours
9.	Analysis of RTD studies in Plug flow reactor	2 hours
10.	Analysis of RTD studies in Mixed flow reactor	2 hours
Total Laboratory Hours		20 hours

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE2002	L	T	P	J	C
Course title	PROCESS EQUIPMENT DESIGN AND ECONOMICS	2	0	2	4	4
Pre-requisite	CHE1006	Syllabus version				
		1.2				

Course Objectives:

1. Summarize the concepts of unit operations and unit processes in chemical engineering.
2. Impart knowledge on the concepts of design of major equipment
3. Understand the economics and feasibility analysis of the process industry

Course Outcomes (CO):

1. Understand and read flowcharts and ways of interpreting the drawings
2. Explain the procedure involved in selection and design of fluid handling equipment, pressure vessels, heat transfer equipment
3. Summarize the basics to design separation equipment and ideal reactors
4. Apply Pinch Technology to solve the energy recovery and the Heat Exchanger network.
5. Apply economic principles to do cost estimation of projects and equipments, selection between alternatives and replacement and profit analysis in chemical industries
6. Analyse open ended process equipment design problems

Module:1	**Introduction and Pressure vessel**	**4 hours**
Introduction - Types of flowchart preparation; Fluid handling equipment; Mechanical design of pressure Vessel.		
Module:2	**Heat transfer equipment**	**5 hours**
Design of Double pipe, shell and tube heat exchanger; Principles of dryer design.		
Module:3	**Heat Exchanger Network**	**4 hours**
Introduction to Pinch Technology – pinch point – Composite and Grand Composite curves; Find Heat exchanger network for simple processes.		
Module:4	**Separation process equipment**	**4 hours**
Design of Distillation column and absorbers – plate type and packed columns.		
Module:5	**Principles and Design of Reactors**	**4 hours**
Concepts of ideal reactor design – adiabatic and catalytic reactors		
Module:6	**Cost Estimation of Projects**	**4 hours**
Cost estimation of Chemical Projects; Cost estimation of individual equipment using algorithms and literature.		
Module:7	**Analysis of Cost Estimation**	**4 hours**
Time value of money; Depreciation; Profitability analysis; Analysis of alternatives and replacements using cost diagrams.		
Module:8	**Contemporary issues**	**1 hour**
	Total Lecture hours	**30 hours**
Text Books		

1.	Peters M., Timmerhaus K., West R., Plant Design and Economics for Chemical Engineers, 5th ed., McGraw Hill, USA, 2017.
2.	Kemp I.C., Pinch Analysis and Process Integration: A User Guide on Process Integration for Efficient Use of Energy, 2nd ed., Butterworth-Heinemann, USA, 2007.
Reference Books	
1.	Joshi. M.V., Mahajani. V.V., Process Equipment Design, 3rd ed., Mc-Millan India Ltd., India, 2000.
2.	Richard A. Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz, Debangsu Bhattacharyya, Analysis, Synthesis and Design of Chemical Processes, 4th ed., Prentice Hall, USA, 2013.
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test	

Laboratory Experiments

1.	Basics of 3D drawing and applications	2 hours
2.	Extrusion of surfaces and geometries	2 hours
3.	Design and drawing of Pressure vessel to dimensions	2 hours
4.	Design and drawing of a Shell and Tube heat Exchanger	2 hours
5.	Design and drawing of a bubble cap tray	2 hours
6.	Design and drawing of Rotary Louvre dryer	2 hours
7.	Analysis of the performance of a Heat Exchanger (Aspen)	2 hours
8.	Design and analysis of Distillation Column (Aspen)	2 hours
9.	Cost Estimation of a Distillation Column (Aspen)	2 hours
10.	Dynamic simulation experiment on distillation column (Aspen)	2 hours
Total Laboratory Hours		20 hours

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE3001	L	T	P	J	C
Course title	COMPUTATIONAL METHODS IN PROCESS ENGINEERING	3	0	2	0	4
Pre-requisite	MAT3003	Syllabus version				
		1.2				

Course Objectives:

1. Formulate problems for roots of a function, solution of simultaneous equations, optimized value of a given function, numerical integration and differentiation, ODE and PDE
2. Solve roots of a function, simultaneous equations, optimization, numerical integration, ODE and PDE
3. Develop MATLAB code for finding the roots of a function, solution of a simultaneous equations, optimization, numerical integration, ODE and PDE

Course Outcomes (CO):

1. Formulate engineering problem as mathematical model for an appropriate solution using numerical methods
2. Determine roots of a single equation and simultaneous equations
3. Solve optimization, regression and numerical integration using different methods
4. Evaluate ordinary differential equation involving initial value and boundary value problems
5. Estimate the solution for partial differential equation involving elliptical and parabolic equation
6. Create MATLAB program for roots finding, simultaneous equations, optimization, regression and curve fitting, numerical integration, ODE and PDE

Module:1	Finding the Roots	6 hours

Computers and error analysis, Mathematical models for solving engineering problems, programming and software; Finding roots of a single equation- Direct methods (bisection, Regula falsi) - Indirect methods (Newton-Raphson, Secant method)

Module:2	Solution for Simultaneous Equations	5 hours

Types of matrices and matrix operation rules; Solution for linear system of simultaneous equations – Direct methods (Gauss Elimination, Gauss Jordan), Iterative methods (Gauss-Jacobi and Gauss-Seidel); Overview of non-linear system of equations

Module:3	Interpolation and Regression Analysis	7 hours

Newton's divided-difference interpolating polynomial – Linear - polynomial - quadratic rules; Lagrange interpolating polynomial - Linear - polynomial Regression.

Module:4	Optimization	7 hours

One-Dimensional Unconstrained Optimization – Golden section search and Newton's Method; Overview on multidimensional unconstrained optimization – gradient and non-gradient methods; Constrained optimization – Simplex method; Optimization of Chemical Processes using Aspen Plus.		
Module:5	**Integration and Differentiation**	**5 hours**
Newton cotes Integration- Trapezoid method - Simpson's 1/3rd rule - Simpson's 3/8th rule; Numerical differentiation - Forward - Backward - Central difference methods		
Module:6	**Ordinary Differential Equations**	**6 hours**
Initial Value Problems – Euler - Predictor-corrector - Runge-Kutta methods; Boundary Value Problems – Shooting method - Central difference method		
Module:7	**Partial Differential Equations**	**7 hours**
Finite difference solutions of elliptic equations – Liebmann's method - finite difference solutions of parabolic equations – Crank-Nicolson and implicit methods - Overview of hyperbolic equations; Case study on solving PDEs		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**
Text Books		
1.	Chapra S.C, Canale R.P, Numerical Methods for Engineers, 7th ed., McGraw Hill Publications, USA, 2016.	
2.	Kamal I.M., Al-Malah, Aspen Plus: Chemical Engineering Applications, 1st ed., John Wiley & Sons Inc., USA, 2016.	
Reference Books		
1.	Dorfman K.D., Daoutidis P, Numerical Methods with Chemical Engineering Applications, 1st ed., Cambridge University Press, USA, 2017.	
2.	Jana A.K., Chemical Process Modelling and Computer Simulation, 2nd ed., Prentice Hall of India, India, 2011.	
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test		
Laboratory Experiments		
1.	Develop MATLAB code for bisection / Regula falsi method	2 hours
2.	Develop MATLAB code for Newton Raphson / Secant method	2 hours
3.	Develop MATLAB code for Gauss Elimination / Gauss Jordan method	2 hours
4.	Develop MATLAB code for Gauss Seidel method	2 hours
5.	Develop Aspen Plus simulation for solving simultaneous equations in distillation column	2 hours
6.	Develop MATLAB code for Numerical Integration	2 hours

7.	Develop MATLAB code for ODE – Euler / Modified Euler method	2 hours
8.	Develop MATLAB code for ODE – Runge Kutta method	2 hours
9.	Develop MATLAB code for PDE – Liebmann's method	2 hours
10.	Develop MATLAB code to optimize a chemical process involving PDE	2 hours
Total Laboratory Hours		20 hours

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE3002	L	T	P	J	C
Course title	PROCESS INSTRUMENTATION AND CONTROL	2	0	2	4	4
Pre-requisite	MAT3003	Syllabus version				
		1.2				

Course Objectives:

1. Understand the basic concepts of measuring instruments used in process industries
2. Explain the importance of process control mechanism and their applications in chemical process industries
3. Describe principles of modes of controllers and their general characteristics and study the stability analysis of digital control system

Course Outcomes (CO):

1. Demonstrate knowledge of chemical process systems as well as the operating principles of common instruments
2. Understand concepts of the mathematical modeling and develop transfer functions of open loop control systems and their responses with different forcing functions
3. Develop closed loop block diagram and analyze with set point and load changes to calculate offset
4. Identify the modes of controllers required for process system with their characteristics and tune the controllers with the right technique for optimization of the system
5. Analyze the stability of the control system with time and frequency domain analysis techniques
6. Compare different advanced control schemes to various processes

Module:1	Process Instrumentation	4 hours

Principles and classification of process control instruments - Temperature - Pressure - Fluid Flow Rate - Liquid Level - pH - Viscosity - Humidity of gases and Concentration by Spectroscopy and Chromatography methods.

Module:2	Introduction to Process Control	6 hours

Laplace transformation - transform of standard functions - derivatives and integrals - inversion theorems - Open loop system - Transfer functions - Forcing functions - step, pulse, impulse and sinusoidal - First order and Higher order system dynamics - First order systems in series - linearization and its application in process control - Continuous and batch processes- Transportation lag.

Module:3	Feedback Control Block Diagram	4 hours

Closed loop system - Development of block diagram - Block diagram reduction - Servo and Regulator problem - Transient response of closed loop control systems and their stability - OFFSET calculation.

Module:4	Controllers and Control Action	4 hours

Transfer function of controllers and control valve - Characteristics of ON-OFF, Proportional, Integral and Derivative control modes - P - PI - PD - PID control modes - Principles of Pneumatic and Electronic Controllers - I/P converter - Control valve - Construction - Sizing - Characteristics.		
Module:5	**Time and Frequency Domain Analysis**	**5 hours**
Stability criteria- Routh's stability criteria - Root locus diagram - Frequency response analysis - Gain margin - Phase margin and cross over frequency - Bode plot - Polar plot and Nyquist plot.		
Module:6	**Controller Tuning**	**2 hours**
Process reaction curve - Cohen-Coon method - IMC tuning - Ziegler Nichols method.		
Module:7	**Advanced Process Control**	**3 hours**
Introduction to multivariable control - Computer applications in process control - Advanced control strategies - Cascade control - Ratio control - Feed-Forward control - Inferential control - Adaptive control - Control of Reactor - Distillation towers - Heat Exchangers.		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**30 hours**
Text Books		
1.	Seborg D. E., Edgar, T. F., Mellichamp D. A., Process Dynamics and Control, 3rd ed.,Wiley India, New Delhi, 2013.	
2.	Stephanopoulos G., Chemical Process Control, 1st ed., Pearson Education India, New Delhi, 2015.	
Reference Books		
1.	Coughanowr C. R., Koppel L. M., Process System Analysis and Control, 3rd ed., McGraw Hill, New Delhi, 2013.	
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test		
Laboratory Experiments		
1.	Automatic temperature control loop in a heating tank.	2 hours
2.	Automatic level control loop in a cylindrical tank.	2 hours
3.	Automatic flow control loop in a pipe line.	2 hours
4.	Automatic cascade control loop.	2 hours
5.	Dynamics of non-interacting tanks.	2 hours
6.	Dynamics of interacting tanks.	2 hours
7.	Controller tuning using an open loop method (Cohen-Coon method) in Simulink.	2 hours

8.	Controller tuning using a closed loop method (Ziegler–Nichols method) in Simulink.	2 hours
9.	Control Valve Characteristics.	2 hours
10.	Dynamics of Ratio control using ProSIM.	2 hours
Total Laboratory Hours		20 hours

Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE3003	L	T	P	J	C
Course title	MASS TRANSFER	3	0	0	0	3
Pre-requisite	MAT3003, CHE1005	Syllabus version				
		1.2				

Course Objectives:

1. Understand the principles of diffusion in gas, liquid and solid phases
2. Interpret the relation between mass transfer coefficients and the theories of mass transfer for different separation operations
3. Demonstrate the working principles of cooling tower, dryer and crystallizer

Course Outcomes (CO):

1. Solve molecular diffusion in fluids and solids using correlation and theories
2. Compare various mass transfer coefficients and analogies for various Chemical Engineering applications
3. Interpret the theories of mass transfer for individual and overall mass transfer coefficients
4. Design of humidification and dehumidification equipment's based on material and energy balances
5. Estimate the Psychometric properties of air-water system using charts and equations
6. Discuss different types of mass transfer equipment's cooling tower, drier, crystallizer used for Industrial applications

Module:1	Diffusion	6 hours

Introduction to Mass transfer operation, Fick's law of diffusion, Steady state molecular diffusion in fluids under stagnant and laminar flow conditions, Diffusion coefficient measurement and prediction

Module:2	Molecular diffusion in Fluids	6 hours

Molecular diffusion in gas and Liquids, Multicomponent diffusion, Diffusion through variable cross-sectional area, Diffusivity in solids and its applications

Module:3	Mass transfer coefficients	6 hours

Introduction to mass transfer coefficient, Correlation for convective mass transfer coefficient ,Correlation of mass transfer coefficients for single cylinder, Packed column, flow over a flat plate

Module:4	Theories of mass transfer	5 hours

Penetration theory, Surface Renewal Theory, Interphase mass transfer, two film theory, Overall mass transfer coefficients

Module:5	Humidification	7 hours

Basic concepts, Principles of Humidification –Definitions Wet Bulb Temperature &Adiabatic Saturation Temperatures –Air/Water System psychrometric and Psychrometric Charts – Utilization of Psychrometric Charts – Dehumidification – Cooling Towers – Mechanical Draft Towers: forced draft towers and induced draft towers; Design calculations of cooling tower		
Module:6	**Drying**	**7 hours**
Principles of Drying-Definitions of moisture and other terms on Drying, Classification of Drying operations. Rate of Drying -Constant and Falling Rate Drying. Moisture movement in solids -Through Circulation Drying - Rate of drying for Continuous Direct heat Driers-Types of Dryers used in practice and their operation-Batch and Continuous Dryers		
Module:7	**Crystallization**	**6 hours**
Crystal Geometry - Invariant Crystals - Principles of Crystallization- Super saturation-Nucleation-Crystal growth -Material & Energy Balance applied to Crystallizers-Types of Crystallizers used in practice		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Dutta, B.K., Principles of Mass transfer and Separation Processes. Prentice-Hall of India, New Delhi 2007.
2.	Treybal, R.E., Mass-Transfer Operations, 3rd ed, McGraw-Hill 1981.
Reference Books	
1.	Cussler, E.L, Diffusion: MassTransfer in Fluid Systems, Cambridge university press,2017
2.	Christie J Geankoplis, Transport processes and Unit Operations, 4th ed, Prentice Hall India Pvt.Ltd, 2003
3.	Anantharaman N , Meera Sheriffa Begum K.M., Mass transfer-Theory and practice, Prentice-Hall of India, New Delhi, 2011

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE4001	L	T	P	J	C
Course title	EQUILIBRIUM STAGED OPERATIONS	2	0	2	4	4
Pre-requisite	CHE3003	Syllabus version				
		1.2				

Course Objectives:

1. Understand the basic principles of staged and continuous contact separation equipment involved in equilibrium staged operations such as distillation, absorption, liquid-liquid extraction, leaching, adsorption and other modern separation operations
2. Perform basic design calculations for staged and continuous contact equilibrium staged separation operations
3. Describe various types of equipment's and modern separation methods for high purity products widely used in separation operation

Course Outcomes (CO):

1. Describe basic principles of various equilibrium staged operations involving material and energy balances
2. Determine the number of equilibrium stages required for distillation and absorption units
3. Determine number of transfer units and height requirements required for extraction, leaching and adsorption units
4. Explain different column/equipment used for various separation applications
5. Recognize modern separation techniques applied in industries for high purity products
6. Develop experiments for various equilibrium staged operations using experimental setup and simulation software such as Aspen Plus, MATLAB Simulink and Pro Simulator

Student Learning Outcomes (SLO): 2,5,14

2. Having a clear understanding of the subject related concepts and of contemporary issues.
5. Having design thinking capability
14. Having an ability to design and conduct experiments, as well as to analyze and interpret data

Module:1	Introduction to Equilibrium Staged Operations	4 hours

Introduction to various equilibrium staged operations - Distillation - absorption- Extraction - leaching - adsorption; Vapour–liquid equilibria; Types of distillation – Flash - azeotropic - Extractive distillations; Develop VLE data using Aspen Plus; Simple mass and energy balance in flash column using simulation software

Module:2	Distillation	6 hours

Distillation column - Types of contact – Tray Vs Packed Column; Derivation of operating line equation for different section and parts of distillation column - rectification section - stripping section - feed tray location - condenser - reboiler - efficiency of distillation column; Determination of theoretical trays - McCabe-Thiele method -Ponchon- Savarit method; Case study of Industrial distillation column for multicomponent separation using Aspen Plus

Module:3	**Absorption**	**4 hours**
Introduction to absorption - Continuous contact counter-current multi-stage absorption (Tray absorber); Design of packed tower based on overall mass transfer coefficient; Absorber column operation using Aspen Plus		
Module:4	**Extraction**	**3 hours**
Liquid–Liquid equilibria – Determination of number theoretical stages – co-current - cross current - counter current contact operations - Classification of extraction equipment		
Module:5	**Leaching**	**3 hours**
General principles of leaching - Factors influencing the leaching rate – Equipment for leaching – Advanced industrial leaching processes		
Module:6	**Adsorption**	**4 hours**
Adsorption theory- Structure of adsorbents - Adsorption isotherms – Langmuir and Freundlich isotherms - Adsorption equipment		
Module:7	**Modern separation techniques**	**4 hours**
Membrane separation - microfiltration - ultrafiltration - nanofiltration - reverse osmosis; Chromatography – liquid chromatography - Advanced separation techniques - Divided wall column, melt crystallization, zone melting; Develop membrane separators using Aspen and solving for optimum purification		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**30 hours**

Text Books	
1.	Dutta B.K., Principles of Mass transfer and Separation Processes, 1st ed., Prentice Hall of India, India, 2007.
2.	Seader J.D., Henley E.J, Roper D.K., Separation Process Principles, , 3rd ed., John Wiley & Sons, USA, 2010.
Reference Books	
1.	Treybal R.E., Mass-Transfer Operations, 3rd ed., McGraw-Hill Inc., USA. 1981.
2.	Jana A.K., Chemical Process Modelling and Computer Simulation, 2nd ed., Prentice Hall of India, India, 2011.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Laboratory Experiments

1.	Diffusion in gas phase	2 hours
2.	Diffusion in liquid phase	2 hours
3.	Wetted wall column	2 hours
4.	Vapor-liquid equilibria using Aspen Plus or ProSim	2 hours

5.	Simple distillation	2 hours
6.	Multi Component distillation using Aspen Plus or ProSim	2 hours
7.	Liquid-liquid equilibria using Aspen Plus or ProSim	2 hours
8.	Liquid-liquid extraction	2 hours
9.	Continuous distillation using Aspen Plus or ProSim	2 hours
10.	Adsorption using Aspen Plus or ProSim	2 hours
Total Laboratory Hours		20 hours

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

PROGRAMME ELECTIVE

JULY 2019

Course code	CHE1007	L	T	P	J	C
Course title	SAFETY AND HAZARD ANALYSIS	2	0	0	4	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Critically understand the importance of safety in process industries
2. Assess and identify the potential hazards in process industries
3. Identify and evaluate the causes of accident in a chemical industry

Course Outcomes (CO):

1. Distinguish the typical sources of risk in a process plant by hazard identification and examination of case studies
2. Assess the severity of the consequences of incidents
3. Identify a Hazard and Operability Study (HAZOP)
4. Explain the legal framework controlling process plant safety in industries
5. Demonstrate how the root cause of incidents can be investigated and analysed and the various human and technical aspects of such causes
6. Identify hazard and conduct safety audit.

Module:1	Introduction to Safety in Chemical process Industries	5 Hours

Need for Development of Safety Consciousness in Chemical Industries - Hazard, Risk, Danger, Accident; Promotion of industrial safety, extreme operating conditions, toxic chemicals - safe handling; Psychological attitude towards safety.

Module:2	Safety Programs in Industries	5 Hours

Importance of Safety Programs in industries; Elements of Safety Program; Effective Realization; Economic and Social Benefits from Safety Program; Effective Communication Training at various levels of Production and Operation. Accidents identification and prevention.

Module:3	Potential Hazards in Chemical Process Industries	4 Hours

Chemical and Physical job Safety Analysis; High pressure and Temperature Operation; Dangerous and Toxic Chemicals; Routes of entry, Effects of toxicants and its elimination. Toxic release and dispersion models. Radio Active materials; Safe Handling and Operation of materials and Machinery; periodic inspection and replacement.

Module:4	Risk assessment	4 hours

Quantitative risk assessment - rapid and comprehensive risk analysis; Risk due to Radiation, explosion due to over pressure, plant layout Personnel Safety and Protective Equipment; Occupational health and safety.

Module:5	**Hazard Identification**	**4 hours**
Introduction to Hazard identification - Overall risk and hazard analysis - Emergency planning - On site & off site emergency planning - Risk management - ISO 14000 - Safety audits – Checklist - What if analysis – Vulnerability models - Event tree analysis - Fault tree analysis.		
Module:6	**HAZOP**	**4 hours**
HAZOP study - case studies-pumping system-reactor-mass transfer system. Hazard Identification and Assessment; Involvement of Human factors and Errors- Hazard Quantifications-disaster management; Occupational and Industrial Health Hazards; Safety Systems.		
Module:7	**Case studies**	**2 hours**
Dominos effect, Worst case scenario, Fire, Accidents, Chemical release, Explosion, Petroleum, Commercial, Natural disasters, EMS models case studies		
Module:8	**Contemporary Issues**	**2 hours**
Total Lecture hours		**30 hours**

Text Books	
1.	Ericson C.A., Hazard Analysis Techniques for System Safety, 2nd ed., Wiley, USA, 2015.
2.	Gupta A., Industrial Safety and Environment, 2nd ed., Laxmi Publications, India, 2015
Reference Books	
1.	Hyatt, N., Guidelines for process hazards analysis, hazards identification & risk analysis, 1st ed., CRC Press, USA, 2003.
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test	

Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1008	T	P	J	C
Course title	UNIT PROCESSES IN ORGANIC SYNTHESIS	3	0	2	0	4
Pre-requisite	NIL	Syllabus version				
		2.1				

Course Objectives:

1. Impart knowledge on the industrial reactions used in converting organic raw materials into usable products by various processes
2. Develop students understanding towards kinetics and mechanism of various reactions involved in industries
3. Comprehend various instrumental techniques applied in contemporary industries to analyze the organic compounds

Course Outcomes (CO):

1. Recall the physical concepts behind the organic reactions
2. Understand the importance of heterocycles, oxidizing and reducing agents
3. Interpret kinetics and mechanism of nitration, and halogenation reactions
4. Explain the kinetics and mechanism of sulphonation reactions
5. Explain separation and purification of organic compounds through classical separation methods
6. Select suitable chromatographic technique for separation and purification of organic compounds

Module:1	Basic concepts	6 hours

Kinetic theory of gases -Vander Waals equation - Critical constants - Liquifaction of gases, Raoult's law - Ideal solutions-Partially miscible liquids - Phenol water system - Henry's law - Colligative properties - Lowering of vapor pressure - Elevation of boiling point - Depression of freezing point

Module:2	Heterocyclic compounds	8 hours

Aromatics: Structure of benzene and theories of aromaticity – Heterocyclic compounds: Classification – Aromaticity and Basicity of heterocyclic compounds – Preparation and properties of Furan – Thiphene – Pyrrole. Oxidation – Oxidising agents (SeO_2, OsO_4, $KMnO_4$) – Reduction, Reducing agents (Lithium aluminium hydride, metal/acid and sodium metal). Grignard reagents: Synthesis and applications.

Module:3	Nitration	6 hours

Introduction to nitration, Nitrating agents, Kinetics and Mechanism of aromatic nitration process, Equipments for nitration, typical industrial nitration process e.g. preparation of nitrobenzene, nitro acetanilide.

Module:4	Halogenation	6 hours

Halogenating agents, Kinetics and mechanism of halogenation reactions. Apparatus and materials for construction. Technical preparation of chloral and vinyl chloride.

Module:5	Sulphonation	6 hours

Introduction to sulphonation, sulphonation agents and sulphanation agents, chemical and physical factors affecting sulphonation. Mechanism of sulphonation, commercial sulphonation of benzene and naphthalene, sulphation of lauryl alcohol and dimethyl ether.		
Module:6	**Separation and purification methods**	**5 hours**
Separation and purification methods: Classical separation methods: Theories of distillation, fractional distillation, steam distillation, sublimation and zone refining - Solvent extraction - Distribution law - Separation of mixtures, Craig method; Recrystallization of solid products.		
Module:7	**Chromatography**	**6 hours**
Chromatography- Introduction, Different types of chromatographic techniques- TLC, Column, GC, LC, and HPLC-Theory and Instrumentation (GC and HPLC), Applications in the separation of organic molecules.		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**
Text Books		
1.	Groggins P.H., Unit Processes in Organic Synthesis, 5th ed., Tata Mc.Graw Hill Book Company, India, 2009.	
2.	Puri B.R., Sharma L.R., Pathania M.S., Principles of Physical Chemistry, 43rd ed., Vishal Publishing Co., India, 2008.	
Reference Books		
1.	Atkins, P., Paula, J. D. Atkins, Physical Chemistry, 11th ed., Oxford University Press, USA, 2018.	
2.	March, J., Advanced Organic Chemistry: Reactions, Mechanisms and Structures, 4th ed., John Wiley & Sons, USA, 1992.	
3.	A. Bahl, B.S. Bahl, Advanced Organic Chemistry, 5th ed., S. Chand & Co., Ltd., India, 2012.	
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test		
Laboratory Experiments		
1.	Determination of Critical Solution Temperature of the given Phenol-Water system	2 hours
2.	Determination of rate constant of the hydrolysis of ethyl acetate catalyzed by HCl at room temperature	2 hours
3.	Determination of acid value of the given oil sample	2 hours
4.	Determination of saponification value of the given oil sample	2 hours
5.	Sulphonation of 1-Naphthol	2 hours
6.	Reduction of Benzophenone by $NaBH_4$	2 hours
7.	Preparation of Benzoic acid from benzaldehyde by oxidation and it melting point measurement	2 hours

8.	Preparation of m-Dintrobenzene from Nitrobenzene by nitration and it melting point measurement	2 hours
9.	Purification of organic compounds by Fractional distillation	2 hours
10.	Identification of Carbonyl group in an organic compound.	2 hours
11.	Identification of Carboxylic acid group in an organic compound.	2 hours
12.	Preparation of soap or detergent	2 hours
Total Laboratory Hours		24 hours

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1009	L	T	P	J	C
Course title	BIOCHEMICAL ENGINEERING	3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		2.2				

Course Objectives:

1. Impart the basic knowledge and overview of biotechnology covering the principles of cell and kinetics, bioreactor design, sterilization agitation and aeration
2. Understand the physical processes involved in bio-systems
3. Apply the knowledge of chemical engineering principles to biological processes

Course Outcomes (CO):

1. Understand significance and scope of biochemical processes
2. Classify microorganisms and cell functions for industrial biochemical processes, enzyme and kinetics for bioprocesses
3. Apply Chemical Engineering Principles to develop kinetic models for bioprocesses
4. Make use of theoretical basics of chemical engineering and unit operations in designing bioprocess equipment
5. Analyze bioreactor performance
6. Distinguish downstream processing and biological Sewage treatment in solving open ended chemical problems using biochemical route

Module:1	Introduction to Biochemical Engineering	3 hours

An overview of industrial biochemical processes with typical examples comparing chemical and biochemical processes – development and scope of biochemical engineering as a discipline.

Module:2	Basic microbiology and Biochemistry	5 hours

Industrially important microbial strains, their classification – structure – cellular genetics – typical examples of microbial synthesis of biologicals

Module:3	Enzymes & Applications	8 hours

Enzymes - in industry, medicine and food – their classification with typical examples of industrially important enzymes; Mechanism of enzymatic reactions – Michaelis Menten Kinetics – enzymes inhibition factors affecting the reaction rates; Industrial production, purification and immobilization – enzyme reactors with typical examples.

Module:4	Kinetics of Cell Growth	7 hours

Typical growth characteristics of microbial cells – factors affecting growth – Monod model; Modelling of batch and continuous cell growth; Immobilized whole cells and their characteristics – free cell and immobilized cell reactors; Typical industrial examples – transport in cells.

Module:5	Unit Operations in Biochemical engineering	6 hours

Newtonian and non-Newtonian behaviour of broth – agitation and mixing – power consumption; Gas/liquid transport in cells – transfer resistances – mass transfer coefficients & their role in scale up of equipment – O_2 transfer; Heat transport in microbial systems – Heat transfer correlation's; Sterilization cycles; Heat addition & removal during biological production		
Module:6	**Bioreactors**	**8 hours**
Bioreactors - Batch and continuous types, immobilized whole cell and enzyme reactors. Highperformance bioreactors; Reactors in series with and without recycle. Design of reactors and scale up with typical examples; Sterile and non-sterile operations.		
Module:7	**Downstream and effluent treatment processes**	**6 hours**
Downstream processes and effluent treatment: Different Unit operations in down streaming with special reference to membrane separations, extractive fermentation; Anaerobic and aerobic treatment of effluents – typical industrial examples for downstream processing and effluent disposal.		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Bailey J.B., Ollis D.F., Biochemical Engineering Fundamentals, 4th ed., McGraw Hill, USA, 1986.
Reference Books	
1.	Rao D.G., Introduction to Biochemical Engineering, 1st ed., Tata McGraw Hill, India, 2009.
2	Doran P.M., Bioprocess Engineering Principles, 3rd ed., Academic Press, United Kingdom, 2013.
3	Aiba A, Humphrey A.E., Milli. N.R., Biochemical Engineering, 2nd ed., Academic Press, USA, 2004.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1010	L	T	P	J	C
Course title	PROCESS PLANT UTILITIES	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Equip the students with the basic understanding and effective utilization of utilities viz. water, steam, compressor, vacuum pumps, refrigeration and cooling units, insulator, inert gases in process industries and allied operations
2. Impart insights in relation to the different types of fuels and boilers used in process industries for the generation of steam, types of compressors and blowers for handling air and inert gases
3. Expose students to different methods of treatment of wastewater and drinking water

Course Outcomes (CO):

1. Explain the importance of water and various methods for water softening and purification
2. Classify the different types of fuels and boilers used in process industries for the generation of steam
3. Identify the different types of compressors and blowers for handling air and inert gases
4. Summarize the different types of equipment used for humidification, and dehumidification
5. Select a suitable refrigeration system for a typical application in process industries
6. Interpret the application of correct type of insulation system for control of heat losses and learn about proper utilization of inert gases on the process plants

Module:1	Water and Steam	7 hours

Requisites of Industrial Water and its uses; Water treatment methods - ion exchange, demineralization, membranes technology, reverse osmosis. Water resources management.
Properties of steam, Boiler types and mountings, boiler accessories, Indian Boiler Act, 1923. Steam distribution and utilization, steam economy, waste heat utilization

Module:2	Industrial fuels	6 hours

Solid, liquid and gaseous fuels used in chemical process industries for power generation, Typical combustion calculations

Module:3	Compressed Air	6 hours

Types of fans, axial, reciprocating and centrifugal compressors, rotary blowers and vacuum pumps and their performance characteristics. Methods of vacuum development, ejectors and their limitations, materials handling under vacuum, piping systems.

Module:4	Humidification and Dehumidification	5 hours

Properties of Air–Water Vapors and use of Humidity Chart, Equipments used for Humidification, Dehumidification and Cooling Towers

Module:5	Refrigeration & Ventilation	6 hours

Principle of refrigeration, Refrigeration system like compression refrigeration, absorption refrigeration, and chilled water system; Types of refrigerants; Concept of cryogenics and cryogenics characteristics. Air blending, exhaust ventilation and flaring		
Module:6	**Industrial insulation and Inert Gases**	**8 hours**
Importance of insulation, insulation material and their effect on various materials of equipment piping, fitting and valves, insulation for high, intermediate, low and subzero temperatures including cryogenic insulation Introduction, properties of inert gases & their use, sources and methods of generation, general arrangement for inerting system; operational, maintenance and safety aspects		
Module:7	**Effluent treatment**	**5 hours**
Disposal of solid, liquid and gas wastes; pollution control measures – compliance to statutory norms; Effluent Treatment – Case studies like treatment of effluents from paper mills, Dye and Textile industries, petrochemical industries, plastic and rubber industries.		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Broughton J., Process Utility Systems, 3rd ed., Institution of Chemical Engineers, U.K., 2004
Reference Books	
1.	Mujawar B.A., A Textbook of Plant Utilities, 3rd ed., Nirali Prakashan Publication, India, 2007.
2.	Poling B.E., Prausnitz J.M., O'Connell J., The Properties of Gases and Liquid, 5th ed., McGraw Hill, USA, 2008.
3.	Perry, R.H., Green, D. W., Perry's Chemical Engineers Handbook, 8th ed., McGraw Hill, USA, 2007.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE-1011	L	T	P	J	C
Course title	OPTIMIZATION OF CHEMICAL PROCESSES	3	0	0	0	3
Pre-requisite	MAT3003	Syllabus version				
		1.2				

Course Objectives:

1. Provide an overview of state-of-the-art optimization algorithms
2. Impart the theoretical knowledge of chemical engineering principles that underpin optimization techniques.
3. Enhance the modelling skills to describe and formulate optimization problems and their use for solving several types of practically relevant optimization problems in Chemical engineering

Course Outcomes (CO):

1. Demonstrate the basic principles of Chemical Engineering Systems
2. Recognize the different types of optimization problems for process engineering
3. Evaluate single and multivariable optimization chemical engineering problems
4. Execute the complex chemical engineering processes using software tools
5. Identify the different types of hypotheses for the model equations chemical system
6. Solve the Optimal Control and Dynamic optimization problems

Module:1	Formulation of Optimization Problems	6 hours

Nature and Organization of Optimization problem; Mathematical concepts of optimization; Developing model for optimization; Taylor expansion; Gradient and Hessian matrix; Convex functions and sets; Gaussian elimination method

Module:2	Models for Optimization	5 hours

Selection of function; Degrees of freedom; Classification of models; factorial experimental design; constraints in model; Optimality conditions for a single-variable and multi-variable functions

Module:3	Linear and Nonlinear Least square problems	6 hours

One-dimensional search - Methods requiring derivatives (Newton, Quasi Newton, Secant method); Region elimination methods (Interval halving, Fibonacci search, Golden section); Polynomial approximations (Lagrange's, quadratic & Cubic)

Module:4	Multivariable Optimization-I	6 hours

Unconstrained multivariable optimization - Graphical visualization (contour plots, 3D plots); Gradient based methods – Steepest descent, conjugate direction, and Newton methods

Module:5	Multivariable Optimization-II	6 hours

Linear programming (LP) - Graphical solution - Simplex Method; Test for optimality – Barrier methods - Sensitivity analysis; Concept of duality; Introduction to interior-point method – Simulation of Reactor model – ASPEN PLUS and MatLab

Module:6	**Nonlinear Programming**	**7 hours**
Nonlinear programming (NLP) with constraints; Lagrange multipliers - Graphical illustration of NLP problems - KKT necessary and sufficient conditions; Quadratic programming - Successive linear and quadratic programming; Penalty function method; Integer and mixed integer programming. (IP and MIP) - Graphical solution - Branch and bound methods		
Module:7	**Dynamic Programming**	**7 hours**
Dynamic programming - Minimum cost routing problems - Solution of separable nonlinear programming problems; Global optimization problems; Introduction to multi objective optimization problems- Pareto optimal solutions (graphical illustration)		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Edger T.F., Himmelblau D.M., Lasdon L.S., Optimization of Chemical Processes, 2nd ed., McGraw-Hill, USA, 2015.
Reference Books	
1.	Hillier F.S., Lieberman G. J., Introduction to Operations Research, 7th ed., McGraw-Hill, USA, 2001.
2.	Rao S.S., Engineering Optimization: Theory and Practice, 4th ed., John Wiley & Sons Ltd., USA, 2009.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1013	L	T	P	J	C
Course title	NATURAL GAS ENGINEERING	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Impart design experiences essential for graduates to enter the practice of Gas Engineering and pursue lifelong professional development
2. Summarize the necessary theory, application to case studies and engineering project design
3. Implement research that generates, communicates and applies new knowledge for the betterment of society

Course Outcomes (CO):

1. Emphasize fundamentals of mathematics and integrates them in application to traditional Natural Gas Engineering to improve further needs
2. Select, locate and orient systems for offshore problems
3. Develop an ability to revamp and retrofit a system, process to meet desired needs within realistic constraints such as environmental, health, safety, manufacturability and sustainability in the field of Natural Gas
4. Apply natural Gas Refining principles and practices for optimizing resource development and management
5. Recognize the purification mechanism to estimate, design equipment's for processing, storage And transport
6. Inspect project economics and resource valuation methods for design and decision making under conditions of risk and uncertainty

Module:1	Properties and Composition of Natural Gas	6 hours

Natural gas origin – Composition of Natural Gas – Source of Natural Gas – Thermodynamics properties – Compressibility factor for Natural Gas – Heating value and flammability limit of Natural Gas

Module:2	Natural Gas Offshore Drilling	5 hours

Directional Drilling and Horizontal Drilling

Module:3	Natural Gas Offshore Production and Handling	6 hours

Drilling Deepwater Reservoir – Deepwater production systems – Mooring Systems – Gas Terminals

Module:4	Natural Gas Onshore Production and Handling	6 hours

Sucker Rod pumping – Separation , Storage, Transportation of Natural Gas

Module:5	Natural Gas Processing	8 hours

Dehydration – Desulphurization processes (Sour gases, Toxicity of H_2S, Physical and Chemical Absorption process, Carbonate process, sulphur recovery) – Low temperature processes (Joule Thompson effect, Turbo expander, Refrigeration, Low temperature Heat Exchanger)		
Module:6	**Liquid Recovery**	**6 hours**
NGL, LPG, C_3, C_2 Fraction Recovery from Natural Gas		
Module:7	**Economics of Natural Gas**	**6 hours**
Current status in India – Trade & Selection of port location – Economics of Gas Processing		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Arthur J. Kidnay, William R. Parrish, Fundamentals of Natural Gas Processing, 4th ed., Taylor and Francis, CRC Press, UK, 2011.
2.	Subrata K Chakrabarti, Handbook of offshore engineering, 1st ed., Elsevier Publishers, Netherlands, 2005.
Reference Books	
1.	S. Mokhatab, William A. Poe, James G.Speight, Handbook of Natural Gas Transmission and Processing, 1st ed., Gulf Professional Publishing, USA, 2014.
2.	G. Ghalambor, Natural Gas Engineering Handbook, Gulf Publishing Company, USA, 2005.
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test	

Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1014	L	T	P	J	C
Course title	PETROLEUM TECHNOLOGY	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Understand the importance of crude oil as source of fuel and the size of refining industry
2. Interpret the challenges involved in refining from viewpoint of product specifications, economic considerations and environmental regulations
3. Design application of chemical engineering principles to petroleum refining

Course Outcomes (CO):

1. Explain the composition of crude oil and its products, along with its properties and characterization methods
2. Discuss the basic separation and conversion processes used in refining crude oil
3. Implement the chemical engineering principles to the analysis of safe and efficient refinery operations
4. Identify the specifications required for good quality petroleum product
5. Exemplify the process of purification and fractionation of crude oil
6. Interpret the relationship safety and environment in Petroleum Refining Industries

Module:1	Petroleum	6 hours

Exploration Practices - Reservoir Rock Properties - Reservoir types - Reservoir Estimation Origin – Composition - Classification and constituents of petroleum - Dehydration of crude oil- Transportation of crude oil - Classification of petroleum

Module:2	Distillation	6 hours

Components of crude oil distillation - various crude oil distillation systems - uses of petroleum products

Module:3	Cracking	8 hours

Necessity of cracking - Types of cracking - advantages and disadvantages of catalytic cracking over thermal cracking - Houdrys fixed bed processes - Moving bed processes - Fluid bed catalytic cracking processes

Module:4	Reforming	4 hours

Thermal and catalytic Reforming; Polymerization; Alkylation; Isomerization

Module:5	Purification of petroleum products	7 hours

Sweetening processes types –Merox – HDS; Dewaxing; Deasphalt; Lube oil treatment

Module:6	Properties of Petroleum Products	7 hours

Specific gravity - Vapor pressure – Viscosity - red wood viscometer - Flash point - Fire point - Pour point - Smoke point - Aniline point - Diesel index - Octane number - Performance number -		
Cetane number - Properties of greases - Drop point of grease		
Module:7	**Knocking**	**5 hours**
Reasons for knocking - Additives in petrol - Aviation gasoline - Aviation turbine fuel (ATF) - Storage and handling of liquid fuels		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Gary J.H., Handwerk G.E., Kaiser M.J., Petroleum Refining Technology and Economics, 6th ed., CRC Press, USA, 2013.
2.	Speight J.G., Petroleum Refining Process, 1st ed., Taylor and Francis, USA, 2015
3	Bhaskara Rao B.K., Modern Petroleum Refining Processess, 5th ed., Oxibh, India, 2013
Reference Books	
1.	Mohamed A.F., Taher A., Amal E., Fundamentals of Petroleum Refining, 1st ed., Elsevier, USA, 2010.
2.	Nelson, Petroleum Refinery Engineering, 4th ed., McGraw Hill, USA, 2010.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1015	L	T	P	J	C
Course title	PETROCHEMICAL TECHNOLOGY	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Understand the technological principles of organic synthesis and related unit processes
2. Differentiate the different unit operations and unit processes involved in conversion of monomer to polymers
3. Interpret various kinds of application oriented problems faced in chemical industries using analytical techniques

Course Outcomes (CO):

1. Provide a detailed insight of all the chemicals derived from petroleum
2. Explain the different methods for the conversion of monomer to polymers
3. Distinguish different type of polymers for specific application
4. Develop familiarity with major polymerization processes on industrial scale
5. Understand the different process technologies for Elastomers and resins
6. Demonstrate the manufacture of Plastics, Fibres and their applications

Module:1	Petrochemical & Precursors	2 hours

Introduction; Petrochemical & its Precursors

Module:2	Alkanes & Alkenes	7 hours

Introduction to Alkanes and Alkenes; Manufacture of Petrochemical Derivatives from C_1,C_2,C_3,C_4 compounds

Module:3	Aromatics	6 hours

Introduction to Aromatics; Manufacture of Petrochemical Derivatives from – Benzene, Toluene, Xylene, Styrene

Module:4	Alternate Route and its Derivatives	8 hours

Manufacture of VCM by thermal cracking, DMT , PTA, maleic anhydride, cumene, diphenyl

carbonate.		
Module:5	**Polymers**	**8 hours**
Production of - poly butadiene rubber, SBR,SAN, Polyalkylene Terephthalate, Alpha Olefins (Linear), Octenes.		
Module:6	**Plastics & Fibres**	**7 hours**
Production of – Polyacrylonitrile resins, Melamine, formaldehyde resins, SNG, explosives, dyes		
Module:7	**Economics of Petrochemical Industry**	**5 hours**
Current status in India; Trade; Selection of Petrochemical products; Economics of Petrochemical derivatives and Industry		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours	JULY 2019	**45 hours**

Text Books

1.	Mall I.D., Petrochemical Process Technology, 2nd ed., Macmillan Petroleum Chemicals Ltd, UK, 2011.
2.	Chaudhuri U.R., Fundamentals of Petroleum and Petrochemical Engineering, 3rd ed., CRC Press, USA, 2011.

Reference Books

1.	Richard A. Dawe, Modern petroleum technology, 6th ed., John Wiley & Sons Limited, USA, 2012.
2.	Abdulin F., Production of Oil & Gas, 2nd ed., Mir publishers, Russia, 2014.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1016	L	T	P	J	C
Course title	FERMENTATION TECHNOLOGY	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Learn the basics of the various aspects of microbiology and biosystems
2. Impart experimental design thinking capability in relation to various fermenter configurations, modes of operation, growth kinetics and product recovery
3. Extrapolate the design thinking skills to bio related processes with chemical engineering background

Course Outcomes (CO):

1. Understand the importance of fermentation with reference to industrial microbiology
2. Summarize kinetics prevalent in microbial processes
3. Understand the process to select and manage microorganisms from natural source to fermentation
4. Interpret the acquired knowledge on fermenter configuration for different types of cells and enzymes
5. Design of fermenter and the downstream processing of fermentation products
6. Create innovative applications for fermentation technologies for novel products

Module:1	Introduction and history of fermentation processes	4 hours

Development of fermentation process – range of processes under fermentation, Types of fermentation.

Module:2	Microbial growth kinetics	6 hours

Microbial growth - Batch, Continuous and types of fed batch culture – design and kinetics. Comparison of the modes of culture

Module:3	Microbial Strain Management	5 hours

Industrial microorganisms - isolation, preservation and improvement of strains; Storage methods and improvement strategies.

Module:4	Media for industrial fermentations	5 hours

Media formulation - energy, carbon and nitrogen sources, micro nutrients; oxygen requirements; Other non-nutrient and functional components. Effects of media composition on penicillin production; Media optimization.

Module:5	Preparation of aseptic fermentation process	8 hours

Preparation of media and air for pure culture fermentation; Media sterilization - Batch and continuous sterilization processes; Sterilization of fibrous filters and their design; Development of inocula - processes involving yeast, bacterial, fungi; Aseptic inoculation of plant fermentations.

Module:6	**Basic functions of a fermenter**	**8 hours**
Basic functions of fermenter – Aeration and agitation – process requirements and mechanical design aspects; Maintenance of aseptic conditions and foam control. Types of fermenters for industrial applications - stirred & sparred tanks fermenters, Tower fermenter, Packed tower, Air lift and rotating disc fermenters; Solid State fermentation.		
Module:7	**Process technology for bulk products**	**7 hours**
Basic downstream processing; Process technology for bulk products; Production of alcohols, organic acids, enzymes, and antibiotics – flow sheet and process description of modern processes.		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Stanbury P.F., Whitaker A., Steve H., Principles of Fermentation Technology, 3rd ed., Butterworth-Heinemann, USA, 2017.
2.	El-Mansi E., Bryce C.F.A, Arnold L.D., Allman A.R., Fermentation Microbiology and Biotechnology, 2nd ed., CRC Press, USA, 2007.
Reference Books	
1.	Ashok P, Christian L, Carlos R.S., Advances in Fermentation Technology, 1st ed., Asiatech Publishers Inc., India, 2008.
2.	Rhodes A and Pletcher. D.L: Principles of Industrial Microbiology, 3rd ed., Pergamon Press, UK, 1977.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1017	L	T	P	J	C
Course title	FOOD PROCESS ENGINEERING	2	0	0	4	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Emphasize on the basic concepts of unit operations and unit processes in Chemical Engineering with an application to Food technology
2. Impart necessary knowledge required for food processing technology , food quality management, food standards and packaging
3. Familiarize the various properties of the raw material used in food processing and technologies required in transforming them into quality food products and to train the students to use the material handling equipment involved in food processing operations

Course Outcomes (CO):

1. Determine the various engineering properties of the raw material used in food processing which will be useful to design the various food Processing equipment's
2. Device the suitable dryers with considering technical and economical point of view
3. Understand the knowledge in different food processing operations involved in various food manufacturing process
4. Identify and transform different processing technology to produce quality food products
5. Understand the unit operations involved in food technology
6. Organize to learn the packaging material and methods and the cost involved

Module:1	**Introduction to Food**	**4 hours**
Macromolecules-proteins ,Enzymes, Carbohydrates, Micronutrients, Water, Interactions		
Module:2	**Food Microbiology**	**3 hours**
Deteriorative factors and Control. Food additives and preservatives. Adulteration		
Module:3	**Food process calculations**	**3 hours**
Material and energy calculations in food processing		
Module:4	**Unit operations in food processing**	**5 hours**
Material handling, heat transfer, mixing, size reduction, mechanical separations		
Module:5	**Food Preservation Techniques**	**5 hours**
Drying and dehydration, Irradiation, Microwave Heating, Sterilization and Pasteurization – Cleaning/sanitation In Process (CIP and SIP), Fermentation and Pickling		
Module:6	**Food Processing and Food quality**	**5 hours**

Processing of Cereal Grains, Pulses, Vegetables, Fruits, Spices, Fats and Oils, Bakery, Confectionary and Chocolate Products Soft and Alcoholic Beverages, Dairy Products, Meat, Poultry and Fish Products, Food quality parameters and their evaluation FSSAI and safety concepts in food processing. Quality control and Food standard organizations			
Module:7	**Packaging and canning**		**3 hours**
Concepts, definition, Significance, classification – fresh and processed; Basic packaging materials, types of packaging, Packaging methods. Newer methods of thermal processing, batch and continuous; application of infrared, microwaves. packaging design, retort pouch packing, vacuum packaging; costs of packaging and recycling of materials and Labelling			
Module:8	**Contemporary issues**		**2 hours**
Total Lecture hours			**30 hours**
Text Books			
1.	Rao C.G., Essentials of Food Processing Engineering, 1st ed., BS Publications, India, 2005.		
2.	Subbulakshmi G, Udipi Shobha A., Food Processing and Preservation, 1st ed., New Age International, India, 2017.		
Reference Books			
1.	Khetarpaul N., Food Processing and Preservation, 1st ed., Daya Publications, India, 2005.		
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1018	L	T	P	J	C
Course title	MEMBRANE SEPARATIONS TECHNOLOGY	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.21				

Course Objectives:

1. Understand basic principles of membrane separation and characterization methods available for membranes
2. Derive various transport mechanism involved in MF, UF, NF, RO and gas separation membranes
3. Select membranes for different industrial separation and purification application

Course Outcomes (CO):

1. Understand the basic principle of membrane separation processes
2. Describe different technics available for membrane characterization
3. Derive various transport models for membrane flux and concentration polarization for various membrane systems
4. Compute membrane flux, concentration polarization and fouling using various transport models for various membrane systems
5. Analyze a membrane process and design components to carry out a specific separation
6. Select membranes for gas and bio separation application

Module:1	Membrane Materials, Preparation and Characterization	5 hours

Introduction - Historical development of membranes - types of membrane processes - types of synthetic membranes - membrane materials - membrane module; Membrane preparation – Phase inversion process – casting methods; Membrane characterization - Measurement of pore size - solute properties – visual methods - bubble point method - liquid displacement method, molecular weight cut-off (MWCO), microbial challenge test

Module:2	Membrane Transport Theory	6 hours

Membrane transport theory – Introduction, solution-diffusion model; Structure-permeability relationship in solution diffusion membranes; Pore-flow membranes.

Module:3	Concentration Polarization	6 hours

Concentration polarization – Introduction, boundary layer film model; Concentration polarization in liquid separation process; Cross-flow, co-flow and counter-flow processes.

Module:4	Microfiltration and Ultrafiltration	6 hours

Microfiltration: Introduction and history, applications; Recent trends and progress in MF/UF technology; Ultra filtration: Introduction and history – characterization of ultrafiltration membranes – concentration polarization and membrane fouling, membrane cleaning – membrane and modules – system design – application

Module:5	**Nanofiltration**	**7 hours**
Nanofiltration: Introduction – process principles – application of nanofiltration for the production of drinking water and process water – solvent resistance nanofiltration		
Module:6	**Reverse Osmosis**	**7 hours**
Reverse osmosis: Introduction – membrane categories – membrane selectivity – membrane transport concentration polarization – membrane modules – membrane fouling control – membrane cleaning applications		
Module:7	**Recent development in Membrane Processes**	**6 hours**
Recent material and module configurations for Microfiltration and ultrafiltration; Thin film composite membranes – Biofouling protection; Integrated membrane systems; Gas separation - Hydrogen separation– oxygen and oxygen enriched air; Membrane distillation and Ceramic membranes		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Dutta B.K., Principles of Mass transfer and Separation Processes, 1st ed., Prentice Hall of India, India, 2007.
2.	Mulder M., Basic Principles of Membrane Technology, 2nd ed., Springer Science, USA, 1991.
Reference Books	
1.	Kaushik K.N., Membrane Separation Process, 1st ed., Prentice Hall of India, India, 2008.
2.	Cui Z.F., Muralidhara H.S., Membrane Technology: A Practical Guide to Membrane Technology and Applications in Food and Bioprocessing, 1st ed., Elsevier, USA, 2010.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1019	L	T	P	J	C
Course title	POLYMER TECHNOLOGY	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Understand different types of polymers
2. Identify the various technologies and types of polymerization techniques
3. Analyze the polymer processing techniques and polymer additives

Course Outcomes (CO):

1. Classify and characterize polymers and polymeric reactions
2. Explain the different methods of polymerization
3. Identify the processing technologies for different polymer synthesis and their additives
4. Identify suitable polymer for specific application
5. Distinguish different type of polymers for various applications
6. Demonstrate the novel biopolymers and their applications

Module:1	Introduction to polymer	5 hours

Monomer; polymers and their classification: Degree of polymerization. Polymeric reaction: addition; condensation and copolymerization

Module:2	Methods of polymerization	6 hours

Bulk, solution, emulsion and suspension polymerization

Module:3	Structure and size of polymer	6 hours

Structure of polymers, Characterization of polymers: Molecular weight, Crystallinity, Glass transition temperature and mechanical properties: testing of polymers

Module:4	Polymer processing additives	6 hours

Fillers, plasticizers, Anti-oxidants, colorants, stabilizers, and other related additives

Module:5	Polymer processing techniques	6 hours

Injection and compression transfer moulding methods; calendaring, extrusion, thermoforming, powder coating

Module:6	Polymeric materials	9 hours

Polyethylene; polypropylene; polymethyl methacrylate; polyvinyl chloride; polytetra-fluoroethylene, polyacrylate, polyesters; Polymeric foams – Polyurethane, polystyrene.

Module:7	Special polymers and bio polymers	5 hours

Polycarbonates, polysulphones; aromatic polyamides; aromatic polyester; photo conductive polymers; wool silk and cellulose derivatives, Protein based polymers and Bio-nano-composites			
Module:8	**Contemporary issues**		**2 hours**
Total Lecture hours			**45 hours**
Text Books			
1.	Gowariker V.R., Viswanathan N.V., Sreedhar J., Polymer Science, 2nd ed., New Age Publishers, India, 2015.		
2.	Ebewele R.O., Polymer Science and Technology, 1st ed., CRC press, USA, 2000.		
Reference Books			
1.	Froed J.R., Polymer science & Technology, 1st ed., Prentice Hall Publishers, USA, 2014.		
2.	Young R.J., Lovell P.A., Introduction to Polymers, 1st ed., CRC Press, USA, 2011.		
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1020	L	T	P	J	C
Course title	FERTILIZER TECHNOLOGY	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Introduce production of various NPK fertilizers and their importance
2. Impart knowledge of bio fertilizers, fluid fertilizers and controlled release fertilizers
3. Identify pollutions involved in fertilizer manufacture and their controlling strategies to maintain the pollution standards

Course Outcomes (CO):

1. Realize the role of essential elements for plant growth and the need of nitrogenous, phosphate and potash fertilizers
2. Identify reactions and unit operations involved in the manufacturing of various fertilizers
3. Outline various physical and chemical properties of fertilizers
4. Categorize the major engineering problems associated in fertilizer manufacturing process
5. Explain the importance of bio fertilizers, fluid fertilizers and controlled release fertilizer
6. Analyze the impact of pollution from fertilizer industry based on pollution standards

Module:1	Introduction to Fertilizers	7 hours

Introduction to fertilizers- Importance, Feed stocks for the production of Ammonia. Processes for gasification of fossil fuel and methods of production of ammonia and nitric acid

Module:2	Nitrogenous Fertilizers	7 hours

Nitrogenous fertilizers – Ammonium sulphate, Urea, Ammonium chloride, Ammonium nitrate and Calcium ammonium nitrate, Their methods of production, Characteristics and specification, Storage and handling

Module:3	Phosphatic Fertilizers	5 hours

Phosphatic Fertilizers: Raw materials – phosphate rock, sulphur, pyrites etc. Processes for the production of sulphuric and phosphoric acids. Phosphatic fertilizers – ground rock phosphate, bone meal – Single superphosphate, Triple superphosphate, thermal phosphates – their methods of production, characteristics and specifications.

Module:4	Potassic Fertilizers	5 hours

Potaasic fertilizers- Potassium Chloride, Potassium sulphate, Potassium magnesium sulphate, Potassium hydroxide, Potassium nitrate – Methods of production: their characteristics and specifications.

Module:5	NPK Fertilizers	7 hours

NPK fertilizers: Urea ammonium phosphate, ammonium phosphate sulphate, Nitrophosphates, and various grades of NPK fertilizers produced in the country

Module:6	**Other Fertilizer**	**7 hours**
Fertilizers and granulated mixtures; Biofertilisers, Nutrient - Secondary nutrients and micronutrients; Fluid fertilizers, Granular fertilizers, Controlled release fertilizers, Slow release fertilizers		
Module:7	**Pollution control**	**5 hours**
Pollution from fertilizer industry, Solid, liquid and gaseous pollution control and standards		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Book	
1.	Handbook of fertilizer technology, Association of India, New Delhi, 1977
2.	Fertilizer Manual, United Nations Industrial Development Organization, United Nations, New York, 1967.
Reference Books	
1.	Rao G., Sittig M., Dryden's Outlines of Chemical Technology, 3rd ed., East West Press, India, 2010.
2.	Austin T.G., Shreve's Chemical Process Industries, 5th ed., Tata McGraw-Hill Education Pvt. Ltd, USA, 2012.
3.	Shukla S.D., Pandey G.N., A Text Book of Chemical Technology, 1st ed., Vikas Publishing House Pvt. Ltd, India, 1978.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE1023	L	T	P	J	C
Course title	PRODUCTION AND OPERATIONS MANAGEMENT	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Develop the student understanding levels of product and process layout fundamentals
2. Apply the knowledge of statistics for performing quality control and Inspection and project planning
3. Make the students to analyze situations and use different models for decision making

Course Outcomes (CO):

1. Explain the concepts of production and operations
2. Design the product and process layout
3. Evaluate the material inventory and manage the supply
4. Judge the quality control and Inspection using statistical tools
5. Develop Gantt chart, and conduct project evaluation and review
6. Analyze situations and use different models for decision making

Module:1	Introduction to Production and Operations Management	6 hours

Production system, production management; Operating system, operations management – classifications, objectives and scope

Module:2	Plant Location and Layout	6 hours

Factors influencing plant location - location models; Plant layout – objectives, classifications; Design of product and process layout.

Module:3	Supply of Resources	6 hours

Materials Management - purchasing; ABC Analysis

Module:4	Inventory Management/Control	6 hours

Inventory Management – objectives, benefit, technique; Inventory models - without shortage, with shortage

Module:5	Quality Control and Inspection	6 hours

Statistical Quality Control Methods - p, x and R charts etc.,

Module:6	Project Planning	7 hours

Scheduling models – Gantt chart; Priority decision rule, Network Models, PERT, CPM

Module:7	Decision Making	6 hours

General Model for decision making - Bayes' Decision Rule; Decision Making under Uncertainty and Risk; Decision Tree Method			
Module:8	**Contemporary issues:**		**2 hours**
Total Lecture hours			**45 hours**
Text Books			
1.	Chary S.N., Production and Operations Management, 5th ed., Tata McGraw-Hill Education Pvt. Ltd., India, 2012		
2.	Panneerselvam R., Production and Operations Management, 3rd ed., PHI Learning Pvt. Ltd., India, 2012		
Reference Books			
1.	Garg, A.K., Production and Operations Management, 1st ed., Tata McGraw-Hill Education Pvt. Ltd., India, 2012		
2	Montgomery, D.C., Introduction to Statistical Quality Control, 6th ed., John Wiley & Sons, Inc. USA, 2009		
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE2003	L	T	P	J	C
Course title	CHEMICAL PRODUCT DESIGN	3	0	0	0	3
Pre-requisite	CHE1004	Syllabus version				
		1.2				

Course Objectives:

1. Train the students in identifying the needs and converting needs to product specifications
2. Facilitate generation of innovative ideas for chemical products and select among the ideas
3. Familiarize the student with intellectual property issues and manufacture and design of speciality products

Course Outcomes (CO):

1. Understand and analyze the needs of the customers
2. Apply engineering knowledge to convert needs to product specifications
3. Create and generate innovative ideas for products
4. Evaluate and select among ideas
5. Analyze the manufacture of products
6. Design better marketable products

Module:1	Introduction	1 hour
Introduction to chemical product design		
Module:2	**Needs of chemical product**	**6 hours**
Customer needs - consumer products		
Module:3	**Needs to specifications**	**6 hours**
Converting needs to specifications - revising product specifications		
Module:4	**Ideas**	**8 hours**
Human sources of ideas - chemical sources of ideas - sorting the ideas - screening the ideas.		
Module:5	**Selection of ideas**	**8 hours**
Selection using thermodynamics - selection using kinetics - less objective criteria - rise in product selection		
Module:6	**Product manufacture**	**6 hours**
Intellectual property - supplying missing information - final specifications - micro structured products - device manufacture		
Module:7	**Specialty chemical manufacture and Economic Concerns**	**8 hours**
First steps towards production - separations - specialty scale up - Product versus process design - process economics - economics for products		

Module:8	**Contemporary issues**			**2 hours**
Total Lecture hours				**45 hours**
Text Books				
1.	Cussler E.L., Moggridge G. D., Chemical Product Design, Cambridge University Press, 2nd ed., UK, 2011.			
Reference Books				
1.	Seider W.D., Seader J D., Lewin D.R., Product and Process Design Principles, Wiley, 4th ed., USA, 2016.			
2.	Wei J., Product Engineering: Molecular Structure and Properties, Oxford University Press, 1st ed., UK, 2007.			
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test				
Recommended by Board of Studies		04-03-2016		
Approved by Academic Council		40th	Date	18-03-2016

Course code	CHE2006	L	T	P	J	C
Course title	FUELS AND COMBUSTION	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Develop the understanding levels of fuels and combustion fundamentals
2. Classify and introduce different types of fuel and fuel analysis techniques that assists the students to choose most convenient fuel for a process involving combustion`
3. Engage the students in designing various control techniques for handling various environmental issues resulting from combustion of fuels

Course Outcomes (CO):

1. Classify the various types of fuels like liquid, solid and gaseous fuels available for firing in boilers and furnaces
2. Compare various fuel properties and its efficient use
3. Choose the right type of fuel depends on various factors such as availability, storage, handling, pollution and cost of fuel
4. Differentiate the properties of exhaust and flue gases
5. Execute basic engineering and science concepts for the design of various combustion equipment
6. Interpret various air pollution controlling techniques for reducing the pollution generated from combustion of various fuels

Module:1	Classification and Properties of Fuels	5 hours

Fuels-Types and characteristics of fuels-Determination of properties of fuels-Fuel analysis-Proximate and ultimate analysis-Calorific value (CV)-Gross and net calorific values (GCV,NCV)-Bomb Calorimetry-empirical equations for CV estimation

Module:2	Solid Fuels	6 hours

Origin of coal-Ranking of coal-Washing, cleaning and storage of coal-Renewable Solid Fuels-comparative study of Solid, liquid and gaseous fuels-selection of coal for different industrial applications-carbonization of coal

Module:3	Liquid fuels	6 hours

Origin of crude oil-composition of crude petroleum-classification of crude petroleum-Removal of salt from crude oil-processing of crude petroleum-Fractionation distillation-ADU and VDU-Cracking-Hydrotreatment and Reforming

Module:4	Gaseous fuels	6 hours

Rich and lean gas-Wobbe index-Natural gas-Dry and wet natural gas-Foul and sweet NG-LPG-LNG-CNG-Methane-Producer Gas-Water gas-Coal Gasification-Gasification Efficiency

Module:5	Combustion	7 hours

General principles of combustion-types of combustion processes-Combustion chemistry-Combustion equations-Kinetics of combustion-combustion of solid fuels-Combustion calculations-air fuel ratio-Excess air calculations		
Module:6	**Combustion Equipment**	**7 hours**
Analysis of flue gases by Orsat apparatus-Combustion of solid fuels-grate firing and pulverized fuel firing system-Fluidized bed combustion-Circulating fluidized bed boiler-Burners-Factors affecting burners and combustion		
Module:7	**Air Pollution**	**6 hours**
Types of pollution-Combustion generated air pollution-Effects of air pollution-Pollution of fossil fuels and its control-Pollution from automobiles and its control		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Kenneth K.K., Principles of Combustion, 2nd ed., Wiley Publications, USA, 2012
2.	Phillips H.J., Fuels-solid, liquid and gases–Their analysis and valuation, 1st ed., Foster Press, USA, 2010
Reference Books	
1.	Speight J.G., The Chemistry and Technology of Coal, 3rd ed., Taylor and Francis Ltd., USA, 2016
2.	Sarkar S., Fuels and combustion, 3rd ed., Universities Press, India, 2009

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE3004	L	T	P	J	C
Course title	HETEROGENEOUS REACTION ENGINEERING	2	0	0	4	3
Pre-requisite	CHE2001	Syllabus version				
		1.2				

Course Objectives:

1 Introduce students about catalytic phenomena with an extension to reactor design and catalyst characterization

2. Build upon the fundamentals of heterogeneous reactions, design, and analysis of non-catalytic, catalytic fluid-solid reactors including multi-phase reactors

3. Engage students in handling most common industrial chemical and biochemical reactors to achieve production goals for processes involving homogeneous or heterogeneous reaction systems

Course Outcomes (CO):

1. Understand the heterogeneous reaction systems and design the reactors for fluid-solid systems
2. Analyze the mechanism of non-catalytic solid-fluid reactions
3. Analyze the role of catalyst in reactions and the transport mechanism in heterogeneous catalysts
4. Design and characterize catalyst surface properties for better activation of the catalyst
5. Identify critical parameters affecting the performance of heterogeneous and multi-phase reactors
6. Construct and apply a general problem solving approach to design heterogeneous and multiphase reactors

Module:1	Introduction to Heterogeneous Reaction Engineering	2 hours

Introduction to heterogeneous reacting systems - Sharp interface and volume reaction models - determination of rate-controlling steps and application to design of reactors - bio reactors

Module:2	Non-catalytic solid-fluid reactions	4 hours

Shrinking core model – Gas film controlling – Ash layer controlling – Chemical reaction controlling – Shrinking spherical particles – Fluidized bed reactor

Module:3	Introduction to Catalytic Reactions	4 hours

Definition and properties - Steps involved in catalytic reactions - Rate laws mechanisms - Rate limiting step		
Module:4	**Transport Mechanism in heterogeneous catalysts**	**5 hours**
Transport effects in heterogeneous catalysis - Internal effectiveness - External transport limitations and overall effectiveness		
Module:5	**Catalysts preparation & characterization**	**4 hours**
Definition and types of catalysts – Industrial catalysts – Preparation and characterization of the catalysts, Surface area and pore volume determination		
Module:6	**Catalyst deactivation methods**	**4 hours**
Types of catalyst deactivation – Determining the order of deactivation – Catalyst regeneration methods		
Module:7	**Design of Reactors for Fluid-Liquid and Fluid-Solid reactions**	**5 hours**
Reactor design fundamentals and methodology, rate data analysis - Overall view of Fluidized, Packed and Moving bed reactors- Fluid-liquid reactions: Film and Penetration theories - Fluid-solid catalytic reactions		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours	**30 hours**

Text Books

1.	Levenspiel O., Chemical Reaction Engineering, 3rd ed., Wiley Publications, USA, 2006
2.	Fogler H.S., Elements of Chemical Reaction Engineering, 5th ed., Prentice Hall India Pvt. Ltd., India, 2016

Reference Books

1.	Miller, G. T., Chemical Reaction Engineering, 1st ed., CRS publications, USA, 2016

2.	Vannice, M. A., Kinetics of Catalytic Reactions. 2nd ed., Springer, USA, 2010		
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE3006	L	T	P	J	C
Course title	PROCESS PLANT SIMULATION	3	0	0	4	4
Pre-requisite	MAT3003	Syllabus version				
		1.2				

Course Objectives:

1. Emphasize the basic concepts of steady state process plant simulation
2. Impart the knowledge and awareness to understand the validity and physicochemical interpretation of thermodynamic models and their limitations
3. Develop the skills for plant simulation and optimization, solve chemical engineering problems encountered in chemical industries using professional software's

Course Outcomes (CO):

1. Understand the principles for developing a Process flow sheet and its execution
2. Illustrate the approaches to follow in plant simulation
3. Overcome the debottleneck existing in process plant and have maximum productivity
4. Implement the strategies for solving simple and complex plant problems
5. Utilize commercial software's for complete simulation of refineries
6. Interpret steady state process plant simulation

Module:1	Introduction	5 hours

Introduction to Process Synthesis - Flow sheeting & simulation - Degrees of freedom – Process Equipment's - Process flow sheet

Module:2	Approaches to Process Simulation	6 hours

Sequential modular approach and Simultaneous modular approaches - Equation solving approach used in process plant simulation

Module:3	Equation Solving Approach	8 hours

Partitioning - Decomposition - Disjointing - PTM - SWS - Steward - Rudd Algorithms; Sparcity - Direct Methods - Pivoting - Iterative methods - BTF- BBTF Block Back Substitution- BTS - etc

Module:4	Decomposition of Networks	7 hours

Tearing Algorithms in decomposition of networks – digraph - signal flow graph - BM Algorithm – BTA - K&S Algorithm - M&H Algorithm - related problems

Module:5	Convergence Promotion	6 hours

Linear equation - nonlinear equation - Convergence promotion scheme Newton's method - Direct Substitution- Wegstein's method - Dominant eigen value method - Quasi-Newton methods; Acceleration criterion

Module:6	Application of Flow Sheeting Software	5 hours

Flow sheeting software: Aspen Plus-Steady state simulation - Aspen Hysys dynamic simulation

Module:7	**Case Studies: (Un)Steady State Process Simulation**	**6 hours**
Complete plant (un)steady state simulation: Any process such as Ammonia plant - Biodiesel plant - NG liquefaction		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Robin S., Chemical Process Design and Integration, 2nd ed., Wiley, USA, 2016.
2.	Babu B.V., Process Plant Simulation, 1st ed., Oxford University Press, India, 2004.
Reference Books	
1.	Westerberg A.W., Hutchison H.P., Motard R.L., Winter P., Process Flow sheeting, 1st ed., Cambridge Press, UK, 2011.
2.	Richard T., Analysis, Synthesis and Design of Chemical Processes, 1st ed., Pearson Education International, USA, 2009.
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test	
Recommended by Board of Studies	04-03-2016
Approved by Academic Council	40th Date 18-03-2016

Course code	CHE3007	L	T	P	J	C
Course title	MULTIPHASE FLOW	3	0	0	0	3
Pre-requisite	CHE1005, CHE1006	Syllabus version				
		1.2				

Course Objectives:

1. Emphasis the concepts of multiphase systems in the processing industry
2. Formulate momentum, energy and material balance models in multiphase systems
3. Develop design thinking skills to understand multiphase flows in chemical industries

Course Outcomes (CO):

1. Define and relate the basic types of multiphase systems in process industries
2. Identify the type of flow-pattern and flow regimes for fluid-fluid (gas-liquid and liquid-liquid) and fluid-solids systems
3. Construct one dimensional Steady state models in multiphase flows
4. Interpret Drift Flux models two phase system
5. Formulate and estimate flow properties for phase change systems
6. Design and fabricate the columns to handle for multiphase system in chemical engineering operations

Module:1	Introduction to multiphase flow, type of flow and applications	9 hours

Basic fluid flow concepts: Flow field description – conservation laws – viscous flow – turbulent flow – pressure drop - Review of Single Phase Flow; Scope and significance - applications

Module:2	Flow pattern maps and Regime	11 hours

Flow patterns for gas-liquid; gas-solid; liquid-liquid; liquid-solid system; Heated tubes – horizontal – vertical- Vertical flow; horizontal flow; co-current; counter current systems; Gas-liquid-solid three phase flows

Module:3	One dimensional steady state flow	9 hours

Definitions and common Terminologies - simple analytical model - homogenous flow model.

Module:4	Drift flux model	4 hours

Theory of drift flux model and its application

Module:5	Separated flow model	4 hours

Separated flow model for stratified and annular flow; Correction factor and analysis.

Module:6	Two phase flow with phase change	4 hours

Boiling flow heat transfer - regimes - bubble growth

Module:7	Measurement techniques	2 hours

Sampling Methods - Integral Methods – Local Measurement techniques - hold up studies - analysis			
Module:8	**Contemporary issues**		**2 hours**
Total Lecture hours			**45 hours**
Text Books			
1.	Wallis, One Dimensional Two-phase flow, McGraw Hill Book Company,1st ed., USA, 2000.		
2.	John G.C., John R.T., Convective Boiling and Condensation, Oxford University Press, 3rd ed., UK, 2002.		
Reference Books			
1.	Clement K. S., Two Phase Flow – Theory and Applications, 1st ed., Taylor and Francis, USA, 2003.		
2.	Govier, G.W., Aziz K., The Flow of Complex Mixture in Pipes, 2nd ed., Society of Petroleum Engineers Publishers, USA, 2008.		
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE3008	L	T	P	J	C
Course title	INDUSTRIAL POLLUTION ENGINEERING	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Explain the legislation and standards related to air, water and solid wastes in Indian context
2. Identify and design treatment equipments for air and water pollution
3. Illustrate the effective methods of solids waste treatment techniques

Course Outcomes (CO):

1. Understand basics of pollution parameters and characteristics of industrial wastes
2. Distinguish types of standards and legislations and resource optimization methods
3. Categorize sources, types, and control equipment's for industrial air pollution
4. Classify and design methods of wastewater treatment
5. Differentiate various solid waste disposal techniques
6. Evaluate waste treatment flow sheets of various process industries

Module:1	Introduction	5 hours

Types of industries - Characteristics of industrial wastes - Fundamental definition of pollution parameters - Effects of industrial pollutants on environment – air, water and land.

Module:2	Standards and legislation	5 hours

Environmental legislations related to prevention and control of industrial effluents - EP ACT- EIA - EMP - ISO 14000 series - Combined treatment of industrial wastewater - Resource optimization through industrial symbiosis - waste minimization techniques.

Module:3	Industrial air pollution control	7 hours

Air pollution meteorology (generation, transportation and dispersion of air pollutants) - Principles and design of air pollution control equipment: gravity settling chambers - air cyclones - ESPs - filters - wet scrubbers.

Module:4	Industrial waste water treatment	6 hours

Selection, design and performance analysis of industrial waste water treatment processes: Preliminary - Primary - Secondary treatment processes.

Module:5	Advanced wastewater treatment	7 hours

Chemical oxidation - Ozonation - Photo catalysis - Wet Air Oxidation - Adsorption - Evaporation - Ion Exchange - Membrane Technologies.

Module:6	Hazardous Solid waste management	5 hours

Classification of hazardous waste - waste disposal methods - Composting - Landfill- Briquetting -

Gasification - Incineration.		
Module:7	**Case studies**	**8 hours**
Sources - Characteristics - Waste treatment flow sheets for selected industries such as Textiles - Tanneries - Pharmaceuticals - Electroplating - Pulp and Paper - Refineries - Fertilizer - Thermal power plants - Wastewater reclamation concepts.		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Rao C.S., Environmental Pollution Control Engineering, 3rd ed., New Age International Publishers, India, 2018.
2.	Karia G.L., Christian R.A., Wastewater Treatment: Concepts and Design Approach, 2nd ed., Eastern Economy Edition, India, 2013.
Reference Books	
1.	Pollution Control Law Series: PCLS/02/2010, Central Pollution Control Board, 6th ed., India, 2010.
2.	Tchobanoglous G., Theisen H., Vigil S.A., Integrated Solid Waste Management,1st ed., McGraw Hill Education, India, 2014.
3.	Bhatia S.C., Environmental Pollution and Control in Chemical Process Industries, 2nd ed., Khanna publishers, India, 2013.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE4002	L	T	P	J	C
Course title	TRANSPORT PHENOMENA	3	0	0	0	3
Pre-requisite	CHE1006, CHE3003	Syllabus version				
		1.2				

Course Objectives:

1. Emphasis the basic concepts of transport phenomena, the similarities of the governing relations of momentum, heat, and mass transfer
2. Solve appropriate differential equations such as momentum, thermal energy, and mass species balance, accounting convective and diffusive (molecular-scale) fluxes, with sources and sinks to obtain velocity, temperature and concentration profiles
3. Develop design thinking skills to solve various kinds of application oriented problems faced in chemical industries using analytical techniques

Course Outcomes (CO):

1. Understand and relate transport properties of molecular transfer of momentum, energy and mass transport.
2. Solve and physically interpret one-dimensional steady state momentum transfer, heat conduction and species diffusion problems
3. Make use of Navier-Stoke's equation with right boundary conditions to examine the problems related to fluid, heat and mass transfer
4. Evaluate the interphase transport properties for internal flow and external flow and estimate powere that required for fluid flow
5. Understand simultaneous heat, mass and momentum transfer analysis
6. Formulate and solve industrial problems along with appropriate approximations and boundary conditions

Module:1	Transport by Molecular Motion	6 hours

Phenomenological laws of transport properties - Newtonian and non-Newtonian fluids; Rheological models - theories of transport properties of gases and liquids - effect of pressure and temperature - Transport analogy

Module:2	Vector and tensor analysis	2 hours

Vector - coordinate system - time derivatives

Module:3	1D Viscous Flow – Shell Balance	8 hours

General method of shell balance approach to transfer problems; boundary conditions - rectilinear flow - curvilinear flow - momentum flux and velocity distribution - Newtonian fluids – non-Newtonian fluids - pipe - annular flow

Module:4	Equations of Change	8 hours

Equation of Motion and Continuity - Integral Conservation Equations- Navier-Stokes and Euler Equation Constitutive relation - Dimensional analysis – Applications.		
Module:5	**Turbulent Flow and Interphase momentum transfer**	**8 hours**
Turbulent models - RANS equation - Reynolds stresses; Internal flow- External flow - Boundary Layer Theory - Isothermal System - Flow through conduits - Empirical correlation – friction factor, drag coefficient - Ergun Equation - Flow through porous media		
Module:6	**Heat Transfer by conduction and convection**	**6 hours**
Shell Balance - Equations of energy - Heat Transfer coefficient - COMSOL Simulation		
Module:7	**Mass Transfer**	**5 hours**
Microscopic balances - General equations Boundary conditions - Mass transfer co-efficient, Homogeneous reaction, Fixed bed catalytic reactor - steady state system.		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Bird R. B., Stewart W. E., Lightfoot E. N., Transport Phenomena, 2nd ed., John Wiley & Sons Inc., USA. 2012.
2.	Wick C.E., Welty J., Wilson R.E., Fundamentals of Momentum, heat and Mass Transfer, 5th ed., John Wiley & Sons Inc., USA, 2016.
Reference Books	
1.	Thomson W.J., Introduction to Transport Phenomena, Pearson Education Asia, India, 2001.
2.	William M. Dean, Analysis of Transport Phenomena, Oxford University Press, India, 2011.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE4003	L	T	P	J	C
Course title	MODELLING AND SIMULATION IN PROCESS ENGINEERING	2	0	2	0	3
Pre-requisite	CHE3001	Syllabus version				
		2.2				

Course Objectives:

1. Explain the representation and simulation of physical systems using a mathematical formulations
2. Develop the typical mathematical models for the chemical process industries
3. Enhance the skill of engineering software applications which illustrate a variety of modelling techniques

Course Outcomes (CO):

1. Demonstrate the basic principles of chemical engineering for modeling of chemical system
2. Apply mathematical tools to solve model equations
3. Analyze the linear steady state and un-steady state lumped system of process industries
4. Construct the model equations for the Chemical Engineering system
5. Evaluate the model solving ability for various unit processes and unit operations
6. Execute the algorithm for different chemical engineering systems

Module:1	Modeling Conservative Principles and Models	4 hours

Introduction of process modeling; definition of modelling and simulation; different types of models; application of mathematical modeling; Fundamental Laws – Continuity equation, energy equation, and equation of motion, transport equation, equation of state, phase and chemical equilibrium, chemical kinetics

Module:2	Steady State Lumped Systems	4 hours

Degree of freedom analysis; single and network of process units; systems yielding linear and non-linear algebraic equations; solution of linear and non-linear algebraic equations

Module:3	Flow Sheeting and Process design	4 hours

Steady state flow sheeting; approach to flow sheeting systems; introduction to sequential modular approach; simultaneous modular approach and equation solving approach; nested inside-out algorithms

Module:4	Unsteady State Lumped Systems	4 hours

Microscopic balances for Unsteady state and dynamic simulation–liquid level tank–gravity flow tank–jacketed stirred tank heater; Isothermal and Non-isothermal reactors–flash and distillation column; Solution of ODE initial value problems

Module:5	**Dynamic Simulation of Unsteady State Lumped Systems**	**5 hours**
Solution of ODE initial value problems; matrix differential equations; simulation of closed loop systems		
Module:6	**Process Modelling of Distributed Systems**	**4 hours**
Analysis of compressible flow; heat exchanger; plug flow reactor; solution of ODE boundary value problems –Sedimentation–Heat conduction–Diffusion; classification and solution of partial differential equations		
Module:7	**Process modelling of distributed systems-II**	**3 hours**
Pressure vessels–Stresses in thin and thick cylindrical shell due to internal pressure– Circumferential and longitudinal stresses – Spherical shells subjected to internal pressure		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**30 hours**

Text Books

1.	Varma A.K., Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering, 1st ed., CRC Press, USA, 2017.
2.	Bequette B.W., Process Dynamics: Modeling, Analysis and Simulation, 1st ed., Prentice Hall Inc., USA, 2010.

Reference Books

1.	Luyben W.L., Process Modelling Simulation and Control, 3rd ed., McGraw-Hill, USA, 1996.
2.	Ramirez W., Computational Methods in Process Simulation, 2nd ed., Butterworths Publishers, USA, 2005.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

Laboratory Experiments

1.	Develop and solve the objective function for reaction system using Algebric equations	2 hours
2.	Develop mathematical model for two interacting tanks in series	2 hours
3.	Design the jacketed stirred tank heater	2 hours
4.	Optimization of Van de-Vusse reaction kinetics using semi-batch reactor operation	2 hours
5.	Determination of kinetic rate of non-isothermal CSTRs in series	2 hours
6.	Design and Develop the objective functions for Biochemical reactor	2 hours
7.	Analyze the mixing performance of reactant in mixing tank	2 hours
8.	Simulation of unsteady state heat conduction equation using MatLab	2 hours

9.	Solve the elliptic PDE using PDE toolbox	2 hours
10.	Solve the parabolic PDE using PDE toolbox	2 hours
Total Laboratory Hours		20 hours

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

Course code	CHE4005	L	T	P	J	C
Course title	FLUIDIZATION ENGINEERING	3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		1.2				

Course Objectives:

1. Illustrate the physical and chemical concepts aspects of fluidization process
2. Describe the various fluidization regimes and their models
3. Design of various units of fluidized bed widely used in industrial practice

Course Outcomes (CO):

1. Distinguish the behavior of fluidization under various operating conditions
2. Elucidate the various industrial applications of fluidization
3. Determine minimum fluidization velocity and terminal velocity
4. Design suitable gas distributor for fluidized beds
5. Apply various models for designing the fluidized bed systems
6. Analyze the performance of various fluidized bed systems

Module:1	Introduction to Fluidization	7 hours

Concept of Fluidization - Special Features of Fluidization - Comparison with other Contacting Methods - Advantages and Disadvantages of Fluidized Beds - Industrial Applications of Fluidized Beds - Historical Highlights - Physical Operation - Chemical Operations.

Module:2	Characterization of Fluidization I	6 hours

Gross Behavior of Fluidized Beds – Minimum and Terminal Velocities in Fluidized Beds

Module:3	Characterization of Fluidization II	6 hours

Geldart Classifications of Particles – Mapping of Fluidization Regions – Design of Distributors – Power Consumption

Module:4	Bubble Mechanics in Fluidized Beds	7 hours

Bubbles in Dense Beds - Single Rising Bubble - Coalescence and Splitting of Bubbles – Bubble Formation above a Distributor. Bubbling Fluidized Beds - Experimental Findings - Estimation of Bed Properties - Bubbling Bed Model

Module:5	Entrainment and Elutriation	6 hours

Free Board Behavior - Entertainment from Tall and Short Vessels. Constant Approach. Flow Pattern of Gases through Fluidized Beds - Solid Movement - Mixing, Segregation and Staging

Module:6	Heat Transfer in Fluidized Beds	5 hours

Heat Transfer between Fluid and Solid - Determination and Interpretation of Heat Transfer. Heat Transfer between Fluidized Beds and Surface - Experimental Findings and Theoretical Studies

Module:7	**Miscellaneous systems**	**6 hours**
Conical fluidized bed - Inverse fluidized bed - Draft tube systems; Semi fluidized bed systems, Annular systems and typical applications		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Kunii D., Levenspiel O., Fluidization Engineering, 2nd ed., Butterworth Heinemann, UK, 2013.
2.	Yang W.C., Handbook of Fluidization and Fluid – Particle System, 1st ed., CRC Press, USA, 2003.
Reference Books	
1.	Grace J.R., Avidan A.A., Knowlton T.M., Circulating Fluidized Beds, 1st ed., Springer, USA, 2011.
2.	L.G. Gibilaro, Fluidization Dynamics, 1st ed., Butterworth Heinemann, UK, 2001.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	40th	Date	18-03-2016

JULY 2019

CHY1004	Materials & Instrumental Techniques	L	T	P	J	C
		3	0	2	0	4
Pre-requisite	**Chemistry of 12th standard or equivalent**	**Syllabus version**				
		v. 2.0				

Course Objectives:

- To understand the chemistry of engineering materials and the correlation between structure and properties
- To improve analytical capability of students by using instrumental analytical techniques

Course Outcomes:

- Interpret structure, hardening mechanisms, phase behaviour and properties of selected alloys.
- Identify and formulate composite materials and lubricants.
- Develop methods to synthesize nanomaterials.
- Illustrate structures of carbon nanomaterials and apply them in devices.
- Classify and describe semiconductor materials and solar energyconversion methods.
- Determine metals like iron, sodium and potassium using colorimetry and flame emission photometry.
- Analyse crystalline samples employing powder X-ray diffraction using the skills learnt in the class.
- Examine and describe morphology and composition of materials by SEM, EDX and TEM techniques.

Module:1	Metals and Alloys	4 hours

Powder metallurgy - metallic structures and properties – phase behaviour of iron-carbon alloys - hardening mechanisms of steel –shape memory alloys

Module:2	Composite Materials and Lubricants	6 hours

Composites - types of composites - polymer matrix composites, metal matrix composites, ceramic matrix composites; applications of composites in automobiles and aerospace industries.
Lubricants - classification, properties and mechanism of different types of lubricants.

Module:3	Nanomaterials - I	6 hours

Basics of nanomaterials - unique properties of nanomaterials and their benefits; size dependency on properties of CdSe nanocrystals and silver nanoparticles; preparation of nanomaterials: top-down and bottom-up approaches- high-energy ball milling, sol-gel method, solution phase synthesis of copper nanoparticles
Fullerene - preparation by laser evaporation and arc methods, properties of fullerenes and their applications

Module:4	Nanomaterials - II	6 hours

Carbon nanotubes and graphene- preparation of carbon nanotubes by laser evaporation, arc discharge method and CVD, properties and applications of carbon nanotubes; Graphene - preparation, properties and applications;engineering applications of nanomaterials, nanoelectromechanical systems (NEMS)

Module:5	**Semiconductor Materials and Solar Energy Conversion**	**11 hours**
Band gap – Fermi level; importance of silicon – silicon wafer preparation- metallurgical silicon, electronic grade silicon, single crystal silicon, float zone technique; chemical processes involved in preparation of complementary metal-oxide-semiconductor (CMOS) IC - photolithography, wet etching, plasma etching, ion implantation, metalation, thin film deposition; alternatives to silicon Solar energy conversion methods - principles and devices – photovoltaic cells, p-n junction solar cell, liquid junction solar cell, multiple junction solar cell, dye-sensitized solar cell.		
Module:6	**Spectroscopic Techniques**	**5 hours**
Interaction between electromagnetic radiation and matter – absorption and emission spectroscopy– Beer-Lambert law; spectrometric instrumentation principle, instrumentation of UV-Vis spectroscopy; colorimetric determination of Iron in steel; atomic absorption spectroscopy-principle, instrumentation and determination of lead in an environmental sample; Flame emissions photometry-principle, instrumentation and determination of Na and K present in water		
Module:7	**Diffraction and Microscopic Techniques**	**5 hours**
powder X-ray diffraction - principle and instrumentation; XRD pattern of ruby Electron microscopy - TEM, SEM, SEM-EDAX - principle, instrumentation and application; characterization of metal nanoparticles using electron microscopy		
Module:8	**Contemporary Issues**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Bradley D. Fahlman, "Materials Chemistry", 2011, 2nd Edition, Springer Publications, New York.
2.	Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, "Analytical Chemistry", 2013, 7th Edition, John Wiley & Sons, Inc., New York.

Reference Books

1.	Douglas A Skoog, F James Holler, Stanley R Crouch, 2016, 7th Edition, "Principles of Instrumental Analysis", Cengage Learning, Boston, USA.
2.	Ray F. Egerton., "Physical Principles of Electron Microscopy – An introduction to TEM, SEM and AFM", 2016, 2nd Edition, Springer, USA,

Mode of Evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & FAT

List of Challenging Experiments (Indicative)

1.	Preparation of ruby by combustion method and X-ray diffraction analysis	1 hour
2.	**Preparation of semiconductor ZnO nanoparticles and UV-Vis spectroscopic analysis**	2 hours
3.	Analysis of copper in brass using iodometry	2 hours
4.	Quantification of sodium and potassium in oral dehydration solution by flame photometry	2 hours

5.	Estimation of sulphate ions in water by light scattering technique			2 hours
6.	Quantification divalent iron content in steel using calorimetry			2 hours
7.	Aromatic content of given lubricating oil by measuring its aniline point			1 hour
8.	Determination of pour point and cloud point of a lubricant oil			1 hour
9.	Quality checking of lubricant by measuring its viscosity			1 hour
10.	Photodegradation kinetics of methylene blue dye by nano ZnO photocatalyst			2 hours
11.	Preparation of Cu/CuO nanoparticles and imaging using electron microscopy			1 hour
12.	Preparation of iron nanoparticles and investigating its magnetic property			1 hour
			Total Laboratory Hours	18 hours
Mode of Evaluation: Viva-voce and Lab performance & FAT				
Recommended by Board of Studies	12.08.2017			
Approved by Academic Council	No. 46	Date	24.08.2017	

EEE1001	Basic Electrical and Electronics Engineering	L	T	P	J	C
		2	0	2	0	3
Pre-requisite	NIL	Syllabus version				
		v. 1.0				

Course Objectives:

1. To understand the various laws and theorems applied to solve electric circuits and networks
2. To provide the students with an overview of the most important concepts in Electrical and Electronics Engineering which is the basic need for every engineer

Course Outcomes:

1. Solve basic electrical circuit problems using various laws and theorems
2. Analyze AC power circuits and networks, its measurement and safety concerns
3. Classify and compare various types of electrical machines
4. Design and implement various digital circuits
5. Analyze the characteristics of semiconductor devices and comprehend the various modulation techniques in communication engineering
6. Design and conduct experiments to analyze and interpret data

Module:1	DC circuits	5 hours

Basic circuit elements and sources, Ohms law, Kirchhoff's laws, series and parallel connection of circuit elements, Node voltage analysis, Mesh current analysis, Thevenin's and Maximum power transfer theorem

Module:2	AC circuits	6 hours

Alternating voltages and currents, AC values, Single Phase RL, RC, RLC Series circuits, Power in AC circuits-Power Factor- Three Phase Systems – Star and Delta Connection- Three Phase Power Measurement – Electrical Safety –Fuses and Earthing, Residential wiring

Module:3	Electrical Machines	7 hours

Construction, Working Principle and applications of DC Machines, Transformers, Single phase and Three-phase Induction motors, Special Machines-Stepper motor, Servo Motor and BLDC motor

Module:4	Digital Systems	5 hours

Basic logic circuit concepts, Representation of Numerical Data in Binary Form- Combinational logic circuits, Synthesis of logic circuits

Module:5	Semiconductor devices and Circuits	7 hours

Conduction in Semiconductor materials, PN junction diodes, Zener diodes, BJTs, MOSFETs, Rectifiers, Feedback Amplifiers using transistors. Communication Engineering: Modulation and Demodulation - Amplitude and Frequency Modulation

	Total Lecture hours:	30 hours	

Text Book(s)				
1.	1. John Bird, 'Electrical circuit theory and technology ', Newnes publications, 4 th Edition, 2010.			
Reference Books				
1.	Allan R. Hambley, 'Electrical Engineering -Principles & Applications' Pearson Education, First Impression, 6/e, 2013			
2.	Simon Haykin, 'Communication Systems', John Wiley & Sons, 5 t h Edition, 2009.			
3.	Charles K Alexander, Mathew N O Sadiku, 'Fundamentals of Electric Circuits', Tata McGraw Hill, 2012.			
4.	Batarseh, 'Power Electronics Circuits', Wiley, 2003			
5.	H. Hayt, J.E. Kemmerly and S. M. Durbin, 'Engineering Circuit Analysis', 6/e, Tata McGraw Hill, New Delhi, 2011.			
7.	Fitzgerald, Higgabogan, Grabel, 'Basic Electrical Engineering', 5t h edn, McGraw Hill, 2009.			
8.	S.L.Uppal, 'Electrical Wiring Estimating and Costing ', Khanna publishers, NewDelhi, 2008.			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar				
List of Challenging Experiments (Indicative)				
1.	Thevenin's and Maximum Power Transfer Theorems – Impedance matching of source and load			2 hours
2.	Sinusoidal steady state Response of RLC circuits			2 hours
3.	Three phase power measurement for ac loads			2 hours
4.	Staircase wiring circuit layout for multi storey building			2 hours
5.	Fabricate and test a PCB layout for a rectifier circuit			2 hours
6.	Half and full adder circuits.			2 hours
7.	Full wave Rectifier circuits used in DC power supplies. Study the characteristics of the semiconductor device used			2 hours
8.	Regulated power supply using zener diode. Study the characteristics of the Zener diode used			2 hours
9.	Lamp dimmer circuit (Darlington pair circuit using transistors) used in cars. Study the characteristics of the transistor used			2 hours
10.	Characteristics of MOSFET			2 hours
			Total Laboratory Hours	20 hours
Mode of assessment: Assignment / FAT				
Recommended by Board of Studies	29/05/2015			
Approved by Academic Council	37th AC	Date	16/06/2015	

Course code	RENEWABLE ENERGY SOURCES	L	T	P	J	C
MEE1011		2	2	2	0	4
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To help students gain essential knowledge on the importance of various renewable energy sources
2. To familiarize the students with principles of energy conversion for various renewable energy sources
3. To do practical experiments for energy resource performance under different operating conditions
4. To understand the method for assessment of various input energy resources for meeting the specific requirements.
5. To know the limitations in renewable energy conversion techniques

Course Outcomes:

1. Explain the current energy scenario and requirement of migration to renewable energy sources
2. Demonstrate the knowledge of various solar thermal energy applications
3. Design solar PV systems under stand-alone mode and analyze the performance of solar cells
4. Design a bio-gas digester
5. Analyze the performance of wind mills
6. Assess the power potential of a given site and choose adequate hydro turbine
7. Explain various methods for harvesting the ocean energy
8. Experimentally determine performance of various renewable energy conversion devices working under different operating conditions

Module:1	Classification of Energy	5 hours

Energy chain and common forms of usable energy - Present energy scenario - World energy status - Energy scenario in India - Introduction to renewable energy resources - Introduction to Solar Energy - Energy from Sun - Spectral distribution of Solar radiation - Instruments for measurement of solar radiation - Solar radiation data analysis

Module:2	Applications of Solar Energy	6 hours

Thermal applications - Introduction to Solar thermal collectors - Types - Principle of operation of different collectors - Flat plate - Evacuated tube collectors - Compound parabolic collectors - Solar air heaters - Solar dryers -solar cookers - solar stills - Solar ponds - concentrating collectors - line type - point type - Methods of Solar power generation - Power towers

Module:3	Introduction to Solar Photovoltaics	5 hours

Physics of solar cells - Cell and module. Manufacturing Process– Characteristics of cells and module - Performance parameters -BoS- PV System applications - Stand alone- Grid connected systems.		
Module:4	**Bio Energy Sources**	**4 hours**
Energy through various processes - Energy through fermentation - Gasification - various types of gasifiers -Pyrolysis - Fixed bed and fast Pyrolysis - Bio energy through digestion - Types of Digesters- Factors affecting the yield of products.		
Module:5	**Wind Energy**	**4 hours**
resource assessment - types of wind turbines - selection of components - blade materials - power regulation - various methods of control - wind farms - site selection - off shore wind farms - Solar Wind Hybrid energy systems.		
Module:6	**Small Hydro Power Systems**	**2 hours**
Introduction - types - system components, discharge curve and estimation of power potential - Turbines for SHP.		
Module:7	**Ocean Energy**	**2 hours**
Power generation through OTEC systems - various types - Energy through waves and tides - Energy generation through geothermal systems – types.		
Module:8	**Contemporary issues:**	**2 hours**
Discussion on Recent developments in the area of renewable energy systems and their integration		
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	John Andrews, Nick Jelley (2013), Energy Science: Principles, technologies and impacts, Oxford Universities press.
Reference Books	
1.	Fang Lin You, Hong ye (2012), Renewable Energy Systems, Advanced conversion
	technologies and applications, CRC Press
2	John.A.Duffie, William A.Beckman (2013), Solar Engineering of Thermal processes, Wiley
3	A.R.Jha (2010), Wind Turbine technology, CRC Press.
4	Godfrey Boyle (2012), Renewable Energy, power for a sustainable future, Oxford University Press..

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)		
1.	1. Estimation of Solar radiation: Pyranometer, pyrheliometer. 2. Testing the yield of a Solar still in outdoor conditions (Multiple sessions). 3. Wind Energy Experimental Set up – I. 4. Wind Energy Experimental Set up – II. 5. Testing of Solar PV system in PV training Kit. 6. Fuel Cell Experiment. 7. Performance of Biomass stove. 8. Production of Bio-diesel by Transesterification process. 9. Flash Point and Fire point comparison for conventional fuels and alternate fuels. 10. Production of Hydrogen from Electrolysis with PV system. 11. Estimation of Figures of Merit in a Solar cooker. 12. Performance characteristics of a Solar thermal collector. 13. Exergy analysis of a Solar cabinet dryer.	30 x 14
	Total Laboratory Hours	17 hours
Mode of assessment:		
Recommended by Board of Studies	17-08-2017	
Approved by Academic Council	No. 47	Date 05-10-2017

Course code	COMPUTATIONAL FLUID DYNAMICS	L	T	P	J	C
MEE4006		2	1	2	0	4
Pre-requisite	MEE1004, MEE2005, MAT3005 (or) MEE1032, MEE1033/MEE2005, MAT3005	Syllabus version				
		v. 2.2				

Course Objectives:

1. To provide the students with sufficient background to understand the mathematical representation of the governing equations for fluid flow and heat transfer problems.
2. To equip the students to address complex fluid flow and heat transfer problems by approximating the governing differential equations with boundary conditions through Finite difference and finite volume discretization methods.
3. To enable students to understand different types of grid and its attributes and their suitability for different engineering applications
4. Develop the students to use appropriate turbulence model for solving engineering problems.

Course Outcomes:

1. Apply mathematics and engineering fundamentals to recognize the type of fluid flow and heat transfer that occur in a particular physical system and to use the appropriate model equations to investigate the problem.
2. Solve governing equations using finite difference discretization technique
3. Solve governing equations using finite volume method
4. Generate appropriate type of grids required for solving engineering problems accurately.
5. Apply suitable turbulence model for the chosen real world engineering problems.
6. Solve fluid flow and heat transfer problems using commercial CFD tools

Module:1	Introduction	1 hour

CFD overview - Applications of CFD.

Module:2	Governing Equations of Fluid Dynamics and Heat Transfer:	6 hours

Models of Flow – Conservation and Non-conservation form - Continuity, Momentum and Energy Equation in conservation and non-conservation form (differential equations only) - Characteristics of PDE's - elliptic, parabolic and hyperbolic.

Module:3	Discretization and Finite Difference method	7 hours

Discretization: Basic aspects of Discretization – Comparison of finite difference, finite volume and finite element techniques.

Finite Difference method: Forward, Backward and Central difference schemes, Transient one and two dimensional conduction - Explicit, implicit, semi-implicit and ADI methods - Stability analysis and error estimation.

Module:4	**Grid Generation**	**3 hours**
Grid Generation: Choice of grid, grid oriented velocity components, Cartesian velocity components, staggered and collocated arrangements.		
Module:5	**Convection and Diffusion**	**7 hours**
Convection and Diffusion: Steady one-dimensional convection and diffusion - Central difference, upwind, quick, exponential, hybrid and power law schemes- False diffusion, SIMPLE – Algorithm.		
Module:6	**Turbulence Modeling**	**4 hours**
Turbulence Modeling : Introduction – Types of Turbulence modeling – Reynolds Time Averaging – Reynolds Time Averaged conservation equations – Boussinesq approach – One equation k - □ model.		
Module:7	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**30hours**

Text Book(s)	
1.	John D Anderson, Computational Fluid Dynamics – The Basics with Applications, 1st Edition, McGraw Hill, 2012.
Reference Books	
1.	Chung T.J, Computational Fluid Dynamics, Cambridge University Press, 2014.
2.	Muralidhar K and Sundararajan T, Computational Fluid Flow and Heat Transfer, Narosa Publications, New Delhi, 2014.
3.	Versteeg H.K and Malalasekara W, An Introduction to Computational Fluid Dynamics - The Finite Volume Method, 2nd Edition, Pearson, 2010.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)		
1.	Modeling of simple and complex geometries.	3 hours
2.	Hexahedral meshing for simple geometries like square duct, circular pipe.	3 hours
3.	O-grid hexa meshing for circular pipe.	3 hours
4.	Tetrahedral meshing for simple geometries including fluid and solid domains.	3 hours
5.	Preprocessing in FLUENT – Case setup and analyzing for already mesh generated model.	3 hours
6.	Steady state temperature distribution in a rectangular plate (ANSYS Fluent and FDM).	3 hours
7.	Diffuser for a hydropower turbine.	3 hours

8.	Flow over an airfoil - Laminar and turbulent flow.			3 hours
9.	Supersonic flow past a wedge in a channel.			3 hours
10.	Exercise (for each student – different exercise) from FLUENT tutorial (case setup, analyzing, and post-processing).			3 hours
			Total Laboratory Hours	**30 hours**
Mode of assessment:				
Recommended by Board of Studies	17-08-2017			
Approved by Academic Council	47	Date	05-10-2017	