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]

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VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

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

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

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

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

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

VISION STATEMENT OF 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 ChemicalEngineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems in Chemical engineering and allied disciplines.
2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in the 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 leading to careers in engineering, management, teaching and research.

PROGRAMME OUTCOMES (POs)

1. Engineering Knowledge :Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.

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

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

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

5. Modern Tool Usage :Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the

consequent responsibilities relevant to the professional engineering practice.

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

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

9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

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

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

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

B. Tech ChemicalEngineering

PROGRAMME SPECIFIC OUTCOMES (PSOs)

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

1. Analyze and solve complex engineering 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

S.No	Description	Credits	Maximum Credits
1	PC - Programme Core	**60**	**60**
2	PE - Programme Elective	**35**	**35**
3	UC-University Core	**53**	**53**
4	UE - University Elective	**12**	**12**
5	BC- Bridge Course	**0**	**0**
6	NC- Non Credit Course	**5**	**5**
	Total credits	**165**	**165**

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	ChemicalProcessIntegration	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	ComputationalFluid Dynamics	2	2	2	0	4

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	Arithmeticproblem solving Introductionto quantitative,logical and verbal ability	0	0	0	0	1
18	STS 2101	Gettingstarted to skill enhancement	0	0	0	0	1

	STS 2201	Numerical abilityandcognitiveintelligence					
19	STS 2102 STS 2202	Enhancingproblem solvingskills Advancedaptitudeandreasoningskills	0	0	0	0	1
20	STS 3101 STS 3201	Introduction to programmingskills Programmingskills foremployment	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 (BC) Foundation English II (BC)	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

University Elective-12 Credits

UNIVERSITYCORE

Course code	Technical Answers forReal WorldProblems (TARP)	L	T	P	J	C
CHE1901		1	0	0	4	2
Pre-requisite	PHY1999 and115 Credits Earned	Syllabus version				
		v. 1.0				

CourseObjectives:

1. To help students to identifythe needfordeveloping newer technologies forindustrial / societal Needs
2. To train students to propose and implement relevant technologyforthe development ofthe prototypes /products
3. To makethe students learn to the usethe methodologies available to assessthedeveloped prototypes /products

CourseOutcomes:

1. Identifyreal lifeproblems related tosociety.
2. Applyappropriatetechnology(ies) toaddress theidentified problems usingengineering principles and arrive at innovativesolutions

Module:1 **15 hours**

1. Identification ofreal lifeproblems
2. Field visits can bearranged bythe facultyconcerned
3. 6 – 10 students can formateam (within thesame/different discipline)
4. Minimum of eight hourson self-managed teamactivity
5. Appropriate scientificmethodologies to beutilized to solve theidentifiedissue
6. Solution should be in theform of fabrication/coding/modeling/product design/process design/relevant scientificmethodology(ies)
7. Consolidated report to besubmitted forassessment
8. Participation, involvement and contribution in group discussions duringthecontacthours willbeused as the modalities forthe continuous assessment ofthe theorycomponent
9. Project outcome to be evaluated in terms oftechnical, economical, social,environmental, political and demographicfeasibility
10. Contribution of eachgroup member to beassessed
11. Theprojectcomponent to have three reviews with the weightageof20:30:50

Mode ofEvaluation:(NoFAT)Continuous Assessment theproject done–Mark weightageof 20:30:50 – project reportto be submitted, presentation and project reviews

Recommended byBoardofStudies	04-03-2016		
Approved byAcademicCouncil	No. 47	Date	05-10-2017

CHE1902	IndustrialInternship	L	T	P	J	C
		0	0	0	0	1
Pre-requisite	Completion ofminimumofTwosemesters					

CourseObjectives:

The courseis designed so as to exposethe students to industryenvironment and to takeup on-site assignment as trainees orinterns.

CourseOutcomes:

1. Have anexposureto industrial practicesand to work inteams
2. Communicate effectively
3. Understand the impact ofengineeringsolutions in aglobal, economic,environmental and societal context
4. Develop the abilityto engagein research and to involve in life-longlearning
5. Comprehend contemporaryissues
6. Engagein establishinghis/herdigitalfootprint

Contents	**4**	**Weeks**

Four weeks of work at industrysite.

Supervised byan expertat theindustry.

Mode ofEvaluation:Internship Report, Presentation and Project Review

Recommended byBoardofStudies	28-02-2016		
Approved byAcademicCouncil	No. 37	Date	16-06-2015

Course code	ComprehensiveExamination	L	T	P	J	C
CHE1903		0	0	0	0	1
Pre-requisite	Minimumof115 Credits Earnedorat the endofthe 7th semester	Syllabus version				
		v. 1.0				

CourseObjectives:

1. To measurestudent'scompetencyand masteryofconcepts in the field of chemical engineering.
2. To evaluatetheabilityofstudents to move into thedissertation phaseof theirdegree.

CourseOutcomes:

1.Define, explain and summarizethe basicprinciples of chemical engineering.
2. Usethe principles ofscience and mathematics to identify,formulate and solveadvanced engineeringproblems.
3.Evaluatethe hypotheses, methods, results and conclusions of published scientificliteratureand applyconclusions to theirownwork.

Contents

Process Calculations and Thermodynamics: Steady and unsteady state massandenergy balancesincluding multiphase,multi-component,reactingandnon-reacting systems.Useoftie components;recycle, bypassandpurge calculations;Gibb'sphase ruleanddegree of freedom analysis.FirstandSecondlawsofthermodynamics.Applicationsoffirstlawto closeandopen systems.SecondlawandEntropy.Thermodynamicpropertiesofpuresubstances:Equationof State and residualproperties,propertiesofmixtures:partialmolarproperties,fugacity,excess properties andactivity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium

Momentum Transfer: Fluid statics, Newtonian and non-Newtonian fluids, shell- balances includingdifferential form of Bernoulli equation and energy balance, Macroscopic friction factors, dimensional analysis, flow through pipeline systems, flowmeters, pumps and compressors, flowpast immersed bodies includingpacked and fluidized beds, Turbulent flow: fluctuatingvelocity, universal velocityprofile and pressuredrop.

MechanicalOperations: Particlesize andshape,particle size distribution,size reductionand classificationof solidparticles;free andhinderedsettling;centrifuge and cyd0nes-;thickeningand classification, flotation, filtration, agitation and mixing; conveyingof solids.

HeatTransfer: Steadyandunsteady heatconduction,convectionandradiation,HeatTransfer throughfins,thermalboundary layerandheattransfercoefficients,boiling,condensationand evaporation;typesofheatexchangersandevaporatorsandtheirprocesscalculations.Designof double pipe, shell andtube heat exchangers, and single and multiple effectevaporators.

Mass Transfer: Fick's laws, moleculardiffusion in fluids, mass transfercoefficients, film, penetration and surfacerenewal theories; analogies; stage-wise andcontinuous contacting and stageefficiencies; HTU&NTUconcepts;designand operation ofequipment fordistillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification adsorption and crystallization.

Chemical ReactionEngineering: Theories of reaction rates; kinetics of homogeneous reactions,interpretationofkineticdata,singleandmultiplereactions in idealreactors,non-idealreactors;residencetimedistribution,singleparameter model; non-isothermalreactors; kinetics ofheterogeneouscatalytic reactions; diffusion effects incatalysis.

Instrumentation and ProcessControl: Measurement of process variables; sensors, transducers and their dynamics, process modeling and linearization, transfer functions and dynamic responsesofvarioussystems, systemswithinverseresponse,processreactioncurve, controller modes(P, Pl,andPIO);controlvalves;analysisof closedloopsystemsincluding stability,frequencyresponse, controller tuning, cascade andfeed forwardcontrol.

Chemical Technology: Inorganic chemical industries (sulfuricacid, phosphoricacid, chloro-alkali industry, cement, paint, glass industry), fertilizers (Ammonia, Urea,SSPand TSP); natural products industries (Pulp and Paper, Sugar,Oil, and Fats); petroleumrefiningand petrochemicals; Fermentation products:Ethanol, citric acid, antibiotics, penicillin polymerization industries (polyethylene, polypropylene, PVC and polyestersyntheticfibers).

Plant DesignandEconomics: Principlesof processeconomicsand costestimationincluding depreciationandtotalannualizedcost,cost indices,rateofreturn,paybackperiod,discountedcash flow,optimizationinprocessdesignandsizing ofchemicalengineering equipmentsuchas compressors, heat exchangers, multistagecontactors.

Assessment / Criteria: Computer based on lineExamination

ModeofEvaluation: Computer based Evaluation

Recommended byBoardofStudies	04-03-2016		
Approved byAcademicCouncil	No. 47	Date	05.10.2017

CourseCode	CourseTitle	L	T	P	J	C
CHE1904	CapstoneProject	0	0	0	0	12
Pre-requisite	Aspertheacademicregulations	Syllabus version				
		v. 1.0				

CourseObjectives:

Toprovidesufficienthands-onlearningexperiencerelatedtothedesign,developmentandanalysisofsuitableproduct/processsoastoe

CourseOutcomes:

1. Formulatespecificproblemstatementsforill-definedreallifeproblemswithreasonableassumptionsandconstraints.
2. Performliteraturesearchand/orpatentsearchintheareaofinterest.
3. Conductexperiments/DesignandAnalysis/solutioniterationsanddocumenttheresults.
4. Performerroranalysis/benchmarking/costing
5. Synthesizetheresultsandarriveatscientificconclusions/products/solution
6. Documenttheresultsintheformoftechnicalreport/presentation

Mode ofEvaluation:Periodicreviews,Presentation,Finaloralviva,Postersubmission

Recommended byBoardofStudies	10-06-2015		
Approved byAcademicCouncil	37th AC	Date	16-06-2015

Coursecode	EngineeringChemistry	L	T	P	J	C
CHY1701		3	0	2	0	4
Pre-requisite	Chemistry of12th standard or equivalent	Syllabusversion				
		1.1				

CourseObjectives:

1. To imparttechnologicalaspects ofappliedchemistry
2. To layfoundationforpracticalapplication ofchemistryin engineering aspects

CourseOutcomes(CO):

1. Recallandanalyzetheissuesrelatedtoimpuritiesinwaterandtheirremovalmethodsandapplyrecent methodologies in watertreatment fordomestic andindustrial usage
2. Evaluatethecausesofmetalliccorrosionandapplythemethodsforcorrosionprotectionofmetals
3. Evaluatetheelectrochemicalenergystoragesystemssuchaslithiumbatteries,fuelcellsandsolar cells,anddesign for usage in electricalandelectronic applications
4. Assessthequalityofdifferentfossilfuelsandcreateanawarenesstodevelopthealternativefuels
5. Analyzethepropertiesofdifferentpolymersanddistinguishthepolymerswhichcanbedegradedandde monstrate their usefulness
6. Applythetheoreticalaspects:(a)inassessingthewaterquality;(b)understandingtheconstructionandw orkingofelectrochemicalcells;(c)analyzingmetals,alloysandsoilusinginstrumentalmethods;(d)eva luatingtheviscosityandwaterabsorbingpropertiesofpolymericmaterials

Module:1	Water Technology	5 hours

Characteristicsofhardwater-hardness,DO,TDSinwaterandtheirdetermination– numericalproblemsinhardnessdeterminationbyEDTA;Moderntechniquesofwateranalysisforindustrial use- Disadvantages of hard water in industries.

Module:2	Water Treatment	8 hours

Watersofteningmethods:-Lime-soda,Zeolite and ion exchange processesand their applications.Specificationsofwaterfordomesticuse(ICMRandWHO);Unitprocessesinvolvedinwatertr eatment for municipal supply- Sedimentation with coagulant- SandFiltration - chlorination;Domesticwaterpurification–Candlefiltration-activatedcarbonfiltration;Disinfectionmethods-Ultrafiltration, UVtreatment, Ozonolysis, ReverseOsmosis; Electrodialysis.

Module:3	Corrosion	6 hours

Dry andwetcorrosion-detrimentaleffectstobuildings,machines,devices&decorativeartforms,emphasizingDifferentialaeratio n,Pitting,GalvanicandStresscorrosioncracking;Factorsthatenhance corrosion and choiceof parameters tomitigatecorrosion.

Module:4	CorrosionControl	4 hours

Corrosionprotection-cathodicprotection–sacrificialanodicandimpressedcurrentprotection methods; Advancedprotective coatings: electroplatingandelectrolessplating, PVD and CVD.Alloyingforcorrosionprotection–BasicconceptsofEutecticcompositionandEutecticmixtures-Selectedexamples – Ferrousandnon-ferrousalloys.

Module:5	ElectrochemicalEnergySystems	6 hours

Briefintroductiontoconventionalprimaryandsecondarybatteries;Highenergyelectrochemicalenergysystems:Lithiumbatteries–Primaryandsecondary,itsChemistry,advantagesandapplications. Fuelcells–Polymermembranefuelcells,Solid-oxidefuelcells-workingprinciples,advantages,applications. Solarcells–Types–Importanceofsiliconsinglecrystal,polycrystallineandamorphoussiliconsolar cells,dye sensitizedsolarcells-workingprinciples,characteristics and applications.		
Module:6	**FuelsandCombustion**	**8 hours**
Calorificvalue-DefinitionofLCV,HCV.Measurementofcalorificvalueusingbombcalorimeterand Boy's calorimeterincludingnumericalproblems. Controlledcombustionoffuels-Airfuelratio–minimumquantityofairbyvolumeandbyweight-Numericalproblems-threewaycatalyticconverter-selectivecatalyticreductionofNO_X;KnockinginICengines-Octaneand Cetanenumber- Antiknockingagents.		
Module:7	**Polymers**	**6 hours**
Differencebetweenthermoplasticsandthermosettingplastics;Engineeringapplicationofplastics-ABS,PVC,PTFEandBakelite;Compoundingofplastics:moulding ofplasticsfor Carparts,bottlecaps(Injectionmoulding),Pipes,Hoses(Extrusionmoulding),MobilePhoneCases,Battery Trays,(Compressionmoulding),Fibrereinforcedpolymers,Composites(Transfermoulding),PETbottles (blowmoulding); Conductingpolymers-Polyacetylene-Mechanismofconduction–applications(polymersinsensors,self-cleaningwindows)		
Module:8	**Contemporary issues:**	**2 hours**
LecturebyIndustryExperts		
	Total Lecture hours:	**45 hours**

Text Book(s)

1. SashiChawla,ATextbookofEngineeringChemistry,DhanpatRaiPublishingCo.,Pvt.Ltd.,Educational and Technical Publishers, New Delhi, 3rdEdition, 2015.
2. O.G.Palanna, McGraw HillEducation(India)PrivateLimited, 9thReprint, 2015.
3. B.Sivasankar,EngineeringChemistry1stEdition, Mc GrawHill Education(India),2008
4. "Photovoltaic solarenergy:Fromfundamentals to Applications",AngÃ1e Reinders,Pierre Verlinden, Wilfried van Sark,AlexandreFreundlich, Wileypublishers, 2017.

Reference Books

1. O.V.RoussakandH.D.Gesser,AppliedChemistry-A Text Bookfor EngineersandTechnologists,SpringerScienceBusinessMedia,NewYork, 2ndEdition, 2013.
2. S.S.Dara,ATextbookofEngineeringChemistry,S.Chand&CoLtd.,NewDelhi,20thEdition, 2013.

Modeof Evaluation:Internal Assessment (CAT,Quizzes, DigitalAssignments)& FAT

List ofExperiments		**CO:6**
1.	WaterPurification:Estimation of waterhardnessbyEDTA method and itsremovalbyion-exchangeresin	1 h 30 min
2.	WaterQualityMonitoring: Assessmentoftotaldissolved oxygenin differentwater samplesby Winkler's method	3 h
3.	Estimation of sulphate/ chloride in drinkingwater byconductivitymethod	
4/5	MaterialAnalysis:Quantitativecolorimetricdeterminationof divalent	**3h**
	metalionsofNi/Fe/Cuusingconventionalandsmartphonedigital-imagingmethods	
6.	Analysis ofIron in carbon steelbypotentiometry	1 h 30 min

7.	ConstructionandworkingofanZn-Cuelectrochemicalcell			1 h 30 min
8.	Determination of viscosity-average molecularweight of differentnatural/syntheticpolymers			1 h 30 min
9.	Arduinomicrocontrollerbasedsensorformonitoringtemperature/conductivityin samples.			1 h 30 min
			Total Laboratory Hours	**17 hours**
Modeof Evaluation: Viva-voceandLab performance&FAT				
RecommendedbyBoardof Studies	31-05-2019			
ApprovedbyAcademicCouncil	55th ACM	Date	13-06-2019	

Coursecode	PROBLEM SOLVINGANDPROGRAMMING	L	T	P	J	C
CSE1001		0	0	6	0	3
Pre-requisite	NIL	Syllabusversion				
		1.0				

CourseObjectives:

1. To developbroad understandingofcomputers,programminglanguages and their generations
2. Introduce theessential skills fora logical thinkingfor problem solving
3. To gainexpertise in essential skills in programmingfor problem solvingusingcomputer

CourseOutcome:

1.Understand the workingprinciple of a computerand identifythe purposeof acomputerprogramminglanguage
2. Learn various problemsolvingapproachesandabilityto identifyanappropriateapproach tosolve the problem
3. Differentiate theprogramming Language constructs appropriatelyto solveanyproblem
4. Solve variousengineeringproblems usingdifferent data structures
5. Ableto modulatethegiven problem usingstructuralapproach of programming
6. Efficientlyhandledatausing at les to process and storedataforthegivenproblem

List ofChallengingExperiments(Indicative)

1.	Steps in Problem SolvingDrawing Flowchart usingyEdtool/Raptor Tool	4 hours
2.	IntroductiontoPython,DemoonIDE,Keywords,Identifiers,I/OStatements,Simple Program to displayHello world inPython.	4 hours
3.	OperatorsandExpressions in Python	4 hours
4.	AlgorithmicApproach 1:Sequential	2
5.	AlgorithmicApproach 2:Selection(if,elif,if.. else, nested ifelse	2 hours
6.	AlgorithmicApproach 3:Iteration(whileand for)	4 hours
7.	Stringsand its Operations	2 hours
8.	RegularExpressions	2 hours
9.	Listand its operations.	2 hours
10.	Dictionaries: operations	2 hours
11.	Tuplesand its operations	2 hours
12.	Set and its operations	2 hours
13.	Functions,Recursions	2 hours
14.	SortingTechniques(Bubble/Selection/Insertion)	4 hours
15.	SearchingTechniques :SequentialSearchandBinarySearch	3 hours
16.	Filesand its Operations	4 hours
	Total Laboratoryhours	**45 hours**

Text Book(s)				
1.	John V. Guttag., 2016.Introduction to computation andprogrammingusingpython: withapplications to understandingdata.PHIPublisher.			
Reference Books				
1.	CharlesSeverance.2016.Pythonforeverybody: exploringdata in Python 3,CharlesSeverance.			
2	CharlesDierbach.2013.Introduction to computer scienceusingpython: a computationalproblem-solvingfocus.WileyPublishers.ModeofEvaluation: PAT/			
Modeof Evaluation: CAT / Assignment / Quiz/ FAT / Project / Seminar				
RecommendedbyBoardof Studies		04-04-2014		
ApprovedbyAcademicCouncil		38th AC	Date	23-10-2015

Coursecode	Problem Solving AndObjectOrientedProgramming	L	T	P	J	C
CSE1002		0	0	6	0	3
Pre-requisite	NIL	Syllabusversion				
		v1.0				

CourseObjectives:

1. To emphasize thebenefits of objectorientedconcepts.
2. To enablestudents to solvethe real time applications usingobject orientedprogrammingfeatures
3. To improvethe skills of a logical thinkingand tosolve the problems usinganyprocessingelements

CourseOutcomes:

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	StructuredProgramming	12 hours

StructuredProgramming conditionaland loopingstatements- arrays -functions- pointers - dynamic memoryallocation- structure

Module:2	Introduction to objectorientedapproach	10 hours

Introduction to object orientedapproach:Whyobject orientedprogramming?- Characteristicsof objectorientedlanguage:classesand objects-encapsulation -data abstraction- inheritance - polymorphism-Merits and Demerits of object orientedprogramming.UML-classdiagram ofOOP -Inline functiondefaultargument function-Exceptionhandling(Standard) - reference:independentreference function returningreference passbyreference.

Module:3	Classes and objects	14 hours

Classesandobjects: Definition of classesaccessspecierclassversus structureconstructordestructor copyconstructorand its importance arrayofobjectsdynamic objects- friendfunction-friendclass

Module:4	Polymorphismand Inheritance	26 hours

Polymorphism andInheritance:Polymorphism-compile time polymorphismfunction over-loadingoperatoroverloading.Inheritance- typesof inheritance - constructorsand destructors in inheritance constraints of multiple inheritance-virtual baseclass -run time polymorphism - functionoverriding.

Module:5	ExceptionhandlingandTemplates	18 hours

ExceptionhandlingandTemplatesExceptionhandling(user-denedexception) - Functiontem-plate, Class templateTemplatewithinheritance ,STLContainer,Algorithm,Iterator-vector,list, stack, map.

Module:6	IO Streams and Files	10hours
IOstreams and Files IOstreams, Manipulators- overloading Inserters(<<) and Extractors(>>)Sequential and Random files – writing and reading objects into/fromfiles		
	Total Lecture hours:	90hours

Text Book(s)	
1.	StanleyB Lippman, JoseeLajoie,BarbaraE, Moo, C++ primer,Fifthedition,Addison-Wesley, 2012.
2	Ali Bahrami,Object oriented Systemsdevelopment,TataMcGraw-Hill Education, 1999.
3	Brian W. Kernighan, Dennis M. Ritchie ,TheC programmingLanguage, 2nd edition,Prentice HallInc., 1988.
Reference Books	
1.	Bjarne stroustrup, The C++ programmingLanguage,Addison Wesley, 4thedition, 2013.
2	HarveyM. Deitel and Paul J.Deitel,C++ Howto Program, 7th edition,Prentice Hall, 2010.
3	MaureenSprankleand Jim Hubbard,Problem solvingandProgrammingconcepts, 9th
Modeof Evaluation: CAT / Assignment / Quiz/ FAT / Project / Seminar	

List ofChallengingExperiments(Indicative)

1	**PostmanProblem** Apostmanneedstowalkdowneverystreetinhisareainordertodeliverthemail.Assumethatthedistancesbetweenthestreetsalongtheroadsaregiven.Thepostmanstartsatthepostoncea ndreturnsbacktotheposto_ceafterdeliveringallthemails.Implementanalgorithmtohelpthepostmantowalkminimum distance forthe purpose.	5hrs
2	**BudgetAllocation for MarketingCampaign** AmobilemanufacturingcompanyhasgotseveralmarketingoptionssuchasRadioadvertisementcampaign,TVnon-peakhourscampaign,Citytoppapernetwork,Viralmarketingcampaign,Webadvertising.Fromtheirpreviousexperience,theyhavegotastatisticsaboutpaybacksforeachmarketingoption.Giventhemarketingbudget(rupeesincrores)forthecurrentyearanddetailsofpaybacksforeachoption,implementanalgorithmtodeterminetheamountthatshallspentoneachmarketingoptionsothatthecompanyattainsthemaximumpro_t.	5 hrs.
3	**MissionariesandCannibals** Three missionariesandthree cannibals areon oneside ofariver, alongwith aboatthatcan hold one or two people.Implementan algorithm to find awayto geteveryone to theother sideof the river,without ever leavingagroupofmissionaries in one placeoutnumberedbythe cannibals in that place.	5hrs.

4	**Register Allocation Problem** A register is a component of a computer processor that can hold any type of data and can beaccessed faster. As registers are faster to access, it is desirable to use them to the maximum sothat the code execution is faster. For each code submitted to the processor, a registerinterference graph (RIG) is constructed. In a RIG, a node represents a temporary variable andan edge is added between two nodes (variables) t1 and t2 if they are live simultaneously at somepoint in the program. During register allocation, two temporaries can be allocated to the sameregister if there is no edge connecting them. Given a RIG representing the dependenciesbetween variables in a code, implement an algorithm to determine the number of registersrequired 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. Thepurpose of a server is to share hardware and software resources among clients. All the clientssubmit the jobs to the server for execution and the server may get multiple requests at a time. Insuch 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 thatthere are two servers that schedules jobs based on time and memory. The servers are named asTime_Schedule_Server and memory_Schedule_Server respectively. Design a OOP model andimplement the time_Schedule_Server and memory_Schedule_Server. TheTime_Schedule_Server arranges jobs based on time required for execution in ascending orderwhereas memory_Schedule_Server arranges jobs based on memory required for execution inascending order.	5 hrs
6	**Fragment Assembly in DNA Sequencing** DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all otherorganisms. 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 issheared into millions of small fragments (reads) which assemble to form a single genomicsequence ("superstring"). Each read is a small string. In such a fragment assembly, given a set ofreads, the objective is to determine the shortest superstring that contains all the reads. Forexample, given a set of strings, {000, 001, 010, 011, 100, 101, 110, 111} the shortest superstringis 0001110100. Given a set of reads, implement an algorithm to find the shortest superstring thatcontains 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 indifferent locations. Given a set of power points and the distances between them, implement analgorithm to find the minimum cable required.	5 hrs

RecommendedbyBoardof Studies	29.10.2015		
ApprovedbyAcademicCouncil	39th AC	Date	17-12-2015

CourseCode	CourseTitle	L	T	P	J	C
ENG1901	TechnicalEnglish-I	0	0	4	0	2
Pre-requisite	FoundationEnglish-II	SyllabusVersion				
		1				

CourseObjectives:

1. To enhance students' knowledgeofgrammarandvocabularyto readandwrite error-freelanguage in real lifesituations.
2. To make the students'practice the most commonareasofwrittenand spoken communications skills.
3. To improvestudents' communicative competencythrough listeningand speakingactivities in theclassroom.

CourseOutcomes:

1. Develop a betterunderstandingofadvancedgrammarrulesandwritegrammaticallycorrectsentences.
2. Acquirewidevocabularyandlearnstrategies for error-free communication.
3. Comprehendlanguage and improvespeakingskills in academicandsocialcontexts.
4. Improve listeningskills so as to understand complexbusinesscommunication in a varietyofglobalEnglishaccentsthrough proper pronunciation.
5. Interpret texts, diagramsandimproveboth readingandwritingskills which would helpthem intheir academic as well asprofessionalcareer.

Module:1	AdvancedGrammar	4 hours

Articles,Tenses,Voice and Prepositions
Activity:Worksheets onImpersonal PassiveVoice, Exercisesfrom the prescribed text

Module:2	VocabularyBuilding I	4 hours

IdiomsandPhrases,Homonyms,Homophones and HomographsActivity:Jigsaw Puzzles;VocabularyActivitiesthrough Web tools

Module:3	Listeningfor SpecificPurposes	4 hours

Gist, monologues, shortconversations, announcements, briefingsanddiscussionsActivity:Gapfilling;Interpretations

Module:4	Speakingfor Expression	6 hours

Introducingoneselfandothers,MakingRequests&responses,Inviting and Accepting/DecliningInvitationsActivity:Brief introductions; Role-Play; Skit.

Module:5	Reading for Information	4 hours

ReadingShort Passages,NewsArticles,TechnicalPapersand Short StoriesActivity: Readingspecificnewspaperarticles;blogs

Module:6	WritingStrategies	4 hours

Joiningthe sentences, word order, sequencingthe ideas, introductionand conclusionActivity: Short Paragraphs; Describingfamiliarevents; storywriting

Module:7	VocabularyBuilding II

Enrich thedomain specific vocabularybydescribingObjects, Charts, Food,Sports andEmployment.
Activity: Describing Objects, Charts, Food, Sports andEmployment

Module:8	**ListeningforDaily Life**	**4 hours**
Listeningforstatistical information, Shortextracts, Radio broadcastsandTV interviewsActivity: Takingnotes and Summarizing		
Module:9	**ExpressingIdeasandOpinions**	**6 hours**
Telephonic conversations,Interpretation ofVisuals and describingproducts andprocesses.Activity: Role-Play(Telephonic); DescribingProducts and Processes		
Module:10	**ComprehensiveReading**	**4 hours**
ReadingComprehension,Makinginferences, ReadingGraphics, Note-making, andCriticalReading. Activity: Sentence Completion;Cloze Tests		
Module:11	**Narration**	**4 hours**
Writingnarrative short story,Personalmilestones,officiallettersand E-mails.Activity: Writingan E-mail;Improvingvocabularyand writingskills.		
Module:12	**Pronunciation**	**4 hours**
Speech Sounds, Word Stress,Intonation, Various accents Activity:PracticingPronunciation through web tools;Listeningto various accents of English		
Module:13	**Editing**	**4 hours**
Simple, Complex&CompoundSentences,Direct&Indirect Speech, Correction of Errors,Punctuations. Activity:PracticingGrammar		
Module:14	**ShortStory Analysis**	**4 hours**
"TheBoundary"byJhumpaLahiri Activity: Readingandanalyzingthethemeof the short story.		
	Total Lecture hours	**60 hours**
Text Book / Workbook		
1.	Wren,P.C.;Martin,H.;PrasadaRao,N.D.V.(1973–2010).*HighSchoolEnglishGrammar &Composition*. New Delhi: SultanChandPublishers.	
2	Kumar,Sanjay,;PushpLatha.(2018)EnglishLanguageandCommunicationSkillsforEngineers,India:OxfordUniversityPress.	
Reference Books		
1.	GupthaS C, (2012)*Practical English Grammar &Composition*, 1st Edition,India:Arihant Publishers	

2.	StevenBrown,(2011)Dorolyn Smith**,** *Active Listening**3***, 3rdEdition, UK:Cambridge UniversityPress.
3.	LizHamp-Lyons,BenHeasley,(2010)*Study Writing*,2ndEdition, UK:Cambridge UniversityPres.
4.	KennethAnderson,JoanMaclean,(2013)TonyLynch,*StudySpeaking*,2ndEdition,UK: Cambridge,UniversityPress.
5.	EricH.Glendinning,BeverlyHolmstrom, (2012)*Study Reading*,2ndEdition, UK: CambridgeUniversityPress.
6.	MichaelSwan,(2017)*PracticalEnglishUsage*(PracticalEnglishUsage),4thedition,UK:Oxford UniversityPress.
7.	MichaelMcCarthy,FelicityO'Dell,(2015)*EnglishVocabularyinUseAdvanced*(SouthAsian Edition), UK:CambridgeUniversityPress.
8.	MichaelSwan,CatherineWalter,(2012)*OxfordEnglishGrammarCourseAdvanced*,Feb,4thEditi on, UK: OxfordUniversityPress.
9.	Watkins,Peter.(2018)*TeachingandDevelopingReadingSkills:CambridgeHandbooksfor Language teachers*,UK:Cambridge UniversityPress.
10.	(*The BoundarybyJhumpa Lahiri)*URL:https://www.newyorker.com/magazine/2018/01/29/the-boundary?intcid=inline_amp

Mode ofevaluation: Quizzes,Presentation, Discussion, Role play, Assignments andFAT

List ofChallengingExperiments(Indicative)		
1.	Self-Introduction	**12 hours**
2.	Sequencing Ideasand Writinga Paragraph	**12 hours**
3.	ReadingandAnalyzing Technical Articles	**8 hours**
4.	ListeningforSpecificityinInterviews(ContentSpecific)	**12 hours**
5.	IdentifyingErrors in a Sentence or Paragraph	**8 hours**
6.	WritinganE-mailbynarratinglife events	**8 hours**
	Total Laboratory Hours	**60 hours**

Mode ofevaluation: Quizzes,Presentation, Discussion, Role play, Assignments andFAT

Recommendedby Board ofStudies	08.06.2019	
Approved by AcademicCouncil	55	Date:13-06-2019

CourseCode	CourseTitle	L	T	P	J	C
ENG1902	TechnicalEnglish-II	0	0	4	0	2
Pre-requisite	71%to 90% EPT score	SyllabusVersion				
		1				

CourseObjectives:

1. ToacquireproficiencylevelsinLSRWskills on parwith the requirementsforplacementinterviews of high-endcompanies/ competitive exams.
2. Toevaluatecomplexargumentsand to articulate their ownpositions on arangeof technicalandgeneraltopics.
3. Tospeak ingrammaticalandacceptable English with minimalMTI,aswellasdevelopavast andactive vocabulary.

CourseOutcomes:

1. Communicate proficientlyin high-endinterviewsand exam situationsandallsocialsituations
2. Comprehendacademicarticlesanddraw inferences
3. Evaluatedifferentperspectiveson atopic
4. Writeclearlyand convincinglyin academicas wellasgeneralcontexts
5. Synthesize complexconcepts and presentthem in speechandwriting

Module:1	Listeningfor ClearPronunciation	4 hours

Ice-breaking,Introduction to vowels,consonants,diphthongs.
Listeningto formalconversations in BritishandAmerican accents (BBC and CNN)aswellas other 'native'accents
Activity:Factualandinterpretive exercises; note-makingin a varietyofglobalEnglishaccents

Module:2	IntroducingOneself	4 hours

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

Module:3	EffectiveWriting	6 hours

Writing:BusinesslettersandEmails, Minutes andMemos
Structure/template ofcommon businesslettersandemails:inquiry/ complaint/ placingan order;Formats of Minutes andMemos
Activity: Students writea businessletterand Minutes/ Memo

Module:4	ComprehensiveReading	4 hours

Reading: ReadingComprehensionPassages,Sentence Completion(Technical and GeneralInterest),Vocabularyand Word Analogy
Activities: Clozetests, Logicalreasoning, Advanced grammarexercises

Module:5	Listening to Narratives	4 hours

Listening:Listeningto audio files of shortstories,News, TVClips/ Documentaries, MotivationalSpeeches in UK/ US/globalEnglishaccents.
Activity: Note-makingandInterpretiveexercises

Module:6	Academic Writing andEditing	6 hours

Writing:Editing/ ProofreadingsymbolsCitationFormats
Structureof anAbstractandResearch Paper
Activity: WritingAbstractsand research paper; Work withEditing/Proofreading exercise

Module:7	Team Communication	4 hours

Speaking: GroupDiscussionsandDebates oncomplex/ contemporarytopicsDiscussionevaluationparameters, usinglogic in debates
Activity:Group Discussions on general topics

Module:8	**Career-orientedWriting**	**4 hours**
Writing:Resumesand Job ApplicationLetters, SOPActivity: Writingresumesand SOPs		
Module:9	**Reading for Pleasure**	**4 hours**
Reading: Readingshort stories Activity:Classroomdiscussionandnote-making,criticalappreciation of theshort story		
Module:10	**CreativeWriting**	**4 hours**
Writing:Imaginative,narrative and descriptiveprose Activity: Writingaboutpersonalexperiences,unforgettableincidents,travelogues		
Module:11	**AcademicListening**	**4 hours**
Listening:Listeningin academiccontexts Activity:Listeningto lectures,Academic Discussions, Debates, Review Presentations,ResearchTalks,ProjectReview Meetings		
Module:12	**ReadingNature-basedNarratives**	**4 hours**
Narratives on Climate Change,Nature and EnvironmentActivity:Classroomdiscussions,studentpresentations		
Module:13	**TechnicalProposals**	**4 hours**
Writing:Technical ProposalsActivities: Writinga technicalproposal		
Module:14	**PresentationSkills**	**4 hours**
PersuasiveandContent-Specific PresentationsActivity:Technical Presentations		
	Total Lecture hours:	**60 hours**

Text Book / Workbook

1.	Oxenden,CliveandChristinaLatham-Koenig.*NewEnglishFile:AdvancedStudentsBook*.Paperback.Oxford UniversityPress,UK,
2	Rizvi, Ashraf. *Effective Technical Communication*. McGraw-HillIndia, 2017.

Reference Books

1.	Oxenden,CliveandChristinaLatham-Koenig,*NewEnglishFile:Advanced:Teacher'sBookwithTestandAssessment*.CD-ROM:Six-levelGeneralEnglishCourseforAdults.Paperback.Oxford UniversityPress,UK, 2013.
2.	Balasubramanian,T.*English Phoneticsfor the Indian Students: A Workbook*.LaxmiPublications, 2016.
3.	PhilipSeargeantandBillGreenwell,*FromLanguagetoCreativeWriting*.BloomsburyAcademic, 2013.
4.	Krishnaswamy, N. *Eco-English*. BloomsburyIndia, 2015.
5.	Manto,SaadatHasan.*SelectedShortStories*.Trans.AatishTaseer.RandomHouseIndia,2012.
6.	Ghosh, Amitav. *TheHungryTide*. Harper Collins, 2016.
7.	Ghosh,Amitav.*TheGreatDerangement:ClimateChangeandtheUnthinkable*.PenguinBooks, 2016.
8.	*The MLAHandbook for Writersof Research Papers,*8th ed. 2016.
	<u>Online Sources:</u>

	https://americanliterature.com/short-short-stories.(75*short* shortstories)http://www.eco-ction.org/dt/thinking.html(Leopold,Aldo."ThinkinglikeaMountain")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 ofevaluation: Quizzes,Presentation, Discussion, Role play, Assignments andFAT

List ofChallengingExperiments(Indicative)		
1.	Self-Introduction usingSWOT	**12 hours**
2.	Writingminutes of meetings	**10 hours**
3.	Writinganabstract	**10 hours**
4.	Listeningto motivationalspeechesand interpretation	**10 hours**
5.	Cloze Test	**6 hours**
6.	Writinga proposal	**12 hours**
	Total Laboratory Hours	**60 hours**

Mode ofevaluation: Quizzes,Presentation, Discussion, Role play, Assignments andFAT

Recommended by Board ofStudies	08.06.2019	
Approved by AcademicCouncil	55	Date:13-06-2019

CourseCode	Coursetitle	L	T	P	J	C
ENG1903	AdvancedTechnicalEnglish	0	0	2	4	2
Pre-requisite	Greaterthan 90 %EPT score	SyllabusVersion				
		1				

CourseObjectives:

1. To review literaturein anyform oranytechnical article
2. To infercontent in social mediaandrespondaccordingly
3. To communicatewith people across theglobe overcomingtrans-cultural barriersandnegotiatesuccessfully

CourseOutcomes:

1. Analyzecriticallyand write goodreviews
2. Articulate research papers, projectproposals andreports
3. Communicate effectivelyin a trans-cultural environment
4. Negotiateand lead teamstowardssuccess
5. Presentideas in an effective manner usingweb tools

Module:1	Negotiationand Decision MakingSkillsthroughLiterary Analysis	5 hours

Concepts of NegotiationandDecision MakingSkills
Activity:Analysis of excerpts fromShakespeare's"TheMerchant ofVenice" (court scene)and discussion on negotiationskills.
Criticalevaluation of excerpts fromShakespeare's"Hamlet"(Monologue byHamlet)anddiscussion on decision makingskills

Module:2	Writingreviews and abstractsthroughmovieinterpretations	5 hours

Review writingandabstract writingwith competency
Activity: WatchingCharlesDickens"Great Expectations" andwriting amovie review
WatchingWilliam F.Nolan's"Logan's Run" andanalyzingit in tunewith the presentscenario of depletion of resources and writinganabstract

Module:3	TechnicalWriting	4 hours

Stimulateeffective linguisticsforwriting:content and styleActivity:Proofreading
Statement ofPurpose

Module:4	Trans-CulturalCommunication	4 hours

NuancesofTrans-culturalcommunicationActivity:
Groupdiscussionand case studies ontrans-culturalcommunication.Debate on trans-culturalcommunication.

Module:5	ReportWritingand ContentWriting	4 hours

Enhancingreportage onrelevant audio-visualsActivity:
Watch adocumentaryonsocialissuesand draft a reportIdentifyavideo onanysocial issueandinterpret

Module:6	Draftingproject proposals andarticle writing	4 hours

Dynamics of draftingproject proposals and research articles

Activity:
Writinga project proposal.Writinga researcharticle.

Module:7	**TechnicalPresentations**	**4 hours**
Buildsmartpresentation skills andstrategies Activity:Technical presentations usingPPT and Web tools		
	Total Lecture hours	**30 hours**
Text Book/ Workbook		
1.	Raman,Meenakshi&SangeetaSharma.*TechnicalCommunication:PrinciplesandPractice*,3rd edition, Oxford UniversityPress, 2015.	
Reference Books		
1	BasuB.N. *TechnicalWriting*, 2011 Kindle edition	
2	Arathoon,Anita.*Shakespeare's The Merchant ofVenice*(Text with Paraphrase),EvergreenPublishers, 2015.	
3	Kumar, SanjayandPushpLata.*English Languageand Communication Skills for Engineers,* Oxford UniversityPress,India, 2018.	
4	Frantisek,Burda.*On Transcultural Communication*, 2015,LAPLambertAcademicPublishing,UK.	
5	Geever, C. Jane. *TheFoundation Center's Guideto ProposalWriting*, 5thEdition, 2007, Reprint 2012 TheFoundationCenter, USA.	
6	Young, Milena. *Hacking Your Statement of Purpose: A ConciseGuide toWriting Your SOP*,2014Kindle Edition.	
7	Ray,Ratri,*WilliamShakespeare'sHamlet*, TheAtlantic Publishers, 2011.	
8	C Muralikrishna&Sunitha Mishra,*Communication Skills for Engineers,*2nd edition, NY: Pearson,2011.	
Mode ofEvaluation: Quizzes,Presentation, Discussion, Role Play, Assignments		
List ofChallengingExperiments(Indicative)		
1.	Enacting acourt scene- Speaking	**6 hours**
2.	Watchingamovieand writingareview	**4 hours**
3.	Trans-cultural – case studies	**2 hours**
4.	Draftingareport on anysocial issue	**6 hours**
5.	TechnicalPresentation usingweb tools	**6 hours**
6.	Writinga research paper	**6 hours**
J- ComponentSampleProjects		
1.	Short Films	
2.	Field Visits and Reporting	
3.	Case studies	
4.	Writingblogs	
5.	Vlogging	
	Total Hours(J-Component)	**60 hours**
Mode ofevaluation: Quizzes,Presentation, Discussion, Role play, Assignments andFAT		
Recommended by Board ofStudies	08.06.2019	
Approved by AcademicCouncil	55	Date:13-06-2019

CourseCode	Ethics and Values	L	T	P	J	C
HUM1021 / HUM1032		2	0	0	0	2
Pre-requisite	Nil	SyllabusVersion				
		1.1				

CourseObjectives:

1. To understandandappreciate the ethical issues facedbyan individual in profession, societyand polity
2. To understand the negative healthimpacts ofcertain unhealthybehaviors
3. To appreciate the need andimportance of physical, emotionalhealthandsocialhealth

CourseOutcomes:

Studentswill be able to:

1. Comprehend moral and ethical values.
2. Understand various social problems andlearn to act ethically
3. Understand theconceptofaddictionand how it will affect the physical andmentalhealth
4. Identifyethical concernsin researchandintellectual contexts, includingacademic integrity, useandcitation of sources, the objective presentationof data,and thetreatment of human subjects
5. Identifythe maintypologies,characteristics,activities,actorsand forms ofcybercrime

Module:1	Being Good and Responsible	5 hours

Gandhianvalues such astruth andnon-violence –Comparative analysis onleaders ofpast andpresent – Society's interests versusself-interests- Personal Social Responsibility: Helpingtheneedy, charityand servingthe society

Module:2	Social Issues 1	4 hours

Harassment – Types - Prevention of harassment,Violence and Terrorism

Module:3	Social Issues 2	4 hours

Corruption:Ethicalvalues,causes,impact,laws,prevention– Electoralmalpractices;White collarcrimes -Taxevasions– Unfairtradepractices

Module:4	AddictionandHealth	5 hours

Peerpressure-Alcoholism: Ethicalvalues,causes,impact,laws,prevention– Illeffects ofsmoking-Prevention of Suicides;
Sexual Health:Preventionandimpactof pre-marital pregnancy andSexually TransmittedDiseases

Module:5	Drug Abuse	3 hours

Abuseof differenttypesof legal and illegaldrugs:Ethicalvalues,causes, impact, lawsandprevention

Module:6	Personal and Professional Ethics	4 hours

Dishonesty-Stealing-Malpractices in Examinations– Plagiarism

Module:7	AbuseofTechnologies	3 hours

Hackingandothercybercrimes,Addictiontomobilephoneusage,VideogamesandSocialnetworkingweb sites				
Module:8	**Contemporary Issues:**			**2 hours**
Guestlecturesby Industrial Experts				
	Total Lecture Hours:		**30 hours**	
Reference Books				
1.	Dhaliwal,K.K(2016),"GandhianPhilosophyofEthics:AStudyofRelationshipbetweenhis PresuppositionandPrecepts, Writers Choice,NewDelhi,India.			
2.	Vittal, N (2012), "EndingCorruption?-Howto Clean upIndia?",Penguin Publishers, UK.			
3.	Pagliaro,L.A.andPagliaro,A.M(2012),"HandbookofChildandAdolescentDrugandSubstanceAb use:Pharmacological ,DevelopmentalandClinicalConsiderations",WileyPublishers,U.S.A.			
4.	Pandey, P. K(2012), "Sexual Harassment andLaw inIndia",LambertPublishers,Germany.			
Mode ofEvaluation: Quizzes, CAT,FAT,Digitalassignments,poster/collage makingandSeminars				
RecommendedbyBoardof Studies		26-07-2017		
ApprovedbyAcademicCouncil		No. 46	Date	24-08-2017

CourseCode	Calculus for Engineers	L	T	P	J	C
MAT1011		3	0	2	0	4
Pre-requisite	10+2 MathematicsorMAT1001	SyllabusVersion				
		1.0				

CourseObjectives:

1. To provide the requisiteandrelevantbackgroundnecessaryto understand theotherimportantengineeringmathematicscoursesoffered forEngineersand Scientists.
2. To introduce important topics of appliedmathematics, namelySingleandMultivariable Calculus and VectorCalculus etc.
3. To impart the knowledgeofLaplace transform,animportanttransform technique forEngineerswhichrequiresknowledge of integration

CourseOutcomes:

1. Apply differentiation to solve max/min problems and compute volumes of revolution and surface areas of revolution using Integration.
2. Apply the 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.
4. Evaluate multiple integrals in Cartesian, Polar, Cylindrical and Spherical coordinates.
5. Analyse the concepts of gradient, directional derivatives, divergence, curl and apply them to find the circulation, work done, conservative field and Greens′, Stokes, Gauss divergence theorem.
6. Develop programming tools for engineering problems and visualize solutions.

Module:1	Application ofSingleVariableCalculus	9 hours

Differentiation- Extrema on anInterval-Rolle'sTheorem and theMean ValueTheorem-Increasingand Decreasingfunctions andFirstderivative test-Second derivativetest-MaximaandMinima-Concavity.Integration-Average function value - Area between curves-Volumesof solids of revolution -

Module:2	Laplacetransforms	7 hours

DefinitionofLaplacetransform-Properties-Laplacetransformofperiodicfunctions-Laplacetransform of unit step function,Impulse function-Inverse Laplace transform-Convolution.

Module:3	MultivariableCalculus	4 hours

Functionsoftwovariables-limitsandcontinuity-partialderivatives–totaldifferential-Jacobianand its properties.

Module:4	Application ofMultivariableCalculus	5 hours

Taylor'sexpansionfortwovariables–maximaandminima–constrainedmaximaandminima-Lagrange's multipliermethod.

Module:5	Multipleintegrals	8 hours

Evaluationofdoubleintegrals–changeoforderofintegration–changeofvariablesbetweenCartesianandpolarco-ordinates-Evaluationoftripleintegrals-changeofvariablesbetweenCartesianandcylindricalandsphericalco-ordinates-BetaandGammafunctions–interrelation -evaluation of multiple integrals using gamma andbetafunctions.			
Module:6	**Vector Differentiation**		**5 hours**
Scalarandvectorvaluedfunctions–gradient,tangentplane–directionalderivative-divergenceandcurl–scalarand vector potentials–Statement of vectoridentities-Simpleproblems			
Module:7	**Vector Integration**		**5 hours**
line,surfaceandvolumeintegrals-StatementofGreen's,Stoke'sandGaussdivergencetheorems-verification and evaluation of vectorintegrals usingthem.			
Module:8	**Contemporary Issues:**		**2 hours**
IndustryExpertLecture			
	Total Lecture hours:		**45 hours**
Text Book(s)			
[1]Thomas' Calculus,GeorgeB.Thomas,D.WeirandJ.Hass, 13th edition,Pearson, 2014.[2]AdvancedEngineeringMathematics,ErwinKreyszig,10thEdition,Wiley India, 2015.			
Reference Books			
1. HigherEngineeringMathematics, B.S.Grewal, 43rdEdition,Khanna Publishers, 2015 2. HigherEngineeringMathematics, John Bird,6thEdition, ElsevierLimited,2017. 3. Calculus:EarlyTranscendentals, James Stewart, 8thedition,CengageLearning,2017. 4. EngineeringMathematics,K.A.StroudandDexterJ.Booth,7thEdition,PalgraveMacmillan(2013)			
Mode ofEvaluation			
DigitalAssignments, Quiz, ContinuousAssessments,FinalAssessmentTest			
List ofChallengingExperiments(Indicative)			
1.	Introduction to MATLABthroughmatrices,andgeneral Syntax		2 hours
2	Plottingand visualizingcurvesandsurfaces in MATLAB – Symboliccomputations usingMATLAB		2 hours
3.	EvaluatingExtremum ofa singlevariablefunction		2 hours
4.	Understandingintegrationas Area under thecurve		2 hours
5.	Evaluation of Volume by Integrals(Solids of Revolution)		2 hours
6.	Evaluatingmaxima andminimaof functions of severalvariables		2 hours
7.	Applying Lagrange multiplier optimization method		2 hours
8.	EvaluatingVolume under surfaces		2 hours
9.	Evaluatingtripleintegrals		2 hours
10.	Evaluatinggradient, curl anddivergence		2 hours
11.	Evaluatingline integralsin vectors		2 hours
12.	ApplyingGreen's theorem to realworld problems		2 hours
	TotalLaboratoryHours		**24 hours**
Mode of Evaluation:			
WeeklyAssessment,FinalAssessmentTest			
RecommendedbyBoardof Studies	03-06-2019		
ApprovedbyAcademicCouncil	No. 55	Date	13-06-2019

CourseCode	Statistics for Engineers	L	T	P	J	C
MAT2001		3	0	2	0	4
Prerequisites	MAT1011 – Calculus forEngineers	SyllabusVersion: 1.0				

CourseObjectives:

1. To providestudents with a frameworkthat will helpthem choosethe appropriatedescriptive methods in variousdataanalysis situations.
2. To analysedistributions andrelationship ofreal-time data.
3. Toapplyestimationandtestingmethodstomakeinferenceandmodellingtechniquesfordecisionmaking.

CourseOutcomes:

1. Analyze statistical data using measures of central tendency and dispersion.
2. Analyze and apply the concepts of random variables and distribution functions to obtain moments and characteristic functions.
3. Analyze the experimental data using correlation and regression analysis and interpret the results.
4. Apply the concepts of inferentail statistics and interpret the results.
5. Apply the statistical methodology in solving reliability engineering problems.
6. Develop programming tools for engineering problems and visualize solutions.

Module:1	Introduction to Statistics	6 hours
Introductiontostatisticsanddataanalysis-Measures of centraltendency –Measures ofvariability-[Moments-Skewness-Kurtosis (Concepts only)].		
Module:2	**Randomvariables**	8 hours
Introduction-randomvariables-ProbabilitymassFunction,distributionanddensityfunctions -jointProbabilitydistributionandjointdensityfunctions-Marginal,conditionaldistributionanddensityfunctions-Mathematicalexpectation,anditspropertiesCovariance,momentgeneratingfunction– characteristic function.		
Module:3	**Correlation and regression**	4 hours
CorrelationandRegression–RankCorrelation-PartialandMultiplecorrelation-Multipleregression.		
Module:4	**ProbabilityDistributions**	7 hours
Binomialand Poisson distributions– Normaldistribution – Gamma distribution– Exponentialdistribution – Weibull distribution.		
Module:5	**Hypothesis Testing I**	4 hours
Testingofhypothesis–Introduction-Typesoferrors,criticalregion,procedureoftestinghypothesis-Largesampletests-ZtestforSingleProportion,DifferenceofProportion,meananddifference of means.		
Module:6	**Hypothesis Testing II**	9 hours
Smallsampletests-Student'st-test,F-test-chi-squaretest-goodnessoffit-independenceofattributes-DesignofExperiments-Analysisofvariance–oneandtwowayclassifications-CRD-RBD-LSD.		
Module:7	**Reliability**	5 hours
Basicconcepts- Hazard function-Reliabilitiesof seriesandparallel systems- SystemReliability-Maintainability-Preventive andrepairmaintenance- Availability.		

Module:8	**ContemporaryIssues**	2 hours	
IndustryExpertLecture			
	Total Lecture hours	**45 hours**	

Text book(s)

1. Probability andStatistics for engineersa n d scientists,R.E.Walpole,R.H.Myers,S.L.MayersandK.Ye, 9th Edition,PearsonEducation(2012).
2. AppliedStatisticsandProbabilityforEngineers,DouglasC.Montgomery,GeorgeC.Runger,6th Edition, JohnWiley&Sons (2016).

Reference books

1. ReliabilityEngineering,E.Balagurusamy,TataMcGrawHill,Tenthreprint2017.
2. Probabilityand Statistics, J.L.Devore, 8th Edition, Brooks/Cole,CengageLearning(2012).
3. Probabilityand Statistics forEngineers,R.A.Johnson,MillerFreund's, 8th edition, Prentice HallIndia(2011).
4. Probability, Statistics and ReliabilityforEngineersandScientists,Bilal M.AyyubandRichardH.McCuen, 3rd edition, CRC press(2011).

Mode ofEvaluation

DigitalAssignments(Solutionsbyusingsoftskills),ContinuousAssessmentTests,Quiz,FinalAssessmentTest.

List ofExperiments(Indicative)		
1.	Introduction: UnderstandingData types;importing/exportingdata.	2 hours
2.	Computing SummaryStatistics /plottingandvisualizing datausingTabulation and GraphicalRepresentations.	2 hours
3.	Applyingcorrelation andsimple linearregression model to real dataset;computingand interpretingthecoefficient ofdetermination.	2 hours
4.	Applyingmultiple linearregression model to realdataset;computingandinterpretingthe multiple coefficient of	2 hours
5.	Fittingthe followingprobabilitydistributions: Binomial distribution	2 hours
6.	Normal distribution, Poissondistribution	2 hours
7.	TestingofhypothesisforOnesamplemeanandproportionfromreal-timeproblems.	2 hours
8.	TestingofhypothesisforTwosamplemeansandproportionfromreal-time problems	2 hours
9.	Applyingthe t test forindependent and dependentsamples	2 hours
10.	ApplyingChi-squaretestforgoodnessoffittestandContingencytesttoreal dataset	2 hours
11.	PerformingANOVAforrealdatasetforCompletelyrandomizeddesign,RandomizedBlockdesign,Latin squareDesign	2 hours
	Total laboratoryhours	**22 hours**

Mode ofEvaluation: WeeklyAssessment, Final Assessment Test

RecommendedbyBoardof Studies	03-06-2019		
ApprovedbyAcademicCouncil	No. 55	Date:	13-06-2019

Coursecode	LEAN START-UPMANAGEMENT	L	T	P	J	C
MGT1022		1	0	0	4	2
Pre-requisite	Nil	Syllabusversion				
		v. 2.2				

CourseObjectives:

Theobjective of thecourseis to makeastudent to create andcommercialize the product

CourseOutcome:

Upon successfulcompletion ofthe coursethe students will be able to

1. Understand developingbusiness models and growth drivers
2. Usethe businessmodelcanvas to map out keycomponents of enterprise
3. Analyze market size, cost structure,revenue streams, and valuechain
4. Understandbuild-measure-learnprinciples
5. Foreseeingandquantifyingbusiness andfinancialrisks

Module:1		2 hours

CreativityandDesignThinking (identifythe verticalforbusinessopportunity, understandyourcustomers,accuratelyassess marketopportunity)

Module:2		3 hours

Minimum ViableProduct(Value Proposition, CustomerSegments,Build-measure-learn process)

Module:3		3 hours

Business Model Development(Channels and Partners, Revenue Model andstreams,KeyResources, Activities and Costs, CustomerRelationshipsandCustomerDevelopmentProcesses,Businessmodelcanvas –the lean model-templates)

Module:4		3 hours

Business Plan and Access to Funding(visioningyourventure, takingthe product/ service tomarket, Market plan includingDigital&ViralMarketing, start-up finance - Costs/Profits&Losses/cash flow, Angel/VC,/BankLoansand Keyelements of raisingmoney)

Module:5		2 hours

Legal,Regulatory, CSR, Standards,Taxes

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

Text Book(s)

1.	SteveBlank,K&SRanch(2012)TheStartupOwner'sManual:TheStep-By-StepGuideforBuildinga GreatCompany, 1st edition
2.	SteveBlank(2013)TheFour Steps to the Epiphany,K&SRanch; 2nd edition
3.	EricRies(2011)The LeanStartup:How Today'sEntrepreneursUse ContinuousInnovation to Create RadicallySuccessfulBusinesses,CrownBusiness
Reference Books	
1.	Steve Blank (2014) Holdinga Catbythe Tail, ,K&SRanchPublishingLLC
2.	Karal T Ulrich, ProductDesignandDevelopment,SDEppinger,McGrawHill
3.	PeterThiel,(2014)Zeroto One:Notes on Startups, or How toBuild theFuture,CrownBusiness;
4.	LeanAnalytics: UseDatato Build aBetter Startup Faster(LeanSeries), Alistair Croll&Benjamin Yoskovitz,O'ReillyMedia; 1st Edition
5.	MartyCagan, (2008)Inspired:HowToCreate ProductsCustomersLove,SVPGPress;1stedition

RecommendedbyBoardof Studies	17-08-2017		
ApprovedbyAcademicCouncil	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. Comprehend the dual nature of radiation and matter
2. Compute Schrodinger's equations to solve finite and infinite potential problems.
3. Analyze quantum ideas at the nanoscale.
4. Apply quantum ideas for understanding the operation and working principle of optoelectronic devices.
5. Apply the Maxwell's equations in differential and integral form.
6. Select appropriate optical fibers for different Engineering applications.
7. Explain concept of Lorentz Transformation for Engineering applications.
8. Demonstrate the quantum mechanical ideas

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.	AjoyGhatak and K. Thyagarajan, Introduction to Fiber Optics, 2010, Cambridge University Press.

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

List of Experiments

1.	DeterminationofPlanck'sconstantusingelectroluminescenceprocess	2 hrs
2.	Electrondiffraction	2 hrs
3.	Determinationofwavelengthoflasersource(He-Ne laseranddiodelasersof differentwavelengths)usingdiffractiontechnique	2 hrs
4.	Determinationof sizeoffineparticleusinglaserdiffraction	2 hrs
5.	Determinationof thetrackwidth(periodicity) inawrittenCD	2 hrs
6.	OpticalFibercommunication(source+opticalfiber+detector)	2 hrs
7.	AnalysisofcrystallitesizeandstraininanaNo-crystallinefilmusingX-raydiffraction	2 hrs
8.	NumericalsolutionsofSchrödingerequation(e.g.particle inaboxproblem) (canbegivenas anassignment)	2 hrs
9.	Lasercoherencelengthmeasurement	2 hrs
10.	Prooffortransverse natureofE.M. waves	2 hrs
11.	QuantumconfinementandHeisenberg'suncertaintyprinciple	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 studentsconfident enough to handlethe day to day issues.
2. To develop the "ThinkingSkill"ofthe students, especially Creative ThinkingSkills
3. To train thestudentsto be innovative inall their activities
4. To prepare aproject report on a sociallyrelevant theme asasolution to the existing issues

Course Outcomes:

1. Comprehend the various types of thinking skills.
2. Explain the innovative and creative ideas.
3. Analyze a suitable solution for socially relevant issues

Module:1 A	Self Confidence	1 hour

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

Project : Exploring self, understanding surrounding,thinking about how s(he) can be acontributor forthe society, Creating abig picture of beingan innovator– writing a1000words imaginary autobiographyof self– Topic"MrX– the great innovatorof2015" and upload. **(4 non- contact hours)**

Module:1 B	Thinking Skill	1 hour

Thinking and Behaviour– Typesofthinking– Concrete– Abstract, Convergent, Divergent,Creative, Analytical, Sequentialand Holistic thinking– ChunkingTriangle– Context Grid – Examples – Case Study.

Project : Meeting atleast 50 peoplebelonging to variousstrataoflife and talkto them / make field visits to identify amin of100societyrelated issues, problemsforwhich theyneed solutionsand categories them and upload alongwith details of people met and lessonslearnt. **(4 non- contact hours)**

Module:1 C	Lateral ThinkingSkill	1 hour

BloomsTaxonomy– HOTS– Outofthe box thinking– deBono lateral thinking model –Examples

Project : Last weeks -incomplete portion to be done anduploaded

Module:2 A	Creativity	1 hour

CreativityModels–Walla–Barrons–Koberg&Begnall– Examples

Project: Selecting5outof 100issuesidentifiedforfuturework. Criteria based approachf o r prioritisation, use of statistical tools& upload. **(4 non- contact hours)**

Module:2 B	Brainstorming	1 hour

25 brainstorming techniquesand examples

Project: Brainstormandcomeoutwithasmanysolutionsas possibleforthe top 5 issues identified &upload. **(4 non- contact hours)**

Module:3	MindMapping	1 hour

Mind Mappingtechniquesandguidelines. Drawing amind map

Project: UsingMindMapsgetanothersetof solutionsforthe next 5 issues(issue6–10). **(4 non- contact hours)**

Module:4 A	Systemsthinking	1 hour

SystemsThinkingessentials–examples–Counter Intuitive condemns

Project : Select 1 issue / problem forwhich the possiblesolutionsareavailable withyou.ApplySystems Thinking process andpickuponesolution[explanationshouldbegiven whytheotherpossiblesolutionshavebeen leftout].Goback to the customer and assessthe acceptability and upload.. **(4 non- contact hours)**

Module:4 B	DesignThinking	1 hour

Designthinkingprocess–Humanelementofdesign thinking– casestudy

Project : Applydesignthinkingto theselectedsolution, apply theengineering&scientifictingetoit.Participate in"design week" celebrationsuploadthe weekslearning

out come.		
Module:5 A	**Innovation**	**1 hour**
DifferencebetweenCreativityandInnovation–Examples ofinnovation–Being innovative. **Project:** Aliteraturesearchesonprototypingofyoursolution finalized.Prepare aprototypemodel or processand upload. . **(4 non- contact hours)**		
Module:5 B	**BlocksforInnovation**	**1 hour**
IdentifyBlocksforcreativityandinnovation – overcomingobstacles – Case Study **Project :**Project presentation on problem identification,solution,innovations-expectedresults– InterimreviewwithPPTpresentation. . **(4 non- contact hours)**		
Module:5 C	**InnovationProcess**	**1 hour**
StepsforInnovation–rightclimateforinnovation **Project:** Refiningtheproject,basedonthereviewreportanduploading the text. . **(4 non- contact hours)**		
Module:6 A	**Innovation in India**	**1 hour**
Storiesof10 Indian innovations **Project:** Makingthe project better with add ons. . **(4 non- contact hours)**		
Module:6 B	**JUGAAD Innovation**	**1 hour**
Frugal andflexible approach toinnovation -doing more with less Indian Examples **Project:** FinetuningtheinnovationprojectwithJUGAADprinciples and uploading (Credit for JUGAADimplementation). **(4 non- contact hours)**		
Module:7 A	**Innovation Project Proposal Presentation**	**1 hour**
Projectproposal contents, economicinput, ROI– Template **Project:** Presentationoftheinnovativeprojectproposalandupload. **(4 non- contact hours)**		
Module:8 A	Contemporary issuein Innovation	**1 hour**
Contemporary issuein Innovation **Project:** Final project Presentation , Vivavoce Exam (**4 non- contact hours)**		
	Total Lecture hours:	**15 hours**

Text Book(s)	
1.	How to have Creative Ideas, Edward debone,Vermilonpublication, UK, 2007
2.	The Artof Innovation, Tom Kelley &Jonathan Littman, ProfileBooks Ltd, UK, 2008

Reference Books	
1.	Creating Confidence, MeribethBonct, Kogan Page India Ltd, New Delhi, 2000
2.	Lateral Thinking Skills, Paul Sloane, KeoganPage India Ltd, NewDelhi, 2008
3.	Indian Innovators, Akhat Agrawal, JaicoBooks, 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 Threereviewswith weightageof25 :25 : 50 alongwithreports			
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				

CourseObjectives:

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 materials and their engineering properties
2. Analyse the behaviour of structural and machine components subjected to various loading and support conditions based on principles of equilibrium
3. Solve problems using the concept of centroid/centre of gravity
4. Evaluate moment of inertia of areas and bodies
5. Apply the concept of stress and strain to analyze structural members and machine parts under various loading condition
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 4thed., McGraw Hill, 2010.
3.	Beer, Tata McGraw Hill ,(in SI Units)Mechanics Of Materials ,Dewolf &Johnston 2004 ,Publications

Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test		
Recommended by Board of Studies	15-04-2019	
Approved by AcademicCouncil	55th	13-06-2019

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

CourseObjectives:

1.Formulatematerialbalances to solve for compositions andflowrates of process streams
2.Incorporate singleandmultiplereactions into unitoperationswithin chemicalprocesses
3.Performmaterial and energy balance calculationsin various systems

Course Outcomes (CO):

1. Apply mole concept and ideal gas equation to express the composition of mixtures
2. Apply the concept of humidity and use psychrometric chart for air-water vapor systems
3. Solve 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

Unitsanddimensions–Conversionfactors–Moleconcept–Conceptofnormality,molarity,andmolality–Densityandspecificgravity–Methodsofexpressingcompositionofmixturesandsolutions–Weightfraction–Molefraction–Volumetriccomposition–Idealgaslaw–Dalton'slaw – Amagat'slaw

Module:2	Vapor pressure and Humidity calculations	6 hours

Vaporpressureandliquids–Antoineequation,Vaporpressureofimmisciblelіquidsandidealsolutions – Raoult'slaw – Humidity and Saturation– Relative and percentage saturation, Wet bulband dry bulb temperature,Dew point– Use of humidity chartfor engineering calculations

Module:3	Material Balancewithout Chemical Reaction	12 hours

Lawofconservationofmass–Processflowsheet–Materialbalancecalculationsinvolvingdrying, dissolution,distillation,crystallization, evaporation,absorption and extraction

Module:4	Material balancewithChemicalReaction	7 hours

Stoichiometricequation–stoichiometricratio–limitingreactant–excessreactant–percentexcess–conversion – yield

Module:5	Recycle andBypass Operation	7 hours

Recycle, Purge, Bypass calculations in operations such as evaporation, distillation, anddrying

Module:6	Combustioncalculations	10 hours

Calorific value of fuels, Flue gas analysis, Orsat analysis,theoretical andexcess air requirementfor solid, liquid and gaseous fuels

Module:7	Energy balance	8 hours

Standardheatofformation–Standardheatofcombustion–StandardHeatofreaction–Hess'slaw–Determinationofheatofreactionattemperaturesotherthanstandardtemperatureusingspecific heat relationships– Calculation oftheoretical flametemperature				
Module:8	**Contemporary issues**			**2 hours**
	Total Lecture hours			**60 hours**
Text Books				
1.	HimmelblauD.M.,BasicPrinciplesandCalculationsinChemicalEngineering,8th ed.,Prentice Hall, India, 2012.			
2.	BhattB.I.,ThakoreS.B.,Stoichiometry,5th ed.,TataMcGraw–HillBookCompany,NewDelhi, 2011.			
Reference Books				
1.	FelderR,RousseauR,ElementaryPrinciplesofChemicalProcesses,3rd ed.,JohnWiley&Sons, 2000.			
2.	NarayananK.V.,LakshmikuttyB,Stoichiometry and Processcalculations, Prentice HallIndia Limited, NewDelhi, 2006.			
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test				
Recommended by Board of Studies	15-04-2019			
Approved by AcademicCouncil	55th	Date	13-06-2019	

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

CourseObjectives:

1. Enhancethebasicknowledgeandintuitiveunderstandingofthermodynamicsonthephysical and chemical system
2. Introducetheconceptsofpartialmolarproperties,fugacity,activity,vapour-liquidequilibriumfor ideal and real substances existingin more than one phasesunderequilibrium
3. Generalize the designthinking skillson propertyestimationto chemicalindustries

Course Outcomes (CO):

1. Analyze thermodynamic equilibrium for ideal and nonideal systems
2. Evaluate the thermodynamic properties for pure substances
3. Estimate the partial molar properties of solutions
4. Construct and analyze the phase equilibrium data, P-x-y, T-x-y diagram for ideal binary miscible vapour-liquid systems.
5. Analysze VLE for non-ideal miscible systems using property models
6. Determine the equilibrium rate constant for chemical reactions.

Module:1	Fundamental conceptsand definitions	5 hours

Introduction-DefinitionandBasicConcepts-classicalandstatisticalthermodynamics-ConceptofContinuum-Thermodynamicsteadystate-equilibriumstateprocess,Volumetricpropertiesofpure fluids: PVT Relations- Ideal gas- Real gas-

Module:2	Laws of thermodynamics	6 hours

First law analysis– Closed non-flow system- Steady state flowsystemsand their analysis; Secondlawofthermodynamics-changeininternalenergy-enthalpy-entropycalculationforprocess-phase change; Heat effects - standardheat of reaction

Module:3	Thermodynamicpropertiesofpure fluids	7 hours

Gibbsfreeenergy-Helmholtzfreeenergy-exactdifferentialequation-thermodynamicpropertyrelations-Maxwell'srelationsandapplications-fugacity-activityofpuresubstances-determination of fugacity of pure gases, solids andliquids

Module:4	Thermodynamicpropertiesofsolution	7 hours

Mixtureofpurefluids-Partialmolarproperties-Chemicalpotential-fugacitiesinsolution;Idealsolutions-LewisRandalrule-Raoult'slaw-Henry'slaw;Gibbs- Duhemequation;Residualproperties-Property changes of mixingfor ideal- non-ideal solutions- Excess properties relationsand Gibbs free energycalculation

Module:5	Phase equilibria	6 hours

Phaserule-criteriaofphaseequilibrium-singlecomponent-multiplecomponents;VaporLiquidEquilibriaforidealsolutions-Phasediagramforbinarysystems using ASPEN PLUS-constanttemperatureequilibria- constantpressureequilibria- phase

Module:6	Vapor liquid equilibria- non-ideal solutions	7 hours

Nonidealsolution–Azeotropessystems-minimumboiling–maximumboiling–VLE– P-x-ydiagramandT-x-y diagram using ASPEN PLUS;Bubblepoint–Dew Point–calculationmethods–Van Laarequation - Margulesequation - Wilsonequation. MulticomponentSystems– flash vaporization;Consistency Testfor VLE Data				
Module:7	**Chemicalreactionequilibria**			**5 hours**
Chemicalreactionequilibria-Reactioncoordinates-criteriaforchemicalequilibrium,equilibriumconstant-GibbsFreeEnergyofthereaction-effectoftemperatureonequilibriumconstant- equilibriumconstant of homogeneousgas and liquid				
Module:8	**Contemporary issues**			**2 hours**
Total Lecture hours				**45 hours**
Text Books				
1.	NarayananK.V.,ATextbookofChemicalEngineeringThermodynamics,2nd ed.,PrenticeHall India,New Delhi, 2012			
2.	AhujaP,ChemicalEngineeringThermodynamics,2nd ed.,PHILearningPvt.Ltd.,NewDelhi, 2012.			
Reference Books				
1.	SmithJ.M.,Van Ness H.C.,Abbott M.M.,Introduction to ChemicalEngineeringThermodynamics, 8th ed., McGraw-Hill, New York, 2018.			
2.	RaoY.V.C.,ChemicalEngineeringThermodynamics,1st ed.,UniversityPress,NewDelhi,2005.			
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test				
Recommended by Board of Studies		15-04-2019		
Approved by AcademicCouncil		55th	Date	13-06-2019

Course code	CHE1004	L	T	P	J	C
Course title	CHEMICAL TECHNOLOGY	3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

CourseObjectives:

1. Introducethebasicinformationandthesystematicdiagramsof Unitoperationsinvolvedinchemicalindustries.
2. Familiarize the conceptsofdesign, operation detailsand schematic of industrial equipment.
3. Ascertain therightseparation technology for easy separationof chemical components

Course Outcomes (CO):

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

Module:1	Chloro-alkali and CementIndustries	6 hours

Manufactureofsodaash;causticsoda–manufactureofcalciumhypochlorite;manufactureofsulphur andsulphuricacid;manufacture ofPortland cement;manufacture of glass

Module:2	IndustrialGases	5 hours

Manufactureofcarbon-di-oxide;hydrogen;oxygenandnitrogen;acetylene;watergas;producergas and manufacture of natural gas

Module:3	FertilizerIndustries	8 hours

Manufactureofnitricacidandurea;manufactureofphosphorusandphosphoricacid;manufactureofsuper phosphate and triplesuperphosphate;manufactureof potassium chloride

Module:4	Cellulose, Sugar and Oil ProductionIndustries	7 hours

Productionofpulp–manufactureofpaperandmanufactureofviscousrayon;manufactureofsugarandstarch;refiningofedible oilsandfats;manufactureofsoapsanddetergents;bio-degradabilityofsurfactants

Module:5	PetroleumIndustries	6 hours

Petroleumrefining processes; reforming; cracking;secondary refining processes

Module:6	Petrochemical Industries	6 hours

Introductionto Petrochemical processes; Manufacture of C_2,C_3,C_4chemicalcompounds

Module:7	Polymer Industries	5 hours

Introduction;manufactureofnylon6;nylon6,6;manufactureofsilicones;manufactureofureaformaldehyde;manufacture of phenol formaldehyde

Module:8	Contemporary issues	2 hours

Total Lecture hours				**45 hours**
Text Books				
1	RaoG.,SittigM.,Dryden'sOutlinesofChemicalTechnology,3rd ed.,EastWestPress, India, 2010.			
2	AustinG.T., Shreve'sChemical Process Industries, 5th ed., McGraw Hill, USA, 2012.			
Reference Books				
1	MatarS.,HatchL.F.,ChemistryofPetrochemicalProcesses,4th ed.,GulfPublishing,USA, 2005.			
2	Nelson W.L.,Petroleum Refinery Engineering, 4th ed., McGrawHill, USA, 2005.			
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test				
Recommended by Board of Studies		15-04-2019		
Approved by AcademicCouncil		55th	Date	13-06-2019

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

CourseObjectives:

1. Understandthefluidproperties,thefundamentalprinciplesandtheoremrelatedtomomentumtransfer
2. Apply thephysical and mathematicalmodelsto analysethe fluid flow phenomenainengineeringapplications
3. Solve thesteady stateand un-steady state momentumtransfer problems

Course Outcomes (CO):

1. Explain the properties of Newtonian and Non-Newtonian fluid and basic principles of momentum transfer
2. Develop the governing equations related to momentum transfer phenomena
3. Analyze the performance of flow measuring devices and fluid moving machineries
4. Solve the problems related to the losses incurred during fluid flow
5. Predict the fluid flow behaviour using non-dimensional numbers
6. Analyze the fluid flow phenomena through packed and fluidized beds

Module:1	Basic Concept of Momentum Transfer	5 hours

IntroductionandSignificanceofMomentumTransferinChemicalEngineering.Definitionoffluid-Classificationoffluids–Newtonianfluid–Characteristicpropertiesoffluids–Non-NewtonianFluidsandtheirclassification.Fluidstatics:Pascal'slawandHydrostaticlawofequilibrium; Pressure and its measurement-Manometers

Module:2	Concept of Fluid FlowPhenomena	7 hours

Kinematicsoffluidflow,Dynamicsoffluidflow–Basicequationsgoverningfluidflow–typesoffluidflow.EquationofContinuityanditsapplication,Equationofmotion–DerivationofEuler'sequation, Bernoulli's equation and its application in fluid flow

Module:3	FlowMeasuring Devices	5 hours

Importanceofmetering–Classification flowmeasuringdevices,Principleandworking ofOrificemeter, Venturi meter,Pitottube,Variable area meters:Rotameter

Module:4	Flowthrough Circular Pipes	8 hours

FlowoffluidsinLaminarregime–VelocityProfile,ShearStressDistribution–Hagen–Poiseuilleequation-Conceptofaveragevelocity–ConceptofKineticenergycorrectionfactor,ConceptofFluidfriction–Skinfriction–Formfriction–Factorsaffectingfriction–Frictionfactor–ApplicationofMoody's diagram, Minor losses and

Module:5	Dimensional Analysis	4 hours

Dimensionalhomogeneity–RaleighandBuckinghamπtheorems–Non-dimensionalnumbers, model laws

Module:6	Fluid Flow through Packed and Fluidized Bed	7 hours

Flowpastimmersedbodies–Significanceofformfriction-ConceptofDrag,DragCoefficientsand ParticleReynolds number - Drag Coefficient vs. ParticleReynolds number curves forregularandirregularshapedsolidparticles.Flowoffluidsthroughpackedbeds– Packingandtypesofpacking-Pressuredropacrosspackedbeds–KozenyCarmanequation– Ergun'sequation-LoadingandFloodingPackedBeds. ConceptofFluidization–Condition forSolidparticlestobein a suspended conditionin a flowingfluid– minimum fluidizationvelocity		
Module:7	**Transportation of Fluids**	**7 hours**
TransportationComponents-Pipe,FittingsandValves,TypesofFittings,valves-StuffingBoxes,MechanicalSeals– Estimationofheadlossfromfittingsandvalves,Conceptofminorlosses-typesofminorlosses.FluidMovingMachinery:Pumps– ClassificationandworkingofCentrifugalPumpsandPositiveDisplacementPumpsBasicPrinciplesofCentrifugalPumps–PumpCharacteristics–ConceptofSpecificSpeed,NetPositiveSuctionHead-		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books

1.	FoxR.W.,McDonaldA.T.,PirtchardP.J.,MitchellJ.W.,IntroductiontoFluidMechanics,9th ed., WileyPublications, 2015.
2.	CengelY.A.,CimbalaJ.M.,FluidMechanics(SIE):FundamentalsandApplications,3rd ed., McgrawHill, New York, 2014.

Reference Books

1.	McCabe,Smith,Harriott,UnitOperationsofChemicalEngineering7th ed.,McGrawHill,USA,2014.
2.	Som S.K., Biswas G., Chakraborty S., Introduction to Fluid Mechanics and Fluid Machines, 3rd ed., Tata McGrawHill, India, 2011.

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

LaboratoryExperiments

1.	Determination of coefficient of discharge of venturimeter	2 hours
2.	Calibration ofan orifice meter	2 hours
3.	Determination of friction factorfor flow throughcircular pipe	2 hours
4.	Determination of loss of coefficientdue to suddenenlargement, sudden contraction, bend andelbow	2 hours
5.	Determination ofReynolds apparatus	2 hours
6.	Verification of Bernoulli'stheorem	2 hours
7.	Performance characteristics of centrifugalpump at rated speed	2 hours
8.	Determination of pressure drop per unitlengthas a function of superficial velocityoffluidization medium	2 hours
9.	Verification of relationshipbetweenfluid flowand pressure drop per unit lengthofpacking	2 hours
10.	Determination of frictionfactorfor flow through noncircular pipe	2 hours
	Total Laboratory Hours	20 hours

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

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

CourseObjectives:

1. Explain the fundamentalprinciples ofheat transfer and variousmodes of heat transfer
2. Solve heattransfer problems using the principles ofheat transfer in differentmodes
3. Design and estimate heat loads for heat transferequipments such as heatexchangers andevaporators

Course Outcomes (CO):

1. Classify the different modes of heat transfer with their significance
2. Analyze steady/unsteady state conductive heat transfer problems
3. Analyze the convective heat transfer mechanism in fluids with and without phase change
4. Examine radioactive heat transfer with and without radiation shields
5. Evaluate the performance of various types of heat exchangers
6. Calculate the heat transfer rate and surface area of evaporators

Module:1	Conduction	5 hours

Basicconcepts – Conduction –Fourier's Lawof Heat conduction–Concept of ThermalConductivity– Generalizedconductionequationincartesian,cylindricalandsphericalsystems;SteadyStateConduction –Heattransfercompositesystems–Criticalthicknessofinsulation–Conductionwith heat Generation

Module:2	Extended Surfaces andUnsteady stateconduction	3 hours

Extended surfaces– types and applicationsoffins– Fin efficiencyand effectiveness– Finperformance;Unsteadystateheatconduction–Lumpedparametersystem– ConductionthroughSemiInfiniteSolids

Module:3	Convection(without phase change)	5 hours

FundamentalsofConvection–Thermalboundarylayer&Convectiveheattransfercoefficients– ConvectioncorrelationsthroughDimensionalanalysis;Laminarflowoveraflatplate– Turbulentflowoveraflatplate–Flowovercylinders–Internalflowthroughpipes–annularspaces–Natural convection in vertical - inclined and horizontal surfaces.

Module:4	Convection(withphase change)	3 hours

CondensationandBoiling–DropwiseandFilmtypeCondensation–Filmcondensationonavertical plate;Boiling–Nucleate boiling and filmboiling correlations–Critical flux

Module:5	Radiation	3 hours

Radiation heattransfer– Thermalradiation – Laws of radiation – Black body concepts– Emissivepower– Radiation shape factor– Graybodies – Radiationshields

Module:6	Heat Exchangers	5 hours

Heatexchangers–Typesandpracticalapplication– ConceptofLMTD&Overallheattransfercoefficient;Effectiveness– NTUmethodforheatexchangerdesign;Foulingfactorandestimation ofOverall heat transfer

Module:7	**Evaporators**	**4 hours**
Introduction–TypesofEvaporators–Capacity–Steameconomy–Boilingpointelevation(Duhringrule);Materialandenergybalanceofsingleeffectevaporator;Theoryofmultipleeffectevaporators;Design of singleand multiple effectevaporators, Vapor		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours	**30 hours**

Text Books	
1.	GhajarA.J.,CengelY.A.,Heat andMass 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.	FrankKreith,RajMManglik,PrinciplesofHeatTransfer,8th ed.,CengageLearning,USA,2016.
2.	Frank.P.Incropera,DavidP.Dewitt,FundamentalsofHeat&MassTransfer,6th ed.,JohnWiley& Sons, USA, 2010.
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test	

LaboratoryExperiments

1.	Measurement of thermal conductivity of Metals&insulators	2 hours
2.	AnalysisofTransientHeat Conduction	2 hours
3.	Performance of NaturalConvection	2 hours
4.	AnalysisofFin efficiency&effectiveness	2 hours
5.	Emissivitymeasurement	2 hours
6.	Performance of Double Pipe Heat Exchanger	2 hours
7.	Performance of Agitated Vessel	2 hours
8.	Performance of PlatetypeHeat Exchanger	2 hours
9.	Performance of Heat Transfer inpacked bed	2 hours
10.	Performance of Cooling tower	2 hours
	Total Laboratory Hours	20 hours

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

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

CourseObjectives:

1. Introducethe basic information and the systematic diagrams ofUnit operations involved inchemicalindustries
2. Learn theconcepts ofdesign, operation details and schematic of industrialequipment
3. Choose the rightseparation technology for easyseparationof chemical components

Course Outcomes (CO):

1. Understand the basic principles involved in different unit operations
2. Calculate the size distribution of particulate matter
3. Analyze the performance of various size reduction equipment
4. Identify the suitable separation technique based on particle characteristics
5. Estimate the filtration and sedimentation parameters involved in solid – liquid separation
6. Design an agitation vessel based on standard design criterion

Module:1	Introduction to Particulate Solids	4 hours

ParticleShape,Size,MixedParticleSizesandSizeAnalysis–CumulativeandDifferentialAnalysis–VariousMeanDiameters–ScreenAnalysisStandardScreens–VariousIndustrialScreens

Module:2	ParticleSeparation	3 hours

IntroductiontoParticleSeparation–ElectrostaticPrecipitationandMagneticSeparation-StorageofSolids

Module:3	Size Reduction	8 hours

SizeReduction–PrinciplesofComminution-EnergyandPowerRequirementsinComminution-MechanicalEfficiency-LawsofCrushing-SizeReductionEquipment–Crushers-Grinders-Cutting Machines– Open and Closed Circuit Operation

Module:4	Particulate Solids Flow	5 hours

MotionofaParticlethroughaFluid–TerminalVelocity–FreeandHinderedSettling.Classification:SeparationsRatio–ClassificationEquipment–GravitySettlingTank–Elutriator–Cone Classifiers– BowlClassifier –CentrifugalClassifier –Cyclone

Module:5	Hydro-Mechanical Separations	7 hours

Sedimentation:GravitySedimentation–Mechanism–ContinuousSedimentation–Thickener–Designofthickener–ClassifierandClarifier–SettlingArea–CentrifugalSedimentation-Centrifuges-Hydro clones.Floatation:Equipment– Modifiers – Collectors- FrothingAgents

Module:6	Filtration	8 hours

Filtration–FilterMedia–FilterAids–PrinciplesofCakeFiltration–ConstantPressureFiltration –ConstantRateFiltration-PressureDropThroughFilterCake–CompressibleandIncompressibleFilterCakes-SpecificCakeResistance-FilterMediumResistance.FiltrationEquipment–FilterPresses–LeafFilter-RotaryContinuousFilters.PrinciplesofCentrifugalFiltration-Washing ofFilter Cakes

Module:7	Agitation and Mixing	8 hours
AgitationandMixingofLiquids–PrinciplesofAgitation–AgitationEquipment–Impellers–FlowPatterninAgitatedVessel-PowerConsumptioninAgitatedvessel.Flownumber–PowerCorrelation-Calculationofpowerconsumption.Blendingandmixing-Jetmixers–MotionlessMixers.MixingofSolids:MixturesforCohesivesolids–PowerrequirementsCriteriaformixereffectiveness. Mixers forfree flowing granular solids - Rate of		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours	**45 hours**

Text Books	
1.	McCabe W.,Smith J.,Harriott P., UnitOperations of ChemicalEngineering, 7th ed., McGrawHillEducation;USA, 2014.
Reference Books	
1.	CoulsonJ.M.,RichardsonJ.F.,ChemicalEngineering,Volume2(ParticleTechnology&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.,MechanicalOperations(FundamentalPrinciplesandApplications),3rd ed., NiraliPrakasam, India, 2012.
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test	

LaboratoryExperiments

1.	Performance ofPlateand Framefilter press	2 hours
2.	Performance of RotaryDrumFilter	2 hours
3.	Performance of LeafFilter	2 hours
4.	AnalysisofJaw crusher parameters	2 hours
5.	AnalysisofRoll crusherparameters	2 hours
6.	AnalysisofBall millparameters	2 hours
7.	Sieve analysis	2 hours
8.	Measurement of Drag	2 hours
9.	Batch sedimentationperformance	2 hours
10.	Beakerdecantation analysis	2 hours
	Total Laboratory Hours	20 hours

Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test			
Recommended by Board of Studies	15-04-2019		
Approved by AcademicCouncil	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 types of chemical reactions
2. Analyze the batch reactor data using rate equations and reaction kinetics
3. Design ideal reactors for elementary chemical reactions
4. Evaluate the multiple reactor systems and multiple reactions
5. Evaluate the performance of non-isothermal reactors
6. Analyze non-ideal behavior of reactors using RTD studies

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 AcademicCouncil	55th	Date	13-06-2019

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

CourseObjectives:

1. Summarize the concepts of unit operations andunit processes in chemicalengineering.
2. Impart knowledge on the concepts ofdesign ofmajorequipment
3. Understand the economics and feasibilityanalysis of the process industry

Course Outcomes (CO):

1. Examine the process flow diagrams used in chemical and allied industries
2. Analyze the design of fluid handling equipment
3. Evaluate the performance of Heat, Mass transfer equipment and reactors
4. Develop Heat Exchanger Network using Pinch Technology
5. Apply economic principles for cost estimation in chemical industries.
6. Evaluate the performance of process equipment using simulation tools

Module:1	Introduction andPressure vessel	4 hours

Introduction-Typesofflowchartpreparation;Fluidhandlingequipment;Mechanicaldesignofpressure Vessel.

Module:2	Heat transferequipment	5 hours

Design of Double pipe, shell and tubeheat exchanger;Principles of dryer design.

Module:3	HeatExchangerNetwork	4 hours

Introduction to Pinch Technology –pinch point– Composite and GrandCompositecurves; FindHeat exchanger networkfor simpleprocesses.

Module:4	Separation process equipment	4 hours

Design of Distillationcolumn and absorbers– plate typeandpacked columns.

Module:5	PrinciplesandDesignofReactors	4 hours

Concepts of idealreactordesign– adiabatic and catalytic reactors

Module:6	Cost Estimation of Projects	4 hours

Cost estimation ofChemical Projects; Cost estimation of individual equipment using algorithmsand literature.

Module:7	Analysis ofCost Estimation	4 hours

Timevalueof money; Depreciation; Profitability analysis;Analysis of alternatives andreplacements using costdiagrams.

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 forEfficient Use of Energy, 2nded., Butterworth-Heinemann,USA, 2007.	
Reference Books		
1.	Joshi.M.V.,Mahajani.V.V., Process Equipment Design, 3rded., Mc-Millan India Ltd., India, 2000.	
2.	Richard A. Turton,Richard C. Bailie,Wallace B. Whiting,Joseph A. Shaeiwitz, DebangsuBhattacharyya, Analysis, Synthesis andDesign of Chemical Processes,4thed.,Prentice Hall,USA, 2013.	
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test		
LaboratoryExperiments		
1.	Basics of 3D drawing and applications	2 hours
2.	Extrusion of surfaces and geometries	2 hours
3.	Design and drawing of Pressurevessel to dimensions	2 hours
4.	Design and drawing of a Shell andTube heat Exchanger	2 hours
5.	Design and drawing of a bubble cap tray	2 hours
6.	Design anddrawing ofRotary Louvre dryer	2 hours
7.	Analysisofthe performance of a Heat Exchanger(Aspen)	2 hours
8.	Design and analysis of DistillationColumn(Aspen)	2 hours
9.	Cost Estimation of aDistillationColumn (Aspen)	2 hours
10.	Dynamicsimulationexperiment ondistillationcolumn (Aspen)	2 hours
Total Laboratory Hours		20 hours
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test		
Recommended by Board of Studies	15-04-2019	
Approved by AcademicCouncil	55th	Date 13-06-2019

Course code	CHE3001	L	T	P	J	C
Course title	COMPUTATIONALMETHODS IN PROCESSENGINEERING	3	0	2	0	4
Pre-requisite	MAT3003	Syllabus version				
		1.2				

CourseObjectives:

1. Formulateproblemsforrootsofafunction,solutionofsimultaneousequations,optimizedvalueofa given function,numericalintegration and differentiation,ODE and PDE
2. Solverootsofafunction,simultaneousequations,optimization,numericalintegration,ODEand PDE
3. DevelopMATLABcode for finding theroots of a function, solutionof a simultaneousequations,optimization,numerical integration,ODE and PDE

Course Outcomes (CO):

1. Determine the roots of a single equation using closed and open computational methods
2. Compute the solution for simultaneous equations using direct and indirect computational methods
3. Apply suitable optimization, regression and numerical integration methods for engineering applications
4. Solve ordinary differential equations (ODE) involving initial value and boundary value problems
5. Solve partial differential equation (PDE) involving elliptical and parabolic equation
6. Develop MATLAB program for the solution of single equation, simultaneous equations, optimization, regression, numerical integration, ODE and PDE

Module:1	Finding the Roots	6 hours

Computersanderroranalysis,Mathematicalmodelsforsolvingengineeringproblems,programmingandsoftware;Findingrootsofasingleequation-Directmethods(bisection,Regulafalsi)- Indirectmethods (Newton-Raphson, Secantmethod)

Module:2	Solution for SimultaneousEquations	5 hours

Typesofmatrices andmatrix operation rules;Solution for linearsystemof simultaneousequations –Directmethods(GaussElimination,GaussJordan),Iterativemethods(Gauss-JacobiandGauss-Seidel);Overviewofnon-linearsystemofequations

Module:3	Interpolation andRegression Analysis	7 hours

Newton'sdivided-differenceinterpolatingpolynomial–Linear-polynomial-quadraticrules;Lagrangeinterpolatingpolynomial- Linear- polynomial Regression.

Module:4	Optimization	7 hours

One-DimensionalUnconstrainedOptimization–GoldensectionsearchandNewton'sMethod;Overviewonmultidimensionalunconstrainedoptimization –gradientandnon-gradientmethods;Constrainedoptimization–Simplexmethod;OptimizationofChemicalProcessesusingAspen Plus.

Module:5	Integration and Differentiation	5 hours

Newtoncotes Integration-Trapezoid method - Simpson's 1/3rdrule - Simpson's 3/8thrule; Numericaldifferentiation-Forward- Backward- Central differencemethods

Module:6	**Ordinary DifferentialEquations**	**6 hours**
Initial ValueProblems –Euler - Predictor-corrector - Runge-Kuttamethods;Boundary ValueProblems –Shooting method - Centraldifferencemethod		
Module:7	**Partial Differential Equations**	**7 hours**
Finitedifferencesolutionsofellipticequations–Liebmann'smethod-finitedifferencesolutionsofparabolicequations–Crank-Nicolsonandimplicitmethods-Overviewofhyperbolicequations;Case study onsolving PDEs		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours	**45 hours**

Text Books	
1.	ChapraS.C,CanaleR.P,NumericalMethodsfor Engineers, 7th ed.,McGraw HillPublications, USA, 2016.
2.	KamalI.M.,Al-Malah,AspenPlus:ChemicalEngineeringApplications,1st ed.,JohnWiley& Sons Inc., USA, 2016.
Reference Books	
1.	DorfmanK.D.,DaoutidisP,NumericalMethodswithChemicalEngineeringApplications,1st ed., CambridgeUniversity Press, USA, 2017.
2.	JanaA.K.,ChemicalProcessModellingandComputerSimulation,2nd ed.,PrenticeHallof India, India,2011.

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

LaboratoryExperiments

1.	Develop MATLAB code for bisection / Regula falsimethod	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 simulationfor solvingsimultaneous equations in distillation column	2 hours
6.	Develop MATLAB code for Numerical Integration	2 hours
7.	Develop MATLAB code for ODE – Euler /Modified Eulermethod	2 hours
8.	Develop MATLAB code for ODE – Runge Kuttamethod	2 hours
9.	Develop MATLAB code for PDE– Liebmann'smethod	2 hours
10.	Develop MATLAB codetooptimize a chemical process involving PDE	2 hours
Total Laboratory Hours		20 hours

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

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

CourseObjectives:

1. Understandthe basic concepts of measuring instruments usedin process industries
2. Explaintheimportanceofprocesscontrolmechanismandtheirapplicationsinchemicalprocess industries
3. Describeprinciplesofmodesofcontrollersandtheirgeneralcharacteristicsandstudythestability analysis of digitalcontrolsystem

CourseOutcomes (CO):

1. Explain chemical process systems and the operating principles of common instruments.
2. Analyze the performance of the obtained transfer function model of the given open loop control systems for various standard inputs.
3. Analyze the performance of closed loop system for set point and load input variations.
4. Select suitable controllers required for the given process to obtain the desired performance.
5. Analyze the stability of the given control system using time domain and/or frequency domain technique.
6. Compare the performance of various advanced control schemes used in various processes.

Module:1	Process Instrumentation	4 hours

Principlesandclassificationofprocesscontrolinstruments-Temperature-Pressure-FluidFlowRate-LiquidLevel-pH-Viscosity-HumidityofgasesandConcentrationbySpectroscopyandChromatographymethods.

Module:2	Introduction to ProcessControl	6 hours

Laplacetransformation-transformofstandardfunctions-derivativesandintegrals-inversiontheorems-Openloopsystem-Transferfunctions-Forcingfunctions-step,pulse,impulseandsinusoidal-FirstorderandHigherordersystemdynamics-Firstordersystemsinseries-linearizationanditsapplicationinprocesscontrol-Continuousandbatchprocesses-Transportationlag.

Module:3	Feedback Control Block Diagram	4 hours

Closedloopsystem-Developmentofblockdiagram-Blockdiagramreduction-ServoandRegulatorproblem-Transientresponseofclosedloopcontrolsystemsandtheirstability-OFFSETcalculation.

Module:4	Controllers andControl Action	4 hours

Transferfunctionofcontrollersandcontrolvalve-CharacteristicsofON-OFF,Proportional,IntegralandDerivativecontrolmodes-P-PI-PD-PIDcontrolmodes-PrinciplesofPneumatic and ElectronicControllers - I/P converter - Control valve- Construction-Sizing - Characteristics.

Module:5	**Time and Frequency Domain Analysis**	**5 hours**
Stabilitycriteria-Routh'sstabilitycriteria-Rootlocusdiagram-Frequencyresponseanalysis-Gain margin- Phase margin and crossover frequency - Bodeplot - Polar plot and Nyquist plot.		
Module:6	**Controller Tuning**	**2 hours**
Process reactioncurve - Cohen-Coonmethod - IMCtuning - Ziegler Nichols method.		
Module:7	**Advanced Process Control**	**3 hours**
Introductiontomultivariablecontrol- Computerapplicationsinprocesscontrol - Advancedcontrolstrategies-Cascadecontrol-Ratiocontrol-Feed-Forwardcontrol-Inferentialcontrol-Adaptive control - Controlof Reactor-Distillationtowers-HeatExchangers.		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours	**30 hours**

Text Books

1.	SeborgD.E.,Edgar,T.F.,MellichampD.A.,ProcessDynamicsandControl,3rded.,WileyIndia, New Delhi, 2013.
2.	StephanopoulosG.,ChemicalProcessControl,1sted.,PearsonEducationIndia,NewDelhi,2015.

Reference Books

1.	CoughanowrC.R.,KoppelL.M.,ProcessSystemAnalysisandControl,3rded.,McGrawHill, New Delhi, 2013.

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

LaboratoryExperiments

1.	Automatictemperature control loop in a heating tank.	2 hours
2.	Automatic level control loop ina cylindrical tank.	2 hours
3.	Automaticflow control loop inapipe line.	2 hours
4.	Automatic cascade control loop.	2 hours
5.	Dynamics of non-interactingtanks.	2 hours
6.	Dynamics of interacting tanks.	2 hours
7.	Controllertuning using an open loopmethod(Cohen-Coonmethod) inSimulink.	2 hours
8.	Controllertuning using a closed loopmethod(Ziegler–Nicholsmethod) in Simulink.	2 hours
9.	Control Valve Characteristics.	2 hours
10.	Dynamics of Ratio control usingProSIM.	2 hours
	Total Laboratory Hours	20 hours

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

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

CourseObjectives:

1. Understand the principles of diffusion in gas,liquid and solid phases
2. Interpretthe relation betweenmass transfer coefficients andthe theories of mass transfer fordifferent separation operations
3. Demonstratetheworkingprinciples of coolingtower, dryerandcrystallizer

Course Outcomes (CO):

1. Determine diffusivity in fluids and solids using correlations and theories
2. Compute various mass transfer coefficients through correlations/analogies used in various chemical engineering applications
3. Apply the theories of mass transfer for individual and overall mass transfer coefficients
4. Estimate the design parameters required for humidification and dehumidification equipment
5. Estimate the psychometric properties of gas-vapor systems using charts and/or equations
6. Explain different types of mass transfer equipment, i.e., cooling tower, drier, and crystallizer used for industrial applications

Module:1	Diffusion	6 hours

IntroductiontoMasstransferoperation,Fick'slawofdiffusion,Steadystatemoleculardiffusioninfluidsunderstagnantandlaminarflowconditions,Diffusioncoefficientmeasurementandprediction

Module:2	Molecular diffusionin Fluids	6 hours

Moleculardiffusion in gas and Liquids, Multicomponentdiffusion, Diffusion throughvariablecross-sectionalarea, Diffusivity in solids and its applications

Module:3	Masstransfercoefficients	6 hours

Introductiontomasstransfercoefficient,Correlationforconvectivemasstransfercoefficient,Correlationofmasstransfercoefficientsforsinglecylinder,Packedcolumn,flowoveraflatplate

Module:4	Theoriesofmasstransfer	5 hours

PenetrationtheorySurfaceRenewalTheory,Interphasemasstransfer,twofilmtheory,Overallmasstransfercoefficients

Module:5	Humidification	7 hours

Basic concepts,Principlesof Humidification–DefinitionsWetBulb Temperature &AdiabaticSaturationTemperatures–Air/WaterSystempsychrometricandPsychrometricCharts–UtilizationofPsychrometricCharts–Dehumidification–CoolingTowers–MechanicalDraftTowers:forceddrafttowersandinduceddrafttowers;Designcalculationsofcoolingtower

Module:6	Drying	7 hours

PrinciplesofDrying- DefinitionsofmoistureandothertermsonDrying,ClassificationofDryingoperations.RateofDrying-ConstantandFallingRateDrying.Moisturemovementinsolids -ThroughCirculation Drying- Rate of drying for Continuous Direct heat Driers-Types ofDryers usedinpractice and their operation-			
Module:7	**Crystallization**		**6 hours**
CrystalGeometry-InvariantCrystals-PrinciplesofCrystallization-Supersaturation-Nucleation-Crystalgrowth-Material&EnergyBalanceappliedtoCrystallizers-TypesofCrystallizersused in practice			
Module:8	**Contemporary issues**		**2 hours**
Total Lecture hours			**45 hours**
Text Books			
1.	Dutta,B.K.,PrinciplesofMasstransferandSeparationProcesses.Prentice-HallofIndia,New Delhi 2007.		
2.	Treybal, R.E., Mass-Transfer Operations, 3rd ed, McGraw-Hill 1981.		
Reference Books			
1.	Cussler, E.L,Diffusion:MassTransfer inFluid Systems,Cambridgeuniversitypress,2017		
2.	ChristieJGeankoplis,TransportprocessesandUnitOperations,4th ed,PrenticeHall India Pvt.Ltd, 2003		
3.	AnantharamanN,MeeraSheriffaBegumK.M.,Masstransfer-Theoryandpractice,Prentice-Hall of India, New Delhi, 2011		
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test			
Recommended by Board of Studies	15-04-2019		
Approved by AcademicCouncil	55th	Date	13-06-2019

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

CourseObjectives:

1. Understand the basic principles ofstaged and continuouscontact separation equipment involvedin equilibrium staged operations such as distillation,absorption,liquid-liquidextraction,leaching, adsorptionandothermodern separationoperations
2. Performbasic design calculations for staged and continuous contact equilibriumstagedseparationoperations
3. Describevarious typesof equipment's and modernseparationmethods for high purity products widely usedin separation operation

Course Outcomes (CO):

1. Apply material and energy balances for various mass transfer operations.
2. Calculate the number of equilibrium stages required for various equilibrium staged operations.
3. Determine the number of transfer units and height requirements for continuous contact equilibrium staged operations.
4. Identify the different column/equipment used for various separation applications.
5. Choose modern separation techniques applied in industries for high purity products.
6. Evaluate the performance of various equilibrium staged operations using experimental setup and/or simulation tools

Module:1	Introduction to Equilibrium Staged Operations	4 hours

Introductiontovariousequilibriumstagedoperations-Distillation-absorption-Extraction-leaching-adsorption;Vapour–liquidequilibria;Typesofdistillation–Flash-azeotropic-Extractivedistillations;DevelopVLEdatausingAspenPlus;Simplemassandenergybalanceinflash column using simulation software

Module:2	Distillation	6 hours

Distillationcolumn-Typesofcontact–TrayVsPackedColumn;Derivationofoperatinglineequationfordifferentsectionandpartsofdistillationcolumn-rectificationsection-strippingsection-feed traylocation-condenser-reboiler-efficiency of distillationcolumn;Determinationoftheoreticaltrays-McCabe-Thielemethod-Ponchon-Savaritmethod;CasestudyofIndustrialdistillation column for multicomponentseparation using

Module:3	Absorption	4 hours

Introductiontoabsorption-Continuouscontactcounter-currentmulti-stageabsorption(Trayabsorber);Designofpackedtowerbasedonoverallmasstransfercoefficient;Absorbercolumnoperation using Aspen Plus

Module:4	Extraction	3 hours

Liquid–Liquidequilibria–Determinationofnumbertheoreticalstages–co-current-crosscurrent - countercurrentcontact operations-Classification ofextraction equipment

Module:5	Leaching	3 hours

Generalprinciplesofleaching-Factorsinfluencingtheleachingrate–Equipmentforleaching– Advanced industrial leachingprocesses		
Module:6	**Adsorption**	**4 hours**
Adsorptiontheory-Structureofadsorbents-Adsorptionisotherms–LangmuirandFreundlichisotherms - Adsorption equipment		
Module:7	**Modern separation techniques**	**4 hours**
Membraneseparation-microfiltration-ultrafiltration-nanofiltration-reverseosmosis;Chromatography–liquidchromatography-Advancedseparationtechniques - Divided wall column, melt crystallization, zone melting;Developmembraneseparators using Aspen and solvingfor optimumpurification		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**30 hours**

Text Books	
1.	DuttaB.K.,PrinciplesofMasstransferandSeparationProcesses,1st ed.,PrenticeHallofIndia, India,2007.
2.	Seader J.D., HenleyE.J,RoperD.K.,Separation ProcessPrinciples, ,3rd ed., JohnWiley&Sons, USA,2010.
Reference Books	
1.	Treybal R.E.,Mass-Transfer Operations, 3rd ed., McGraw-Hill Inc.,USA. 1981.
2.	JanaA.K.,ChemicalProcessModellingandComputerSimulation,2nd ed.,PrenticeHallofIndia, India,2011.
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test	

LaboratoryExperiments

1.	Diffusionin gas phase	2 hours
2.	Diffusionin liquid phase	2 hours
3.	Wetted wall column	2 hours
4.	Vapor-liquidequilibria using Aspen Plus or ProSim	2 hours
5.	Simpledistillation	2 hours
6.	Multi Component distillation using Aspen Plus or ProSim	2 hours
7.	Liquid-liquidequilibria using Aspen Plus or ProSim	2 hours
8.	Liquid-liquidextraction	2 hours
9.	Continuousdistillation using Aspen Plus or ProSim	2 hours
10.	Adsorption using Aspen Plus orProSim	2 hours
Total Laboratory Hours		20 hours

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

Coursecode	Applications ofDifferential and DifferenceEquations	L	T	P	J	C
MAT2002		3	0	2	0	4
Pre-requisite	MAT1011 -Calculus for Engineers	SyllabusVersion				
		1.0				

CourseObjectives (CoB):

[1] Presentingthe elementarynotions ofFourierseries,which is vital in practical harmonicanalysis

[2]Impartingthe knowledge ofeigenvaluesandeigen vectors ofmatricesand the transformtechniques to solve linearsystems,thatarise in sciencesandengineering[3]Enrichingtheskills in solvinginitial and boundaryvalue problems

[3]Impartthe knowledgeandapplicationofdifferenceequationsandtheZ-transformindiscretesystems,that areinherent in naturalandphysical processes

CourseOutcome(CO):

1. Apply the Fourier series tools in the fields of physics and engineering.
2. Apply the concepts of eigenvalues, eigen vectors and diagonalisation in engineering systems.
3. Analyse the concepts of differential equations and apply them to obtain the solutions of homogeneous and non-homogeneous systems.
4. Analyze the series solutions of Bessel's, Legendre and Strum-Liouville′s problem by using eigen values and eigen functions.
5. Analyse and apply the Z-transform in digital signal processing and control systems.
6. Develop programming tools for engineering problems and visualize solutions.

Module:1	Fourier series:	6 hours

Fourierseries -Euler'sformulae- Dirichlet's conditions- Change of interval-Halfrangeseries – RMS value – Parseval's identity–Computationof harmonics

Module:2	Matrices:	6 hours

EigenvaluesandEigenvectors-Propertiesofeigenvaluesandeigenvectors–Cayley-Hamiltontheorem-Similarityoftransformation-Orthogonaltransformationandnatureofquadratic form

Module:3	Solution ofordinarydifferential equations:	6 hours

Linearsecondorderordinarydifferentialequationwithconstantcoefficients–Solutionsofhomogenousandnon-homogenousequations-Methodofundeterminedcoefficients–methodofvariationofparameters–SolutionsofCauchy-EulerandCauchy-Legendredifferentialequations

Module:4	Solution ofdifferentialequations throughLaplacetransformand	8 hours

SolutionofODE's-NonhomogeneoustermsinvolvingHeavisidefunction,Impulsefunction-SolvingnonhomogeneoussystemusingLaplacetransform–Reductionof*n*thorderdifferentialequationtofirstordersystem-Solvingnonhomogeneoussystemoffirstorderdifferentialequations $(X' = AX + G)$ and

Module:5	**StrumLiouville'sproblems and power series Solutions:**	**6 hours**
TheStrum-Liouville's Problem- Orthogonalityof Eigenfunctions-Seriessolutions ofdifferentialequations about ordinaryandregularsingularpoints-Legendredifferentialequation - Bessel'sdifferentialequation		
Module:6	**Z-Transform:**	**6 hours**
Z-transform -transforms of standardfunctions-InverseZ-transform:bypartial fractionsandconvolutionmethod		
Module:7	**Difference equations:**	**5 hours**
Differenceequation-Firstandsecondorderdifferenceequationswithconstantcoefficients -Fibonaccisequence-Solutionofdifferenceequations-Complementaryfunction-Particularintegralbythemethodofundeterminedcoefficients-Solutionofsimpledifferenceequations using Z-transform		
Module:8	**ContemporaryIssues**	**2 hours**
IndustryExpertLecture		
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	AdvancedEngineeringMathematics,ErwinKreyszig,10th Edition,JohnWiley India, 2015

Reference Books

1.	HigherEngineeringMathematics, B. S. Grewal, 43rdEdition, Khanna Publishers, India, 2015
2.	AdvancedEngineering MathematicsbyMichaelD. Greenberg,2ndEdition,Pearson Education,Indian edition,2006

Mode ofEvaluation

DigitalAssignments(Solutions byusing soft skills), ContinuousAssessmentTests, Quiz, FinalAssessmentTest		
1.	SolvingHomogeneousdifferentialequations arisinginengineeringproblems	2 hours
2.	Solvingnon-homogeneousdifferentialequationsandCauchy,Legendre equations	2 hours
3.	Applyingthe technique ofLaplace transform to solve differentialequations	2 hours
4.	Applications of Second order differentialequations to Mass springsystem (damped, undamped,Forcedoscillations),LCRcircuitsetc.	2 hours
5.	VisualizingEigen valueand Eigen vectors	2 hours
6.	Solvingsystem of differential equationsarisinginengineeringapplications	2 hour
7.	Applyingthe Power series method to solve differentialequationsarisingin engineeringapplications	2 hours
8.	ApplyingtheFrobeniusmethod to solve differentialequationsarisingin engineeringapplications	2 hours

9.	VisualisingBesselandLegendrepolynomials			2 hours
10.	EvaluatingFourierseries-Harmonicseries			2 hours
11.	Applying Z-Transforms to functionsencounteredinengineering			2 hours
12.	SolvingDifference equations arisingin engineeringapplications			2 hours
			TotalLaboratoryHours	**24 hours**
Mode ofEvaluation: WeeklyAssessment,Final Assessment Test				
RecommendedbyBoardof Studies	03-06-2019			
ApprovedbyAcademicCouncil	No. 55	Date	13-06-2019	

Coursecode	ComplexVariables andPartialDifferentialEquation	L	T	P	J	C
MAT3003		3	2	0	0	4
Pre-requisite	MAT2002 ApplicationsofDifferential andDifference Equations	Syllabusversion				
		1.0				

CourseObjectives (CoB):

Theaim of this course isto present a comprehensive,compactandintegratedtreatment of twomost importantbranchesof appliedmathematics for engineersand scientists namelythefunctions of complexvariable andPartialdifferentialequations in finite and infinite domains

CourseOutcomes(CO):

1. Construct analytic functions and find complex potential of fluid flow and electric fields
2. Apply conformal mapping in geometrical transformations
3. Evaluate analytic function in Taylor′s series, Laurent′s series and pole of order, and apply Cauchy Residue theorem in evaluating some real integrals
4. Solve first order partial differential equations and find the solution of partial differential equations, and its applications in one dimensional heat and wave equations
5. Apply Fourier series, Fourier transform techniques to solve engineering problems

Module:1	AnalyticFunctions	6 hours

Complexvariable-Analyticfunctionsand Cauchy– Riemannequations - LaplaceequationandHarmonicfunctions - Construction of Harmonicconjugateandanalyticfunctions- Applicationsof analytic functions to fluid-flow andField problems.

Module:2	Conformal and Bilineartransformations	5 hours

Conformalmapping -Elementarytransformations-translation,magnification,rotation,inversion.ExponentialandSquaretransformations($w = e^z$, z^2)-Bilineartransformation-Cross-ratio-Images of the regionsboundedbystraight lines under the abovetransformations.

Module:3	Powerseries	4 hours

FunctionsgivenbyPower Series-Taylor andLaurentseries-singularities -poles – Residues.

Module:4	ComplexIntegration	5 hours

Integration ofacomplexfunctionalong acontour-Cauchy-Goursat theorem-Cauchy's integralformula-Cauchy'sresiduetheorem-Evaluationofrealintegrals-Indentedcontourintegral.

Module:5	PartialDifferentialequationsoffirstorder	6 hours

Formationand solution of partialdifferential equation-General,Particular,CompleteandSingularintegrals- PartialDifferentialequationsof firstorder of theforms: F(p,q)=0,F(z,p,q)=0,F(x,p)=G(y,q)andClairaut's form-Lagrange'sequation:Pp+Qq =R.

Module:6	ApplicationsofPartialDifferential	10 hours

	Equations		
Linearpartialdifferentialequations of higher order withconstantcoefficients. Solution of apartialdifferential equation byseparation ofvariables-BoundaryValueProblems-onedimensionalwave and heat equations- Fourier series solution.			
Module:7	**Fouriertransforms**	**7 hours**	
ComplexFouriertransform and properties-Relation betweenFourierandLaplacetransforms-Fourier sine andcosinetransforms–Convolution Theorem andParseval'sidentity.			
Module:8	**Contemporaryissues:**	**2 hours**	
IndustryExpertLecture			
	Total Lecture hours:	**45 hours**	
Tutorial	• A minimum of 10problems to be worked out bystudents inventoryTutorial Class • Another 5 problems perTutorial Class to be givenashome work.	**30 hours**	
Text Book(s)			
1.	AdvancedEngineering Mathematics,ErwinKreyszig, 10th Edition,JohnWiley& Sons (Wileystudent Edison) (2015)		
Reference Books			
1	HigherEngineeringMathematics, B. S. Grewal,43rd Edition (2019), Khanna Publishers,NewDelhi		
2	Afirstcourseincomplexanalysiswithapplications,G.DennisZill,PatrickD.Shanahan,3rd Edition, 2013, JonesandBartlettPublishersSeries in Mathematics:		
3	AdvancedEngineering Mathematics,Michael,D.Greenberg,2nd Edition,PearsonEducation(2006)		
4	AdvancedEngineering Mathematics,PeterV. O' Neil, 7th Edition, CengageLearning(2012)		
5	ComplexAnalysis forMathematicsandEngineers, JH Mathews, R. W.Howell,5th Edition, NarosaPublishers(2013)		
Mode ofEvaluation:			
DigitalAssignments(Solutions byusingsoft skill),Quiz, Continuous Assessments,FinalAssessmentTest.			
RecommendedbyBoardof Studies	03-06-2019		
ApprovedbyAcademicCouncil	No. 55	Date	13-06-2019

CourseCode	ENGINEERING DRAWING	L	T	P	J	C
MEE1001		1	0	4	0	3
Pre-requisite	NIL	Syllabusversion				
		v. 2.2				

CourseObjectives:

1. Understandand escalate the importance of basic concepts and principles of EngineeringDrawing (components, sections,views,andgraphicalrepresentation).
2. Enablethe studentswith various conceptslike dimensioning, conventions andstandardsrelated to working drawings in order to become professionally efficient.
3. Develop theability to communicatewithothersthrough the language of technical drawing andsketching.
4. Abilityto readandinterpretengineeringdrawingscreatedbyothers.
5. Abilityto draw orthographic projectionsand sections.
6. Develop an understandingfor size specificationproceduresand useof SIand traditional units oflinearmeasure.

CourseOutcomes:

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, letteringpractice, Elements of dimensioning- systems of dimensioning.

Module:2	GeometricConstructions	2 hours

Free handsketching, Conic sections,Special curves.

Module:3	Projection ofPoints andProjection ofLines	2 hours

Projection ofPoints: First and ThirdAngle Projections; Projection ofpoints.
ProjectionofLines: Projectionofstraightlines(Firstangleprojectiononly);Projectionoflinesinclined to oneplaneandboth planes, true lengthand trueinclinations.

Module:4	Projection ofSolids andSection ofSolids	3 hours

Projectionofsolids:Classificationofsolids,Projectionofsolidsinsimpleposition,Projectionofsolids inclined to one plane.
Sections of Solids: Rightregularsolids and auxiliaryviews for thetrueshapeof thesections.

Module:5	**Development ofSurfaces**	**2 hours**
Development of surfacesforvariousregularsolids.		
Module:6	**IsometricProjectionandPerspectiveProjection**	**2 hours**
IsometricProjection: Isometricscales,Isometricprojections of simple andcombination ofsolids;**PerspectiveProjection:**Orthographicrepresentation of aperspective views– Planefiguresandsimple solids - Visual raymethod.		
Module:7	**OrthographicProjection**	**2 hours**
Conversion of pictorial viewinto orthographicProjection.		
Module:8	**Contemporaryissues**	**1 hours**
	Total Lecture hours:	**15 hours**
Text Book(s)		
1.	VenugopalKandPrabhuRajaV, "EngineeringGraphics",New AGEInternational Publishers, 2015.	
Reference Books		
1.	N. D.Bhatt,EngineeringDrawing,CharotarpublishingHouse,2012.	
2	Natarajan, K. V., A Text book of EngineeringGraphics, DhanalakshmiPublishers, 2012.	
Modeof Evaluation: CAT / Assignment / Quiz/ FAT / Project / Seminar		
List ofChallengingExperiments(Indicative)		
1.	Identifying the incorrectdimensioningandcorrectit as perBIS standards forEngineeringComponents.	4 hours
2.	Tutorials on free hand sketchingof theplan viewof stadium,garden, etc.,	4 hours
3.	Tutorialsongeometricconstructionslike conicsandspecialcurvesforprojection of cricket ball,missile projection,etc.,	4 hours
4.	Representation of orthographicprojection ofpoints	4 hours
5.	Representationoforthographicprojectionoflines(Firstangleprojectiononly)inclinedtooneplaneandprojectionoflinesinclinedtoboththeplanes-solvingproblemslikeelectricalbulbshangingfromtheroof,findingthe shortestdistance between fan to electrical switch board,etc.,	8 hours
6.	Sketching orthographicprojectionofsolidsinsimplepositionandprojectionof solids inclined to oneplaneforhousehold accessoriesandobjects.	8 hours
7.	Drawing theauxiliaryviews,orthographicviewsandtrueshapeofsectionedregularsolids	4 hours
8.	Developmentoflateralsurfacesoftheregularshapesandsectionedshapesforwater cans,refrigerator,cylindercontainer, funnel, etc.,	4 hours
9.	Conversionoforthographic viewsto isometric viewsfor engineeringcomponents.	8 hours
10.	Tutorialproblemsonperspectiveprojectionofplanefiguresandsimplesolids fortrain with track,landscape,etc.,	4 hours

11.	Conversionofpictorialdrawingintoorthographicprojectionforengineeringcomponents,architecturalstructures,etc.,			8 hours
			TotalLaboratoryHours	**60 hours**
Modeof assessment:				
RecommendedbyBoardof Studies	17-08-2017			
ApprovedbyAcademicCouncil	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				

CourseObjectives:

1. Criticallyunderstandthe importance of safety in process industries
2. Assess and identify the potentialhazards in process industries
3. Identify and evaluate thecauses of accident in a chemical industry

Course Outcomes (CO):

1. Identify the typical sources of risk in a process plant by hazard identification and examination of case studies
2. Analyze the severity of the consequences of incidents
3. Develop a Hazard and Operability Study (HAZOP)
4. Understand the legal frameworks 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	Introductionto Safety in ChemicalprocessIndustries	5 Hours

NeedforDevelopmentofSafetyConsciousnessinChemicalIndustries-Hazard,Risk,Danger,Accident;Promotionofindustrialsafety,extremeoperatingconditions,toxicchemicals-safehandling;Psychological attitude towards safety.

Module:2	Safety Programs in Industries	5 Hours

ImportanceofSafetyProgramsinindustries;ElementsofSafetyProgram;EffectiveRealization;Economicand SocialBenefitsfrom Safety Program;EffectiveCommunicationTrainingatvariouslevelsofProductionandOperation.Accidents identification and prevention.

Module:3	PotentialHazards in ChemicalProcessIndustries	4 Hours

Chemicaland Physicaljob Safety Analysis;High pressure and TemperatureOperation;DangerousandToxicChemicals;Routesofentry,Effectsoftoxicantsanditselimination.Toxicreleaseanddispersionmodels.RadioActivematerials;SafeHandlingandOperationofmaterialsandMachinery; periodic inspectionand replacement.

Module:4	Risk assessment	4 hours

Quantitativeriskassessment-rapidandcomprehensiveriskanalysis;RiskduetoRadiation,explosionduetooverpressure,plantlayoutPersonnelSafetyandProtectiveEquipment;Occupational health andsafety.

Module:5	HazardIdentification	4 hours

IntroductiontoHazardidentification-Overallriskandhazardanalysis-Emergencyplanning-Onsite&offsiteemergencyplanning-Riskmanagement-ISO14000-Safetyaudits–Checklist- What if analysis – Vulnerabilitymodels - Event tree analysis - Fault tree analysis.

Module:6	**HAZOP**	**4 hours**
HAZOPstudy-casestudies-pumpingsystem-reactor-masstransfersystem.HazardIdentificationandAssessment;InvolvementofHumanfactorsandErrors-HazardQuantifications-disastermanagement;OccupationalandIndustrialHealthHazards;SafetySystems.		
Module:7	**Case studies**	**2 hours**
Dominoseffect,Worstcasescenario,Fire,Accidents,Chemicalrelease,Explosion,Petroleum,Commercial, Naturaldisasters, EMS models casestudies		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours	**30 hours**

Text Books	
1.	Ericson C.A., Hazard Analysis Techniques for SystemSafety,2nd ed.,Wiley,USA, 2015.
2.	GuptaA.,Industrial Safety andEnvironment, 2nd ed., Laxmi Publications,India, 2015
Reference Books	
1.	Hyatt,N.,Guidelinesforprocesshazardsanalysis,hazardsidentification&riskanalysis,1st ed., CRC Press, USA, 2003.

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

Course code	CHE1008	T	P	J	C
Course title	UNITPROCESSES IN ORGANICSYNTHESIS	3	0	2	4
Pre-requisite	NIL	Syllabus version			
		2.1			

CourseObjectives:

1. Impartknowledgeontheindustrialreactionsusedinconvertingorganicrawmaterialsintousable products by variousprocesses
2. Developstudentsunderstandingtowardskineticsandmechanismofvariousreactionsinvolvedin industries
3. Comprehendvariousinstrumentaltechniquesappliedincontemporaryindustriestoanalyzetheorganic compounds

Course Outcomes (CO):

1. Review 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

Kinetictheoryofgases-VanderWaalsequation-Criticalconstants-Liquifactionofgases,Raoult'slaw-Idealsolutions-Partiallymiscibleliquids-Phenolwatersystem-Henry'slaw-Colligativeproperties-Loweringofvaporpressure-Elevationofboilingpoint-Depressionoffreezing point

Module:2	Heterocycliccompounds	8 hours

Aromatics:Structureofbenzeneandtheoriesofaromaticity–Heterocycliccompounds:Classification–AromaticityandBasicityofheterocycliccompounds–PreparationandpropertiesofFuran–Thiphene–Pyrrole.Oxidation–Oxidisingagents(SeO_2,OsO_4,$KMnO_4$)–Reduction,Reducingagents(Lithiumaluminiumhydride,metal/acidandsodiummetal).Grignardreagents:Synthesis andapplications.

Module:3	Nitration	6 hours

Introductiontonitration,Nitratingagents,KineticsandMechanismofaromaticnitrationprocess,Equipments fornitration,typicalindustrialnitrationprocesse.g.preparationofnitrobenzene,nitroacetanilide.

Module:4	Halogenation	6 hours

Halogenatingagents,Kineticsandmechanismofhalogenationreactions.Apparatusandmaterialsfor construction.Technicalpreparation of chloraland vinyl chloride.

Module:5	Sulphonation	6 hours

Introduction tosulphonation, sulphonationagentsand sulphanationagents, chemicalandphysicalfactorsaffectingsulphonation.Mechanismofsulphonation,commercialsulphon benzene and naphthalene,sulphationoflauryl alcohol and dimethyl ether.

Module:6	Separationand purificationmethods	5 hours

Separationandpurificationmethods:Classicalseparationmethods:Theoriesofdistillation,fractionaldistillation,steamdistillation,sublimationandzonerefining-Solventextraction-Distributionlaw - Separation of mixtures, Craigmethod;Recrystallization of solid products.

Module:7	**Chromatography**	**6 hours**
Chromatography-Introduction,Differenttypesofchromatographictechniques-TLC,Column,GC,LC,andHPLC-TheoryandInstrumentation(GCandHPLC),Applicationsintheseparationoforganic molecules.		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books

1.	GrogginsP.H.,UnitProcessesinOrganicSynthesis,5th ed.,TataMc.GrawHillBookCompany, India, 2009.
2.	PuriB.R.,SharmaL.R.,PathaniaM.S.,PrinciplesofPhysicalChemistry,43rd ed.,VishalPublishin gCo., India, 2008.

Reference Books

1.	Atkins,P.,Paula,J.D.Atkins,PhysicalChemistry,11th ed.,OxfordUniversityPress,USA,2018.
2.	March,J.,AdvancedOrganicChemistry:Reactions,MechanismsandStructures,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: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test

LaboratoryExperiments

1.	Determination ofCritical Solution Temperature of the givenPhenol-Watersystem	2 hours
2.	Determination ofrate constant of the hydrolysis of ethyl acetatecatalyzed by HCl at roomtemperature	2 hours
3.	Determination ofacidvalue of thegiven oilsample	2 hours
4.	Determination of saponificationvalue of the givenoil sample	2 hours
5.	Sulphonation of 1-Naphthol	2 hours
6.	Reductionof Benzophenone by $NaBH_4$	2 hours
7.	Preparation of Benzoic acid frombenzaldehyde by oxidation and itmelting point measurement	2 hours
8.	Preparation of m-DintrobenzenefromNitrobenzene by nitration andit melting pointmeasurement	2 hours
9.	Purification oforganic compounds by Fractionaldistillation	2 hours
10.	Identification of Carbonyl groupin an organiccompound.	2 hours
11.	Identification of Carboxylic acidgroup in anorganiccompound.	2 hours
12.	Preparation ofsoap or detergent	2 hours
	Total Laboratory Hours	24 hours

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

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

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

CourseObjectives:

1. Impart the basic knowledge andoverview ofbiotechnology coveringthe principles of cell andkinetics, bioreactordesign,sterilization agitationand aeration
2. Understand the physical processesinvolvedin bio-systems
3. Apply the knowledge of chemical engineeringprinciples tobiologicalprocesses

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 ofindustrial biochemical processes withtypicalexamplescomparingchemical andbiochemicalprocesses –development and scopeof biochemicalengineering as a discipline.

Module:2	Basic Microbiology and Biochemistry	5 hours

Industriallyimportantmicrobialstrains,theirclassification–structure–cellulargenetics– typicalexamples of microbialsynthesis of biologicals

Module:3	Enzymes&Applications	8 hours

Enzymes-inindustry,medicineandfood– theirclassificationwithtypicalexamplesofindustriallyimportantenzymes;Mechanismofenzymaticreactions–MichaelisMenten Kinetics – enzymesinhibitionfactorsaffectingthereactionrates;Industrialproduction,purificationandimmobilizati

Module:4	Kinetics ofCell Growth	7 hours

Typicalgrowthcharacteristicsofmicrobialcells–factorsaffectinggrowth– Monodmodel;Modellingofbatchandcontinuouscellgrowth;Immobilizedwholecellsandtheircharacteristics

Module:5	UnitOperations in Biochemicalengineering	6 hours

Newtonianandnon-Newtonianbehaviourofbroth–agitationandmixing– powerconsumption;Gas/liquidtransportincells–transferresistances– masstransfercoefficients&theirroleinscaleupofequipment– O_2transfer;Heattransportinmicrobialsystems–Heattransfercorrelation's; Sterilizationcycles; Heat addition & removal during biologicalproduction

Module:6	**Bioreactors**	**8 hours**
Bioreactors- Batchandcontinuoustypes,immobilizedwholecellandenzymereactors.Highperformancebioreactors; Reactors inseries withand withoutrecycle.Designof reactorsandscale up with typical examples;		
Module:7	**Downstream and effluenttreatmentprocesses**	**6 hours**
Downstreamprocessesandeffluenttreatment:DifferentUnitoperationsindownstreamingwithspecialreference tomembraneseparations,extractivefermentation;Anaerobicandaerobictreatmentofeffluents–typicalindustrialexamplesfordownstreamprocessingandeffluentdisposal.		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours	**45 hours**

Text Books	
1.	Bailey J.B.,OllisD.F.,BiochemicalEngineeringFundamentals,4th ed.,McGrawHill, USA, 1986.
Reference Books	
1.	RaoD.G., Introductionto BiochemicalEngineering,1st ed.,Tata McGrawHill, India, 2009.
2	DoranP.M., BioprocessEngineering 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: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test	

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

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

CourseObjectives:

1. Equipthestudentswiththebasicunderstandingandeffectiveutilizationofutilitiesviz.water,steam,compressor,vacuumpumps,refrigerationandcoolingunits,insulator,inertgasesinprocess industries and alliedoperations
2. Impartinsightsinrelationtothedifferenttypesoffuelsandboilersusedinprocessindustriesfor the generation of steam, types of compressors and blowers forhandling air andinert gases
3. Expose students to differentmethods 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 for specific applications
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 ofIndustrial Waterandits uses; Watertreatmentmethods- ion exchange,demineralization,membranestechnology,reverseosmosis.Waterresourcesmanagement. Propertiesofsteam,Boilertypesandmountings,boileraccessories,IndianBoilerAct,1923.Steamdistribution and utilization,steameconomy, waste heat utilization

Module:2	Industrial fuels	6 hours

Solid,liquidandgaseousfuelsusedinchemicalprocessindustriesforpowergeneration,Typicalcombustioncalculations

Module:3	Compressed Air	6 hours

Typesof fans,axial, reciprocatingandcentrifugalcompressors,rotaryblowersandvacuum pumpsandtheirperformancecharacteristics.Methodsofvacuumdevelopment,ejectorsandtheirlimitations,materials handling undervacuum, piping systems.

Module:4	Humidification and Dehumidification	5 hours

PropertiesofAir–WaterVaporsanduseofHumidityChart,EquipmentsusedforHumidification,Dehumidification and

Module:5	Refrigeration& Ventilation	6 hours

Principleofrefrigeration,Refrigerationsystemlike compression refrigeration,absorption refrigeration,andchilled water system;Types of refrigerants;Conceptof cryogenicsandcryogenics characteristics. Air blending,exhaustventilation and flaring

Module:6	Industrial insulationand Inert Gases	8 hours

Importanceofinsulation,insulationmaterialandtheireffectonvariousmaterialsofequipmentpiping,fitting andvalves,insulationforhigh,intermediate,lowandsubzerotemperaturesincluding cryogenic insulation Introduction,propertiesofinertgases&theiruse,sourcesandmethodsofgeneration,generalarrangement forinertingsystem; operational, maintenance and safety aspects		
Module:7	**Effluent treatment**	**5 hours**
Disposalofsolid,liquidandgaswastes;pollutioncontrolmeasures– compliancetostatutorynorms;EffluentTreatment– Casestudiesliketreatmentofeffluentsfrompapermills,DyeandTextile industries,petrochemical		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours	**45 hours**

Text Books

1.	BroughtonJ.,ProcessUtilitySystems,3rd ed.,InstitutionofChemicalEngineers,U.K.,2004

Reference Books

1.	MujawarB.A.,ATextbookofPlantUtilities,3rd ed.,NiraliPrakashanPublication,India,2007.
2.	Poling B.E.,PrausnitzJ.M.,O'ConnellJ.,ThePropertiesofGasesandLiquid,5th ed.,McGraw Hill,USA, 2008.
3.	Perry,R.H.,Green,D.W.,Perry'sChemicalEngineersHandbook,8th ed.,McGrawHill,USA, 2007.

Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test			
Recommended by Board of Studies	15-04-2019		
Approved by AcademicCouncil	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				

CourseObjectives:

1. Provide an overview ofstate-of-the-artoptimizationalgorithms
2. Impartthetheoreticalknowledgeofchemicalengineeringprinciplesthatunderpinoptimizationtechniques.
3. Enhancethemodellingskillstodescribeandformulateoptimizationproblemsandtheiruseforsolving several types of practically relevantoptimizationproblems in Chemicalengineering

Course Outcomes (CO):

1. Demonstrate the basic principles of Chemical Engineering Optimization
2. Classify 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

NatureandOrganizationofOptimizationproblem;Mathematicalconceptsofoptimization;Developingmodelforoptimization;Taylorexpansion;GradientandHessianmatrix;Convexfunctions and sets;Gaussianeliminationmethod

Module:2	Models for Optimization	5 hours

Selection of function;Degreesof freedom;Classification of models; factorialexperimental design;constraints in model;Optimalityconditions forasingle-variable and multi-variablefunctions

Module:3	Linear and Nonlinear Least square problems	6 hours

One-dimensionalsearch-Methodsrequiringderivatives(Newton,QuasiNewton,Secantmethod);Regioneliminationmethods(Intervalhalving,Fibonaccisearch,Goldensection);Polynomialapproximations(Lagrange's,quadratic &

Module:4	MultivariableOptimization-I	6 hours

Unconstrainedmultivariableoptimization- Graphicalvisualization(contourplots, 3D plots);Gradient basedmethods– Steepestdescent, conjugate direction, and Newtonmethods

Module:5	MultivariableOptimization-II	6 hours

Linear programming (LP)- Graphical solution- Simplex Method; Test foroptimality – Barriermethods - Sensitivityanalysis;Concept of duality;Introduction to interior-pointmethod – Simulation of Reactor model – ASPEN PLUS and MatLab

Module:6	NonlinearProgramming	7 hours

Nonlinearprogramming(NLP)withconstraints;Lagrangemultipliers-Graphicalillustrationof

NLPproblems-KKTnecessaryandsufficientconditions;Quadraticprogramming-Successivelinearandquadraticprogramming;Penaltyfunctionmethod;Integerandmixedintegerprogramming. (IP and MIP)- Graphicalsolution - Branch and bound methods		
Module:7	**DynamicProgramming**	**7 hours**
Dynamicprogramming-Minimumcostroutingproblems-Solutionofseparablenonlinearprogrammingproblems;Globaloptimizationproblems;Introductiontomultiobjectiveoptimization problems- Pareto optimalsolutions(graphical illustration)		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours	**45 hours**

Text Books

1. EdgerT.F.,HimmelblauD.M.,LasdonL.S.,OptimizationofChemicalProcesses,2nd ed., McGraw-Hill,USA, 2015.

Reference Books

1. HillierF.S.,LiebermanG.J.,IntroductiontoOperationsResearch,7th ed.,McGraw-Hill,USA, 2001.
2. RaoS.S.,EngineeringOptimization:TheoryandPractice,4th ed.,JohnWiley&SonsLtd., USA, 2009.

Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test			
Recommended by Board of Studies	15-04-2019		
Approved by AcademicCouncil	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				

CourseObjectives:

1. Impartdesignexperiencesessentialforgraduatestoenterthepracticeof GasEngineeringandpursue lifelongprofessionaldevelopment
2. Summarize the necessarytheory,applicationtocase studies and engineeringprojectdesign
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	Propertiesand Composition of Natural Gas	6 hours

Naturalgasorigin–CompositionofNaturalGas–SourceofNaturalGas–Thermodynamicsproperties–CompressibilityfactorforNaturalGas–HeatingvalueandflammabilitylimitofNatural Gas

Module:2	Natural GasOffshore Drilling	5 hours

Directional Drilling andHorizontalDrilling

Module:3	Natural GasOffshore Production andHandling	6 hours

Drilling DeepwaterReservoir– Deepwater production systems– Mooring Systems– GasTerminals

Module:4	Natural Gas OnshoreProduction andHandling	6 hours

Sucker Rod pumping– Separation ,Storage,Transportation ofNatural Gas

Module:5	Natural GasProcessing	8 hours

Dehydration–
Desulphurizationprocesses(Sourgases,ToxicityofH$_2$S,PhysicalandChemicalAbsorptionprocess,Carbonateprocess,sulphurrecovery)–Lowtemperatureprocesses(JouleThompsoneffect, Turbo

Module:6	Liquid Recovery	6 hours

NGL, LPG, C_3, C_2Fraction Recovery fromNaturalGas

Module:7	**Economicsof NaturalGas**	**6 hours**
Current status in India–Trade &Selection ofport location –EconomicsofGas Processing		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours	**45 hours**

Text Books	
1.	ArthurJ.Kidnay,WilliamR.Parrish,FundamentalsofNaturalGasProcessing,4th ed.,Taylor andFrancis, CRCPress,UK, 2011.
2.	SubrataKChakrabarti,Handbookofoffshoreengineering,1st ed.,ElsevierPublishers,Netherlands,2005.
Reference Books	
1.	S.Mokhatab,WilliamA.Poe,JamesG.Speight,HandbookofNaturalGasTransmissionand Processing, 1st ed., GulfProfessional Publishing,USA,2014.
2.	G. Ghalambor, Natural Gas EngineeringHandbook, Gulf PublishingCompany,USA, 2005.
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test	

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

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

CourseObjectives:

1. Understand the importance of crude oil as source of fuel and the size ofrefining industry
2. Interpretthechallenges involvedinrefining fromviewpoint of product specifications, economicconsiderations and environmental regulations
3. Design application ofchemical engineering principlesto petroleumrefining

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

ExplorationPractices-ReservoirRockProperties-Reservoirtypes-ReservoirEstimationOrigin – Composition-Classificationandconstituentsof petroleum - Dehydration of crude oil- Transportation ofcrude oil- Classification of petroleum

Module:2	Distillation	6 hours

Componentsofcrudeoildistillation-variouscrudeoildistillationsystems-usesofpetroleumproducts

Module:3	Cracking	8 hours

Necessityofcracking-Typesofcracking-advantagesanddisadvantagesofcatalyticcrackingoverthermalcracking-Houdrysfixedbedprocesses-Movingbedprocesses-Fluidbedcatalyticcrackingprocesses

Module:4	Reforming	4 hours

Thermal and catalyticReforming; Polymerization; Alkylation;Isomerization

Module:5	Purificationof petroleumproducts	7 hours

Sweeteningprocesses types–Merox– HDS; Dewaxing; Deasphalt;Lube oil treatment

Module:6	Propertiesof Petroleum Products	7 hours

Specific gravity- Vaporpressure –Viscosity - red woodviscometer- Flash point- Firepoint -Pour point- Smoke point - Anilinepoint- Diesel index - Octanenumber- Performancenumber-

Cetanenumber - Properties of greases - Drop point of grease

Module:7	Knocking	5 hours

Reasonsforknocking-Additivesinpetrol-Aviationgasoline-Aviationturbinefuel(ATF)-Storageandhandling of liquid fuels

Module:8	**Contemporary issues**		**2 hours**
Total Lecture hours			**45 hours**
Text Books			
1.	GaryJ.H.,HandwerkG.E.,KaiserM.J.,PetroleumRefiningTechnologyandEconomics,6th ed., CRC Press, USA,2013.		
2.	Speight J.G.,Petroleum Refining Process, 1st ed., Taylor andFrancis,USA,2015		
3	Bhaskara RaoB.K., Modern PetroleumRefiningProcessess,5th ed., Oxibh, India, 2013		
Reference Books			
1.	MohamedA.F.,TaherA.,AmalE.,FundamentalsofPetroleumRefining,1st ed.,Elsevier,USA, 2010.		
2.	Nelson,PetroleumRefinery Engineering,4th ed.,McGraw Hill, USA, 2010.		
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test			
Recommended by Board of Studies	15-04-2019		
Approved by AcademicCouncil	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 AcademicCouncil	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				

CourseObjectives:

1. Learn thebasics of the various aspects of microbiologyandbiosystems
2. Impartexperimentaldesignthinkingcapabilityinrelationtovariousfermenterconfigurations,modes ofoperation, growth kineticsand productrecovery
3. Extrapolatethedesignthinkingskills to biorelated processeswithchemicalengineeringbackground

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 fermentationprocesses	4 hours

Developmentoffermentationprocess– rangeof processes under fermentation, Types offermentation.

Module:2	Microbialgrowth kinetics	6 hours

Microbialgrowth- Batch,Continuous and typesoffed batch culture – design and kinetics.Comparison of the modes of culture

Module:3	MicrobialStrainManagement	5 hours

Industrialmicroorganisms-isolation,preservationandimprovementofstrains;Storagemethodsand improvementstrategies.

Module:4	Mediaforindustrialfermentations	5 hours

Mediaformulation-
energy,carbonandnitrogensources,micronutrients;oxygenrequirements;Othernon-nutrientandfunctionalcomponents.Effectsofmediacompositiononpenicillinproduction;Media

Module:5	Preparationofasepticfermentationprocess	8 hours

Preparationofmediaandairforpurecultrefermentation;Mediasterilization-Batchandcontinuoussterilizationprocesses;Sterilizationoffibrousfiltersandtheirdesign;Developmentofinocula-processesinvolvingyeast,bacterial,fungi;Asepticinoculationofplantfermentations.

Module:6	Basicfunctionsofafermenter	8 hours

Basicfunctionsoffermenter–Aerationandagitation–processrequirementsandmechanicaldesignaspects;Maintenanceofasepticconditionsandfoamcontrol.Typesoffermentersforindustrialapplications-stirred&sparredtanksfermenters,Towerfermenter,Packedtower,Airlift and rotating disc		
Module:7	**Processtechnologyforbulkproducts**	**7 hours**
Basicdownstreamprocessing;Processtechnologyforbulkproducts;Productionofalcohols,organic acids,enzymes,and antibiotics– flowsheet and processdescription of modern processes.		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours	**45 hours**
Text Books		
1.	StanburyP.F.,WhitakerA.,SteveH.,PrinciplesofFermentationTechnology,3rd ed.,Butterworth-Heinemann,USA, 2017.	
2.	El-MansiE.,BryceC.F.A,ArnoldL.D.,AllmanA.R.,FermentationMicrobiologyandBiotechnolog	
Reference Books		
1.	AshokP,ChristianL,CarlosR.S.,AdvancesinFermentationTechnology,1st ed.,AsiatechPublishers Inc., India, 2008.	
2.	RhodesAandPletcher.D.L:PrinciplesofIndustrialMicrobiology,3rd ed.,PergamonPress, UK, 1977.	
Mode of evaluation: ContinuousAssessment Test,Quizzes, Assignments, Final Assessment Test		
Recommended by Board of Studies	15-04-2019	
Approved by AcademicCouncil	55th Date	13-06-2019

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

CourseObjectives:

1. EmphasizeonthebasicconceptsofunitoperationsandunitprocessesinChemicalEngineeringwithan applicationtoFoodtechnology
2. Impart necessary knowledgerequired for food processing technology ,foodqualitymanagement,foodstandardsandpackaging
3. Familiarizethevariouspropertiesoftherawmaterialusedinfoodprocessingandtechnologies requiredintransformingthemintoqualityfoodproductsandtotrainthestudentstousethematerialhandli ngequipment involved in foodprocessingoperations

Course Outcomes (CO):

1. Determine the various engineering properties of the raw material used in food processing useful to design the various food Processing equipments
2. Select suitable dryers based on 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. Apply appropriate unit operations involved in food technology
6. Understand about the packaging material and methods and the cost involved

Module:1	IntroductiontoFood	4 hours
Macromolecules-proteins,Enzymes,Carbohydrates,Micronutrients,Water,Interactions		
Module:2	**FoodMicrobiology**	**3 hours**
DeteriorativefactorsandControl.Foodadditivesandpreservatives.Adulteration		
Module:3	**Food processcalculations**	**3 hours**
Materialandenergycalculationsinfoodprocessing		
Module:4	**Unitoperationsinfoodprocessing**	**5 hours**
Materialhandling,heattransfer,mixing,sizereduction,mechanicalseparations		
Module:5	**FoodPreservationTechniques**	**5 hours**
Dryinganddehydration,Irradiation,MicrowaveHeating,SterilizationandPasteurization– Cleaning/sanitationInProcess(CIPandSIP),FermentationandPickling		
Module:6	**FoodProcessingandFoodquality**	**5 hours**
ProcessingofCerealGrains,Pulses,Vegetables,Fruits,Spices,FatsandOils,Bakery,Confectionaryand ChocolateProductsSoftandAlcoholicBeverages,DairyProducts,Meat,PoultryandFishProducts,Foo dqualityparametersandtheirevaluationFSSAIandsafetyconceptsinfoodprocessing.Qualitycontrolan dFoodstandardorganizations		
Module:7	**Packagingandcanning**	**3 hours**

Concepts,definition,Significance,classification – freshandprocessed;Basicpackagingmaterials,typesofpackaging,Packagingmethods.Newermethodsofthermalprocessing,batchandcontinuous;applicationofinfrared,microwaves.packagingdesign,retortpouchpacking,vacuumpackaging;costsofpackagingandrecyclingofmaterialsandLabelling			
Module:8	**Contemporary issues**		**2 hours**
	Total Lecture hours		**30 hours**
Text Books			
1.	Rao C.G., Essentials ofFood Processing Engineering, 1st ed., BSPublications,India,2005.		
2.	SubbulakshmiG,UdipiShobhaA.,FoodProcessingandPreservation,1st ed.,NewAge International, India, 2017.		
Reference Books			
1.	KhetarpaulN.,Food Processing and Preservation, 1st ed., DayaPublications, India,2005.		
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test			
Recommended by Board of Studies	15-04-2019		
Approved by AcademicCouncil	55th	Date	13-06-2019

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

CourseObjectives:

1. Understand basic principles of membraneseparation and characterizationmethodsavailable formembranes
2. Derive varioustransportmechanisminvolved in MF, UF,NF, ROandgas separationmembranes
3. Select membranesfordifferentindustrialseparation and purificationapplication

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 andCharacterization	5 hours

Introduction-Historicaldevelopmentofmembranes-typesofmembraneprocesses-typesofsyntheticmembranes-membranematerials-membranemodule;Membranepreparation–Phaseinversionprocess–castingmethods;Membranecharacterization-Measurementofporesize-soluteproperties–visualmethods-bubblepointmethod-liquiddisplacementmethod,molecularweight cut-off(MWCO),microbialchallenge test

Module:2	MembraneTransport Theory	6 hours

Membranetransporttheory– Introduction,solution-diffusionmodel;Structure-permeabilityrelationship insolution diffusionmembranes;Pore-flow membranes.

Module:3	ConcentrationPolarization	6 hours

Concentrationpolarization–Introduction,boundarylayerfilmmodel;Concentrationpolarizationin liquidseparation process; Cross-flow, co-flowand counter-flow processes.

Module:4	Microfiltration andUltrafiltration	6 hours

Microfiltration:Introduction and history,applications;Recent trends andprogressinMF/UFtechnology; Ultra filtration:Introduction and history– characterization of ultrafiltrationmembranes– concentrationpolarization and membrane fouling, membranecleaning – membraneand modules– systemdesign – application

Module:5	Nanofiltration	7 hours

Nanofiltration:Introduction– processprinciples – application of nanofiltrationforthe productionofdrinking water and process water – solvent resistancenanofiltration

Module:6	**Reverse Osmosis**	**7 hours**
Reverse osmosis:Introduction– membrane categories– membraneselectivity– membranetransportconcentration polarization –membranemodules– membrane fouling control–membrane cleaningapplications		
Module:7	**Recent development in MembraneProcesses**	**6 hours**
Recent material and moduleconfigurations for Microfiltrationand ultrafiltration; Thinfilmcompositemembranes– Biofouling protection; Integrated membranesystems;Gas separation -Hydrogen separation– oxygen and oxygen enriched air;Membranedistillationand Ceramicmembranes		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books	
1.	DuttaB.K.,PrinciplesofMasstransferandSeparationProcesses,1st ed.,PrenticeHallofIndia, India,2007.
2.	MulderM.,BasicPrinciplesofMembraneTechnology,2nd ed.,SpringerScience,USA,1991.
Reference Books	
1.	Kaushik K.N.,MembraneSeparation Process, 1st ed., Prentice Hall of India, India, 2008.
2.	Cui Z.F., MuralidharaH.S.,Membrane Technology: A Practical Guide to MembraneTechnologyand Applications in Food and Bioprocessing, 1st ed., Elsevier,USA,

Mode of evaluation:ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test			
Recommended by Board of Studies	15-04-2019		
Approved by AcademicCouncil	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				

CourseObjectives:

1. Understanddifferenttypes of polymers
2. Identify the various technologiesand typesof polymerizationtechniques
3. Analyze thepolymer processing techniques andpolymer additives

Course Outcomes (CO):

1. Classify various polymer and polymerization reactions
2. Explain the different methods of polymerization
3. Identify the processing technologies for different polymer synthesis and their additives
4. Explain various polymer processing techniques
5. Distinguish different type of polymers for various applications
6. Demonstrate the novel biodegradable polymers and their applications

Module:1	Introduction to polymer	5 hours

Monomer;polymersand their classification:Degree of polymerization.Polymericreaction:addition; condensationandcopolymerization

Module:2	Methods of polymerization	6 hours

Bulk, solution,emulsion and suspension polymerization

Module:3	Structure and size of polymer	6 hours

Structureofpolymers,Characterizationof polymers: Molecular weight, Crystallinity,Glasstransitiontemperature andmechanicalproperties:testing of polymers

Module:4	Polymer processingadditives	6 hours

Fillers, plasticizers, Anti-oxidants,colorants,stabilizers, andother related additives

Module:5	Polymer processingtechniques	6 hours

Injectionandcompressiontransfermouldingmethods;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 andbio polymers	5 hours

Polycarbonates, polysulphones;aromaticpolyamides;aromaticpolyester; photo conductivepolymers; wool silkand cellulosederivatives, Proteinbasedpolymers and Bio-nano-composites

Module:8	Contemporary issues	2 hours

Total Lecture hours				**45 hours**
Text Books				
1.	GowarikerV.R.,ViswanathanN.V.,SreedharJ.,PolymerScience,2nd ed.,NewAgePublishers, India, 2015.			
2.	Ebewele R.O.,Polymer Science andTechnology, 1st ed., CRC press, USA, 2000.			
Reference Books				
1.	Froed J.R.,Polymer science &Technology, 1st ed., PrenticeHall Publishers,USA,2014.			
2.	YoungR.J., Lovell P.A., Introduction to Polymers, 1st ed., CRC Press, USA, 2011.			
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test				
Recommended by Board of Studies		15-04-2019		
Approved by AcademicCouncil		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				

CourseObjectives:

1. Introduceproduction of various NPKfertilizers and their importance
2. Impart knowledge of bio fertilizers, fluid fertilizersand controlled release fertilizers
3. Identifypollutionsinvolvedinfertilizermanufactureandtheircontrollingstrategiestomaintainthe pollution standards

Course Outcomes (CO):

1. Analyze 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

Introductiontofertilizers-Importance,FeedstocksfortheproductionofAmmonia.Processesforgasificationof fossil fuel and

Module:2	Nitrogenous Fertilizers	7 hours

Nitrogenous fertilizers – Ammoniumsulphate, Urea, Ammonium chloride,Ammoniumnitrate andCalciumammoniumnitrate,Theirmethodsofproduction,Characteristicsandspecification,Storage andhandling

Module:3	PhosphaticFertilizers	5 hours

PhosphaticFertilizers:Rawmaterials–phosphaterock,sulphur,pyritesetc.Processesfortheproductionofsulphuricandphosphoricacids.Phosphaticfertilizers–groundrockphosphate, bonemeal–Singlesuperphosphate,Triplesuperphosphate,thermalphosphates–

Module:4	Potassic Fertilizers	5 hours

Potaasicfertilizers-PotassiumChloride,Potassiumsulphate,Potassiummagnesiumsulphate,Potassiumhydroxide,Potassiumnitrate–Methodsofproduction:theircharacteristicsandspecifications.

Module:5	NPK Fertilizers	7 hours

NPKfertilizers:Urea ammoniumphosphate,ammoniumphosphate sulphate,Nitrophosphates,and various grades of NPKfertilizers produced in the country

Module:6	Other Fertilizer	7 hours

Fertilizers and granulatedmixtures; Biofertilisers,Nutrient-Secondary nutrients andmicronutrients;Fluidfertilizers,Granularfertilizers,Controlled release fertilizers,Slow releasefertilizers

Module:7	**Pollution control**	**5 hours**
Pollution from fertilizerindustry,Solid, liquid andgaseous pollutioncontrol 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.	RaoG., SittigM., Dryden'sOutlines of ChemicalTechnology,3rd ed.,EastWestPress,India, 2010.
2.	AustinT.G.,Shreve'sChemicalProcessIndustries,5th ed.,TataMcGraw-HillEducation Pvt. Ltd, USA, 2012.
3.	ShuklaS.D.,PandeyG.N.,ATextBookofChemicalTechnology,1st ed.,VikasPublishing House Pvt. Ltd, India, 1978.

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

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

CourseObjectives:

1. Developthestudentunderstanding levels ofproduct and process layoutfundamentals
2. Applytheknowledgeofstatisticsforperformingqualitycontrolandinspectionandprojectplanning
3. Make thestudents to analyzesituations and use differentmodels for decisionmaking

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. Examine 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 OperationsManagement	6 hours

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

Module:2	Plant Location and Layout	6 hours

Factorsinfluencingplantlocation-locationmodels;Plantlayout–objectives,classifications;Design of product and process layout.

Module:3	Supply of Resources	6 hours

MaterialsManagement - purchasing;ABC Analysis

Module:4	InventoryManagement/Control	6 hours

InventoryManagement–objectives,benefit,technique;Inventorymodels-withoutshortage,withshortage

Module:5	Quality Control and Inspection	6 hours

Statistical QualityControl Methods -p, x and Rcharts etc.,

Module:6	Project Planning	7 hours

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

Module:7	Decision Making	6 hours

GeneralModelfordecisionmaking-Bayes'DecisionRule;DecisionMakingunderUncertaintyand Risk;Decision Tree Method

Module:8	Contemporaryissues:	2 hours

Total Lecture hours				**45 hours**
Text Books				
1.	CharyS.N.,ProductionandOperationsManagement,5th ed.,TataMcGraw-HillEducationPvt. Ltd., India, 2012			
2.	PanneerselvamR.,ProductionandOperationsManagement,3rd ed.,PHILearningPvt.Ltd.,India, 2012			
Reference Books				
1.	Garg,A.K.,ProductionandOperationsManagement,1st ed.,TataMcGraw-HillEducation Pvt. Ltd., India, 2012			
2	Montgomery,D.C.,IntroductiontoStatisticalQualityControl,6th ed.,JohnWiley&Sons,Inc. USA, 2009			
Mode ofevaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test				
Recommended by Board of Studies		15-04-2019		
Approved by AcademicCouncil		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				

CourseObjectives:

1. Train thestudents in identifying the needs andconvertingneeds to product specifications
2. Facilitate generationof innovative ideas forchemical products and select among the ideas
3. Familiarize the student with intellectualproperty issues andmanufacture and design ofspeciality products

Course Outcomes (CO):

1. Analyze the needs of customers
2. Apply engineering knowledge to convert needs to product specifications
3. Create 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 chemicalproduct**	**6 hours**
Customer needs- consumer products		
Module:3	**Needs to specifications**	**6 hours**
Convertingneedsto specifications -revising product specifications		
Module:4	**Ideas**	**8 hours**
Human sources of ideas - chemicalsources of ideas- sorting the ideas - screening theideas.		
Module:5	**Selection ofideas**	**8 hours**
Selection usingthermodynamics- selection using kinetics-lessobjective criteria-rise inproduct selection		
Module:6	**Product manufacture**	**6 hours**
Intellectual property - supplyingmissinginformation- final specifications-microstructuredproducts - devicemanufacture		
Module:7	**SpecialtychemicalmanufactureandEconomicConcerns**	**8 hours**
Firststepstowardsproduction-separations- specialtyscaleup-Productversusprocessdesign-process economics- economics for products		
Module:8	**Contemporary issues**	**2 hours**
Total Lecture hours		**45 hours**

Text Books				
1.	CusslerE.L.,MoggridgeG.D.,ChemicalProductDesign,CambridgeUniversityPress,2nded., UK, 2011.			
Reference Books				
1.	SeiderW.D.,SeaderJD.,LewinD.R.,ProductandProcessDesignPrinciples,Wiley,4thed.,USA, 2016.			
2.	WeiJ.,ProductEngineering:MolecularStructureandProperties,OxfordUniversityPress,1st ed., UK, 2007.			
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, FinalAssessment Test				
Recommended by Board of Studies		15-04-2019		
Approved by AcademicCouncil		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				

CourseObjectives:

1. Developtheunderstanding levels offuels and combustionfundamentals
2. Classifyandintroducedifferenttypesoffuelandfuelanalysistechniquesthatassiststhestudents to choosemostconvenient fuel for a processinvolvingcombustion`
3. Engagethestudentsindesigningvariouscontroltechniquesforhandlingvariousenvironmentalissues resulting fromcombustion of fuels

Course Outcomes (CO):

1. Classify the various types of fuels and their properties
2. Interpret the results of proximate and ultimate analysis of fuels
3. Identify the suitable fuel based on various factors such as availability, storage, handling, pollution and cost
4. Evaluate the properties of 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 andProperties ofFuels	5 hours

Fuels-Typesandcharacteristicsoffuels-Determinationofpropertiesoffuels-Fuelanalysis-Proximateandultimateanalysis-Calorificvalue(CV)-Grossandnetcalorificvalues(GCV,NCV)-BombCalorimetry-empiricalequations for CV estimation

Module:2	Solid Fuels	6 hours

Originofcoal-Rankingofcoal-Washing,cleaningandstorageofcoal-RenewableSolidFuels-comparativestudyofSolid,liquidandgaseousfuels-selectionofcoalfordifferentindustrialapplications-carbonization ofcoal

Module:3	Liquidfuels	6 hours

Origin of crude oil-composition of crudepetroleum-classification of crudepetroleum-Removalofsalt fromcrude oil-processing ofcrude petroleum-Fractionationdistillation-ADU and VDU-Cracking-Hydrotreatment and Reforming

Module:4	Gaseousfuels	6 hours

Richandleangas-Wobbeindex-Naturalgas-Dryandwetnaturalgas-FoulandsweetNG-LPG-LNG-CNG-Methane-ProducerGas-Watergas-CoalGasification-GasificationEfficiency

Module:5	Combustion	7 hours

General principlesof combustion-types of combustionprocesses-Combustionchemistry-Combustion equations-Kinetics of combustion-combustion of solid fuels-Combustion calculations-air fuel ratio-Excess air calculations

Module:6	CombustionEquipment	7 hours

Analysis of flue gases byOrsatapparatus-Combustion ofsolid fuels-grate firing andpulverizedfuelfiringsystem-Fluidizedbedcombustion-Circulatingfluidizedbedboiler-Burners-Factorsaffectingburners and combustion		
Module:7	**AirPollution**	**6 hours**
Types of pollution-Combustiongenerated air pollution-Effects of air pollution-Pollution offossil fuels andits control-Pollutionfromautomobiles and itscontrol		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours	**45 hours**

Text Books	
1.	Kenneth K.K.,Principles of Combustion,2nd ed., WileyPublications,USA, 2012
2.	PhillipsH.J.,Fuels-solid,liquidandgases–Theiranalysisandvaluation,1st ed.,FosterPress, USA, 2010
Reference Books	
1.	SpeightJ.G.,TheChemistryandTechnologyofCoal,3rd ed.,TaylorandFrancisLtd.,USA,2016
2.	Sarkar S., Fuels and combustion,3rd ed., Universities Press, India, 2009

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

Coursecode	CHE2007	L	T	P	J	C
Coursetitle	PROCESSINTENSIFICATION	3	0	0	0	3
Pre-requisite	CHE1006	Syllabusversion				
		1.0				

CourseObjectives:

1. Understand theconcept of ProcessIntensification
2. Applythe techniquesof intensification to a range ofchemicalprocesses
3. Inferalternative solutions keepingin view point, theenvironmental protection,economicviabilityandsocialacceptance

CourseOutcomes(CO):

1. Understand the scientific background,techniques and applications of intensification in theprocessindustries
2. Applyprocessintensification in industrialprocesses
3. Implementmethodologies for processintensification
4. Identifyscale up issues in the chemicalprocess
5. Interpret thefeasibilityof theprocess intensification
6. Formulate and solve processchallengesusingintensificationtechnologies

Module:1	Introduction	6 hours

TechniquesofProcessIntensification(PI)Applications-Thephilosophyandopportunitiesof ProcessIntensification-Mainbenefitsfromprocessintensification-ProcessintensifyingEquipment - Processintensification toolbox- Techniquesfor

Module:2	ProcessIntensificationThroughMicroReactionTechnology	6 hours

EffectofminiaturizationonunitoperationsandreactionsImplementationofMicroreactionTechnologyfrombasicProperties-TechnicalDesignRules-InherentProcessRestrictionsinMiniaturizedDevicesandTheirPotentialSolutions-MicrofabricationofReactionandunitoperationDevices-WetandDryEtchingProcesses

Module:3	MixingAndFlowPatterns	8 hours

Scalesofmixing-Flowpatternsinreactors-Mixinginstirredtanks:Scaleupofmixing-Heattransfer-Mixinginintensifiedequipment-ChemicalProcessinginHighgravityFieldsAtomizer-UltrasoundAtomization-HighintensityinlineMIXERSreactors-Staticmixers–Ejectors-Teemixers-Impingingjets-RotorstatormixersDesignPrinciplesofstaticMixersandApplicationsofstatic mixers-Higee reactors

Module:4	CombinedChemicalReactorHeatExchangersAndReactorSeparators	6 hours

Principlesofoperation–Applications-Reactiveabsorption-Reactivedistillation-ApplicationsofRD Processes

Module:5	CompactHeat Exchangers	8 hours

Classificationofcompactheatexchangers-Plateheatexchangers-Spiralheatexchangers-Flowpattern-Heattransferandpressure drop-Flattubeandfinheatexchangers-Microchannelheatexchangers–Phasechangeheattransfer-Selectionofheatexchangertechnology-Feed/effluentheatexchangers-Integratedheatexchangersinseparationprocesses-Designofcompact heat exchanger- examples		
Module:6	**EnhancedFields**	**6 hours**
Energybasedintensifications–Sonochemistry-Basicsofcavitation-CavitationReactors-Flow over a rotatingsurface- Hydrodynamiccavitationapplications-Cavitation reactordesign–Nusselt flowmodel andmass transfer-Sonocrystallization; Reactive separations		
Module:7	**CaseStudies**	**3 hours**
Reactive Extraction CaseStudies- Absorption of NO_x-CokeGas Purification		
Module:8	**Contemporaryissues**	**2 hours**
	TotalLecturehours	**45 hours**

Text Books	
1.	Segovia H., Juan G.,Bonilla P., Adrián, Process Intensification in ChemicalEngineeringdesignoptimizationandcontrol,1st ed.,Springer,Mexico,20
2.	DavidR., Colin R., AdamH., ProcessIntensificationEngineeringfor Efficiency,SustainabilityandFlexibility,2nd ed.,Elsevier, Netherlands, 2013.
Reference Books	
1.	Andrzej S., Jacob A., Moulijn, Re-engineering the chemical processing plant:processintensification, 1st ed.,Marcel DekkerInc,USA, 2004.
2.	ReayD.,RamshawC.,HarveyA.,ProcessIntensification,1st ed.,Elsevier,Netherlands, 2008.

Mode ofevaluation: Continuous AssessmentTest, Quizzes, Assignments,FinalAssessmentTest			
RecommendedbyBoardof Studies	15-04-2019		
Approved by AcademicCouncil	55th	Date	13-06-2019

Coursecode	CHE2008	L	T	P	J	C
Coursetitle	CHEMICAL ENGINEERING COMPUTATIONAL FLUID DYNAMICS	2	0	0	4	3
Pre-requisite	CHE1005, CHE1006	Syllabusversion				
		1.0				

CourseObjectives:

1. Recall the basicfluidandheattransfergoverningequations
2. Utilize basicaspects ofdiscretizationforgridgeneration
3. Estimate fluid flowand heattransferproblems

CourseOutcomes(CO):

1. Understandandselectthe governingequationsof fluid flow and heat transfer
2. Enable to solveoneandtwo-dimensional ordinaryand partial differentialequationsusingtraditionalCFDtools
3. Makeuse ofdiscretizationtechniquesfor derivatives and differential equations to solvenumerically
4. Examine generaltransformationequations for grid generation
5. Recommendsuitable explicit, implicitand semi-implicit methods of finitedifference schemefor givenproblems
6. Solve fluid flow fieldandtemperature field to designanyprocess equipment using somepopularCFD techniques

Module:1	GoverningEquations	4 hours

Navier-StokesEquations; Completeenergyequations-complete mass conservationequations;ParabolizedNavier-StokesEquations;Euler Equations

Module:2	Conservation lawsandforms ofequations	5 hours

ModelsofFlow– ConservationformContinuity;MomentumandEnergyEquationinconservationform(differentialequations only)-CharacteristicsofPDE's-Elliptic;parabolicandhyperbolic

Module:3	Discretization	5 hours

FiniteDifferencemethod-Forward;BackwardandCentraldifferenceschemes-Finitevolume-Finiteelement techniques

Module:4	Gridgeneration	5 hours

Choiceofgrid-gridorientedvelocitycomponents-Cartesianvelocitycomponents-Staggeredandcollocatedarrangements

Module:5	ConvectionandDiffusion	3 hours

Steady one-dimensional convection and diffusion- Central difference; upwind, quick,exponential,hybrid and powerlaw schemes-Falsediffusion, Simple algorithm

Module:6	CFDTechniques	3 hours

ADITechnique -Pressure correctionTechnique Simplealgorithm

Module:7	CaseStudy	3 hours

Industriallyimportantprocessequipment- Heatexchangers;Fluid flow; Mixing equipments; Cycloneseparators			
Module:8	**Contemporaryissues**		**2 hours**
	TotalLecturehours		**30 hours**
Text Books			
1.	PletcherR.H.,TannehillJ.C.,AndersonD.A.,Computationalfluidmechanicsandheattransfer, 3rd ed., CRC Press, USA, 2012.		
2.	Aref H.,ComputationalFluid Dynamics,1st ed.,CambridgeUniversityPress, USA,2017.		
Reference Books			
1.	VersteegH.K.,MalalasekeraW.,Anintroductiontocomputationalfluiddynamics:Thefinitevolume method, 2nd ed.,Prentice Hall,UK, 2007.		
2.	HirschC.,Computationofinternalandexternalflows:Thefundamentalsofcomputationalfluid dynamics, 2nd ed.,Butterworth-Heinemann,USA, 2007.		
Mode ofevaluation: Continuous AssessmentTest, Quizzes, Assignments,FinalAssessmentTest			
RecommendedbyBoardof Studies	15-04-2019		
Approved by AcademicCouncil	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 AcademicCouncil	55th	Date	13-06-2019

Coursecode	CHE3005	L	T	P	J	C
Coursetitle	CHEMICALPROCESSINTEGRATION	3	0	0	0	3
Pre-requisite	CHE2002	Syllabusversion				
		v.2.1				

CourseObjectives:

- Toimpartthestrategyforeffectiveandenergyefficientwayoffinetuningtheprocessdesignso asto maximize profit by minimizing utilities.
- Toprovidean insightonthe utilitieswith theirstandardsandconservationaspects.
- Tocatersthefundamentalknowledgeaboutenergyefficientchemicalprocess design.

ExpectedCourseOutcome:

1. Understand the scientific background, techniques and applications of intensification in theprocess 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	DistillationSequencing	7hours

Needforcolumnsequencing,distillationsequencingforsimplecolumns,columnswithmorethantwoproducts,columnsusing thermalcoupling, distillationsequencingforazeotropicdistillation

Module:2	HeatExchangerNetworks –Targets	6hours

Compositecurve,problemtablealgorithm,networkenergytargets,heatexchangeareatargets,numberofshellstarget,capitalcost and totalcost targets

Module:3	HeatExchangerNetworks–Network Design	6hours

PinchDesignmethod,streamsplitting,designofmultiplepinches,superstructureapproach,tradeoffs,networkstreamdata.

Module:4	HeatIntegration–ProcessEquipment	6hours

Useofcompositecurveforintegrationofreactors,heatintegrationindistillationcolumnsanddistillationsequences.

Module:5	Energyconsuming –ProcessUtilities	6hours

Heatintegrationofevaporator,heatintegrationofdryers,heatintegrationofboilers,heatintegrationofcompressors and refrigerator

Module:6	Watersystemdesign	6hours

Wateruseinprocessindustries,designformaximumwaterreuse,designforminimumwastewatertreatmentflowrate,targetinganddesignfor effluenttreatment and regeneration

Module:7	Cleanprocesstechnology	6hours

Sources of Waste from Chemical Production. Clean Process Technology for Chemical Reactors, SeparationandRecycleSystems,ProcessOperations andProcessutilities. LifeCycleAnalysis

Module:8	Contemporaryissues	2hours

	TotalLecturehours:		**45hours**
TextBook(s)			
1.	RobinSmith,"ChemicalProcess:DesignandIntegration",JohnWileyandSons,2016		
2.	RichardTurton, RichardC.Bailie,WallaceB.Whiting,JosephA.Shaeiwitz,DebangsuBhattacharyya,"Analysis,SynthesisandDesignofChemicalProcesses",PrenticeHall,2012.		
ReferenceBooks			
1.	AlexandreC.Dimian, CostinS.Bildea, AntonA. Kiss,"Integrated Designand Simulationof ChemicalProcesses",ElsevierPublications,2014.		
2	Ian C. Kemp, "Pinch Analysis and Process Integration: A User Guide on ProcessIntegration",Elsevier Publications, 2008		
ModeofEvaluation:ContinuousAssessmentTest,Quizzes,Assignments,FinalAssessmentTest			
RecommendedbyBoardofStudies	04.03.2016		
ApprovedbyAcademicCouncil	40	Date	18.03.2016

Coursecode	CHE3006	L	T	P	J	C
Coursetitle	PROCESSPLANTSIMULATION	3	0	0	4	4
Pre-requisite	MAT3003	Syllabusversion				
		1.2				

CourseObjectives:

1. Emphasizethe basicconcepts of steadystate processplantsimulation
2. Impart theknowledgeandawareness to understand the validityandphysicochemicalinterpretation of thermodynamic models and theirlimitations
3. Develop theskills forplant simulationandoptimization, solve

CourseOutcomes(CO):

1. Understand the principles for developing a Process flow sheet and its execution
2. Examine 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 simulation of chemical processes
6. Interpret steady state process plant simulation

Module:1	Introduction	5 hours

IntroductiontoProcessSynthesis-Flowsheeting&simulation-Degreesoffreedom–ProcessEquipment's - Process flow sheet

Module:2	Approaches toProcessSimulation	6 hours

SequentialmodularapproachandSimultaneousmodularapproaches-Equationsolvingapproachusedin processplantsimulation

Module:3	EquationSolvingApproach	8 hours

Partitioning-Decomposition-Disjointing-PTM-SWS-Steward-RuddAlgorithms;Sparcity-Direct Methods -Pivoting-Iterative methods - BTF-BBTFBlockBack Substitution- BTS -etc

Module:4	DecompositionofNetworks	7 hours

Tearing Algorithms in decomposition of networks– digraph- signalflowgraph-BMAlgorithm– BTA -K&SAlgorithm-M&HAlgorithm-related problems

Module:5	ConvergencePromotion	6 hours

Linearequation -nonlinear equation -Convergence promotionscheme Newton's method - Direct Substitution-Wegstein'smethod-Dominanteigenvaluemethod-Quasi-Newtonmethods;Accelerationcriterion

Module:6	ApplicationofFlowSheeting Software	5 hours

Flow sheetingsoftware:Aspen Plus-Steadystatesimulation- AspenHysysdynamic simulation

Module:7	CaseStudies: (Un)SteadyState ProcessSimulation	6 hours

Completeplant(un)steadystatesimulation:AnyprocesssuchasAmmoniaplant-Biodieselplant -NG liquefaction

Module:8	Contemporaryissues	2 hours

TotalLecturehours			**45 hours**
Text Books			
1.	Robin S., ChemicalProcessDesignandIntegration,2nd ed.,Wiley,USA, 2016.		
2.	BabuB.V.,Process Plant Simulation, 1st ed.,Oxford UniversityPress,India, 2004.		
Reference Books			
1.	WesterbergA.W.,HutchisonH.P., MotardR.L.,WinterP.,ProcessFlowsheeting,1st ed., Cambridge Press, UK, 2011.		
2.	RichardT.,Analysis,SynthesisandDesignofChemicalProcesses,1st ed.,PearsonEducation International,USA, 2009.		
Mode ofevaluation: Continuous AssessmentTest, Quizzes, Assignments,FinalAssessmentTest			
RecommendedbyBoardof Studies	15-04-2019		
Approved by AcademicCouncil	55th	Date	13-06-2019

Coursecode	CHE3007	L	T	P	J	C
Coursetitle	MULTIPHASEFLOW	3	0	0	0	3
Pre-requisite	CHE1005, CHE1006	Syllabusversion				
		1.2				

CourseObjectives:

1. Emphasis the concepts ofmultiphase systems in the processingindustry
2. Formulate momentum, energyandmaterial balancemodels in multiphase systems
3. Developdesign thinking skills to understandmultiphase flows in chemicalindustries

CourseOutcomes(CO):

1. Define 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	Introductiontomultiphaseflow, type of flowand applications	9 hours

Basicfluidflowconcepts:Flowfielddescription–conservationlaws–viscousflow–turbulentflow–pressure drop -Reviewof Single PhaseFlow;Scope andsignificance - applications

Module:2	Flowpatternmaps and Regime	11 hours

Flowpatternsforgas-liquid;gas-solid;liquid-liquid;liquid-solidsystem;Heatedtubes–horizontal–vertical-Verticalflow;horizontalflow;co-current;countercurrentsystems;Gas-liquid-solidthree phase flows

Module:3	One dimensionalsteadystate flow	9 hours

DefinitionsandcommonTerminologies-simple analyticalmodel-homogenous flow model.

Module:4	Drift flux model	4 hours

Theoryof driftfluxmodel and its application

Module:5	Separated flowmodel	4 hours

Separatedflowmodel forstratifiedand annular flow; Correctionfactorandanalysis.

Module:6	Two phaseflow withphasechange	4 hours

Boilingflow heat transfer- regimes -bubblegrowth

Module:7	Measurementtechniques	2 hours

Sampling Methods- IntegralMethods – LocalMeasurementtechniques- hold up studies-analysis

Module:8	Contemporaryissues	2 hours

TotalLecturehours			**45 hours**
Text Books			
1.	Wallis, OneDimensional Two-phaseflow, McGraw HillBookCompany,1st ed., USA, 2000.		
2.	John G.C., John R.T., ConvectiveBoiling and Condensation, Oxford UniversityPress, 3rd ed., UK, 2002.		
Reference Books			
1.	ClementK.S.,TwoPhaseFlow–TheoryandApplications,1st ed.,TaylorandFrancis,USA, 2003.		
2.	Govier,G.W., AzizK., The Flow of ComplexMixturein Pipes, 2nd ed.,Societyof Petroleum Engineers Publishers, USA, 2008.		
Mode ofevaluation: Continuous AssessmentTest, Quizzes, Assignments,FinalAssessmentTest			
RecommendedbyBoardof Studies	15-04-2019		
Approved by AcademicCouncil	55th	Date	13-06-2019

Coursecode	CHE3008	L	T	P	J	C
Coursetitle	INDUSTRIALPOLLUTIONENGINEERING	3	0	0	0	3
Pre-requisite	NIL	Syllabusversion				
		1.2				

CourseObjectives:

1. Explain the legislationandstandardsrelated toair,waterandsolid wastes inIndiancontext
2. Identifyanddesigntreatmentequipments forairandwater pollution
3. Illustrate the effectivemethods of solids wastetreatmenttechniques

CourseOutcomes(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. Design various equipment for wastewater treatment
5. Differentiate various solid waste disposal techniques
6. Evaluate waste treatment flow sheets of various process industries

Module:1	Introduction	5 hours

Typesofindustries-Characteristicsofindustrialwastes-Fundamentaldefinitionofpollutionparameters-Effects of industrial pollutants on environment– air,water and land.

Module:2	Standardsandlegislation	5 hours

Environmentallegislationsrelatedtopreventionandcontrolofindustrialeffluents-EPACT-EIA -EMP-ISO14000series-Combinedtreatmentofindustrialwastewater-Resourceoptimizationthrough industrial symbiosis- wasteminimizationtechniques.

Module:3	Industrial air pollutioncontrol	7 hours

Airpollutionmeteorology(generation,transportationanddispersionofairpollutants)-Principlesanddesignofairpollutioncontrolequipment:gravitysettlingchambers-aircyclones-ESPs-filters - wetscrubbers.

Module:4	Industrial wastewater treatment	6 hours

Selection,designandperformanceanalysisof industrial waste watertreatmentprocesses:Preliminary-Primary-Secondarytreatment processes.

Module:5	Advancedwastewater treatment	7 hours

Chemicaloxidation-Ozonation-Photocatalysis-WetAirOxidation-Adsorption-Evaporation -IonExchange -MembraneTechnologies.

Module:6	Hazardous Solidwastemanagement	5 hours

Classificationofhazardouswaste-wastedisposalmethods-Composting-Landfill-Briquetting-Gasification -Incineration.

Module:7	Casestudies	8 hours

Sources-Characteristics-WastetreatmentflowsheetsforselectedindustriessuchasTextiles-Tanneries-Pharmaceuticals-Electroplating-PulpandPaper-Refineries-Fertilizer-Thermalpowerplants - Wastewaterreclamationconcepts.		
Module:8	**Contemporaryissues**	**2 hours**
	TotalLecturehours	**45 hours**
Text Books		
1.	RaoC.S., EnvironmentalPollutionControl Engineering,3rd ed.,NewAgeInternational Publishers,India, 2018.	
2.	KariaG.L.,ChristianR.A.,WastewaterTreatment:ConceptsandDesignApproach,2nd ed., Eastern EconomyEdition,India,2013.	
Reference Books		
1.	PollutionControlLawSeries:PCLS/02/2010,CentralPollutionControlBoard, 6th ed.,India, 2010.	
2.	TchobanoglousG.,TheisenH.,VigilS.A.,IntegratedSolid WasteManagement,1st ed., McGrawHill Education,India, 2014.	
3.	BhatiaS.C.,EnvironmentalPollutionandControlinChemicalProcessIndustries,2nd ed., Khanna publishers,India, 2013.	
Mode ofevaluation: Continuous AssessmentTest, Quizzes, Assignments,FinalAssessmentTest		
RecommendedbyBoardof Studies	15-04-2019	
Approved by AcademicCouncil	55th	Date 13-06-2019

Coursecode	CHE3010	L	T	P	J	C
Coursetitle	COLLOIDS ANDINTERFACIAL SCIENCE	3	0	0	0	3
Pre-requisite	NIL	Syllabusversion				
		1.0				

CourseObjectives:

1. Introduce the studentto the theoryof Colloids andInterface Phenomena
2. Emphasizethestudenttolearnsolutionthermodynamics,stabilityofcolloids,lightscattering,capillary effects
3. Exposethe importance of colloidalphenomenathroughreal time examples

CourseOutcomes(CO):

1. Understandtheconceptoftheoriginoflong-range,non-covalentcolloidalforces(vanderWaals,electrostatic,etc.)
2. Explainthelinkbetweenliquidsurfacetensionandcontactangle,anddemonstratehowcertainexperimentaltechniquescan beusedfortheassessment of liquid surfacetension
3. Applythe knowledgeof thermodynamicsformicellization in surfactant solutions
4. Describethe thermodynamicsof emulsionformationandcalculatethe kinetic andthermodynamic stabilityofsuch emulsions
5. Designcolloidalsystems orengineeredsurfaces of high industrial or technologicalinterest
6. Explaintheinteractionsbetweencolloidsandvisiblelight,aswellastheprinciplesofstaticanddynamic light scattering

Module:1	Introduction to Colloid& Interface Science	6 hours

FundamentalsofColloidScience-Colloids:definition-VanderWaalsinteractions-TheHamakerconstant-ElectrostaticInteractionsinColloids-Theelectricaldoublelayer(EDL)-Zetapotential-Gibbs energyofelectrostatic interactions

Module:2	Surface TensionandContactAngle	6 hours

Surfacetensionofliquids-definition-LewisAcid-Baseinteractions-Surfacetension&contactangle-Measuringcontactangles

Module:3	InteractionsatInterfaces	5 hours

SurfactantsI: definitionsandapplications-SurfactantsII: thermodynamics-Surface excess

Module:4	Emulsions	6 hours

Definitionsandapplications-Typesof emulsions-Thermodynamicsof emulsification-Emulsionstability

Module:5	DesignofInterfacialscience	7 hours

Adsorption-Modelsofadsorption-Adsorptionat the solid-liquid interface-Adsorptionattheliquid-airinterface-Adsorptionat the solid-airinterface

Module:6	PrinciplesofLightScattering	6 hours

Fundamentals oflight scattering-Staticlightscattering-Dynamic light scattering

Module:7	**Application of Colloids and Interfacialphenomena**	**7 hours**
Colloidal and interfacial phenomena in biology-Photovoltaic-Water treatment-Medicine-Tribology-Engineering		
Module:8	**Contemporaryissues**	**2 hours**
	TotalLecturehours	**45 hours**

Text Books	
1.	WangC.,Leblanc R.M.,RecentProgress in Colloid and Surface Chemistry,1st ed.,Oxford UniversityPressInc.,UK,2016
2.	Birdi K.S., Handbook ofSurfaceandColloid Chemistry, 4th ed., CRC Press.,India, 2015
Reference Books	
1.	HiemenzP.C.,RajagopalanR.,PrinciplesofColloidandSurfaceChemistry,3rd ed.,CRC Press, USA, 1997
2.	Rhodes M.,Introduction to ParticleTechnology,2nd ed.,WileyPublications, USA, 2008
Mode ofevaluation: Continuous AssessmentTest, Quizzes, Assignments,FinalAssessmentTest	

RecommendedbyBoardof Studies	15-04-2019		
Approved by AcademicCouncil	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				

CourseObjectives:

1. Emphasisthebasicconceptsoftransportphenomena,thesimilaritiesofthegoverningrelations ofmomentum, heat, and masstransfer
2. Solveappropriatedifferentialequationssuchasmomentum,thermalenergy,andmassspeciesbalance, accountingconvectiveanddiffusive(molecular-scale)fluxes,withsourcesandsinksto obtainvelocity, temperature and concentration profiles
3. Develop designthinking skills to solve various kinds of application orientedproblems faced inchemicalindustriesusinganalyticaltechniques

Course Outcomes (CO):

1. Understand transport properties of momentum, energy and mass transport
2. Analyze one-dimensional steady state momentum transfer, heat conduction and species diffusion problems
3. Examine the problems related to fluid, heat and mass transfer using Navier-Stoke's equation
4. Evaluate the interphase transport properties for internal flow and external 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

Phenomenologicallawsoftransportproperties-Newtonianandnon-Newtonianfluids;Rheologicalmodels-theoriesoftransportpropertiesofgasesandliquids-effectofpressureandtemperature - Transportanalogy

Module:2	Vector and tensor analysis	2 hours

Vector- coordinatesystem - time derivatives

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

Generalmethodofshellbalanceapproachtotransferproblems;boundaryconditions-rectilinearflow-curvilinearflow-momentumfluxandvelocitydistribution-Newtonianfluids–non-Newtonian fluids - pipe -annular flow

Module:4	Equations of Change	8 hours

EquationofMotionandContinuity-IntegralConservationEquations-Navier-StokesandEulerEquation Constitutiverelation - Dimensional analysis– Applications.

Module:5	Turbulent Flowand Interphase momentumtransfer	8 hours

Turbulentmodels-RANSequation-Reynoldsstresses;Internalflow-Externalflow-BoundaryLayerTheory-IsothermalSystem-Flowthroughconduits-Empiricalcorrelation–frictionfactor, dragcoefficient-Ergun Equation - Flow throughporousmedia

Module:6	**Heat Transfer by conduction andconvection**	**6 hours**
Shell Balance - Equations of energy -Heat Transfercoefficient- COMSOLSimulation		
Module:7	**Mass Transfer**	**5 hours**
Microscopicbalances- General equationsBoundaryconditions- Masstransfer 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.	BirdR.B.,StewartW.E.,LightfootE.N.,TransportPhenomena,2nd ed.,JohnWiley&Sons Inc., USA. 2012.
2.	WickC.E.,WeltyJ.,WilsonR.E.,FundamentalsofMomentum,heatandMassTransfer,5th ed., John Wiley& Sons Inc., USA, 2016.
Reference Books	
1.	ThomsonW.J.,Introduction to TransportPhenomena, Pearson Education Asia,India, 2001.
2.	WilliamM.Dean, Analysis of TransportPhenomena,Oxford UniversityPress,India, 2011.
Mode of evaluation: ContinuousAssessment Test, Quizzes,Assignments, Final Assessment Test	
Recommended by Board of Studies	15-04-2019
Approved by AcademicCouncil	55th Date 13-06-2019

Coursecode	CHE4003	L	T	P	J	C
Coursetitle	MODELLINGAND SIMULATION IN PROCESSENGINEERING	2	0	2	0	3
Pre-requisite	CHE3001	Syllabusversion				
		2.2				

CourseObjectives:

1. Explain therepresentationandsimulation of physicalsystemsusing a mathematicalformulations
2. Develop the typicalmathematicalmodels forthe chemicalprocess industries
3. Enhancethe skill of engineeringsoftwareapplications which illustrate a varietyof modellingtechniques

CourseOutcomes(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. Develop the model equations for the Chemical Engineering system
5. Solve the model equation using simulation tools for various unit processes and unit operations
6. Execute the algorithm for different chemical engineering systems

Module:1	ModelingConservativePrinciples and Models	4hours

Introductionofprocessmodeling;definitionofmodellingandsimulation;differenttypesofmodels;application ofmathematicalmodeling;FundamentalLaws– Continuityequation,energyequation,andequationofmotion,transportequation,equationofstate,phasea ndchemicalequilibrium,chemicalkinetics

Module:2	SteadyState LumpedSystems	4 hours

Degreeoffreedomanalysis;singleandnetworkofprocessunits;systemsyieldinglinearandnon-linearalgebraicequations; solution of linearandnon-linearalgebraicequations

Module:3	FlowSheeting and Process design	4 hours

Steadystateflow sheeting;approach to flow sheetingsystems;introduction to sequential modularapproach;simultaneousmodularapproachandequationsolvingapproach;nestedinside-out algorithms

Module:4	UnsteadyState LumpedSystems	4 hours

MicroscopicbalancesforUnsteadystateanddynamicsimulation–liquidleveltank–gravityflowtank–jacketedstirredtankheater;IsothermalandNon-isothermalreactors–flashanddistillationcolumn; Solution of ODEinitial value problems

Module:5	DynamicSimulationof UnsteadyStateLumpedSystems	5 hours

SolutionofODEinitialvalueproblems;matrixdifferentialequations;simulationofclosedloop systems

Module:6	ProcessModeling ofDistributedSystems	4 hours

Analysisofcompressibleflow;heatexchanger;plugflowreactor;solutionofODEboundaryvalueproblems–Sedimentation–Heatconduction–Diffusion;classificationandsolutionofpartialdifferential equations		
Module:7	**Processmodeling ofdistributedsystems-II**	**3 hours**
Pressurevessels–Stressesin thin andthickcylindricalshell due to internalpressure–Circumferential and longitudinalstresses– Spherical shells subjected to internal pressure		
Module:8	**Contemporaryissues**	**2 hours**
TotalLecturehours		**30 hours**

Text Books	
1.	VarmaA.K., ProcessModelling andSimulation in Chemical,Biochemical andEnvironmentalEngineering, 1st ed., CRC Press,USA, 2017.
2.	BequetteB.W.,ProcessDynamics:Modeling,AnalysisandSimulation,1st ed.,Prentice HallInc., USA, 2010.
Reference Books	
1.	Luyben W.L.,ProcessModellingSimulation and Control, 3rd ed.,McGraw-Hill, USA, 1996.
2.	RamirezW.,ComputationalMethodsinProcessSimulation,2nd ed.,ButterworthsPublishers, USA, 2005.

Mode ofevaluation: Continuous AssessmentTest, Quizzes,Assignments,FinalAssessmentTest

LaboratoryExperiments

1.	Develop and solve the objective functionforreaction system usingAlgebricequations	2 hours
2.	Developmathematicalmodel fortwo interactingtanks in series	2 hours
3.	Design the jacketedstirred tank heater	2 hours
4.	Optimization of Vande-Vussereaction kinetics usingsemi-batchreactoroperation	2 hours
5.	Determination ofkinetic rate ofnon-isothermalCSTRs in series	2 hours
6.	DesignandDevelop the objective functions for Biochemicalreactor	2 hours
7.	Analyze the mixingperformance of reactant in mixingtank	2 hours
8.	Simulation of unsteadystateheat conduction equationusingMatLab	2 hours
9.	Solve the elliptic PDE usingPDE toolbox	2 hours
10.	Solve the parabolic PDEusingPDE toolbox	2 hours
Total Laboratory Hours		20 hours

Mode ofevaluation: Continuous AssessmentTest, Quizzes, Assignments,FinalAssessmentTest			
RecommendedbyBoardof Studies	15-04-2019		
Approved by AcademicCouncil	55th	Date	13-06-2019

Coursecode	CHE4005	L	T	P	J	C
Coursetitle	FLUIDIZATIONENGINEERING	3	0	0	0	3
Pre-requisite	Nil	Syllabusversion				
		1.2				

CourseObjectives:

1. Illustrate the physicalandchemicalconceptsaspects of fluidizationprocess
2. Describethe various fluidization regimes andtheir models
3. Designofvarious units of fluidizedbed widelyusedin industrialpractice

CourseOutcomes(CO):

1. Describe 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

ConceptofFluidization-SpecialFeaturesofFluidization-ComparisonwithotherContactingMethods-AdvantagesandDisadvantagesofFluidizedBeds-IndustrialApplicationsofFluidizedBeds - HistoricalHighlights- PhysicalOperation-ChemicalOperations.

Module:2	CharacterizationofFluidizationI	6 hours

GrossBehavior ofFluidizedBeds– Minimum and TerminalVelocities inFluidizedBeds

Module:3	CharacterizationofFluidizationII	6 hours

GeldartClassificationsofParticles–MappingofFluidizationRegions–DesignofDistributors– Power Consumption

Module:4	BubbleMechanics in FluidizedBeds	7 hours

BubblesinDenseBeds-SingleRisingBubble-CoalescenceandSplittingofBubbles– BubbleFormationaboveaDistributor.BubblingFluidizedBeds-ExperimentalFindings-EstimationofBed Properties-Bubbling BedModel

Module:5	Entrainment and Elutriation	6 hours

FreeBoardBehavior-EntertainmentfromTallandShortVessels.ConstantApproach.FlowPattern ofGasesthroughFluidizedBeds-Solid Movement -Mixing, Segregationand Staging

Module:6	HeatTransfer inFluidizedBeds	5 hours

HeatTransferbetweenFluidandSolid-DeterminationandInterpretationofHeatTransfer.HeatTransferbetweenFluidizedBedsandSurface-

Module:7	Miscellaneoussystems	6 hours

Conicalfluidizedbed-Inversefluidizedbed-Drafttubesystems;Semifluidizedbedsystems, Annularsystems and typicalapplications

Module:8	**Contemporaryissues**			**2 hours**
	TotalLecturehours			**45 hours**
Text Books				
1.	Kunii D.,LevenspielO.,FluidizationEngineering,2nd ed.,ButterworthHeinemann,UK, 2013.			
2.	YangW.C.,HandbookofFluidizationandFluid–ParticleSystem,1st ed.,CRCPress, USA, 2003.			
Reference Books				
1.	GraceJ.R.,AvidanA.A.,KnowltonT.M.,CirculatingFluidizedBeds,1st ed.,Springer,USA, 2011.			
2.	L.G.Gibilaro,FluidizationDynamics,1st ed.,Butterworth Heinemann, UK, 2001.			
Mode ofevaluation: Continuous AssessmentTest, Quizzes, Assignments,FinalAssessmentTest				
RecommendedbyBoardof Studies		15-04-2019		
Approved by AcademicCouncil		55th	Date	13-06-2019

Coursecode	CHE4006	L	T	P	J	C
Coursetitle	Introduction to MolecularDynamics and Simulation	3	0	0	0	3
Pre-requisite	CHE1003, CHE3001	Syllabusversion				
		1.0				

CourseObjectives:

1. Introduce molecular simulationtechniques used in soft matterin atomic time andlengthscales
2. Understand the basicsof MolecularDynamics simulation
3. Demonstrate thepredictive capabilities ofthese methods byconsideringaset ofcase-studies

CourseOutcomes(CO):

1. Choose appropriate potentials fora systemof interest
2. Compare various ensembles and demonstrate importanceof thermodynamic properties
3. Identifynon bonded and bondedinteraction and experiment with basic ofMD concepts
4. Summarize the MD algorithm and contrastdifferentintegration schemes
5. SurveyofGromacs terminologies
6. Estimatethe dynamic properties ofproteins, lipids andsurfactants

Module:1	Modelpotentials	5 hours	

Electronic, atomic, molecularsoft matter examples;Interaction potentials-Reduced units

Module:2	StatisticalMechanics	7 hours	

Statistical ensembles; Thermodynamic averages fluctuations; Structural quantities; Timecorrelationfunctionsandtransportcoefficients

Module:3	Basics ofMoleculardynamicssimulations	8 hours	

Non-BondedInteractions;Bondedinteraction;Force Fields; Periodic Boxand Minimum ImageConvention;LongRangeForces

Module:4	Moleculardynamics strategy	5 hours	

Integratingalgorithmsforvelocityandaccelerationupdates;Differenttypesofthermostatsandbarostats

Module:5	Stepsinvolved inGROMACS	6 hours	

EnergyMinimization; Solventandcounterions addition; Equilibrationoftemperatureandpre

Module:6	Overview ofGROMACSFiles	4 hours	

Inputstructurefiles visualization byVMD- Inputfilesrequiredfor MD Simulation- Postprocessingof outputfiles

Module:7	CaseStudy using MD Simulation	8 hours	

MD Simulation biologicallyimportant proteins;Lipids and Surfactants

Module:8	Contemporaryissues	2 hours

Coursecode	CHE4007	L	T	P	J	C
Coursetitle	RHEOLOGY OFCOMPLEXFLUIDS	3	0	0	0	3
Pre-requisite	NIL	Syllabusversion				
		1.0				

CourseObjectives:

1. Makestudentawareaboutcomplexfluidsandstructurelengthscalesinpolymericandcolloidalsystems
2. Providebasicknowledge of thephysics behindcolloidalsystems
3. Impartbasicknowledgeofthephysicsbehindpolymericsolutionsanditsrheologicalbehaviorwith concentrationand temperature

CourseOutcomes(CO):

1. Distinguish amongviscous, elastic and viscoelasticbehavioroffluids
2. Explain the basicforces that giveriseto complexfluidbehavior
3. Identifynon-linear viscoelasticproperties of materials and theircorrespondingbehavior
4. Measure extensional behavior of complexfluids
5. Applyrheologicalbehavior of colloidalsystem forvariousapplications
6. Applyrheologicalbehavior of polymericsystem for variousapplications

Module:1	Elastic SolidandViscousliquid	4 hours

Stresstensor - Principal stresses -Finitedeformation tensor- Neo-Hookeansolid; Velocitygradient,generalviscousfluid, plastic behaviour.

Module:2	Complexfluid andforces	5 hours

Complexfluids–examples,pertinentlengthscales,commonfeatures&applications;Forces– basicsforces that drivethe dynamics andbehavior– steric,van der Waals,electrostaticetc.

Module:3	Linear Viscoelasticity	6 hours

Introduction,models-Kelvin,Maxwell;Linearviscoelasticityinthreedimensions-differentialform;Stressrelaxation,creep,oscillation.

Module:4	Nonlinear Viscoelasticity	7 hours

Nonlinearphenomenon,normalstress,shearthinning,extensionalthickening;Secondorderfluid-Upper-ConvectedMaxwellEquation,LodgeIntegralEquation,Integral Constitutive Equations.

Module:5	ExtensionalViscosity	7 hours

Introduction-Importance,theory;Experimental methods - Homogeneousstretchingmethod,Constantstressdevices;Spinning,Lubricatedflows,Contractionflows,

Module:6	SuspensionRheology	7 hours

Introduction,viscosityofsuspensionofsolidparticlesinNewtonianfluids,colloidalcontributionto viscosity, viscoelasticproperties ofsuspension.		
Module:7	**Rheology ofPolymericLiquids**	**7 hours**
Introduction,polymerchain conformation,zero shearviscosity, rheologyof dilute polymersolution;Concentrated Solutionsand Melts - Temperature Dependence.		
Module:8	**Contemporaryissues**	**2 hours**
TotalLecturehours		**45 hours**

Text Books	
1.	DespandeA.P.,Krishnan J.M.,Sunil KumarP.B., Rheologyof ComplexFluids,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.	BarnesH.A.,HuttonJ.F.,WaltersK.,AnIntroductiontoRheology,17th ed.,Elsevier,UK, 2011.
2	LarsonR.G.,TheStructureandRheologyofComplexFluids,1st ed.,OxfordUniversity Press,UK, 1999.
Mode ofevaluation: Continuous AssessmentTest, Quizzes, Assignments,FinalAssessmentTest	
RecommendedbyBoardof Studies	15-04-2019
Approved by AcademicCouncil	55th Date 13-06-2019

CHY1004	Materials & Instrumental Techniques	L	T	P	J	C
		3	0	2	0	4
Pre-requisite	Chemistry of12th standardor equivalent	Syllabus version				
		v. 2.0				

CourseObjectives:

- To understand the chemistryofengineering materials and the correlation between structure and properties
- To improve analytical capabilityof studentsby usinginstrumental analyticaltechniques

CourseOutcomes:

1. Interpret structure, hardening mechanisms, phase behaviour and properties of selected alloys.
2. Identify and formulate composite materials and lubricants.
3. Develop methods to synthesize nanomaterials.
4. Illustrate structures of carbon nanomaterials and apply them in devices.
5. Classify and describe semiconductor materials and solar energy conversion methods.
6. Determine metals like iron, sodium and potassium using colorimetry and flame emission photometry.
7. Analyse samples employing powder X-ray diffraction, SEM, EDX and TEM techniques.
8. Apply the theoretical aspects: (a) in assessing the water quality; (b) understanding the construction and working of electrochemical cells; (c) analysing metals, alloys and soil using instrumental techniques; (d) evaluating the properties of materials

Module:1	Metals andAlloys	4 hours

Powder metallurgy-metallic structures and properties – phasebehaviourof iron-carbon alloys-hardeningmechanisms of steel–shapememoryalloys

Module:2	Composite Materials andLubricants	6 hours

Composites-types of composites-polymer matrixcomposites, metal matrixcomposites, ceramic matrixcomposites; applications of composites in automobiles and aerospaceindustries.
Lubricants- classification, properties and mechanismof different types of lubricants.

Module:3	Nanomaterials-I	6 hours

Basicsofnanomaterials-uniquepropertiesofnanomaterialsandtheirbenefits;sizedependency onpropertiesof CdSenanocrystalsandsilver nanoparticles;preparationof nanomaterials:top- down andbottom-up approaches- high-energy ball milling, sol-gel method, solution phase synthesis of coppernanoparticles
Fullerene-preparationbylaserevaporationandarcmethods,propertiesoffullerenesandtheir applications

Module:4	Nanomaterials-II	6 hours

Carbonnanotubes andgraphene-preparation ofcarbonnanotubes bylaserevaporation, arc dischargemethodand CVD, propertiesand applications of carbonnanotubes; Graphene-preparation, propertiesand applications;engineeringapplications of nanomaterials, nanoelectromechanical systems (NEMS)

Module:5	**Semiconductor Materials and Solar Energy Conversion**	**11 hours**
Bandgap– Fermi level;importanceof silicon– silicon wafer preparation-metallurgical silicon, electronicgradesilicon, single crystal silicon, float zonetechnique; chemical processesinvolved in preparation of complementarymetal-oxide-semiconductor (CMOS)IC-photolithography, wet etching, plasma etching,ion implantation, metalation, thin film deposition;alternatives to silicon Solar energyconversionmethods-principles anddevices – photovoltaiccells, p-n junction solar cell, liquid junction solar cell, multiple junction solar cell, dye-sensitized solar cell.		
Module:6	**SpectroscopicTechniques**	**5 hours**
Interaction betweenelectromagneticradiation andmatter– absorptionandemission spectroscopy–Beer-Lambert law; spectrometric instrumentation principle, instrumentation of UV-Vis spectroscopy; colorimetric determinationofIron in steel;atomic absorption spectroscopy-principle, instrumentation and determination oflead in an environmental sample; Flame emissions photometry-principle, instrumentation and determinationofNa andK present in water		
Module:7	**Diffraction andMicroscopicTechniques**	**5 hours**
powder X-raydiffraction-principle and instrumentation;XRDpattern ofrubyElectron microscopy - TEM, SEM, SEM-EDAX - principle, instrumentation and application; characterization ofmetalnanoparticles usingelectron microscopy		
Module:8	**Contemporary Issues**	**2 hours**
Lectureby IndustryExperts		
	Total Lecturehours:	**45 hours**

TextBook(s)

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

ReferenceBooks

1.	DouglasA Skoog,FJames Holler, StanleyR Crouch, 2016, 7th Edition,"Principles of Instrumental Analysis",CengageLearning,Boston, USA.
2.	RayF. Egerton.,"Physical Principles of ElectronMicroscopy– An introduction to TEM, SEM and AFM", 2016, 2nd Edition, Springer, USA,

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

List ofChallenging Experiments (Indicative)

1.	Preparation ofrubybycombustion method and X-raydiffraction analysis	1 hour
2.	**PreparationofsemiconductorZnOnanoparticles andUV-Vis spectroscopicanalysis**	2 hours
3.	Analysisofcopper in brass usingiodometry	2 hours
4.	Quantification ofsodium and potassium in oral dehydration solution by flame photometry	2 hours

5.	Estimation of sulphateions in waterbylight scatteringtechnique	2 hours
6.	Quantification divalent iron content in steel using calorimetry	2 hours
7.	Aromatic content ofgiven lubricatingoilbymeasuringits anilinepoint	1 hour
8.	Determination ofpourpointand cloud point of alubricant oil	1 hour
9.	Qualitycheckingof lubricant bymeasuringits viscosity	1 hour
10.	Photodegradation kinetics of methyleneblue dyebynanoZnO photocatalyst	2 hours
11.	Preparation ofCu/CuOnanoparticlesand imaging usingelectron microscopy	1 hour
12.	Preparation ofiron nanoparticles andinvestigatingits magneticproperty	1 hour
	TotalLaboratoryHours	18 hours
Mode ofEvaluation:Viva-voceandLab performance&FAT		
Recommended byBoardofStudies	12.08.2017	
Approved by AcademicCouncil	No. 46	Date 24.08.2017

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

CourseObjectives:

1.Tounderstandthevariouslawsandtheoremsappliedtosolveelectriccircuits andnetworks
2.Toprovidethestudentswithanoverviewofthe mostimportantconceptsinElectricaland Electronics Engineering which is thebasic need for everyengineer

CourseOutcomes:

1.Solve basic electrical circuitproblems usingvarious laws andtheorems
2.AnalyzeAC power circuits and networks, its measurement and safetyconcerns
3.Classifyandcomparevarious types ofelectricalmachines
4.Designand implementvarious digitalcircuits
5.Analyzethecharacteristicsofsemiconductordevicesandcomprehendthevariousmodulation techniques in communication engineering
6.Designand conduct experiments to analyzeand interpretdata

Module:1	**DC circuits**	**5 hours**

Basiccircuitelements and sources, Ohms law, Kirchhoff's laws, seriesandparallel connection of circuitelements, Nodevoltageanalysis, Mesh current analysis, Thevenin'sand Maximum power transfer theorem

Module:2	**AC circuits**	**6 hours**

Alternatingvoltages andcurrents, ACvalues, Single PhaseRL, RC, RLCSeries circuits, Power in AC circuits-PowerFactor-ThreePhaseSystems– Star and DeltaConnection-ThreePhase Power Measurement –Electrical Safety–Fuses andEarthing, Residential wiring

Module:3	**Electrical Machines**	**7 hours**

Construction, WorkingPrinciple and applications of DC Machines, Transformers, Single phase and Three-phaseInduction motors, Special Machines-Stepper motor, ServoMotor and BLDC motor

Module:4	**Digital Systems**	**5 hours**

Basic logiccircuitconcepts, Representation of Numerical Datain BinaryForm-Combinational logic circuits, Synthesisoflogiccircuits

Module:5	**SemiconductordevicesandCircuits**	**7 hours**

Conduction in Semiconductormaterials, PN junction diodes, Zener diodes,BJTs, MOSFETs, Rectifiers, Feedback Amplifiers usingtransistors.Communication Engineering: Modulation and Demodulation -Amplitude and FrequencyModulation

	Total Lecturehours:	**30 hours**	

Text Book(s)

1. 1. John Bird, 'Electricalcircuittheoryand technology', Newnes publications, 4 th Edition, 2010.

ReferenceBooks

1. Allan R. Hambley,'Electrical Engineering-Principles &Applications'Pearson Education, FirstImpression, 6/e, 2013

2.	Simon Haykin,'Communication Systems', John Wiley&Sons, 5 t h Edition, 2009.	
3.	Charles K Alexander, MathewN OSadiku, 'Fundamentals of ElectricCircuits', Tata McGrawHill, 2012.	
4.	Batarseh, 'Power Electronics Circuits', Wiley, 2003	
5.	H. Hayt,J.E. Kemmerlyand S. M. Durbin,'EngineeringCircuitAnalysis',6/e, Tata McGraw Hill, New Delhi, 2011.	
7.	Fitzgerald, Higgabogan,Grabel, 'BasicElectricalEngineering', 5t h edn,McGrawHill, 2009.	
8.	S.L.Uppal,'Electrical WiringEstimating andCosting', Khannapublishers, NewDelhi, 2008.	
Mode ofEvaluation:CAT / Assignment / Quiz/ FAT / Project / Seminar		
List ofChallenging Experiments (Indicative)		
1.	Thevenin's andMaximum Power Transfer Theorems–Impedance matchingof sourceand load	2 hours
2.	Sinusoidal steadystateResponse ofRLCcircuits	2 hours
3.	Threephasepower measurement foracloads	2 hours
4.	Staircasewiringcircuitlayout for multi storeybuilding	2 hours
5.	Fabricate and test a PCB layout for arectifiercircuit	2 hours
6.	Half and fulladder circuits.	2 hours
7.	FullwaveRectifier circuits used in DC power supplies. Studythe characteristics ofthe semiconductor deviceused	2 hours
8.	Regulated power supplyusingzener diode. Studythe characteristics of the Zener diodeused	2 hours
9.	Lamp dimmercircuit(Darlington pair circuitusingtransistors)used in cars. Studythe characteristicsofthe transistor used	2 hours
10.	Characteristics of MOSFET	2 hours
	TotalLaboratoryHours	20 hours
Mode of assessment:Assignment /FAT		
Recommended byBoardofStudies	29/05/2015	
Approved byAcademicCouncil	37thAC	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				

CourseObjectives:

1. To help students gainessential knowledgeon the importanceof various renewableenergy sources
2. To familiarizethe students with principles of energyconversion forvarious renewableenergy sources
3. To do practical experiments for energyresourceperformanceunder differentoperating conditions
4. To understand the method for assessment ofvarious input energyresourcesformeetingthe specificrequirements.
5. To knowthe limitations in renewable energyconversiontechniques

Course Outcomes:

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

Module:1	ClassificationofEnergy	5 hours

Energychain and common forms ofusableenergy -Present energyscenario-World energystatus -Energyscenario inIndia -Introduction to renewable energyresources-Introduction to Solar Energy-Energyfrom Sun-Spectral distribution of Solar radiation-Instruments formeasurement ofsolar radiation-Solarradiation data analysis

Module:2	Applications of Solar Energy	6 hours

Thermalapplications-IntroductiontoSolarthermalcollectors-Types-Principleofoperationof differentcollectors-Flatplate-Evacuatedtubecollectors-Compoundparaboliccollectors- Solar air heaters -Solardryers-solar cookers -solar stills-Solarponds-concentratingcollectors- linetype -pointtype-Methods ofSolarpowergeneration-Power towers

Module:3	Introduction to Solar Photovoltaics	5 hours

Physics ofsolarcells-Celland module. ManufacturingProcess–Characteristics of cells and module-Performanceparameters-BoS-PV System applications- Stand alone-Gridconnected systems.		
Module:4	**Bio Energy Sources**	**4 hours**
Energythrough various processes-Energythroughfermentation -Gasification-various types of gasifiers -Pyrolysis- Fixed bed and fast Pyrolysis-Bio energythrough digestion-Types of Digesters-Factors affectingtheyield ofproducts.		
Module:5	**WindEnergy**	**4 hours**
resource assessment-types of wind turbines-selection of components-blademater ials-power regulation-various methods of control-wind farms-siteselection - off shorewind farms - SolarWind Hybrid energysystems.		
Module:6	**SmallHydro PowerSystems**	**2 hours**
Introduction -types-system components, dischargecurveand estimationofpower potential-Turbines forSHP.		
Module:7	**OceanEnergy**	**2 hours**
Powergeneration through OTEC systems-various types-Energythroughwaves andtides-Energygeneration throughgeothermal systems– types.		
Module:8	**Contemporary issues:**	**2 hours**
Discussion on Recent developments in the areaofrenewable energysystems and their integration		
	Total Lecturehours:	**30 hours**

TextBook(s)

1.	John Andrews, Nick Jelley(2013),EnergyScience: Principles, technologies andimpacts, Oxford Universities press.

ReferenceBooks

1.	Fang Lin You, Hongye (2012), RenewableEnergySystems, Advanced conversion
	technologies and applications, CRCPress
2	John.A.Duffie, William A.Beckman(2013), Solar Engineeringof Thermalprocesses, Wiley
3	A.R.Jha (2010), Wind Turbinetechnology, CRC Press.
4	GodfreyBoyle (2012), RenewableEnergy, powerforasustainablefuture,Oxford University Press..

Mode ofEvaluation:CAT /Assignment / Quiz/ FAT / Project / Seminar

List ofChallenging Experiments (Indicative)		
1.	1.Estimation of Solar radiation: Pyranometer, pyrheliometer. 2.Testingtheyield ofaSolarstillin outdoor conditions (Multiplesessions). 3.Wind EnergyExperimentalSet up– I. 4.Wind EnergyExperimental Set up– II. 5.Testingof Solar PV system in PV trainingKit. 6.Fuel CellExperiment. 7.PerformanceofBiomassstove. 8.Production ofBio-dieselbyTransesterificationprocess. 9. Flash Pointand Firepoint comparison forconventional fuels andalternate fuels. 10.Production ofHydrogenfrom Electrolysiswith PV system. 11.Estimation of Figures ofMeritin a Solar cooker. 12.Performance characteristics ofaSolarthermalcollector. 13.ExergyanalysisofaSolar cabinetdryer.	30 x14
	TotalLaboratoryHours	17 hours
Mode of assessment:		
Recommended byBoardofStudies	17-08-2017	
Approved byAcademicCouncil	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				

CourseObjectives:

1. To provide thestudentswith sufficient background to understand the mathematical representation of thegoverning equations forfluid flow and heattransferproblems.
2. To equip thestudents to address complexfluid flow and heat transfer problems by approximatingthe governingdifferential equations with boundaryconditions throughFinite differenceand finitevolume discretizationmethods.
3. To enable students to understand different types of grid and its attributes and theirsuitability fordifferent engineeringapplications
4. Develop thestudents to use appropriateturbulencemodel forsolvingengineeringproblems.

CourseOutcomes:

1. Applymathematics andengineeringfundamentals to recognizethe typeof fluid flow and heat transfer that occurinaparticular physical system and to usethe appropriatemodel equationsto investigate theproblem.
2. Solve governing equations usingfinite differencediscretizationtechnique
3. Solve governing equations usingfinite volumemethod
4. Generate appropriatetypeofgrids required for solvingengineeringproblemsaccurately.
5. Applysuitable turbulencemodel forthechosenreal world engineeringproblems.
6. Solve fluid flow and heattransfer problems using commercial CFDtools

Module:1	Introduction	1 hour

CFD overview -Applications of CFD.

Module:2	Governing Equations of FluidDynamics andHeatTransfer:	6 hours

Models of Flow – Conservation and Non-conservation form-Continuity,Momentumand Energy Equation in conservationand non-conservation form (differentialequationsonly)-Characteristics ofPDE's -elliptic, parabolic and hyperbolic.

Module:3	DiscretizationandFiniteDifferencemethod	7 hours

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

FiniteDifferencemethod: Forward, Backward and Central differenceschemes, Transient one and two dimensional conduction-Explicit, implicit, semi-implicitand ADImethods -Stability analysisand error estimation.

Module:4	**GridGeneration**	**3 hours**
GridGeneration: Choiceofgrid,grid oriented velocitycomponents, Cartesian velocity components, staggeredand collocated arrangements.		
Module:5	**Convection andDiffusion**	**7 hours**
Convection andDiffusion: Steadyone-dimensionalconvection and diffusion-Central difference,upwind,quick,exponential,hybridandpowerlawschemes-Falsediffusion,SIMPLE – Algorithm.		
Module:6	**Turbulence Modeling**	**4 hours**
Turbulence Modeling: Introduction – Types ofTurbulencemodeling–Reynolds Time Averaging– Reynolds Time Averaged conservation equations– Boussinesqapproach–One equation k - □model.		
Module:7	**Contemporaryissues**	**2 hours**
	Total Lecturehours:	**30hours**

TextBook(s)	
1.	John D Anderson, Computational Fluid Dynamics– TheBasics with Applications, 1st Edition, McGraw Hill, 2012.
ReferenceBooks	
1.	ChungT.J, Computational Fluid Dynamics, CambridgeUniversityPress,2014.
2.	Muralidhar Kand Sundararajan T, Computational Fluid Flow andHeat Transfer, Narosa Publications, New Delhi, 2014.
3.	Versteeg H.K and MalalasekaraW, AnIntroduction to Computational FluidDynamics-The Finite VolumeMethod, 2nd Edition, Pearson, 2010.

Mode ofEvaluation:CAT / Assignment / Quiz/ FAT / Project/ Seminar

List ofChallenging Experiments (Indicative)		
1.	Modelingof simple andcomplexgeometries.	3 hours
2.	Hexahedral meshingforsimple geometries likesquareduct,circular pipe.	3 hours
3.	O-grid hexameshing forcircularpipe.	3 hours
4.	Tetrahedral meshingforsimple geometries includingfluid and solid	3 hours
	domains.	
5.	Preprocessingin FLUENT– Casesetup and analyzingfor alreadymesh generated model.	3 hours
6.	Steadystatetemperaturedistribution in a rectangularplate (ANSYS Fluent andFDM).	3 hours

7.	Diffuserforahydropower turbine.	3 hours
8.	Flow overan airfoil-Laminar and turbulent flow.	3 hours
9.	Supersonic flow past a wedgein a channel.	3 hours
10.	Exercise (foreach student– different exercise) from FLUENTtutorial (casesetup, analyzing,and post-processing).	3 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment:			
Recommended byBoardofStudies	17-08-2017		
Approved byAcademicCouncil	47	Date	05-10-2017