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

[2019-2020 admitted students]

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 THE SCHOOL OF CHEMICAL ENGINEERING

To improve the quality of life through innovations in Chemical Engineering

MISSION STATEMENT OF THE 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.

B. Tech Chemical Engineering

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 recognize the need for independent and lifelong learning

B. Tech Chemical Engineering

PROGRAMME SPECIFIC OUTCOMES (PSOs)

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

1. Analyze 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 (SCHEME)

B. Tech Chemical Engineering

CREDIT STRUCTURE

Category-wise Credit distribution

Category	Credits
University core (UC)	**53**
Programme core (PC)	**60**
Programme elective (PE)	**35**
University elective (UE)	**12**
Total credits	**160**

B. Tech Chemical Engineering

University Core

S.No	Course Code	Course Title	L	T	P	J	C
1	CHE1901	Technical Answers for Real World Problems (TARP)	1	0	0	4	2
2	CHE1902	Industrial Internship	0	0	0	0	1
3	CHE1903	Comprehensive Examination	0	0	0	0	1
4	CHE1904	Capstone Project	0	0	0	0	12
5	CHY1701	Engineering Chemistry	3	0	2	0	4
6	CSE1001	Problem Solving and Programming	0	0	6	0	3
7	CSE1002	Problem Solving and Object Oriented Programming	0	0	6	0	3
8	ENG1901/ ENG1902/ ENG1903	Technical English I Technical English II Advanced Technical English	0/ 0/ 0	0/ 0/ 0	4/ 4/ 2	0/ 0/ 4	2
9	FLC4097	Foreign Language Courses Basket	2	0	0	0	2
10	HUM1021	Ethics and Values	2	0	0	0	2
11	MAT1011	Calculus for Engineers	3	0	2	0	4
12	MAT2001	Statistics for Engineers	3	0	2	0	4
13	MGT1022	Lean Start-up Management	1	0	0	4	2
14	PHY1701	Engineering Physics	3	0	2	0	4
15	PHY1901	Introduction to Innovative Projects	1	0	0	0	1
16	STS 1101 STS 1201	Fundamentals of Aptitude Introduction to problem solving	0	0	0	0	1
17	STS 1102 STS 1202	Arithmetic problem solving Introduction to quantitative, logical and verbal ability	0	0	0	0	1
18	STS 2101	Getting started to skill enhancement	0	0	0	0	1

	STS 2201	Numerical ability and cognitive intelligence					
19	STS 2102 STS 2202	Enhancing problem solving skills Advanced aptitude and reasoning skills	0	0	0	0	1
20	STS 3101 STS 3201	Introduction to programming skills Programming skills for employment	0	0	0	0	1
BRIDGE COURSE – NON CREDIT COURSE							
1	CHY1002	Environmental Sciences	3	0	0	0	3
2	ENG1000/ ENG2000	Foundation English I Foundation English II	0	0	4	0	2
3	EXC4097	Extra & Co- Curricular Activities	0	0	0	0	2
	Total Credits (A)		60				
	Non Credit Course (B)		7				
	University Core Courses (A-B)		53				

B. Tech Chemical Engineering

Programme Core

Sl. No	Course Code	Course Title	L	T	P	J	C
1	CHE1001	Materials Science and Strength of Materials	3	0	0	0	3
2	CHE1002	Process Calculations	4	0	0	0	4
3	CHE1003	Process Engineering Thermodynamics	3	0	0	4	4
4	CHE1004	Chemical Technology	3	0	0	0	3
5	CHE1005	Momentum Transfer	3	0	2	0	4
6	CHE1006	Heat Transfer	2	0	2	4	4
7	CHE1022	Mechanical Operations	3	0	2	0	4
8	CHE2001	Chemical Reaction Engineering	3	0	2	0	4
9	CHE2002	Process Equipment Design and Economics	2	0	2	4	4

10	CHE3001	Computational Methods in Process Engineering	3	0	2	0	4
11	CHE3002	Process Instrumentation and Control	2	0	2	4	4
12	CHE3003	Mass Transfer	3	0	0	0	3
13	CHE4001	Equilibrium Staged Operations	2	0	2	4	4
14	MAT2002	Applications of Differential and Difference Equations	3	0	2	0	4
15	MAT3003	Complex Variables and Partial Differential Equations	3	1	0	0	4
16	MEE1001	Engineering Drawing	1	0	4	0	3
Total							60

B. Tech Chemical Engineering

Programme Electives

Sl. No.	Course Code	Course Title	L	T	P	J	C
1	CHE1007	Safety and Hazard Analysis	2	0	0	4	3
2	CHE1008	Unit Processes in Organic Synthesis	3	0	2	0	4
3	CHE1009	Biochemical Engineering	3	0	0	0	3
4	CHE1010	Process Plant Utilities	3	0	0	0	3
5	CHE1011	Optimization of Chemical Processes	3	0	0	0	3
6	CHE1013	Natural Gas Engineering	3	0	0	0	3
7	CHE1014	Petroleum Technology	3	0	0	0	3
8	CHE1015	Petrochemical Technology	3	0	0	0	3
9	CHE1016	Fermentation Technology	3	0	0	0	3
10	CHE1017	Food Process Engineering	2	0	0	4	3
11	CHE1018	Membrane Separations Technology	3	0	0	0	3
12	CHE1019	Polymer Technology	3	0	0	0	3
13	CHE1020	Fertilizer Technology	3	0	0	0	3

14	CHE1023	Production and Operations Management	3	0	0	0	3
15	CHE2003	Chemical Product Design	3	0	0	0	3
16	CHE2006	Fuels and Combustion	3	0	0	0	3
17	CHE2007	Process Intensification	3	0	0	0	3
18	CHE2008	Chemical Engineering Computational Fluid Dynamics	2	0	0	4	3
19	CHE3004	Heterogeneous Reaction Engineering	2	0	0	4	3
20	CHE3005	Chemical Process Integration	3	0	0	0	3
21	CHE3006	Process Plant Simulation	3	0	0	4	4
22	CHE3007	Multiphase Flow	3	0	0	0	3
23	CHE3008	Industrial Pollution Engineering	3	0	0	0	3
24	CHE3010	Colloids and Interfacial Sciences	3	0	0	0	3
25	CHE4002	Transport Phenomena	3	0	0	0	3
26	CHE4003	Modelling and Simulation in Process Engineering	2	0	2	0	3
27	CHE4005	Fluidization Engineering	3	0	0	0	3
28	CHE4006	Introduction to Molecular Dynamics and Simulation	3	0	0	0	3
29	CHE4007	Rheology of Complex Fluids	3	0	0	0	3
30	CHY1004	Materials and Instrumental Techniques	3	0	2	0	4
31	EEE1001	Basic Electrical and Electronics Engineering	2	0	2	0	3
32	MEE1011	Renewable Energy Sources	2	2	2	0	4
33	MEE4006	Computational Fluid Dynamics	2	2	2	0	4

University Elective Baskets

Management courses

Sl.No	**Code**	**Title**	**L**	**T**	**P**	**J**	**C**
1	MGT1001	Basic Accounting	3	0	0	0	3
2	MGT1002	Principles of Management	2	0	0	4	3
3	MGT1003	Economics for Engineers	2	0	0	4	3

4	MGT1004	Resource Management	2	0	0	4	3
5	MGT1005	Design, Systems and Society	2	0	0	4	3
6	MGT1006	Environmental and Sustainability Assessment	2	0	0	4	3
7	MGT1007	Gender, Culture and Technology	2	0	0	4	3
8	MGT1008	Impact of Information Systems on Society	2	0	0	4	3
9	MGT1009	Technological Change and Entrepreneurship	2	0	0	4	3
10	MGT1010	Total Quality Management	2	2	0	0	3
11	MGT1014	Supply Chain Management	3	0	0	0	3
12	MGT1015	Business Mathematics	3	0	0	0	3
13	MGT1016	Intellectual Property Rights	3	0	0	0	3
14	MGT1017	Business Regulatory Framework For Start-ups	3	0	0	0	3
15	MGT1018	Consumer Behaviour	3	0	0	0	3
16	MGT1019	Services Marketing	3	0	0	0	3
17	MGT1020	Marketing Analytics	2	0	2	0	3
18	MGT1021	Digital and Social Media Marketing	3	0	0	0	3
19	MGT1022	Lean Start-up Management	1	0	0	4	2
20	MGT1023	Fundamentals of Human Resource Management	3	0	0	4	4
21	MGT1024	Organizational Behaviour	3	0	0	4	4
22	MGT1025	Foundations of Management And Organizational Behaviour	3	0	0	4	4
23	MGT1026	Information Assurance and Auditing	2	0	0	4	3
24	MGT1028	Accounting and Financial Management	2	2	0	4	4
25	MGT1029	Financial Management	2	1	0	4	4
26	MGT1030	Entrepreneurship Development	3	0	0	4	4
27	MGT1031	International Business	3	0	0	4	4
28	MGT1032	Managing Asian Business	3	0	0	4	4
29	MGT1033	Research Methods in Management	2	1	0	4	4
30	MGT1034	Project Management	3	0	0	4	4
31	MGT1035	Operations Management	3	0	0	0	3
32	MGT1036	Principles of Marketing	3	0	0	4	4
33	MGT1037	Financial Accounting and Analysis	2	1	0	4	4

34	MGT1038	Financial Econometrics	2	0	0	4	3
35	MGT1039	Financial Markets and Institutions	2	0	0	4	3
36	MGT1040	Personal Financial Planning	2	0	0	4	3
37	MGT1041	Financial Derivatives	2	1	0	4	4
38	MGT1042	Investment Analysis and Portfolio Management	2	0	0	4	3
39	MGT1043	Applications in Neuro Marketing	3	0	0	4	4
40	MGT1044	Global Brand Marketing Strategies	3	0	0	4	4
41	MGT1045	Industrial Marketing	3	0	0	4	4
42	MGT1046	Sales and Distribution Management	3	0	0	4	4
43	MGT1047	Social Marketing	3	0	0	4	4
44	MGT1048	Political Economy of Globalization	3	0	0	4	4
45	MGT1049	Sustainable Business Models	3	0	0	4	4
46	MGT1050	Software Engineering Management	2	0	0	4	3
47	MGT1051	Business Analytics for Engineers	2	2	0	0	3
48	MGT1052	Bottom of the Pyramid Operations	3	0	0	0	3
49	MGT1053	Entrepreneurship Development, Business Communication and IPR	1	0	2	0	2
50	MGT1054	Product Planning and Strategy	2	2	0	0	3
51	MGT1055	Design Management	2	2	0	0	3
52	MGT1056	Accounting and Financial Management	3	0	0	4	4
53	MGT6001	Organizational Behaviour	2	0	0	4	3

Humanities courses

Sl.No	**Code**	**Title**	**L**	**T**	**P**	**J**	**C**
1	HUM1001	Fundamentals of Cyber Laws	3	0	0	0	3
2	HUM1002	Business Laws	3	0	0	0	3
3	HUM1003	Basic Taxation for Engineers	3	0	0	0	3
4	HUM1004	Corporate Law for Engineers	3	0	0	0	3
5	HUM1005	Cost Accounting for Engineers	3	0	0	0	3
6	HUM1006	Business Accounting for Engineers	3	0	0	0	3
7	HUM1007	Contemporary Legal Framework for Business	3	0	0	0	3
8	HUM1009	International Business	3	0	0	0	3
9	HUM1010	Foreign Trade Environment	3	0	0	0	3
10	HUM1011	Export Business	3	0	0	0	3

11	HUM1012	Introduction to Sociology	3	0	0	0	3
12	HUM1013	Population Studies	3	0	0	0	3
13	HUM1021	Ethics and Values	2	0	0	0	2
14	HUM1022	Psychology in Everyday Life	2	0	0	4	2
15	HUM1023	Indian Heritage and Culture	2	0	0	4	2
16	HUM1024	India and Contemporary World	2	0	0	4	2
17	HUM1025	Indian Classical Music	1	0	2	4	1
18	HUM1033	Micro Economics	3	0	0	0	3
19	HUM1034	Macro Economics	3	0	0	0	3
20	HUM1035	Introductory Econometrics	2	0	2	0	2
21	HUM1036	Engineering Economics and Decision Analysis	2	0	0	4	2
22	HUM1037	Applied Game Theory	2	0	0	4	2
23	HUM1038	International Economics	3	0	0	0	3
24	HUM1039	Community Development in India	2	0	0	4	2
25	HUM1040	Indian Social Problems	3	0	0	0	3
26	HUM1041	Indian Society Structure and Change	3	0	0	0	3
27	HUM1042	Industrial Relations and Labour Welfare in India	3	0	0	0	3
28	HUM1043	Mass Media and Society	2	0	0	4	2
29	HUM1044	Network Society	3	0	0	0	3
30	HUM1045	Introduction to Psychology	2	0	2	0	2
31	HUM1706	Business Accounting for Engineers	3	0	0	0	3

UNIVERSITY CORE

Course code	Technical Answers for Real World Problems (TARP)	L	T	P	J	C
CHE1901		1	0	0	4	2
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

CHE1902	Industrial Internship	L	T	P	J	C
		0	0	0	0	1
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	Comprehensive Examination	L	T	P	J	C
CHE1903		0	0	0	0	1
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, chloro-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
CHE1904	Capstone Project	0	0	0	0	12
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. Synthesize the results and arrive at scientific conclusions / products / solution
6. Document the results in the form of technical report / presentation

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	Engineering Chemistry	L	T	P	J	C
CHY1701		3	0	2	0	4
Pre-requisite	Chemistry of 12th standard or equivalent	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 (CO):

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. 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

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		**CO: 6**
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	3 h
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 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	55th 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				
		1.0				

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 Outcome:

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 at les 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	4 hours
2.	Introduction to Python, Demo on IDE, Keywords, Identifiers, I/O Statements, Simple Program to display Hello world in Python.	4 hours
3.	Operators and Expressions in Python	4 hours
4.	Algorithmic Approach 1: Sequential	2
5.	Algorithmic Approach 2: Selection (if, elif, if.. else, nested if else	2 hours
6.	Algorithmic Approach 3: Iteration (while and for)	4 hours
7.	Strings and its Operations	2 hours
8.	Regular Expressions	2 hours
9.	List and its operations.	2 hours
10.	Dictionaries: operations	2 hours
11.	Tuples and its operations	2 hours
12.	Set and its operations	2 hours
13.	Functions, Recursions	2 hours
14.	Sorting Techniques (Bubble/Selection/Insertion)	4 hours
15.	Searching Techniques : Sequential Search and Binary Search	3 hours
16.	Files and its Operations	4 hours
	Total Laboratory 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: PAT / CAT/ FAT		
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	04-04-2014		
Approved by Academic Council	38th AC	Date	23-10-2015

Course code	Problem Solving And Object Oriented Programming	L	T	P	J	C
CSE1002		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 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 specier 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 over-loading 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-dened exception) - Function template , Class template Template with inheritance , STL Container, Algorithm, Iterator - vector, list, stack, map.

Module:6	**IO Streams and Files**	**10 hours**
IO streams and Files IO streams, Manipulators- overloading Inserters(<<) and Extractors(>>)Sequential and Random files – writing and reading objects into/from files		
	Total Lecture 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

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 once and returns back to the post o_ce after delivering all the mails. Implement an algorithm to help the post man to walk minimum distance for the purpose.	5 hrs
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 pro_t.	5 hrs.
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.	5 hrs.

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 hrs
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.	5 hrs
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.	5 hrs
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.	5 hrs

Recommended by Board of Studies	29.10.2015		
Approved by Academic Council	39th AC	Date	17-12-2015

Course Code	Course Title	L	T	P	J	C
ENG1901	Technical English - I	0	0	4	0	2
Pre-requisite	Foundation English-II	Syllabus Version				
		1				

Course Objectives:

1. To enhance students' knowledge of grammar and vocabulary to read and write error-free language in real life situations.
2. To make the students' practice the most common areas of written and spoken communications skills.
3. To improve students' communicative competency through listening and speaking activities in the classroom.

Course Outcomes:

1. Develop a better understanding of advanced grammar rules and write grammatically correct sentences.
2. Acquire wide vocabulary and learn strategies for error-free communication.
3. Comprehend language and improve speaking skills in academic and social contexts.
4. Improve listening skills so as to understand complex business communication in a variety of global English accents through proper pronunciation.
5. Interpret texts, diagrams and improve both reading and writing skills which would help them in their academic as well as professional career.

Module:1	Advanced Grammar	4 hours

Articles, Tenses, Voice and Prepositions
Activity: Worksheets on Impersonal Passive Voice, Exercises from the prescribed text

Module:2	Vocabulary Building I	4 hours

Idioms and Phrases, Homonyms, Homophones and Homographs
Activity: Jigsaw Puzzles; Vocabulary Activities through Web tools

Module:3	Listening for Specific Purposes	4 hours

Gist, monologues, short conversations, announcements, briefings and discussions
Activity: Gap filling; Interpretations

Module:4	Speaking for Expression	6 hours

Introducing oneself and others, Making Requests & responses, Inviting and Accepting/Declining Invitations Activity: Brief introductions; Role-Play; Skit.

Module:5	Reading for Information	4 hours

Reading Short Passages, News Articles, Technical Papers and Short Stories
Activity: Reading specific newspaper articles; blogs

Module:6	Writing Strategies	4 hours

Joining the sentences, word order, sequencing the ideas, introduction and conclusion Activity: Short Paragraphs; Describing familiar events; story writing

Module:7	Vocabulary Building II

Enrich the domain specific vocabulary by describing Objects, Charts, Food, Sports and Employment.
Activity: Describing Objects, Charts, Food, Sports and Employment

Module:8	**Listening for Daily Life**	**4 hours**
Listening for statistical information, Short extracts, Radio broadcasts and TV interviews Activity: Taking notes and Summarizing		
Module:9	**Expressing Ideas and Opinions**	**6 hours**
Telephonic conversations, Interpretation of Visuals and describing products and processes. Activity: Role-Play (Telephonic); Describing Products and Processes		
Module: 10	**Comprehensive Reading**	**4 hours**
Reading Comprehension, Making inferences, Reading Graphics, Note-making, and Critical Reading. Activity: Sentence Completion; Cloze Tests		
Module: 11	**Narration**	**4 hours**
Writing narrative short story, Personal milestones, official letters and E-mails. Activity: Writing an E-mail; Improving vocabulary and writing skills.		
Module:12	**Pronunciation**	**4 hours**
Speech Sounds, Word Stress, Intonation, Various accents Activity: Practicing Pronunciation through web tools; Listening to various accents of English		
Module:13	**Editing**	**4 hours**
Simple, Complex & Compound Sentences, Direct & Indirect Speech, Correction of Errors, Punctuations. Activity: Practicing Grammar		
Module:14	**Short Story Analysis**	**4 hours**
"The Boundary" by Jhumpa Lahiri Activity: Reading and analyzing the theme of the short story.		
	Total Lecture hours	**60 hours**
Text Book / Workbook		
1.	Wren, P.C.; Martin, H.; Prasada Rao, N.D.V. (1973–2010). *High School English Grammar & Composition*. New Delhi: Sultan Chand Publishers.	
2	Kumar, Sanjay,; Pushp Latha. (2018) English Language and Communication Skills for Engineers, India: Oxford University Press.	
Reference Books		
1.	Guptha S C, (2012) *Practical English Grammar & Composition*, 1st Edition, India: Arihant Publishers	

2.	Steven Brown, (2011) Dorolyn Smith**,** *Active Listening* ***3,*** 3rd Edition, UK: Cambridge University Press.
3.	Liz Hamp-Lyons, Ben Heasley, (2010) *Study Writing*, 2nd Edition, UK: Cambridge University Pres.
4.	Kenneth Anderson, Joan Maclean, (2013) Tony Lynch, *Study Speaking*, 2nd Edition, UK: Cambridge, University Press.
5.	Eric H. Glendinning, Beverly Holmstrom, (2012) *Study Reading*, 2nd Edition, UK: Cambridge University Press.
6.	Michael Swan, (2017) *Practical English Usage* (Practical English Usage), 4th edition, UK: Oxford University Press.
7.	Michael McCarthy, Felicity O'Dell, (2015) *English Vocabulary in Use Advanced* (South Asian Edition), UK: Cambridge University Press.
8.	Michael Swan, Catherine Walter, (2012) *Oxford English Grammar Course Advanced*, Feb, 4th Edition, UK: Oxford University Press.
9.	Watkins, Peter. (2018) *Teaching and Developing Reading Skills: Cambridge Handbooks for Language teachers*, UK: Cambridge University Press.
10.	(*The Boundary by Jhumpa Lahiri)* URL: https://www.newyorker.com/magazine/2018/01/29/the-boundary?intcid=inline_amp

Mode of evaluation: Quizzes, Presentation, Discussion, Role play, Assignments and FAT

List of Challenging Experiments (Indicative)		
1.	Self-Introduction	**12 hours**
2.	Sequencing Ideas and Writing a Paragraph	**12 hours**
3.	Reading and Analyzing Technical Articles	**8 hours**
4.	Listening for Specificity in Interviews (Content Specific)	**12 hours**
5.	Identifying Errors in a Sentence or Paragraph	**8 hours**
6.	Writing an E-mail by narrating life events	**8 hours**
	Total Laboratory Hours	**60 hours**

Mode of evaluation: Quizzes, Presentation, Discussion, Role play, Assignments and FAT

Recommended by Board of Studies	08.06.2019	
Approved by Academic Council	55	Date: 13-06-2019

Course Code	Course Title	L	T	P	J	C
ENG1902	Technical English - II	0	0	4	0	2
Pre-requisite	71% to 90% EPT score	Syllabus Version				
		1				

Course Objectives:

1. To acquire proficiency levels in LSRW skills on par with the requirements for placement interviews of high-end companies / competitive exams.
2. To evaluate complex arguments and to articulate their own positions on a range of technical and general topics.
3. To speak in grammatical and acceptable English with minimal MTI, as well as develop a vast and active vocabulary.

Course Outcomes:

1. Communicate proficiently in high-end interviews and exam situations and all social situations
2. Comprehend academic articles and draw inferences
3. Evaluate different perspectives on a topic
4. Write clearly and convincingly in academic as well as general contexts
5. Synthesize complex concepts and present them in speech and writing

Module:1	Listening for Clear Pronunciation	4 hours

Ice-breaking, Introduction to vowels, consonants, diphthongs.
Listening to formal conversations in British and American accents (BBC and CNN) as well as other 'native' accents
Activity: Factual and interpretive exercises; note-making in a variety of global English accents

Module:2	Introducing Oneself	4 hours

Speaking: Individual Presentations
Activity: Self-Introductions, Extempore speech

Module:3	Effective Writing	6 hours

Writing: Business letters and Emails, Minutes and Memos
Structure/ template of common business letters and emails: inquiry/ complaint/ placing an order; Formats of Minutes and Memos
Activity: Students write a business letter and Minutes/ Memo

Module:4	Comprehensive Reading	4 hours

Reading: Reading Comprehension Passages, Sentence Completion (Technical and General Interest), Vocabulary and Word Analogy
Activities: Cloze tests, Logical reasoning, Advanced grammar exercises

Module:5	Listening to Narratives	4 hours

Listening: Listening to audio files of short stories, News, TV Clips/ Documentaries, Motivational Speeches in UK/ US/ global English accents.
Activity: Note-making and Interpretive exercises

Module:6	Academic Writing and Editing	6 hours

Writing: Editing/ Proofreading symbols
Citation Formats
Structure of an Abstract and Research Paper
Activity: Writing Abstracts and research paper; Work with Editing/ Proofreading exercise

Module:7	Team Communication	4 hours

Speaking: Group Discussions and Debates on complex/ contemporary topics
Discussion evaluation parameters, using logic in debates
Activity: Group Discussions on general topics

Module:8	**Career-oriented Writing**	**4 hours**
Writing: Resumes and Job Application Letters, SOP Activity: Writing resumes and SOPs		
Module:9	**Reading for Pleasure**	**4 hours**
Reading: Reading short stories Activity: Classroom discussion and note-making, critical appreciation of the short story		
Module: 10	**Creative Writing**	**4 hours**
Writing: Imaginative, narrative and descriptive prose Activity: Writing about personal experiences, unforgettable incidents, travelogues		
Module: 11	**Academic Listening**	**4 hours**
Listening: Listening in academic contexts Activity: Listening to lectures, Academic Discussions, Debates, Review Presentations, Research Talks, Project Review Meetings		
Module:12	**Reading Nature-based Narratives**	**4 hours**
Narratives on Climate Change, Nature and Environment Activity: Classroom discussions, student presentations		
Module:13	**Technical Proposals**	**4 hours**
Writing: Technical Proposals Activities: Writing a technical proposal		
Module:14	**Presentation Skills**	**4 hours**
Persuasive and Content-Specific Presentations Activity: Technical Presentations		
	Total Lecture hours:	**60 hours**

Text Book / Workbook

1.	Oxenden, Clive and Christina Latham-Koenig. *New English File: Advanced Students Book.* Paperback. Oxford University Press, UK, 2017.
2	Rizvi, Ashraf. *Effective Technical Communication.* McGraw-Hill India, 2017.

Reference Books

1.	Oxenden, Clive 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. Oxford University Press, UK, 2013.
2.	Balasubramanian, T. *English Phonetics for the Indian Students: A Workbook*. Laxmi Publications, 2016.
3.	Philip Seargeant and Bill Greenwell, *From Language to Creative Writing*. Bloomsbury Academic, 2013.
4.	Krishnaswamy, N. *Eco-English*. Bloomsbury India, 2015.
5.	Manto, Saadat Hasan. *Selected Short Stories*. Trans. Aatish Taseer. Random House India, 2012.
6.	Ghosh, Amitav. *The Hungry Tide*. Harper Collins, 2016.
7.	Ghosh, Amitav. *The Great Derangement: Climate Change and the Unthinkable*. Penguin Books, 2016.
8.	*The MLA Handbook for Writers of Research Papers*, 8th ed. 2016.
	Online Sources:

	https://americanliterature.com/short-short-stories. (75 *short* short stories) http://www.eco-ction.org/dt/thinking.html (Leopold, Aldo."Thinking like a Mountain") https://www.esl-lab.com/; http://www.bbc.co.uk/learningenglish/; https://www.bbc.com/news; https://learningenglish.voanews.com/a/using-voa-learning-english-to-improve-listening-skills/3815547.html

Mode of evaluation: Quizzes, Presentation, Discussion, Role play, Assignments and FAT

List of Challenging Experiments (Indicative)		
1.	Self-Introduction using SWOT	**12 hours**
2.	Writing minutes of meetings	**10 hours**
3.	Writing an abstract	**10 hours**
4.	Listening to motivational speeches and interpretation	**10 hours**
5.	Cloze Test	**6 hours**
6.	Writing a proposal	**12 hours**
	Total Laboratory Hours	**60 hours**

Mode of evaluation: Quizzes, Presentation, Discussion, Role play, Assignments and FAT

Recommended by Board of Studies	08.06.2019	
Approved by Academic Council	55	Date: 13-06-2019

Course Code	Course title	L	T	P	J	C
ENG1903	Advanced Technical English	0	0	2	4	2
Pre-requisite	Greater than 90 % EPT score	Syllabus Version				
		1				

Course Objectives:

1. To review literature in any form or any technical article
2. To infer content in social media and respond accordingly
3. To communicate with people across the globe overcoming trans-cultural barriers and negotiate successfully

Course Outcomes:

1. Analyze critically and write good reviews
2. Articulate research papers, project proposals and reports
3. Communicate effectively in a trans-cultural environment
4. Negotiate and lead teams towards success
5. Present ideas in an effective manner using web tools

Module:1	Negotiation and Decision Making Skills through Literary Analysis	5 hours

Concepts of Negotiation and Decision Making Skills
Activity: Analysis of excerpts from Shakespeare's "The Merchant of Venice" (court scene) and discussion on negotiation skills.
Critical evaluation of excerpts from Shakespeare's "Hamlet"(Monologue by Hamlet) and discussion on decision making skills

Module:2	Writing reviews and abstracts through movie interpretations	5 hours

Review writing and abstract writing with competency
Activity: Watching Charles Dickens "Great Expectations" and writing a movie review
Watching William F. Nolan's "Logan's Run" and analyzing it in tune with the present scenario of depletion of resources and writing an abstract

Module:3	Technical Writing	4 hours

Stimulate effective linguistics for writing: content and style
Activity: Proofreading
Statement of Purpose

Module:4	Trans-Cultural Communication	4 hours

Nuances of Trans-cultural communication
Activity:
Group discussion and case studies on trans-cultural communication.
Debate on trans-cultural communication.

Module:5	Report Writing and Content Writing	4 hours

Enhancing reportage on relevant audio-visuals
Activity:
Watch a documentary on social issues and draft a report
Identify a video on any social issue and interpret

Module:6	Drafting project proposals and article writing	4 hours

Dynamics of drafting project proposals and research articles

Activity:
Writing a project proposal.
Writing a research article.

Module:7	Technical Presentations	4 hours

Build smart presentation skills and strategies Activity: Technical presentations using PPT and Web tools		
	Total Lecture hours	**30 hours**
Text Book / Workbook		
1.	Raman, Meenakshi & Sangeeta Sharma. *Technical Communication: Principles and Practice*, 3rd edition, Oxford University Press, 2015.	
Reference Books		
1	Basu B.N. *Technical Writing*, 2011 Kindle edition	
2	Arathoon, Anita. *Shakespeare's The Merchant of Venice* (Text with Paraphrase), Evergreen Publishers, 2015.	
3	Kumar, Sanjay and Pushp Lata. *English Language and Communication Skills for Engineers*, Oxford University Press, India, 2018.	
4	Frantisek, Burda. *On Transcultural Communication*, 2015, LAP Lambert Academic Publishing, UK.	
5	Geever, C. Jane. *The Foundation Center's Guide to Proposal Writing*, 5th Edition, 2007, Reprint 2012 The Foundation Center, USA.	
6	Young, Milena. *Hacking Your Statement of Purpose: A Concise Guide to Writing Your SOP*, 2014 Kindle Edition.	
7	Ray, Ratri, *William Shakespeare's Hamlet*, The Atlantic Publishers, 2011.	
8	C Muralikrishna & Sunitha Mishra, *Communication Skills for Engineers*, 2nd edition, NY: Pearson, 2011.	
Mode of Evaluation: Quizzes, Presentation, Discussion, Role Play, Assignments		
List of Challenging Experiments (Indicative)		
1.	Enacting a court scene - Speaking	**6 hours**
2.	Watching a movie and writing a review	**4 hours**
3.	Trans-cultural – case studies	**2 hours**
4.	Drafting a report on any social issue	**6 hours**
5.	Technical Presentation using web tools	**6 hours**
6.	Writing a research paper	**6 hours**
J- Component Sample Projects		
1.	Short Films	
2.	Field Visits and Reporting	
3.	Case studies	
4.	Writing blogs	
5.	Vlogging	
	Total Hours (J-Component)	**60 hours**
Mode of evaluation: Quizzes, Presentation, Discussion, Role play, Assignments and FAT		
Recommended by Board of Studies	08.06.2019	
Approved by Academic Council	55	Date: 13-06-2019

Course Code	Ethics and Values	L	T	P	J	C
HUM 1021 / HUM1032		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:

Students will be able to:

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 Industrial Experts			
	Total Lecture Hours:	**30 hours**	
Reference Books			
1.	Dhaliwal, K.K (2016), "Gandhian Philosophy of Ethics: A Study of Relationship between his Presupposition and Precepts, Writers Choice, New Delhi, India.		
2.	Vittal, N (2012), "Ending Corruption? - How to Clean up India?", Penguin Publishers, UK.		
3.	Pagliaro, L.A. and Pagliaro, A.M (2012), "Handbook of Child and Adolescent Drug and Substance Abuse: Pharmacological , Developmental and Clinical Considerations", Wiley Publishers, U.S.A.		
4.	Pandey, P. K (2012), "Sexual Harassment and Law in India", Lambert Publishers, Germany.		
Mode of Evaluation: Quizzes, CAT, FAT, Digital assignments, poster/collage making and Seminars			
Recommended by Board of Studies	26-07-2017		
Approved by Academic Council	No. 46	Date	24-08-2017

Course Code	Calculus for Engineers	L	T	P	J	C
MAT1011		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. Apply 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, directional derivatives, divergence, curl and Greens', Stokes, Gauss theorems
6. Demonstrate MATLAB code for challenging problems in engineering

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 -

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- Beta and Gamma functions–interrelation -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 Evaluation:			
Weekly Assessment, Final Assessment Test			
Recommended by Board of Studies	03-06-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course Code	Statistics for Engineers	L	T	P	J	C
MAT2001		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 experimental 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)

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

Reference books

1. Reliability Engineering, E.Balagurusamy, Tata McGraw Hill, Tenth reprint 2017.
2. Probability and Statistics, J.L.Devore, 8th Edition, Brooks/Cole, Cengage Learning (2012).
3. Probability and Statistics for Engineers, R.A.Johnson, Miller Freund's, 8th edition, Prentice Hall India (2011).
4. 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 (Solutions by using soft skills), 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	03-06-2019		
Approved by Academic Council	No. 55	Date:	13-06-2019

Course code	LEAN START-UP MANAGEMENT	L	T	P	J	C
MGT1022		1	0	0	4	2
Pre-requisite	Nil	Syllabus version				
		v. 2.2				

Course Objectives:

The objective of the course is to make a student to create and commercialize the product

Course Outcome:

Upon successful completion of the course the students will be able to

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		**2 hours**

Legal, Regulatory, CSR, Standards, Taxes

Module:6	**Contemporary discussion**	**2 hours**
	Total Lecture hours:	**15 hours**

Text Book(s)

1.	Steve Blank, K & S Ranch (2012)The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company, 1st edition
2.	Steve Blank (2013)The Four Steps to the Epiphany, K&S Ranch; 2nd edition
3.	Eric Ries (2011) The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, Crown Business

Reference Books

1.	Steve Blank (2014) Holding a Cat by the Tail, , K&S Ranch Publishing LLC
2.	Karal T Ulrich, Product Design and Development, SDEppinger, McGraw Hill
3.	Peter Thiel, (2014) Zero to One: Notes on Startups, or How to Build the Future, Crown Business;
4.	Lean Analytics: Use Data to Build a Better Startup Faster(Lean Series), Alistair Croll & Benjamin Yoskovitz,O'Reilly Media; 1stEdition
5.	Marty Cagan, (2008) Inspired: How To Create Products Customers Love, SVPG Press; 1stedition

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

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.

Expected Course Outcome: Students will be able to

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	0	1
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 and categories them and upload along with details of people met and lessons learnt. **(4 non- contact hours)**

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 f o r 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

PROGRAMME CORE

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, Materials (in SI Units), Tata McGraw Hill Johnston & Dewolf, Mechanics Of Publications, 2004	
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test		
Recommended by Board of Studies	15-04-2019	
Approved by Academic Council	55th	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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		15-04-2019		
Approved by Academic Council		55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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 $1/3^{rd}$ rule - Simpson's $3/8^{th}$ 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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019	
Approved by Academic Council	55th	Date 13-06-2019

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

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

Course code	Applications of Differential and Difference Equations	L	T	P	J	C
MAT2002		3	0	2	0	4
Pre-requisite	MAT1011 - Calculus for Engineers	Syllabus Version				
		1.0				

Course Objectives (CoB):

[1] Presenting the elementary notions of Fourier series, which is vital in practical harmonic analysis
[2] Imparting the knowledge of eigenvalues and eigen vectors of matrices and the transform techniques to solve linear systems, that arise in sciences and engineering [3] Enriching the skills in solving initial and boundary value problems
[4] Impart the knowledge and application of difference equations and the Z-transform in discrete systems, that are inherent in natural and physical processes

Course Outcome (CO):

[1] Employ the tools of Fourier series to find harmonics of periodic functions from the tabulated values
[2] Apply the concepts of eigenvalues, eigen vectors and diagonalisation in linear systems
[3] Know the techniques of solving differential equations
[4] understand the series solution of differential equations and finding eigen values, eigen functions of Strum-Liouville's problem
[5] Know the Z-transform and its application in population dynamics and digital signal processing
[6] demonstrate MATLAB programming for engineering problems

Module:1	Fourier series:	6 hours

Fourier series - Euler's formulae - Dirichlet's conditions - Change of interval - Half range series – RMS value – Parseval's identity – Computation of harmonics

Module:2	Matrices:	6 hours

Eigenvalues and Eigen vectors - Properties of eigenvalues and eigen vectors – Cayley-Hamilton theorem - Similarity of transformation - Orthogonal transformation and nature of quadratic form

Module:3	Solution of ordinary differential equations:	6 hours

Linear second order ordinary differential equation with constant coefficients – Solutions of homogenous and non-homogenous equations - Method of undetermined coefficients – method of variation of parameters – Solutions of Cauchy-Euler and Cauchy-Legendre differential equations

Module:4	Solution of differential equations through Laplace transform and matrix method	8 hours

Solution of ODE's - Nonhomogeneous terms involving Heaviside function, Impulse function - Solving nonhomogeneous system using Laplace transform – Reduction of *n*th order differential equation to first order system - Solving nonhomogeneous system of first order differential equations $(X' = AX + G)$ and

$X'' = AX$

Module:5	**Strum Liouville's problems and power series Solutions:**	**6 hours**
The Strum-Liouville's Problem - Orthogonality of Eigen functions - Series solutions of differential equations about ordinary and regular singular points - Legendre differential equation - Bessel's differential equation		
Module:6	**Z-Transform:**	**6 hours**
Z-transform -transforms of standard functions - Inverse Z-transform: by partial fractions and convolution method		
Module:7	**Difference equations:**	**5 hours**
Difference equation - First and second order difference equations with constant coefficients - Fibonacci sequence - Solution of difference equations - Complementary function - Particular integral by the method of undetermined coefficients - Solution of simple difference equations using Z-transform		
Module:8	**Contemporary Issues**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, John Wiley India, 2015
Reference Books	
1.	Higher Engineering Mathematics, B. S. Grewal, 43rd Edition, Khanna Publishers, India, 2015
2.	Advanced Engineering Mathematics by Michael D. Greenberg, 2nd Edition, Pearson Education, Indian edition, 2006

Mode of Evaluation		
Digital Assignments (Solutions by using soft skills), Continuous Assessment Tests, Quiz, Final Assessment Test		
1.	Solving Homogeneous differential equations arising in engineering problems	2 hours
2.	Solving non-homogeneous differential equations and Cauchy, Legendre equations	2 hours
3.	Applying the technique of Laplace transform to solve differential equations	2 hours
4.	Applications of Second order differential equations to Mass spring system (damped, undamped, Forced oscillations), LCR circuits etc.	2 hours
5.	Visualizing Eigen value and Eigen vectors	2 hours
6.	Solving system of differential equations arising in engineering applications	2 hour
7.	Applying the Power series method to solve differential equations arising in engineering applications	2 hours
8.	Applying the Frobenius method to solve differential equations arising in engineering applications	2 hours

9.	Visualising Bessel and Legendre polynomials	2 hours
10.	Evaluating Fourier series-Harmonic series	2 hours
11.	Applying Z-Transforms to functions encountered in engineering	2 hours
12.	Solving Difference equations arising in engineering applications	2 hours
	Total Laboratory Hours	**24 hours**

Mode of Evaluation: Weekly Assessment, Final Assessment Test			
Recommended by Board of Studies	03-06-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course code	Complex Variables and Partial Differential Equation	L	T	P	J	C
MAT3003		3	2	0	0	4
Pre-requisite	MAT2002 Applications of Differential and Difference Equations	Syllabus version				
		1.0				

Course Objectives (CoB):

The aim of this course is to present a comprehensive, compact and integrated treatment of two most important branches of applied mathematics for engineers and scientists namely the functions of complex variable and Partial differential equations in finite and infinite domains

Course Outcomes (CO):

[1] Construct analytic functions and find complex potential of fluid flow and electric fields
[2] Find the image of straight lines by elementary transformations and
[3] Able to express analytic functions in power series
[4] Evaluate real integrals using techniques of contour integration
[5] Analyze partial differential equations, and its applications, design the boundary value problems (one dimensional heat and wave equations) and find Fourier series, Fourier transform techniques in their respective engineering problems.

Student Learning Outcomes (SLO): **1, 2, 9**

[1] Develop an ability to apply mathematics and science in engineering applications
[2] Having a clear understanding of the subject related concepts and of contemporary issues
[9] Having problem solving ability- solving social issues and engineering problems

Module:1	Analytic Functions	6 hours

Complex variable-Analytic functions and Cauchy – Riemann equations - Laplace equation and Harmonic functions - Construction of Harmonic conjugate and analytic functions - Applications of analytic functions to fluid-flow and Field problems.

Module:2	Conformal and Bilinear transformations	5 hours

Conformal mapping - Elementary transformations-translation, magnification, rotation, inversion. Exponential and Square transformations ($w = e^z$, z^2) - Bilinear transformation - Cross-ratio-Images of the regions bounded by straight lines under the above transformations.

Module:3	Power series	4 hours

Functions given by Power Series - Taylor and Laurent series -singularities - poles – Residues.

Module:4	Complex Integration	5 hours

Integration of a complex function along a contour - Cauchy-Goursat theorem- Cauchy's integral formula -Cauchy's residue theorem - Evaluation of real integrals - Indented contour integral.

Module:5	Partial Differential equations of first order	6 hours

Formation and solution of partial differential equation - General, Particular, Complete and Singular integrals - Partial Differential equations of first order of the forms: F(p,q)=0, F(z,p,q)=0, F(x,p)=G(y,q) and Clairaut's form - Lagrange's equation: Pp+Qq = R.

Module:6	**Applications of Partial Differential Equations**	**10 hours**	
Linear partial differential equations of higher order with constant coefficients. Solution of a partial differential equation by separation of variables - Boundary Value Problems-one dimensional wave and heat equations- Fourier series solution.			
Module:7	**Fourier transforms**	**7 hours**	
Complex Fourier transform and properties - Relation between Fourier and Laplace transforms - Fourier sine and cosine transforms – Convolution Theorem and Parseval's identity.			
Module:8	**Contemporary issues:**	**2 hours**	
Industry Expert Lecture			
	Total Lecture hours:	**45 hours**	
Tutorial	• A minimum of 10 problems to be worked out by students inventory Tutorial Class • Another 5 problems per Tutorial Class to be given as home work**.**	**30 hours**	

Text Book(s)

1.	Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, John Wiley & Sons (Wiley student Edison) (2015)

Reference Books

1	Higher Engineering Mathematics, B. S. Grewal, 43rd Edition (2019), Khanna Publishers, New Delhi
2	A first course in complex analysis with applications, G.Dennis Zill, Patrick D. Shanahan, 3rd Edition, 2013, Jones and Bartlett Publishers Series in Mathematics:
3	Advanced Engineering Mathematics, Michael, D. Greenberg, 2nd Edition, Pearson Education (2006)
4	Advanced Engineering Mathematics, Peter V. O' Neil, 7th Edition, Cengage Learning (2012)
5	Complex Analysis for Mathematics and Engineers, JH Mathews, R. W. Howell, 5th Edition, Narosa Publishers (2013)

Mode of Evaluation:

Digital Assignments(Solutions by using soft skill),Quiz, Continuous Assessments, Final Assessment Test.

Recommended by Board of Studies	03-06-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course Code	ENGINEERING DRAWING	L	T	P	J	C
MEE1001		1	0	4	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. Understand and escalate the importance of basic concepts and principles of Engineering Drawing (components, sections, views, and graphical representation).
2. Enable the students with various concepts like dimensioning, conventions and standards related to working drawings in order to become professionally efficient.
3. Develop the ability to communicate with others through the language of technical drawing and sketching.
4. Ability to read and interpret engineering drawings created by others.
5. Ability to draw orthographic projections and sections.
6. Develop an understanding for size specification procedures and use of SI and traditional units of linear measure.

Course Outcomes:

1. Apply BIS and ISO Standards in Engineering Drafting.
2. Graphically construct mathematical curves in engineering applications.
3. Visualize geometrical solids in 3D space through Orthographic Projections
4. Construct isometric scale, isometric projections and views.
5. Draw sections of solids including cylinders, cones, prisms and pyramids.
6. Draw projections of lines, planes, solids, isometric projections and sections of solids including cylinders, cones, prisms and pyramids using Mini-Dafter and CAD.
7. Construct orthographic projections from pictorial views.

Module:1	Lettering and Dimensioning	1 hours

Introduction, lettering practice, Elements of dimensioning - systems of dimensioning.

Module:2	Geometric Constructions	2 hours

Free hand sketching, Conic sections, Special curves.

Module:3	Projection of Points and Projection of Lines	2 hours

Projection of Points: First and Third Angle Projections; Projection of points.
Projection of Lines: Projection of straight lines (First angle projection only); Projection of lines inclined to one plane and both planes, true length and true inclinations.

Module:4	Projection of Solids and Section of Solids	3 hours

Projection of solids: Classification of solids, Projection of solids in simple position, Projection of solids inclined to one plane.
Sections of Solids: Right regular solids and auxiliary views for the true shape of the sections.

Module:5	**Development of Surfaces**	**2 hours**
Development of surfaces for various regular solids.		
Module:6	**Isometric Projection and Perspective Projection**	**2 hours**
Isometric Projection: Isometric scales, Isometric projections of simple and combination of solids; **Perspective Projection:** Orthographic representation of a perspective views – Plane figures and simple solids - Visual ray method.		
Module:7	**Orthographic Projection**	**2 hours**
Conversion of pictorial view into orthographic Projection.		
Module:8	**Contemporary issues**	**1 hours**
	Total Lecture hours:	**15 hours**

Text Book(s)	
1.	Venugopal K and Prabhu Raja V, "Engineering Graphics", New AGE International Publishers, 2015.
Reference Books	
1.	N. D. Bhatt, Engineering Drawing, Charotar publishing House, 2012.
2	Natarajan, K. V., A Text book of Engineering Graphics, Dhanalakshmi Publishers, 2012.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Challenging Experiments (Indicative)		
1.	Identifying the incorrect dimensioning and correct it as per BIS standards for Engineering Components.	4 hours
2.	Tutorials on free hand sketching of the plan view of stadium, garden, etc.,	4 hours
3.	Tutorials on geometric constructions like conics and special curves for projection of cricket ball, missile projection, etc.,	4 hours
4.	Representation of orthographic projection of points	4 hours
5.	Representation of orthographic projection of lines (First angle projection only) inclined to one plane and projection of lines inclined to both the planes- solving problems like electrical bulbs hanging from the roof, finding the shortest distance between fan to electrical switch board, etc.,	8 hours
6.	Sketching orthographic projection of solids in simple position and projection of solids inclined to one plane for household accessories and objects.	8 hours
7.	Drawing the auxiliary views, orthographic views and true shape of sectioned regular solids for household accessories and objects.	4 hours
8.	Development of lateral surfaces of the regular shapes and sectioned shapes for water cans, refrigerator, cylinder container, funnel, etc.,	4 hours
9.	Conversion of orthographic views to isometric views for engineering components.	8 hours
10.	Tutorial problems on perspective projection of plane figures and simple solids for train with track, landscape, etc.,	4 hours

11.	Conversion of pictorial drawing into orthographic projection for engineering components, architectural structures, etc.,			8 hours
			Total Laboratory Hours	**60 hours**
Mode of assessment:				
Recommended by Board of Studies	17-08-2017			
Approved by Academic Council	47	Date	05-10-2017	

PROGRAMME ELECTIVE

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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			**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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019	
Approved by Academic Council	55th	Date 13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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		15-04-2019		
Approved by Academic Council		55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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		15-04-2019		
Approved by Academic Council		55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

Course code	CHE2007	L	T	P	J	C
Course title	PROCESS INTENSIFICATION	3	0	0	0	3
Pre-requisite	CHE1006	Syllabus version				
		1.0				

Course Objectives:

1. Understand the concept of Process Intensification
2. Apply the techniques of intensification to a range of chemical processes
3. Infer alternative solutions keeping in view point, the environmental protection, economic viability and social acceptance

Course Outcomes (CO):

1. Understand the scientific background, techniques and applications of intensification in the process industries
2. Apply process intensification in industrial processes
3. Implement methodologies for process intensification
4. Identify scale up issues in the chemical process
5. Interpret the feasibility of the process intensification
6. Formulate and solve process challenges using intensification technologies

Module:1	Introduction	6 hours

Techniques of Process Intensification (PI) Applications - The philosophy and opportunities of Process Intensification - Main benefits from process intensification - Process intensifying Equipment - Process intensification toolbox - Techniques for Process intensifying application

Module:2	Process Intensification Through Micro Reaction Technology	6 hours

Effect of miniaturization on unit operations and reactions - Implementation of Micro reaction Technology from basic Properties - Technical Design Rules - Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions - Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes

Module:3	Mixing And Flow Patterns	8 hours

Scales of mixing - Flow patterns in reactors - Mixing in stirred tanks: Scale up of mixing - Heat transfer - Mixing in intensified equipment - Chemical Processing in High gravity Fields Atomizer - Ultrasound Atomization - High intensity inline MIXERS reactors - Static mixers – Ejectors - Tee mixers - Impinging jets - Rotor stator mixers - Design Principles of static Mixers and Applications of static mixers - Higee reactors

Module:4	Combined Chemical Reactor Heat Exchangers And Reactor Separators	6 hours

Principles of operation – Applications - Reactive absorption - Reactive distillation - Applications of RD Processes

Module:5	Compact Heat Exchangers	8 hours

Classification of compact heat exchangers - Plate heat exchangers - Spiral heat exchangers - Flow pattern - Heat transfer and pressure drop - Flat tube and fin heat exchangers - Microchannel heat exchangers – Phase change heat transfer - Selection of heat exchanger technology - Feed/effluent heat exchangers - Integrated heat exchangers in separation processes - Design of compact heat exchanger - examples		
Module:6	**Enhanced Fields**	**6 hours**
Energy based intensifications – Sono chemistry - Basics of cavitation - Cavitation Reactors - Flow over a rotating surface - Hydrodynamic cavitation applications - Cavitation reactor design – Nusselt flow model and mass transfer - Sono crystallization; Reactive separations		
Module:7	**Case Studies**	**3 hours**
Reactive Extraction Case Studies - Absorption of NO_x - Coke Gas Purification		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books

1.	Segovia H., Juan G., Bonilla P., Adrián, Process Intensification in Chemical Engineering design optimization and control, 1st ed., Springer, Mexico, 2016.
2.	David R., Colin R., Adam H., Process Intensification Engineering for Efficiency, Sustainability and Flexibility, 2nd ed., Elsevier, Netherlands, 2013.

Reference Books

1.	Andrzej S., Jacob A., Moulijn, Re-engineering the chemical processing plant: process intensification, 1st ed., Marcel Dekker Inc, USA, 2004.
2.	Reay D., Ramshaw C., Harvey A., Process Intensification, 1st ed., Elsevier, Netherlands, 2008.

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

Course code	CHE2008	L	T	P	J	C
Course title	Chemical Engineering Computational Fluid Dynamics	2	0	0	4	3
Pre-requisite	CHE1005, CHE1006	Syllabus version				
		1.0				

Course Objectives:

1. Recall the basic fluid and heat transfer governing equations
2. Utilize basic aspects of discretization for grid generation
3. Estimate fluid flow and heat transfer problems

Course Outcomes (CO):

1. Understand and select the governing equations of fluid flow and heat transfer
2. Enable to solve one and two-dimensional ordinary and partial differential equations using traditional CFD tools
3. Make use of discretization techniques for derivatives and differential equations to solve numerically
4. Examine general transformation equations for grid generation
5. Recommend suitable explicit, implicit and semi-implicit methods of finite difference scheme for given problems
6. Solve fluid flow field and temperature field to design any process equipment using some popular CFD techniques

Module:1	Governing Equations	4 hours

Navier-Stokes Equations; Complete energy equations-complete mass conservation equations; Parabolized Navier-Stokes Equations; Euler Equations

Module:2	Conservation laws and forms of equations	5 hours

Models of Flow – Conservation form Continuity; Momentum and Energy Equation in conservation form (differential equations only) - Characteristics of PDE's - Elliptic; parabolic and hyperbolic

Module:3	Discretization	5 hours

Finite Difference method- Forward; Backward and Central difference schemes- Finite volume- Finite element techniques

Module:4	Grid generation	5 hours

Choice of grid- grid oriented velocity components- Cartesian velocity components- Staggered and collocated arrangements

Module:5	Convection and Diffusion	3 hours

Steady one-dimensional convection and diffusion- Central difference; upwind, quick, exponential, hybrid and power law schemes- False diffusion, Simple algorithm

Module:6	CFD Techniques	3 hours

ADI Technique - Pressure correction Technique Simple algorithm

Module:7	Case Study	3 hours

Industrially important process equipment - Heat exchangers; Fluid flow; Mixing equipments; Cyclone separators			
Module:8	**Contemporary issues**		**2 hours**
	Total Lecture hours		**30 hours**
Text Books			
1.	Pletcher R.H., Tannehill J.C., Anderson D.A., Computational fluid mechanics and heat transfer, 3rd ed., CRC Press, USA, 2012.		
2.	Aref H., Computational Fluid Dynamics, 1st ed., Cambridge University Press, USA, 2017.		
Reference Books			
1.	Versteeg H.K., Malalasekera W., An introduction to computational fluid dynamics: The finite volume method, 2nd ed., Prentice Hall, UK, 2007.		
2.	Hirsch C., Computation of internal and external flows: The fundamentals of computational fluid dynamics, 2nd ed., Butterworth-Heinemann, USA, 2007.		
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

Course code	CHE3005	L	T	P	J	C
Course title	CHEMICAL PROCESS INTEGRATION	3	0	0	0	3
Pre-requisite	CHE2002	Syllabus version				
		v. 2.1				

Course Objectives:

- To impart the strategy for effective and energy efficient way of fine tuning the process design so as to maximize profit by minimizing utilities.
- To provide an insight on the utilities with their standards and conservation aspects.
- To caters the fundamental knowledge about energy efficient chemical process design.

Expected Course Outcome:

Upon completion of this course students would be able to

- Provide solution approach for energy efficient chemical process design
- Develop a methodology of process integration for Heat Exchangers, Evaporators, Dryers, Distillation Columns and Reactors-Some of the energy intensive unit operations
- Design a methodology of distillation column sequencing and reactor networking which are essential for a good process design
- Analyze water pinch technology for minimizing fresh water consumption and waste water reduction

Module:1	Distillation Sequencing	7 hours

Need for column sequencing, distillation sequencing for simple columns, columns with more than two products, columns using thermal coupling, distillation sequencing for azeotropic distillation

Module:2	Heat Exchanger Networks – Targets	6 hours

Composite curve, problem table algorithm, network energy targets, heat exchange area targets, number of shells target, capital cost and total cost targets

Module:3	Heat Exchanger Networks – Network Design	6 hours

Pinch Design method, stream splitting, design of multiple pinches, superstructure approach, tradeoffs, network stream data.

Module:4	Heat Integration – Process Equipment	6 hours

Use of composite curve for integration of reactors, heat integration in distillation columns and distillation sequences.

Module:5	Energy consuming – Process Utilities	6 hours

Heat integration of evaporator, heat integration of dryers, heat integration of boilers, heat integration of compressors and refrigerator

Module:6	Water system design	6 hours

Water use in process industries, design for maximum water reuse, design for minimum waste water treatment flow rate, targeting and design for effluent treatment and regeneration

Module:7	Clean process technology	6 hours

Sources of Waste from Chemical Production. Clean Process Technology for Chemical Reactors, Separation and Recycle Systems, Process Operations and Process utilities. Life Cycle Analysis

Module:8	Contemporary issues	2 hours

	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Robin Smith, "Chemical Process: Design and Integration", John Wiley and Sons, 2016
2.	Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz, Debangsu Bhattacharyya, "Analysis, Synthesis and Design of Chemical Processes", Prentice Hall, 2012.
Reference Books	
1.	Alexandre C. Dimian, Costin S. Bildea, Anton A. Kiss, " Integrated Design and Simulation of Chemical Processes", Elsevier Publications, 2014.
2	Ian C. Kemp, "Pinch Analysis and Process Integration: A User Guide on Process Integration", Elsevier Publications, 2008

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

Recommended by Board of Studies	04.03.2016		
Approved by Academic Council	40	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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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		15-04-2019		
Approved by Academic Council		55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

Course code	CHE3010	L	T	P	J	C
Course title	COLLOIDS AND INTERFACIAL SCIENCE	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.0				

Course Objectives:

1. Introduce the student to the theory of Colloids and Interface Phenomena
2. Emphasize the student to learn solution thermodynamics, stability of colloids, light scattering, capillary effects
3. Expose the importance of colloidal phenomena through real time examples

Course Outcomes (CO):

1. Understand the concept of the origin of long-range, non-covalent colloidal forces (van der Waals, electrostatic, etc.)
2. Explain the link between liquid surface tension and contact angle, and demonstrate how certain experimental techniques can be used for the assessment of liquid surface tension
3. Apply the knowledge of thermodynamics for micellization in surfactant solutions
4. Describe the thermodynamics of emulsion formation and calculate the kinetic and thermodynamic stability of such emulsions
5. Design colloidal systems or engineered surfaces of high industrial or technological interest
6. Explain the interactions between colloids and visible light, as well as the principles of static and dynamic light scattering

Module:1	Introduction to Colloid & Interface Science	6 hours

Fundamentals of Colloid Science-Colloids: definition-Van der Waals interactions-The Hamaker constant-Electrostatic Interactions in Colloids-The electrical double layer (EDL)- Zeta potential-Gibbs energy of electrostatic interactions

Module:2	Surface Tension and Contact Angle	6 hours

Surface tension of liquids-definition-Lewis Acid-Base interactions-Surface tension& contact angle -Measuring contact angles

Module:3	Interactions at Interfaces	5 hours

Surfactants I: definitions and applications-Surfactants II: thermodynamics-Surface excess

Module:4	Emulsions	6 hours

Definitions and applications-Types of emulsions-Thermodynamics of emulsification-Emulsion stability

Module:5	Design of Interfacial science	7 hours

Adsorption-Models of adsorption-Adsorption at the solid-liquid interface-Adsorption at the liquid-air interface-Adsorption at the solid-air interface

Module:6	Principles of Light Scattering	6 hours

Fundamentals of light scattering-Static light scattering-Dynamic light scattering

Module:7	**Application of Colloids and Interfacial phenomena**	**7 hours**
Colloidal and interfacial phenomena in biology-Photovoltaic-Water treatment-Medicine-Tribology-Engineering		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Wang C., Leblanc R.M., Recent Progress in Colloid and Surface Chemistry, 1st ed., Oxford University Press Inc., UK, 2016
2.	Birdi K.S., Handbook of Surface and Colloid Chemistry, 4th ed., CRC Press., India, 2015
Reference Books	
1.	Hiemenz P.C., Rajagopalan R., Principles of Colloid and Surface Chemistry, 3rd ed., CRC Press, USA, 1997
2.	Rhodes M., Introduction to Particle Technology, 2nd ed., Wiley Publications, USA, 2008

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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 Modeling 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 modeling 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	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	15-04-2019	
Approved by Academic Council	55th	Date 13-06-2019

Course code	CHE4006	L	T	P	J	C
Course title	Introduction to Molecular Dynamics and Simulation	3	0	0	0	3
Pre-requisite	CHE1003, CHE3001	Syllabus version				
		1.0				

Course Objectives:

1. Introduce molecular simulation techniques used in soft matter in atomic time and length scales
2. Understand the basics of Molecular Dynamics simulation
3. Demonstrate the predictive capabilities of these methods by considering a set of case-studies

Course Outcomes (CO):

1. Choose appropriate potentials for a system of interest
2. Compare various ensembles and demonstrate importance of thermodynamic properties
3. Identify non bonded and bonded interaction and experiment with basic of MD concepts
4. Summarize the MD algorithm and contrast different integration schemes
5. Survey of Gromacs terminologies
6. Estimate the dynamic properties of proteins, lipids and surfactants

Module:1	**Model potentials**	**5 hours**	
Electronic, atomic, molecular soft matter examples; Interaction potentials- Reduced units			
Module:2	**Statistical Mechanics**	**7 hours**	
Statistical ensembles; Thermodynamic averages fluctuations; Structural quantities; Time correlation functions and transport coefficients			
Module:3	**Basics of Molecular dynamics simulations**	**8 hours**	
Non-Bonded Interactions; Bonded interaction; Force Fields; Periodic Box and Minimum Image Convention; Long Range Forces			
Module:4	**Molecular dynamics strategy**	**5 hours**	
Integrating algorithms for velocity and acceleration updates; Different types of thermostats and barostats			
Module:5	**Steps involved in GROMACS**	**6 hours**	
Energy Minimization; Solvent and counter ions addition; Equilibration of temperature and pressure; Production- Sampling- Analysis validation simulated values with experimental values			
Module:6	**Over view of GROMACS Files**	**4 hours**	
Input structure files visualization by VMD- Input files required for MD Simulation- Post processing of output files			
Module:7	**Case Study using MD Simulation**	**8 hours**	
MD Simulation biologically important proteins; Lipids and Surfactants			
Module:8	**Contemporary issues**	**2 hours**	

Course code	CHE4007	L	T	P	J	C
Course title	RHEOLOGY OF COMPLEX FLUIDS	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.0				

Course Objectives:

1. Make student aware about complex fluids and structure length scales in polymeric and colloidal systems
2. Provide basic knowledge of the physics behind colloidal systems
3. Impart basic knowledge of the physics behind polymeric solutions and its rheological behavior with concentration and temperature

Course Outcomes (CO):

1. Distinguish among viscous, elastic and viscoelastic behavior of fluids
2. Explain the basic forces that give rise to complex fluid behavior
3. Identify non-linear viscoelastic properties of materials and their corresponding behavior
4. Measure extensional behavior of complex fluids
5. Apply rheological behavior of colloidal system for various applications
6. Apply rheological behavior of polymeric system for various applications

Module:1	Elastic Solid and Viscous liquid	4 hours

Stress tensor - Principal stresses - Finite deformation tensor - Neo-Hookean solid; Velocity gradient, general viscous fluid, plastic behaviour.

Module:2	Complex fluid and forces	5 hours

Complex fluids – examples, pertinent length scales, common features & applications; Forces – basics forces that drive the dynamics and behavior – steric, van der Waals, electrostatic etc.

Module:3	Linear Viscoelasticity	6 hours

Introduction, models - Kelvin, Maxwell; Linear viscoelasticity in three dimensions - differential form; Stress relaxation, creep, oscillation.

Module:4	Nonlinear Viscoelasticity	7 hours

Nonlinear phenomenon, normal stress, shear thinning, extensional thickening; Second order fluid - Upper-Convected Maxwell Equation, Lodge Integral Equation, Integral Constitutive Equations.

Module:5	Extensional Viscosity	7 hours

Introduction - Importance, theory; Experimental methods - Homogeneous stretching method, Constant stress devices; Spinning, Lubricated flows, Contraction flows, Open-syphon method.

Module:6	Suspension Rheology	7 hours

Introduction, viscosity of suspension of solid particles in Newtonian fluids, colloidal contribution to viscosity, viscoelastic properties of suspension.		
Module:7	**Rheology of Polymeric Liquids**	**7 hours**
Introduction, polymer chain conformation, zero shear viscosity, rheology of dilute polymer solution; Concentrated Solutions and Melts - Temperature Dependence.		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	Despande A.P., Krishnan J.M., Sunil Kumar P.B., Rheology of Complex Fluids, 1st ed., Springer-Verlag, USA, 2010.
2.	Macosko C.W., Rheology: Principles, Measurements and Application, 9th ed., Wiley-VCH Publications, USA, 2015.
Reference Books	
1.	Barnes H.A., Hutton J.F., Walters K., An Introduction to Rheology, 17th ed., Elsevier, UK, 2011.
2	Larson R.G., The Structure and Rheology of Complex Fluids, 1st ed., Oxford University Press, UK, 1999.
Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test	

Recommended by Board of Studies	15-04-2019		
Approved by Academic Council	55th	Date	13-06-2019

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	3 hours
	domains.	
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