R-23

M.Tech.ProgramRegulations

SchemeofInstruction&Syllabus

(EffectivefromtheBatchAdmittedin2020-2021)

DEPARTMENT OF CHEMICAL ENGINEERINGS

V UNIVERSITY COLLEGE OF ENGINEERING

TIRUPATI- 517502

CH11C ADVANCED TRANSPORT PHENOMENA

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives:

1. Tofamiliarizethestudent withbasicconceptsoftransportphenomenaand brief review of mathematics.
2. Toenablestudentstounderstandtheequationsofchangeforisothermalflow and for non-isothermal flow.
3. Tointroducethemdetailsofequationsofchangeformulticomponent systems.
4. Togivetheminsightintopropertiesoftwo-dimensionalflowsandaspectsof dimensional analysis

Unit-1: Equations of Change for Isothermal Systems: Equation of Continuity, Equation of Motion, Equation of Mechanical Energy, Equations of Change in terms of the Substantial Derivative, Use of the Equations to solve Flow Problems, Dimensional Analysis of the EquationsofChange. VelocityDistributionswith morethan oneIndependent Variable:Time Dependent Flow of Newtonian Fluids. Velocity Distributions in Turbulent Flow - Comparisons of Laminar and Turbulent Flows, Time Smoothed Equations of Change for Incompressible Fluids, Time Smoothed Velocity Profile near a wall, Empirical Expressions for theTurbulent MomentumFlux, Turbulent Flow in Ducts, Turbulent Flow in Jets.

Unit-2: MacroscopicBalances forIsothermal Systems:TheMacroscopicMassBalance,The MacroscopicMomentumBalance,TheMacroscopicMechanical EnergyBalance,Estimation ofthe Viscous loss, Use ofthe Macroscopic Balances for Steady-State Problems, Derivation of the Macroscopic Mechanical Energy Balance.
Equations of Change for Non-Isothermal Systems: The Energy Equation, Special forms of the Energy Equation, The Boussine sq Equation of Motion for Forced and Free Convection, Use ofthe Equationsofchangeto Solve Steady-State Problems,DimensionalAnalysisofthe Equations of Change for Non-Isothermal Systems.

Unit-3: Temperature Distributions in Solids and in Laminar Flow: Heat Conduction with an Electrical Heat Source, Heat Conduction with a Viscous Heat Source. Temperature Distributions with more than One Independent Variable - Unsteady Heat Conduction in Solids,SteadyHeatConductioninLaminar,IncompressibleFlow.TemperatureDistributions inTurbulentFlow-Time-SmoothedEquationsofChangeforIncompressibleNon-Isothermal Flow, Time-Smoothed Temperature Profile near a Wall, Empirical Expressions for the Turbulent Heat Flux TemperatureDistribution for Turbulent Flow in Tubes.

Unit-4: Macroscopic Balances For Non-Isothermal Systems: Macroscopic Energy Balance, Macroscopic Mechanical Energy Balance, Use Of The Macroscopic Balances To Solve Steady State Problems With Flat Velocity Profiles,ConcentrationDistributions in Solidsand in Laminar Flow: Shell Mass Balances Boundary Conditions, Diffusion through a Stagnant Gas Film, Diffusion with a Heterogeneous Chemical Reaction. Concentration Distributions with more than One Independent Variable: Time-Dependent Diffusion, Steady-State TransportinBinaryBoundaryLayers,ConcentrationDistributionsinTurbulentFlow-

Concentration Fluctuations and the Time-Smoothed Concentration, Time-Smoothing of the Equation of Continuity of A, Semi-Empirical Expressions for the Turbulent Mass Flux, Enhancement of MassTransfer by a First-Order Reaction in Turbulent Flow.

Unit -5: Interphase Transport in Multi-Component Systems: Definition of Transfer CoefficientsinOnePhase,AnalyticalExpressionsforMassTransferCoefficients,Correlation of Binary Transfer Coefficients in One Phase, Definition of Transfer Coefficients in Two Phases,MassTransferandChemicalReactions.MacroscopicBalancesFor Multi-Component Systems: Macroscopic Mass Balances, Macroscopic Momentum, Use of the Macroscopic Balances to solve Steady-State Problems.

References

1) ThomsonW.J.,TransportPhenomena,Pearsoneducation,Asia,2001.

2) GeankopolisC.J.,TransportProcessesandUnitOperations,4thEd.,PrenticeHall(India) Pvt.Ltd., New Delhi. 2004.

3) BirdR.B.,StewartW.E.andLightFootE.N.,TransportPhenomena,Revised2nd Edition,John Wiley & Sons, 2007.

Outcomes: Attheendofthecourse,thestudentwillbeableto:

1. Understandthemechanismofmomentum,heatandmasstransportforsteady and unsteady flow.
2. Performmomentum,energyandmassbalancesforagivensystemat macroscopic and microscopic scale.
3. Solvethegoverningequationstoobtainvelocity,temperatureand concentration profiles.
4. Modelthemomentum,heatandmasstransportunderturbulentconditions.
5. Developanalogiesamongmomentum,energyandmasstransport.

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

CH12C SEPARATION PROCESSES

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives:

1) Understandtheclassificationofseparationprocesses
2) Tolearnthefundamentalconceptsofrategovernedprocesses
3) Toimpartthebasicconceptsofmultistageseparationprocesses
4) Understandthedesignofdistillationcolumnusingdifferentmethods
5) Understandtheenergyrequirementsofdifferentseparationprocesses

UNITI

UseandCharacteristicsofSeparationProcesses –Importanceand varietyofSeparations–Characteristics of separation Processes- Inherent separation factors for equilibrium and rate Governed Processes
Simple equilibrium processes: Equilibrium calculations- Checking phase conditions for a mixture-Analysisofsimpleequilibriumseparation-processesforbinaryandmulticomponent systems -Computational and Graphical Approaches.

UnitII

Additional Factors Influencing Product Purities– Incomplete Mechanical Separation of Product Phases – Flow Configuration and Mixing Effects – Batch Operations – Methods of Regeneration – Mass and Heat Transfer Limitations – Stage Efficiencies
Multistage Separation Processes: Increasing product purity - Reducing consumption of separating agent - co-current, crosscurrent and countercurrent flow - Other separation processes - Fixed bed processes.

Unit-III:
Binary Multistage Separations - Distillation: Binary Systems - Equilibrium stages and McCabe-Thiele Diagram - design and other problems – Multistage batch distillation- Straight operating lines and curved operating lines.

UNITIV
PatternsofChange: BinaryandMulticomponentmultistageseparations
GroupMethods -Linear stage-exit relationshipsand constant flowrates-nonlinear stage – Exit Relationships and varying flow rates.
Capacityofcontactingdevices:factorslimitingcapacityandfactorsinfluencingefficiency.

UNITV
EnergyRequirementsofseparationsprocesses:
Thermodynamic efficiency - single stage and multistage separation processes - reduction of energy consumption**.**

SelectionofSeparationprocesses: Factorsinfluencingthechoiceofseparation Process -solvent extraction and Illustrative examples

TEXTBOOKS:

1. SeparationProcesses-C.JudsonKing,,McGraw–Hill,1982

REFERENCEBOOKS

1. SeparationProcessPrinciples -J.D.SeaderandE.J.Henley,,JohnWiley, 1998.
2. MassTransferOperation-R.E.Treybal,,3rdedition-McGraw–Hill1980
3. TransportProcessesandUnitOperations–GeankoplisC.J.4thed–PHIPvt.Ltd

CourseOutcomes: Studentwillbeableto

1) Appliestheconceptsofdiffusionmasstransfer,masstransfercoefficients,convective masstransfer, inter-phase mass transfer, equipment for gas-liquid operations
2) Suggestanddesignequipmentforvariousmasstransferoperations
3) Study ofthestage wisemasstransferoperations,principlesofvariousstagewisecontact processes likedistillation
4) Studentwillbeabletoselectaseparationprocessforaparticularsystem.
5) Abletounderstandtheenergyrequirementsofseparationprocesses

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1			1	1	1			1	1			
CO2				1	2							
CO3			2	1								
CO4			1		2			1	1			
CO5				1	1				1			

CH13C **CHEMICALREACTOR THEORY**

Instruction,hours/week:3 Credits:3 Assessment:40+60

CourseEducationalObjectives:

1) Theemphasisofthiscourseisonthefundamentalsofchemicalreactionkineticsand chemical reactor operation.
2) Theoverallgoalof thiscourseistodevelopacriticalapproachtowardunderstanding complex reaction systems and elucidating chemical reactor design.
3) Integrateconceptsfromscience&engineeringtoconstituteabasisforthedesignof chemical reactor, a key element in the design of chemical process.
4) ProvideafoundationonNon-idealreactorsandRTD
5) Impartknowledgeaboutheterogeneouscatalyticreactors

UNITI

Isothermal Reactor design: Design structure for isothermal reactors - Scale-up of liquid phase batch reactor data to the design of a CSTR - Tubular reactors -Pressure drop in Reactors -Reversible reactions -unsteady state operation ofreactors -Simultaneousreaction and Separation.

UNIT-II

Analysis of Non ideal Reactors -RTD - Measurement and characteristics ofRTD-RTDin ideal reactors -Reactor modeling with the RTD -Zeroand One parameter models -Two-Parameter model - Modeling real reactors with combinations ofideal reactors - Testing a model and determining it's parameters -Other models of non ideal reactors using CSTRs and PFRs

UNIT-III

External diffusion Effect on Heterogeneous Reactions- Binary diffusion -External resistance to mass transfer - the shrinking core model.

Diffusion and reaction in Porous Catalyst –Diffusion and reaction in spherical pellets - InternalEffectivenessfactor -FalsifiedKinetics -Overalleffectivenessfactor -Estimationof diffusion andreaction limited regimes - Mass transfer andreaction ina packed bed

UNIT-IV

InternalTransportProcesses-ReactionandDiffusioninporouscatalysts:

Intra pellet masstransferandintrapelletheattransfer, Masstransfer withreaction,Massand Heat transfer withreaction, effect ofinternal transport on selectivityand poisoning.

UNIT-V

Design of heterogeneous Catalytic Reactors: Fixed bed reactors and isothermal and adiabatic fixed-bed reactors, non isothermal, non adiabatic fixed bed reactors, Two phase model,Fluidized-Bedreactors,OperatingcharacteristicsofFBRs.MassTransferinFluidized Beds: Gas-Solid Mass Transfer, Mass Transfer between the Fluidized-Bed Phases, Reaction in Fluidized Bed. Trickle bed reactor Models, Slurry reactor models.

TextBooks

1. J.M.Smith“ChemicalEngineeringKinetics”3^{rd}ED.,McGrawHill,NewYork1980
2. FoglerH.S.,ElementsofChemicalReactionEng.”,3^{rd}Ed.,PrenticeHall,1999
3. Levenspiel,O.,“ChemicalReactionEng.”JohnWiley&Sons1972.

CourseOutcomes:Student willbeableto

1) learntheimportanceofRTDandNon-idealflowinreactingvessels.
2) Calculate the conversions based on segregated flow model, dispersion model and tanks-in-series models.
3) Understandthediffusionandreactioninaporouscatalyst.
4) Learnthe factorsinfluencing catalystdecay,therole ofpore diffusion on catalystactivity rate.
5) Understandthedesignofheterogeneouscatalyticreactors.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1			1	1	1			1				2
CO2			1		2			1	2			
CO3				1	1			1	1			1
CO4			1	2					1			2
CO5				1					1			

CH16L COMPUTATIONALTECHNIQUESLABORATORY

Instruction,hours/week:4 Credits:2 Assessment:40+60

Objectives:

1. TolearnNumericalmethodsforinterpolation,extrapolation,graphicaldifferentiation and integration, curve fitting….Process Modeling and Simulation ofChemical operations and processes.
2. ToimplementtheaboveonMATLab

Listofexperiments:

1.EulerMethod	2.Runge Kutta4thOrder Method
3.JacobiIterationMethod	4.Gauss-SiedelIterationMethod
5.Lagrange'sIterationMethod	6.NewtonForwardInterpolationMethod
7.NewtonBackwardInterpolationMethod	8,BisectionMethod
9. NewtonRaphsonMethod	10.RegulaFalsiMethod

Outcomes: Attheendofthecourse,thestudentwillbeableto:

1. Usenumericalmethodsforvariousmanipulationsandbecapableofimplementing them on a computing system.

CH17L ADVANCEDCHEMICALENGINEERINGLABORATORY

Instruction,hours/week:4 Credits:2 Assessment:40+60

PGPC01 ResearchmethodologyandIPR

InstructionHours/Week:3 Credits:3
SessionalMarks : 40 EndSemesterExaminationMarks:60

DESCRIPTIONOFTHECOURSE:
Thissubjectsgiveshowtoproceedsystematicallyforresearch,presentresearchfindings.
Thiscourseconsistsofbasicsofresearchmethods,paperwriting,patentingmethodsand requirements..

COURSEEDUCATIONALOBJECTIVES(CEOs):

1. Tounderstandtheimportanceofresearchobjectivesandprocedures
2. Toknowtheproceduresofdatacollectionandreportwritingofresearch.
3. Tohavetheknowledgeoffilingandobtaininga patentonresearchfindings.

UNITI

Meaning, Objectiveand Motivation in Research: Types of Research, Research Approaches, Research Process, Validity and Reliability in Research, Research Design: Features ofGood Design, Types ofResearch Design, Basic Principles of Experimental Design

UNITII

Sampling Design: Steps in Sampling Design, Characteristics of a Good Sample Design, Random Samples and Random Sampling Design Measurement and Scaling Techniques: Errors in Measurement, , Scaling and Scale Construction techniques, Forecasting Techniques, Time Series Analysis, Interpolation and Extrapolation

UNITIII

Methods of Data Collection: Primary Data, Questionnaire and Interviews, Collection of Secondary Data, Cases and Schedules. Professional Attitude and Goals, Concept of Excellence, Ethics in Science and Engineering, Correlation and Regression Analysis, Method ofLeast Squares, Regression Vs. Correlation, Correlation Vs. Determination.

UNITIV

Interpretation of Data and Report Writing, Layout of a Research Paper, Techniques o f Interpretation. Making Scientific Presentationat Conferences and Popular Lecturesto Semi Technical Audience, Participating in Pubic Debates on Scientific Issues

UNITV

Nature of Intellectual property rights, Patents, designs, trademarks and copyrights, History of patenting,process of patenting, patent development, international cooperation on IPR, procedure of granting patent, patent rights, licensing and transferring technology, Geographical Indications ,IPR in biological and systems and software.

Text/ReferenceBooks:

1. ResearchMethodology:MethodsAndTechniques-C.R.Kothari,2ndEdition,New Age International Publishers.
2. StatisticalMethods -SP.Gupta.S.chand&Sons,NewDerhi.
3. IntellectualProPerty-thelawoftrademarks,copyrights,Patents,andtradeSecrets-Deborah E. Bouchoux, Esq.Georgetown University, Fourth edition

CourseOutcomes(COs):

1. Abletoknowresearchimportanceandrequirementsandprocedure
2. Abletoapplysamplingtechniquesforanalysisand forecasting.
3. Able to use methods for data collection and analyze the data using different mathematical techniques.
4. Abletowritereportonresearchdoneandpresenttheresearchfindingsinsystematic manner.
5. Abletohavetheknowledgeto fileandobtainpatentonresearchfinding.

CH14C PROCESS DESIGN AND SYNTHESIS

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives:

1. Tounderstandthesystematicapproachesforthedevelopmentofconceptualchemical process designs

2. To learn the advances in problem formulation and software capabilities which offer the promise of a new generation of practical process synthesis techniques based directly on structural optimization.

3. Learningchemicalprocesssynthesis,analysis,andoptimizationprinciples

4. ProductdesignanddevelopmentprocedureandProcesslifecycleassessment.

UnitI: Introduction

Introduction to fundamental concepts and principles of process synthesisand design and use offlowsheet simulatorstoassistprocessdesign.ProcessFlowsheetModels:AnIntroduction toDesign,Chemicalprocesssynthesis,analysisandoptimization.Introductiontocommercial process design software such as HYSYS, Aspen plus etc., Chemical Process (reactor, heat exchanger, distillation etc) analysis using commercial software

UnitII: Productdesignanddevelopments

Process engineering economics and project evaluation Life Cycle Assessments of process: From design to product development, Engineering Economic Analysis of Chemical Processes, Project costing and performance analysis, Environmental concerns, Green engineering, Engineering ethics, Health and safety.

UnitIII: ReactorNetworks

Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions& for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps

UnitIV: SynthesisofSeparationTrains

Criteria for selection of separation methods, select ion of equipment**:**Absorption, Liquid-liquid extraction Membrane separation, adsorption, leaching, drying, crystallization, Ideal distillation -Column and sequence fundamentals, Sharp splits& sequencing Phase diagrams for 2, 3 and 4 components, Feasibility and vapor owrates for single columns, Residue curve basics, Non-ideal Distillation**-**Azeotropic systems; detecting binary azeotropes, Residue curve maps for azeotropic systems, Topological analysis, Feasibility for single azeotropic columns ,Binary VLLE and pressure-swing separation, Non-ideal distillation synthesis. Equipment sequencing: VLE + VLLE, Detailed Residue Curve Maps, Residue curve maps: Interior structure

UnitV: HeatExchangerNetworkSynthesis

Minimum heating and cooling requirements, Minimum Energy Heat Exchanger Network, Loops and Paths, Reducing Number of Exchangers, HENS basics& graphics, The pinch point approach, Stream Splitting, Performance targets, trade-off& utilities, Heat& power integration, HENS as mathematical programming

References

1. Douglas,J."ConceptualDesignofChemicalProcesses",NewYork,NY:McGraw-HillScience/Engineering/Math, 1988. ISBN: 0070177627.

2. Seider,W.D.,J.D.Seader,andD.R.Lewin."ProductandProcessDesignPrinciples: Synthesis, Analysis, and Evaluation",. *2*nd ed. New York, NY: Wiley, 2004. ISBN: 0471216631.

3. Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz., "Analysis,Synthesis,andDesignofChemicalProcesses",2ndEdition,2002,Prentice Hall ISBN-10: 0-13-064792-6

4. BieglerL.T.,GrossmannI.E.andWesterbergA.W.,"SystematicMethodsof Chemical Process Design", Prentice Hall, 1997.

Outcomes: Attheendofthecourse,thestudentwillbeableto

1. Analyzealternativeprocessesandequipment
2. Synthesizeachemicalprocessflowsheetthat wouldapproximatethereal process
3. Designbestprocessflowsheetforagivenproduct
4. Performeconomicanalysisrelatedtoprocessdesignandevaluateproject profitability
5. HeatExchangerNetworkSynthesis

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

CH14C **FLUIDIZATIONENGINEERING**

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives

1. Tostudythephenomenonoffluidizationwithindustrialprocessingobjective
2. Tostudythevariousregimesoffluidizationandtheirmapping.
3. Tostudythedesignofequipmentsbasedonfluidizationtechnique

UnitI:Introductiontofluidizationandapplications

Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode, Beds for Industrialapplications,coalgasification,synthesisreactions,physicaloperations,cracking of hydrocarbons

UnitII:Mappingoffluidizationregimes

Characterization of particles, mechanics of flow around single particles, minimum fluidization velocity, pressure drop versus velocity diagram, TheGeldart classification of solids,fluidizationwithcarryoverofparticles,terminalvelocityofparticles,distributortypes, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption

UnitIII:Bubblingfluidizedbeds

Davidson model for bubble in a fluidized bed, and its implications, the wake region and movement ofsolidsat bubbles, coalescenceand splitting ofbubbles, bubbleformationabove adistributor, slugflow, Turbulent andfast fluidization - mechanics, flowregimesanddesign equations, Emulsion movement, estimation of bed properties, bubble rise velocity, scale up aspects, flow models, two phase model, K-L model

UnitIV:SolidsmovementandGasdispersion

Verticalandhorizontal movementofsolids,Dispersionmodel,largesolidsinbedsofsmaller particles, staging of fluidized beds

Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient, Heat and mass transfer in fluidized systems, Mixing in fluidized systems - measurements and models.

UnitV:Fluidizedbedreactors

Entrainment and elutriation, Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization, Slugging, Spouted beds, Circulating Fluidized Beds.

Mathematical modelofa homogeneousfluidizedbed,Designofcatalyticreactors,pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts,Designofnoncatalyticreactors,kineticmodelsforconversionofsolids,modelsfor shrinking particles, conversion of solids of unchanging size]

References

1. LevenspielO.andKunniiD.,“FluidizationEngineering”,JohnWiley,1972
2. Liang-ShihFan,“Gas-Liquid-SolidFluidizationEngineering”,Butterworths,1989

CourseOutcomes: Attheendofthecourse,thestudentwillbeableto:

1. Performingandunderstandingthebehaviorfluidizationinfluidizedbed
2. Evaluatethecharacterizationofparticlesandpowerconsumptioninfluidization regimes
3. Understandingtheapplicabilityofthefluidizedbedsinchemicalindustries
4. Dispersionmodel,largesolidsinbedsofsmallerparticles,stagingoffluidized beds,Gas dispersion in beds.
5. Entrainmentandelutriation,Mathematicalmodelofahomogeneousfluidizedbed.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1			1		1			1				
CO2			1	1	2							
CO3					1			1				
CO4			1		2							
CO5			1	1				1				

CH14C **PROCESSPLANTSIMULATION**

Instruction:3 hr/week Credits:3 Evaluation:40+60

CourseObjectives;Studentswillhavetolearnthefollowing

1) LearntheChemicalSystemsModelingandArtificialNeuralNetworks
2) Understand how to design Steady State Extraction and Heat Conduction through Hollow Cylindrical, Unsteady State Mass Balance for CSTR and Heat Transfer in a Tubular Gas Pre Heater
3) UnderstandhowtodesignmodelsfromFluidFlowandReactionEngineering
4) Develop Errors of Measurement, Problems in Data Regression and Solving Equation Solving and Modular Approach
5) Develop Algorithms based on Signal Flow Graph, Tearing Algorithms and Physical and Thermodynamic Properties of Convergence Promotion

UNITI

Modeling Aspects: Deterministic vs. Stochastic Processes, Physical modeling, Mathematical modeling, Chemical Systems Modeling, Cybernetics, Controlled System, Principles of Similarity

Classification of Mathematical Modeling: Independent and Dependent variables, Classificationbasedonvariationofindependentvariables,Classificationbasedon stateofthe process, Classification based on type of the process, Boundary Conditions, The black Box Principle, Artificial Neural Networks

UNITII -ProcessModeling-I

Modelsfrommasstransfer: steadystatesinglestagesolvent extraction,steadystatetwostage solvent extraction, steady state two stage cross current solvent extraction, , steady state N-stage solvent counter current extraction, unsteady state single stage solvent extraction, unsteady state mass balance in a stirredtank and in a mixing tank.

Models fromHeat Transfer :steadystate heat conductionthrougha hollowcylindrical pipe, unsteady state steam heating of a liquid, unsteady state heat loss through a measuring tank, heat transfer through extended surfaces, unsteady state heat transfer in a tubular gas pre heater

UNITIII–ProcessModeling-II

Modelsfrom fluidflow:flowthrougha packed bedcolumn,flowofa filmontheoutsideofa circular tube,annular flow with inner cylinder moving axially, flow between coaxial cylinders and concentric spheres

Models from Reaction Engineering : chemical reaction with diffusion in a tubular reactor, chemical reactorwith heat transfer ina packed bed reactor, gas absorption accompanied by chemical reaction

UNITIV

Error Propagation& Data Regression :Propagation of errors through addition, subtraction, multiplication and division, Errors of measurement, Precision errors, errors method

Data Regression :Theoretical properties, data regression methods, Problems in data regression

ProcessSimulation:ModularApproach,Theequationsolvingapproach

UNITV

Decomposition of Networks :Tearing Algorithms, Algorithms based on signal flow graph and reduced digraph

Convergence Promotion:Newton's method, direct substitution method,Wegstein's method, dominantEigenvaluemethod,quasiNewtonmethod,Criterionforacceleration, Physicaland Thermodynamic Properties

TEXTBOOKS:

1. ProcessPlantSimulation,B.V.Babu,OxfordUniversitypress,2004
2. ProcessModeling, SimulationandControl forChemical Engineers,2^{nd}ed., W. L. Luyben, McGraw-Hill, New York, 1990

REFERENCE:

1. Introduction to Numerical Methods in Chemical Engineering, P. Ahuja, PHI , NewDelhi, 2010
2. ProcessModelingandSimulation,AmiyaK.Jana,2012.

CourseObjectives:Studentswillbetrainedin

1) ModellingAspectsandClassificationofMathematicalModelling
2) HowtoPrepareModelsfromMassTransferandModelsonHeatTransfer
3) HowtoPrepareModelsfromFluidFlowandModelsonReactionEngineering
4) The analysis throughPropagation of Errors, Error Methods, Data Regression Methods and Process Simulation
5) DecompositionofNetworksandConvergencePromotion

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

CH14C COMPUTATIONALFLUIDDYNAMICS

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives

1. Tomakestudentsunderstandthegoverningequationsoffluiddynamicsandtheir derivation from laws of conservation
2. Todevelopagoodunderstandingincomputationalskills,includingdiscretisation, accuracy and stability.
3. Toacquaintthestudentswithaprocessofdevelopingamathematicalandgeometrical model of flow, applying appropriate boundary conditionsand solving system of equations

UnitI:Introductionto FluidDynamics

Concepts of Fluid Flow, Pressure distribution in fluids, Reynolds transport theorem, Integral formof conservation equations, Differential form ofconservationequations,Different Types of Flows, Euler and Navier Stokes equations, Properties of supersonic and subsonic flows, Flow characteristics over various bodies. Philosophy of CFD, Governing equations of fluid dynamicsandtherephysical meaning,Mathematical behaviorofgoverningequationsandthe impactonCFD simulations, SimpleCFDtechniquesandCFL condition.NumericalMethods in CFD: Finite Difference, Finite Volume, and Finite Element, Upwind and downwind schemes, SimpleandSimpler schemes, Higher order methods,Implicitand explicit methods, Study and transient solutions

UnitII :GridGeneration

Basictheoryof structuredgridgeneration,Surfacegridgeneration,Monoblock,multiblock, hierarchical multi block, Moving and sliding multiblock, Grid clustering and grid enhancement. Basic theory of unstructured grid generation, advancing front, Delaunay triangulationandvariouspointinsertionmethods,Unstructuredquadandhexgeneration,grid based methods, various elements in unstructured grids, Surface mesh generation, Surface mesh repair, Volume grid generation, Volume mesh improvement, mesh smoothing algorithms, grid clustering and quality checks for volume mesh. Adaptive, Moving and HybridGrids,Needforadaptiveand,movinggrids,Tet, pyramid, prism,andhexgrids,using various elements in combination

UnitIII:TurbulenceanditsModeling

Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model,The k-e model, Reynolds stress equation models, Algebraic stress equation models

UnitIV:ChemicalFluidMixingSimulation

Stirred tank modeling using the actual impeller geometry, Rotating frame model, The MRF Model Sliding mesh model, Snapshot model, Evaluating Mixing from Flow Field Results, Industrial Examples

UnitIV:Post-ProcessingofCFD results

Contour plots, vector plots, and scatter plots, Shaded and transparent surfaces, Particle trajectories and path line trajectories, Animations and movies, Exploration and analysis of data.

References

1. AndersonJohnD.,"ComputationalFluidDynamics:TheBasicswithApplications", Mc Graw Hill, 1995
2. RanadeV.V.,"ComputationalFlowModelingforChemicalReactorEngineering", Process Engineering Science, Volume 5, 2001
3. KnuppPatrickandSteinbergStanly,"FundamentalsofGridGeneration",CRCPress, 1994
4. WilcoxD.C.,"TurbulenceModellingforCFD",1993
5. WesselingPieter,"AnIntroductiontoMultigridMethods",JohnWiley&Sons,1992
6. ThompsonJ.F.,WarsiZ.U.A.andMastinC.W.,"NumericalGridGeneration: Foundations and Applications", North Holland, 1985
7. PatankarS.V.,"NumericalHeatTransferandFluidFlow",McGraw-Hill,1981
8. GatskiThomasB.,HussainiM.YousuffandLumleyJohnL.,"Simulationand Modelling of Turbulent Flows", Oxford University Press, 1996
9. Laney,C.B.,"ComputationalGasDynamics",CambridgeUni.Press,1998.

Outcomes:Attheendofthecourse,thestudentswillbeableto:

1. Understandthebasicprinciplesofmathematicsandnumericalconceptsoffluid dynamics.
2. Developgoverningequationsforagivenfluidflowsystem.
3. Adaptfinitedifferencetechniquesforfluidflowmodels.
4. Applyfinitedifferencemethodforheattransferproblems.
5. Solve computational fluid flow problems using finite volume techniques. Get familiarized to modern CFD software used for the analysis of complex fluid-flow systems

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1			1	1	1			1	1			
CO2			2	1				1	2			1
CO3			1	1	1			2	1			2
CO4			1		2			1	1			1
CO5			1	1	1			1	1			1

CH15C **INDUSTRIALPOLLUTIONCONTROL**

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives

1. Tounderstandtheimportanceofindustrialpollutionanditsabatement
2. Tostudytheunderlyingprinciplesofindustrialpollutioncontrol
3. Toacquaintthestudentswithcasestudies
4. Studentshouldbeabletodesigncompletetreatmentsystem

UnitI:Industries&Environment

IndustrialscenarioinIndia-Industrialactivityand Environment-UsesofWaterby industry - Sources and types of industrial wastewater - Industrial wastewater and environmental impacts - Regulatory requirements for treatment of industrial wastewater - Industrial waste survey - Industrial wastewater generation rates, characterization and variables - Population equivalent - Toxicity of industrial effluents and Bioassay tests.

UnitII:IndustrialNoise pollution

Sources of noise pollution, characterization of noise pollution prevention& control of noise pollution, Factories Act 1948 for regulatory aspects of noise pollution.

UnitIII:AirPollutantAbatement

Air pollutants scales of concentration, lapse rate and stability, plume behavior, dispersion of air pollutants, atmospheric dispersion equationand its solutions, Gaussian plume models.Air pollution control methods, Source correction methods, Design concepts for pollution abatement systems for particulates and gases. Such as gravity chambers, cyclone separators, filters, electrostatic precipitators, condensation,adsorptionandabsorption, thermal oxidation and biological processes.

UnitIV:Wastewatertreatment processes

Design concepts for primary treatment, grid chambers and primary sedimentation basins, selectionoftreatmentprocessflowdiagram,elementsofconceptualprocessdesign,designof thickner, biological treatment Bacterial population dynamics, kinetics of biological growth and its applications to biological treatment, process design relationships and analysis, determination ofkinetic coefficients, activated sludge process. Design, trickling filter design considerations, advanced treatment processes, Study of environment pollution from process industries and their abatement:Fertilizer, paper and pulp, inorganic acids, petroleum and petrochemicals, recovery of materials from process effluents.

UnitV:SolidwasteandHazardouswastemanagement

xSources and classification, properties, public health aspects, Sanitary land fill design, Hazardous waste classification and rules, management strategies, Nuclear waste disposal Treatment methods– component separation, chemicaland biologicaltreatment,incineration, solidification and stabilization, and disposal methods, Latest Trends in solid waste management.

References

1. RaoC.S.,“EnvironmentalPollutionControlEngineering”,2ndedition
2. MahajanS.P.,“PollutionControlinProcessIndustries”.
3. NemerowN.L.,“Liquidwasteofindustry-theories,PracticesandTreatment”, Addison Wesley, New York, 1971
4. WeberW.J.,“Physico-ChemicalProcessesforwaterqualitycontrol”,Wiley Interscience New York, 1969
5. StraussW.,“IndustrialGasCleaning”,Pergamon,London,1975
6. SternA.C.,“Airpollution”, VolumesItoVI,academicPress,NewYork,1968
7. PetersonandGross.EJr.,“HandBookofNoiseMeasurement”,7thEdn,2003.
8. AntonyMilne,“NoisePollution:ImpactandCounterMeasures”,David&Charles PLC, 2009.

CourseOutcomes: Attheendofthecourse,thestudent willbeableto:

1. Recognizethecausesandeffectsofenvironmentalpollution
2. Analyzethemechanismofproliferationofpollution
3. Developmethodsforpollutionabatementandwasteminimization
4. Designtreatmentmethodsforgas,liquidandsolidwastes
5. NuclearwastedisposalTreatmentmethods

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1			1		1			1				
CO2			1	1								
CO3		2			1			1				
CO4			1		2							
CO5			1	1				1				

CH15C **TRANSPORTINPOROUSMEDIA**

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives:

1. Introducethephysicsandgoverningmechanismscontrollingflowandtransport processes in porous media.
2. LearningLiquidandsolutetransportinporousmedia.

Unit-I: Fundamentals:Mass,momentumandenergytransport,DarcyandNon-Darcy equations, equilibrium and non-equilibrium conditions, species transport, radioactive decay.

Unit-II: Effectivemediumapproximation:equivalentthermalconductivity,viscosity, dispersion.

Unit-III: Exactsolutions:Flowoveraflatplate,flowpastacylinder,boundary-layers, reservoir problems.

Unit-IV: Special topics: Field scale and stochastic modeling, Turbulent flow, compressible flow, multiphase flow, numerical techniques, hierarchical porous media, nano scale porous media, multiscale modeling.

Unit-V: Engineeringapplications:Groundwater,wastedisposal,oilandgasrecovery, regenerators ,energy storage systems. Experimental techniques: Flow visualization, quantitative methods, inverse parameter estimation.

References:

1. PrinciplesofHeatTransferinPorousMedia,byM.Kaviany,SpringerNewYork (1995).
2. TransportPhenomenainPorousMedia, VolumesI-III,editedbyD.R.InghamandI. Pop, Elsevier, New York (1998-2005).
3. DynamicsofFluidsinPorousMedia,J.Bear,Dover(1988).
4. IntroductiontoModelingofTransportPhenomenainPorousMedia,J.BearandY. Bachmat, Kluwer Academic Publishers, London (1990).
5. EnhancedOilRecovery,L.W.Lake,GulfPublishingCo.Texas(1989).
6. TheMathematicsofReservoirSimulation,R.E.Ewing,SIAMPhiladelphia(1983).
7. StochasticMethodsforFlowinPorousMedia:CopingwithUncertainties,Zhang,D., Academic Press, California (2002).
8. TheMethodofVolumeAveraging,S.Whitaker,Springer,NewYork(1999).

Outcomes: Attheendofthiscourse,studentsareableto:

1. Students will understand the mechanisms involved in transport processes in porous mediaandwillbeabletowork withtheequationsthatgovernthefateand transportof gas, water and solutes in porous media.

CH15C CHEMOINFORMATICS

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives

1. TogivestudentsaconceptofChemo-informaticsrelatedtochemicalstructure databases and database search methods

2. Tounderstandthequantummethodsandmodelsinvolvedindrugdiscoveryand targeted drug delivery

3. TostudytheapplicationofChemicalLibraries,VirtualScreening,Predictionof Pharmacological Properties

UnitI :Chemo-informatics

Introduction, scope and application, Basics of Chemo-informatics, Current Chemo-informatics resources for synthetic polymers, pigments. Primary, secondary and tertiary sources of chemical information, Databases: Chemical Structure Databases (PubChem, Binding database, Drugbank), Database search methods:chemical indexing, proximity searching, 2Dand 3D structureand substructure searching. Drawing theChemical Structure: 2D & 3D drawing tools (ACD Chemsketch) Structure optimization.

UnitII:Introductionto quantummethods

Combinatorial chemistry (library design, synthesis and deconvolution), spectroscopic methods and analytical techniques, Representation of Molecules and Chemical Reactions: Different typesofNotations,SMILES Coding,StructureofMol filesand Sd files(Molecular converter, SMILES Translator).

UnitIII:Analysisanduseofchemicalreactioninformation

Chemical propertyinformation, spectroscopicinformation, analytical chemistryinformation, chemicalsafetyinformation,DrugDesigning:PredictionofPropertiesofCompounds,QSAR Data Analysis, Structure-Activity Relationships, Electronic properties, Lead Identification, Molecular Descriptor Analysis.

UnitIV:TargetIdentification

Molecular Modeling and Structure Elucidation: Homology Modelling (Modeller 9v7, PROCHECK), Visualization and validation of the Molecule (Rasmol, Pymol Discovery studio), Applications of Chemoinformatics in Drug Research - Chemical Libraries, Virtual Screening, Prediction of Pharmacological Properties.

UnitV:DrugDiscovery

Structure based drug designing, Docking Studies (Target Selection, Active site analysis, Ligand preparation and conformational analysis, Rigidand flexible docking, Structure based design of lead compounds, Library docking), Pharmacophore - Based Drug Design, Pharmacophore Modeling (Identification of pharmacophore features, Building 2D/3D pharmacophorehypothesis),ToxicityAnalysis-PharmacologicalProperties(Absorption, DistributionandToxicity),GlobalProperties(OralBioavailabilityandDrug-Likeness)(ADME, OSIRIS, and MOLINSPIRATION)

References

1. BajorathJ(2004),“Chemoinformatics:Concepts,MethodsandToolsforDrug Discovery” Humana Press

2. LeachA,GilletV,“AnIntroductiontoChemoinformatics”Revisededition,Springer

3. GasteigerJ.EngelT.“AtextbookofChemoinformatics”Wiley-VCHGmbH&Co. KGaA

4. BuninB.SieselB.GuillermoM.“Chemoinformatics:Theory,Practice&Products”, Springer

5. LavineB.(2005),“ChemometricsandChemoinformatics”,AmericanChemical Society

6. CasteigerJ.andEngelT(2003)“Chemoinformatics”Wiley-VCH

7. BuninBarryA.SieselBrian,MoralesGuillermo,BajorathJürgen.Chemoinformatics: Theory, Practice, & Products Publisher:New York, Springer. 2006.

8. LeachAndrewR.,ValerieJ.Gillet,“AnintroductiontoChemoinformatics”, Publisher: Kluwer academic, 2003. ISBN: 1402013477

9. GasteigerJohann,HandbookofChemoinformatics:FromDatatoKnowledge(4 Volumes),

   2003.Publisher:Wiley-VCH.

CourseOutcomes: Attheendofthecourse,thestudentwillbeableto:

1. The course will introduce the students preparing for professional work in chemistry must learn how to retrieve specific information from the enormous and rapidly expanding chemical literature.

2. Thecoursewillprovideabroadoverviewofthecomputertechnologytochemistryin all of its manifestations.

3. Thecoursewillexposethestudenttocurrentandrelevantapplicationsin QSARand Drug Design.

CH15C ADVANCEDCONTROLSYSTEMS

Instruction:3 hr/week Credits:3 Evaluation:40+60

CourseEducationalObjectives;Studentswillhavetolearnthefollowing

1) LearntheConceptsofAdvancedControlStrategies
2) UnderstandtheMultiInputandMultiOutputcontrolling
3) UnderstandthePurposeofDigitalDataAcquisitionandControl
4) DevelopDiscreteTimeModels&TheirDynamicResponse
5) DesigntheDigitalControllers

UnitI:

Feed Forward and Ratio Control – Introduction, Feed forward controller design based on steady stateand dynamic models, tuningand configuration of feed forward control

Advanced Control Strategies– Cascade control, time delay compensation and inferential control, selectiveand override systems, adaptive control, statistical process control

UnitII:

Control of Multi Input, Multi-Output Systems– Process interactions and control loop interactions, pairing of controlled and manipulated variables, strategy for reducing interactions, decoupling, multivariable control techniques

Supervisory Control– Basic requirements, applications, formulation and solution of optimization problems, unconstrained and constrained optimization

UnitIII:

Digital Computer Control– Digital control systems in process control, distributed instrumentation and control systems, general purpose digital data acquisition, digital control hardware and software, table driven PID controller, Programmable logic controllers and batch process control

Sampling and Filtering of Continuous Measurements– Sampling and signal reconstruction, selectionofsamplingperiod, signalprocessinganddata filtering,comparison ofanalogand digital filters, effect of filter selection on control system performance

UnitIV:

Development of Discrete Time Models – Finite difference models, exact discretization for linear systems, higher order systems, fitting discrete time equationsto process data

DynamicResponseofDiscrete–TimeSystems–Thez-Transform,inversion,pulsetransfer function, relating pulse transfer functions to difference equations, effect of pole and zero locations, conversion between laplace and z- transforms

UnitV:

Analysis of Sampled – Data Control Systems– Open loop block diagram analysis, development of closed loop transfer functions, stability of sampled data control systems

Design of Digital Controllers– Digital PID controller, selection of controller parameters, direct synthesis methods, digital feed forward control, combined load estimation and time delay compensation

TextBooks:

1. ProcessDynamicsandControl–D.E.Seborg,T.F.EdgarandD.A.Mellichamp, John Wiley & Sons
2. ChemicalProcesscontrol–AnIntroductiontoTheoryandPractice-George Stephanopoulos, Prenticehall1990.

CourseObjectives: Studentswillbeabletounderstandandanalyze

1) FeedForward,RatioControlsandAdvancedControllers
2) ControlLoopInteractions&Optimization
3) DigitalComputerControl, selectionofsamplingperiod,comparisonofanaloganddigital filters
4) FiniteDifferenceModels,Z-Transforms,PulseTransferFunctions
5) SamplesandDataControlSystems

II SEMESTER

CH21C MEMBRANESEPARATIONS

Instruction,hours/week:3 Credits:3 Assessment:40+60

CourseEducationalObjectives;Studentswillhavetolearnthefollowing

1) LearnthePropertiesofMembraneandTypesofMembrane
2) LearntheTypesofFiltrationsused
3) DesignReverseOsmosisModule
4) LearnGasSeparationandPervaporation
5) UnderstanddifferentMembraneProcesses

UNITI :

OverViewofMembraneSeparations

Membrane Types, Materials, Preparation and Characterization- Types of Synthetic Membranes – Membrane Modules – Typical Flow patterns – Membrane materials – Pore Characteristics – Membrane Manufacture – Measurement of Pore size and Solute rejection Properties – surface Properties measurement and interpretation

UNITII :

Nano Filtration– principles – nano-filtration membranes – Mass Transfer – Process Limitations – Industrial application

Ultrafiltration -Basic Principles – Membranes – Configuration – Types of Devices – Factorsaffectingperformance–Flux– ModelsforSolventFlux–FoulingandFluxdecline–Methodsto reduce Concentration Polarization – Energy Considerations – Micellar enhanced UF – Affinity UF – Applications

Microfiltration– Basic Principles – Membranes – Transport Mechanism – retention characteristics – Flow Characteristics – Membrane Plugging and Throughput – Fouling – energy Considerations – Applications

UNITIII:

Reverse Osmosis-Concepts– PhenomenonofRO – ModelsforROtransport – Designand Operating parameters– Concentration Polarization – Membrane plugging– Equivalent work requirement–Design ofanROmodule– ROofnon-aqueoussystems–Osmoticpincheffect – Forward osmosis – Applications

Dialysis– Principles – Dialysis systems – Membranes – Mass transfer – Applications – Diffusion dialysis

UNITIV:

Gas Separation- Basic Principles – Membranes – Membrane Modules – Fundamental Mechanisms ofGasTransport -FactorsaffectingGasPermeation–CompleteMixingModel – Cross and Countercurrent models – Applications

Pervaporation- Basic Principles – Advantages – Membrane characteristics – Thermodynamic Considerations – Mass transfer – Thermodynamic Considerations – Design of a Module – Concentration Polarization – factors affecting pervaporation – Temperature drop at the interface – Applications

UNITV:

IonExchange Membrane Process-Basic Principles – Ion exchange Membranes – Energy requirement, Efficiency- Concentration Polarization and limiting current density – Other operating parameters – applications

Liquid Membranes- Types of liquid membranes – Mechanism of Mass transfer – Applications

Other Membrane Processes– Membrane contactor and applications – Membrane distillation – Membrane reactors – PEM Hydrogen Fuel Cell

TextBook

1. MembraneSeparationProcesses–Kaushiknath–PrenticeHall,2008

References

1. ReverseOsmosisandSyntheticMembranesTheory,TechnologyandEngineering, Sourirajan,S National Research Council, Canada.
2. Reverse Osmosis/ Ultrafiltration Process Principles, Sourirajan,S. and Matsuura, T., NationalResearchCouncil,Canada.SeparationProcesses,ElsevierScientificPublication.
3. IndustrialMembraneSeparationTechnology,Scott,K.,andHughes,R.(Eds.),Blackie Academic & Professional London.
4. SeparationProcesses,King,C.J, TataMcGrawHill,NewDelhi.
5. MembraneProcesses,Rautenbatch,R.,andAlbrecht,RJohnWiley&Sons,NewYork.
6. MembraneSeparationProcesses, Baum,B.,Halley,W.andWhite,R.A,Elsevier Scientific Publication

CourseObjectives: Studentsgain

1) KnowledgeonPreparationandCharacterizationofMaterialsandTypesofMembrane
2) KnowledgeonNano-Filtration,Ultra-FiltrationandMicro-Filtration
3) KnowledgeonDesigningReverseOsmosisandDialysis
4) ConceptsofGasSeparationandPervaporationandDesignofPervaporationModule
5) KnowledgeonIonExchangeMembraneProcess,LiquidMembranesandOther Membrane Processes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1		1	1	1				1	1			
CO2			1					2	1			
CO3		1	1					1	1			
CO4			1	1				2	1			
CO5		2		1					1			

CH22C **OPTIMIZATIONTHEORY&PRACTICE**

Instruction,hours/week:3 Credits:3 Assessment:40+60

CourseEducationalObjectives:

1) Tolearnproblemformulationandbasicconceptsofoptimization.
2) Tostudythenumericalmethodstosolvesinglevariableun-constrainedproblems
3) Tounderstandandapply numericalmethodstosolveun-constrainedmulti-variable problems
4) Tolearnlinear&non-linearprogrammingmethods
5) Toknowtheapplicationsofoptimizationthroughdifferentexamples

Unit-I:Introduction

Basic concepts of optimization, applications of optimization,general procedure for solving optimization problem, formulation of the objective function, fitting models to data, classification of functions.

Unit-II:SingleVariableunconstrainedoptimizationmethods

Directsearchmethods-Intervalhalvingmethod,Fibonaccimethod,Goldensectionmethod; Direct root methods-Newton method and Quasi Newton method; Polynomialapproximationmethods-Quadraticinterpolationandcubicinterpolation.

Unit-III:Optimizationofunconstrainedmultivariablefunctions

Direct search methods-random search, grid search, uni-variate search and pattern search methods.;Indirect search methods -steepestdescent,conjugate gradient methods,Newton's method and secant method.

Unit-IV:Linearandnon-linearprogramming

Linearprogramming: Basicconcepts in linearprogramming,StandardLPfrom,Graphical solution and Simplex method.

Non-linearprogramming:Lagrangemultipliermethod,Quadraticprogramming,Penalty function and augmented Lagrangian methods.

Unit–V:Applicationsofoptimization

Optimizingrecovery of waste heat, optimal design and operation of a conventional staged-distillation column, optimal pipe diameter, optimal residence time for maximum yield in chemostat and optimization of a thermal cracker using linear programming.

TextBook:

1. Edgar,T.F.,Himmelblau,D.M.andLadson,L.S.,"OptimizationofChemical Processes", 2nd Ed., McGraw Hill, New York.

ReferenceBooks:

1. Diwaker,U.W.“IntroductiontoAppliedOptimization”,Kluwer.
2. Joshi,M.C.andMoudgalya,K.M.,“Optimization,TheoryandPractice”,Narosa, New Delhi, 2004.
3. Rao,S.S.,EngineeringOptimization:TheoryandPractice, NewAgePublishers.

CourseOutcomes: Studentwillbeableto

1) formulateandanalysetheoptimizationofthegivenphysicalsituation.
2) Applydifferentmethodsofoptimizationandtosuggestatechniqueforspecificproblem
3) Understandthedifferencebetweenconstrainedandunconstrainedoptimization
4) Understandtheimportanceoflinearprogrammingproblems
5) Realizetheimportanceofoptimizationbyunderstandingdifferentexamples

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1		1	1	1				1	1			
CO2		2	1	1				2	1			
CO3		1	1	1		2	1	1	1			
CO4		2	1	1				2	1			
CO5		2	2	1				1	1			

CH25L STEADYSTATESIMULATIONLAB IISemester

Instruction,hours/week:3 Assessment:40+60

Tointroducestudentstouseofsoftwarepackagesfor simulationandalsoanalyzingflow sheets

1. IntroductionofSoftwarepackages.
2. Settingupmodelsforsimulation.
3. Flowsheetingconcepts.
4. SteadystatesimulationforgenerationofVLEdata.
5. Steadystatesimulationforconversioncalculationforsingleandmultiplereactions
6. Steadystatesimulationforheatandcoolingdutyofheatexchangers.
7. Simulationofflashcolumn.

CH26L ADVANCEDINSTRUMENTATIONLAB

Instruction,hours/week:3 Assessment:40+60

Tointroduce studentstouseofnewAnalyticalInstrumentsforanalysislikeUVSpectro Photo meter, HPLC, Atomic Adsorption Spectro Photometer etc.

INDUSTRIALSAFETY

Unit-I: Industrial safety: Accident, causes, types, results and control, mechanical and electricalhazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-II: Fundamentals of maintenance engineering: Definition and aim of maintenance engineering,Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & itsrelation with replacement economy, Servicelife of equipment.

Unit-III: Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reductionmethods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ringlubrication,Definition, principleandfactorsaffectingthecorrosion.Typesofcorrosion, corrosion prevention methods.

Unit-IV: Fault tracing: Fault tracing-concept and importance, decision tree concept, need andapplications, sequenceoffaultfindingactivities, showasdecisiontree,drawdecisiontree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustionengine,v.Boiler, vi. Electrical motors,Typesoffaultsin machine toolsandtheir general causes.

Unit-V: Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing,cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Reference:

1. MaintenanceEngineeringHandbook,Higgins&Morrow,DaInformationServices.
2. MaintenanceEngineering,H.P.Garg,S.ChandandCompany.
3. Pump-hydraulicCompressors,Audels,McgrewHillPublication.
4. FoundationEngineeringHandbook,Winterkorn,Hans,Chapman&HallLondon.

CH23C MODERNCONCEPTSINCATALYSISANDSURFACE PHENOMENON

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives

1. Togivethestudentsinsightintoadvancesincatalyticreactionengineering
2. Tounderstandthemechanismsinvolvedincatalyticreactions
3. Tostudythecatalystcharacterizationtechniques
4. Tostudytheadvancedindustrialapplicationsincatalysis
5. Tounderstandtheprinciplesbehindcatalystdeactivationandstudytheirmodels

UnitI :IntroductiontoCatalysis

Definition of Catalytic activity, Magnitude of Turnover Frequencies and Active Site Concentrations, Evolution of Important Concepts and Techniques in Heterogeneous Catalysis, Classification of Catalysts – Homogeneous, Heterogeneous, Biocatalysts, Dual Functional Catalysts, Enzymes, Solid Catalysts, Powder Catalysts, Pellets, Composition, Active Ingredients, Supportive materials, Catalysts Activation, Catalyst Deactivation.

UnitII:AdsorptioninCatalysis

Adsorption and its importance in Catalysis, Adsorption and potential energy curves, Surface Reconstruction, Adsorption Isotherms and Isobars, Dynamical Considerations, Types of Adsorption Isotherms and their Derivation from Kinetic Principles, Mobility at Surfaces, Kinetics of surface Reactions, Photochemistry on oxide and metallic surfaces, Characterization of the adsorbed molecules

UnitIII:CatalystCharacterization

CatalystCharacterizationMethods–TheirWorkingPrincipleandApplications–XRF,XRD, IR Spectroscopy, XPS, UPS, ESR, NMR; Infrared, Raman, NMR, Mossbauer and X-Ray Absorption spectroscopy, Surface Acidity and Toxicity, Activity, Life time, Bulk density, Thermal stability Crystal Defects, Peroviskites, Spinels, Clays, Pillared Clays, Zeolites

UnitIV:SignificanceofPoreStructureandSurfaceArea

Importance of Surface Area and Pore Structure, Experimental Methods for Estimating Surface Area– Volumetric, Gravimetric, Dynamic Methods, Experimental Methods for Estimating Pore Volumeand Diameter – Gas Adsorption and Mercury Porosimeter Method, Models of the Pore Structure – Hysteresis Loops, Geometric Models, Wheeler's Model, Dusty Gas Model, Random Pore Model, Diffusion in Porous Catalysts – Effective Diffusivity, Knudsen Diffusion, Effect of Intraparticle Diffusion, Non-isothermal Reactions in Pores, Diffusion Control.

UnitV:Industrialapplications–CaseStudies

Industrial processes involving heterogeneous solid catalyst: Synthesis of Methanol, Fiscer-Tropsch Catalysis, Synthesis of Ammonia, Automobile Exhaust Catalysts and Catalyst Monolith, Photocatalytic Breakdown of Water andtheHarnessing of Solar Energy.

Contribution of homogeneous catalytic process in chemical industry:Oxidations of Alkenes suchas production ofacetaldehyde, propyleneoxide etc., Polymerization suchas production of polyethylene, polypropylene or polyester production

References

1. Emmett,P.H.-“CatalysisVol.IandII,ReinholdCorp.",NewYork,1954
2. Smith,J.M.-“ChemicalEngineeringKinetics",McGrawHill,1971
3. ThomasandThomas-“IntroductiontoHeterogeneousCatalysts",AcademicPress, London 1967
4. PietW.N.M.vanLeeuwen,Homogeneouscatalysis:UnderstandingtheArt,Springer, 2004
5. PietW.N.M.vanLeeuwen,andJohnC.Chadwick,Homogeneouscatalysis:Activity-stability –deactivation, Wiley, VCH, 2011.

CourseOutcomes: Attheendofthecourse,thestudent willbeableto:

1. Tounderstandtheconceptsofhomogenousandheterogeneouscatalysis,withspecific examples.
2. Tostudyreactionmechanismsandkineticsofhomogenousandheterogeneous catalytic reactions.
3. Tofamiliarizewiththecharacterizationofcatalysts
4. Tounderstandtheapplicationand mechanismsofseveraltypesofcatalystsin chemical industry.

CH22C ADVANCED DOWNSTREAMPROCESSING

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives

1. Tounderstandtheunitprocessesinvolvedindownstreamprocessing.
2. Tostudyadvancedtreatmentmethods.
3. Tostudytheenergyconservationindifferentseparationprocesses
4. Tounderstandtheunderlyingdesignprinciples

UnitI:Introduction]

Introduction to Downstream processes theory, applications in chemical separation for Gas-Liquid system, Gas-Solid system. Super critical fluids extraction in food, pharmaceutical, environmental and petroleum applications, water treatment, desalination, Bio separation, dialysis, industrial dialysis.

UnitII:DownstreamProcessesinPetrochemicalIndustry

Cryogenic distillation for refinery, petrochemical off gases, natural gases, gas recovery-Olefin, Helium, Nitrogen, Desulfurization - coal, flue gases

UnitIII:AdvancedDistillationProcesses

Azeotropic& extractive distillation - residue curve maps, homogeneous azeotropic distillation, pressure swing distillation, Column sequences, heterogeneous azeotropic distillation.

UnitIV:Energyconservationinseparationprocesses

Energy balance, molecular sieves - zeolights, adsorption, catalytic properties, manufacturing processes, hydrogel process, application, New trends.

UnitIV:Non-IdealMixturesandIonExchange

Separations process synthesis for nonazeotropic mixtures, non ideal liquid mixtures, separation synthesis algorithm, Ion exchange - manufacture of resins, physical& chemical properties, capacity, selectivity, application, regeneration, equipment, catalysis use.

References

1. Perry's"ChemicalEngg.Handbook":McGrawHillPub.
2. DouglasJ.M.,"ConceptualDesignofChemicalProcesses",McGrawHill
3. LiuY.A.,"RecentDevelopmentsinChemicalProcess&PlantDesign",JohnWiley & Sons Inc.
4. TimmerhausK.D.,"CryogenicProcessEngg.",PlenumPress
5. OthmerKirk"EncyclopediaofSeparationTechnology,VolI &II",Wiley Interscience

CourseOutcomes: Attheendofthecourse,thestudent willbeableto:

1. Tolearneffectivestrategiesofdownstreamprocessinginchemicalindustry.
2. Understandtheroleofdownstreamprocessing.
3. Analyzereactors,upstreamanddownstreamprocessesinproduction

CH23C **PROCESSSYNTHESIS&ANALYSIS**

Instruction,hours/week:3 Credits:3 Assessment:40+60

CourseObjectives:

1) Tofamiliarizethestudentsaboutvariouseconomicaspectsofchemicalprocesses
2) ToLearnbasicsofCostestimationandtounderstandthetimevalueofmoney
3) ToLearntheimportanceofCashflowdiagramsandBreak-evenanalysis.
4) ToStudydepreciationmethodsandmethodsofestimationofprofitabilityofanindustry
5) ToStudyaboutheatexchangernetworks.

UNIT-I:

Nature of Process Synthesis & Analysis : Creativeaspects – A hierarchial approach

Enginering Economics : Cost Information – Estimation of Capital and Operating Costs – TotalCapital Investment-Total Product Cost -Time Value ofMoney– Measures ofProcess Profitability – Simplifying the Economic Analysis for Conceptual Design

UNITII :

Economic Decision Making : Solvent Recovery System – Problem Definition& General Considerations – Design of a Gas Absorber – Equipment Design Consideration – Rules of Thumb

Input Information& Batch- Continuous: Input Information – Level 1 Decision – Batch Vs. Continuous

UNITIII:

Input-Output Structure of the Flow Sheet : Decisions for the I/O structure – Design Variables – Over all Material Balances – Stream Costs – Process Alternatives

Recycle Structure of the Flow Sheet : Decisions determining the recycle Structure – Recycle Material balances – reactor Heat Effects – Equilibrium Limitations – Compress Design & Costs – Reactor Design – recycle Economic Evaluation

UnitIV:

Heat Exchanger Networks –Minimum Heating& Cooling Requirements – Minimum Number of Exchangers – Area Estimates – Design of Minimum Energy Heat Exchanger Networks– Loopsand Paths– ReducingtheNumber ofExchanger – StreamSplitting– Heat and Power Integration – Heat Distillation – HAD Process

UNITV:

Separation System : General Structure – Vapor Recovery System – Liquid Separation System – Azeotropic Systems – Rigorous Material Balances

Cost Diagrams and Quick Screening of Process Alternatives-Cost Diagrams for simple and complex process – Quick Screening of Process Alternatives – HAD Process

TextBook:

1. ConceptualDesignofChemicalProcesses,Douglas,J.M.,McGrawHill,

ReferenceBooks:

1. ChemicalProcessDesign,RobinSmith,McGrawHill,
2. ChemicalProcessDesign,DimianA.C,&Bidea,C.S.,Wiley–VCH,2008
3. ChemicalProcessSynthesis&EngineeringDesign,Kumar,A,TataMcGraw Hill,1982
4. SystematicMethodsofChemicalProcessDesign,Bieglar,L.T.,Grossman,E.I and Westerberg, A.W. Prentice Hall Inc.
5. ProductandProcessDesignPrinciples,Seider,W.D.,Seider,J.D&Lewin,D.R. Wiley,2005

CourseOutcomes: Studentwillbeableto

1) understandtheconceptsofEngineeringeconomics
2) Abletoestimatevariouscostsinvolvedina processindustryandevaluatethetaxburden of an establishment
3) Abletoestimateprofitabilityofacompany
4) Understandtheheatexchangernetworksandtheirimportanceinindustry
5) Computebreakevenperiodforaninvestmentandrateofreturn

CH23C MICROANDNANOFLUIDICS

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives:

1. Tointroducetothestudents,thevariousopportunitiesintheemergingfieldofmicro and nano fluids.
2. Tothemakestudentsfamiliarwiththeimportantconceptsapplicabletosmallmicro and nano fluidic devices, their fabrication, characterization and application
3. Togetfamiliarizewiththenewconceptsofreal-timenanomanipulation&

Unit-1: Introduction: Fundamentals of kinetic theory-molecular models, micro and macroscopic properties, binary collisions, distribution functions, Boltzmann equation and Maxwellian distribution functions-Wall slip effects and accommodation coefficients, flow andheattransferanalysisofmicro scaleCouetteflows, Pressuredrivengasmicro-flowswith wall slip effects, heat transfer in micro-Poiseuille flows, effects of compressibility. Pressure Driven Liquid Micro flow: apparent slip effects, physics of near-wall micro scale liquid flows, capillary flows, electro-kinetically driven liquid micro - flows and electric double layer (EDL) effects, concepts of electro osmosis, electrophoresisand dielectro-phoresis.

Unit- 2: Laminar flow: Hagen-Poiseullie eqn, basic fluid ideas, Special considerations of flow insmall channels, mixing, microvalves& micropumps, Approaches toward combining livingcells,microfluidicsand'thebody'onachip,Chemotaxis,cellmotility.CaseStudiesin MicrofluidicDevices.Ionictransport:Polymertransport –microtubuletransportinnanotuble channels driven by Electric Fieldsand by Kinesin Biomolecular Motors - Electrophoresis of individual nanotubules in microfluidic channels.

Unit-3: Fabrication techniques for Nanofluidic channels – Bio molecules separation using Nanochannels - Biomolecules Concentration using Nano channels – Confinement of Bio molecules using Nano channels. Hydrodynamics: Particle moving in flow fields – Potential Functions in Low Renoyld's Number Flow– Arrays ofObstaclesand how particles Move in them: Puzzles and Paradoxes in Low Re Flow.

Unit-4: Micro fluidics and Lab-on-a-chip: Microfluidic Devices - Microchannels, Micro filters, Microvalves,Micropumps,Microneedles,Microreserviors, Micro-reaction chambers. Concepts and Advantages of Microfluidic Devices - Fluidic Transport - Stacking andScaling– MaterialsforTheManufacture(Silicon,Glass,Polymers) -FluidicStructures - Fabrication Methods - Surface Modifications - Spotting - Detection Mechanisms. Microcontact printing of ProteinsStrategies-printing types- methods and characterization-Cell nanostructure interactions-networks for neuronal cells. Applications in Automatic DNA sequencing, DNA and Protein microarrays.

Unit-5: BioMEMS (Micro-Electro-Mechanical Systems): Introduction and Overview, BiosignalTransduction Mechanisms: Electromagnetic Transducers Mechanical Transducers, Chemical Transducers, Optical Transducers – Sensing and Actuating mechanisms (for all types). Case Studies in Biomagnetic Sensors, Applications of optical and chemical transducers. Ultimate Limits of Fabrication and Measurement, Recent Developments in BioMEMSandBioNEMS -Analternativeapproachtotraditional surgery, Specifictargeting oftumorsandotherorgansfordrugdelivery,Micro-visualizationandmanipulation, Implantationofmicrosensors,microactuatorsandothercomponentsof alargerimplanted device or external system (synthetic organs).

TextBooks

1. JoshuaEdel"Nanofluidics"RCSpublishing,2009.

2. PatricTabeling"IntroductiontoMicrofluids"OxfordU.Press,NewYork2005.
3. K.Sarit"NanoFluids;ScienceandTechnology",RCSPublishing,2007.

References

1. M.Madou,FundamentalsofMicrofabrication,CRCPress,1997

2. G.Kovacs,MicromachinedTransducers,McGraw-Hill,1998

3. StevenSSaliterman,FundamentalsofBioMEMSandMedicalMicrodevices,2006

Outcomes: Attheendofthiscourse,studentsareableto:

1. Introduce studentsto the physical principlesto analyze fluid flowin micro and nano-sizedevices. Itunifiesthethermal scienceswithelectrostatics, electrokinetics, colloid science; electrochemistry; and molecular biology.

CH24C PHASETRANSITIONSINPROCESSEQUIPMENT

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives:

1. Basiclawsinthermodynamics.
2. Basicstatisticalconceptsandmethods:heat,work,energy,temperatureandthe kinetictheory of matter; entropy, ensemble, partition function, etc
3. Learningphasetransitioncatalysis
4. Haveagoodgraspofthebasicthermodynamicinteractionsandprocess:adiabatic, isothermal, etc

Unit-I: Thermodynamic aspects of phase transitions: Concept of phase, First-order phase transition,conditions for phase coexistence lines, free energy barrier of nucleation, and crystal-melt interfacial free energy, Ehrenfest classification of phase transitions, Van der Waals equation of state, Critical point

Unit-II: Single phase and multiphase catalytic reactions, Acid--base catalysis, Transition metalcatalysis,Phasetransfercatalysis,Micellarcatalysis,Microemulsioncatalysis,Electron transfer catalysis, Heteropoly acid catalysis, Homogeneous polymer catalysis, Heterogenisation of homogeneous catalysts.

Unit-III: Applications to Multi-phase Systems Stability conditions for a homogeneous system, equilibrium between phases, phase transformations, general relations for a system with several components, general conditions for chemical equilibrium, chemical equilibrium between ideal gases, and the equilibrium constantsin terms of partition functions.

Unit-IV: Phasediagramsand transformationsPhaserule-singleandbinary phasediagrams, leverrule,microstructuralchangesduringcooling,Al_2O_3,Cr_2O_3,Pb-Sn,Ag-PtandFe-Fe_3C Systemsphase diagrams, phase transformations, corrosion-theoriesofcorrosion, controland prevention of corrosion

UNIT-V: Energy balance - heat capacity and calculation of enthalpy changes, Enthalpy changes for phasetransitions, evaporation, clausius - clapeyron equation,

References:

1. Hegedus,L.S.,TransitionMetalsintheSynthesisofComplexOrganicMolecules, University Science Book (2010) 3rd ed.
2. RaghavanV.,MaterialScienceandEngineeringPrenticeHallofIndia,1996
3. David.M.Himmelblau,"Basicprinciplesandcalculationsinchemicalengineering", Prentice Hall of India Ltd., 6th Edition, 1998.
4. A.Hougen,K.M.WatsonandK.A.Ragatz,"ChemicalProcessPrinciples",Vol1, John Wiley, 1960.

Outcomes: Attheendofthiscourse,studentsareableto:

1. Thestudentisexpectedtoobtainconsiderableinsightintovarioustypesofphase transitions, and how these can be described theoretically in different ways

2. Predictrelationshipsbetweenphysicalquantitiesusingthelawsandmethodsof thermodynamics.

3. Findprobabilitiesandthermalquantities(freeenergy,entropy,etc)giventheenergy eigen values of a system.
4. Thestudentisexpectedtoobtainconsiderableinsightintovarioustypesofphase transitions, and how these can be described theoretically in different ways

5. Predictrelationshipsbetweenphysicalquantitiesusingthelawsandmethodsof thermodynamics.

6. Findprobabilitiesandthermalquantities(freeenergy,entropy,etc)giventheenergy eigen values of a system.

CH24C PROCESSINTENSIFICATION

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives:

1. UnderstandtheconceptofProcessIntensification.
2. Knowthelimitationsofintensificationofthechemicalprocesses.
3. Applythetechniquesofintensificationtoarangeofchemicalprocesses.
4. Developvariousprocessequipmentusedforintensifyingtheprocesses.
5. Inferalternativesolutionskeepinginviewpoint,theenvironmentalprotection, economic viability and social acceptance.

Unit-I: Introduction:TechniquesofProcessIntensification(PI)Applications,Thephilosophy andopportunities of Process Intensification, Main benefits from process intensification, ProcessIntensifying Equipment, Process intensification toolbox, Techniques for PI application.

Unit-II: ProcessIntensificationthrough microreactiontechnology:Effect of miniaturization on unitoperations and reactions, Implementation of Microreaction Technology, From basic PropertiesToTechnical DesignRules,Inherent ProcessRestrictionsinMiniaturizedDevices andTheir PotentialSolutions, MicrofabricationofReactionandunit operationDevices -Wet and Dry Etching Processes.

Unit-III: Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing,Heattransfer.Mixinginintensifiedequipment,ChemicalProcessinginHigh-Gravity Fields Atomizer UltrasoundAtomization,Nebulizers,HighintensityinlineMIXERSreactors Staticmixers, Ejectors, Teemixers, Impingingjets, Rotor stator mixers, DesignPrinciples of static Mixers Applications of static mixers, Higee reactors.

Unit-IV: Combined chemical reactor heat exchangers and reactor separators: Principles of operation;Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transferandpressuredrop,Flattube-and-finheat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

Unit-V: Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation,Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell,Microwaves,Electrostatic fields, Sonocrystallization, Reactive separations, Superctrical fluids

References:

1. Stankiewicz,A.andMoulijn,(Eds.),ReengineeringtheChemicalProcessPlants, Process Intensification, Marcel Dekker, 2003.
2. ReayD.,RamshawC.,HarveyA.,ProcessIntensification,ButterworthHeinemann, 2008.
3. Kamelia Boodhoo (Editor), Adam Harvey (Editor),Process Intensification TechnologiesforGreenChemistry:EngineeringSolutionsforSustainableChemical Processing, Wiley, 2013.
4. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián (Eds.)Process IntensificationinChemicalEngineeringDesignOptimizationandControl,Springer, 2016.
5. Reay,Ramshaw,Harvey,ProcessIntensification,EngineeringforEfficiency, Sustainability and Flexibility, Butterworth-Heinemann, 2013.

Outcomes: Attheendofthiscourse,studentsareableto:

1. Assessthevaluesandlimitationsofprocessintensification,cleaner technologiesand waste minimization options.
2. Measureandmonitortheusageofrawmaterialsandwastesgeneratingfrom production and frame the strategies for reduction, reuse and recycle.
3. Obtainalternativesolutionsensuringamoresustainablefuturebasedon environmental protection, economic viability and social acceptance.
4. Analyzedata,observetrendsandrelatethistoothervariables.
5. Planforresearchinnewenergysystems,materialsandprocessintensification.

CH24C MICROFLOWCHEMISTRYANDPROCESSTECHNOLOGY

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives:

1. Introducethestudentstomicroflowchemistryandprocesstechnology.
2. LearningMicromixers,MixingPrinciples.
3. Learningmicroreactorbasedchemicalsproduction

Unit-I: State of the Art of Micro reaction Technology, Structural Hierarchy of Micro reactors, Functional Classification of Micro reactors, Fundamental Advantages of Micro reactors, Advantages of Micro reactors Due to Decrease of Physical Size, Advantages of Micro reactors Due to Increase ofNumber of Units, Potential Benefits of Microreactors
Unit-II: Modern Micro fabrication Techniques for Micro reactors, Evaluation of Suitability ofa Technique, Anisotropic Wet Etching of Silicon, Dry Etching of Silicon, LIGA Process, Injection Molding, Wet Chemical Etching ofGlass, Advanced Mechanical Techniques

Unit-III: Micro mixers, Mixing Principles and Classes of Macroscopic Mixing Equipment, Mixing Principles and Classes of Miniaturized Mixers, Mixing Tee-Type Configuration

Unit-IV: MicrosystemsforGasPhaseReactions, Catalyst SupplyforMicroreactors, Types of Gas Phase Micro reactors, Micro channel Catalyst Structures, H_2/O_2Reaction, Selective Partial Hydrogenation of Benzene, Selective Oxidation of 1-Butene to Maleic Anhydride, SelectiveOxidation ofEthyleneto EthyleneOxide, OxidativeDehydrogenation of Alcohols, Synthesis of Methyl Isocyanate and Various Other Hazardous Gases, Synthesis of Ethylene Oxide, Oxidation of Ammonia

Unit-V: Microsystems for Energy Generation, Micro devices for Vaporization of Liquid Fuels, Micro devices for Conversion of Gaseous Fuels to Syngas by Means of Partial Oxidations, Hydrogen Generation by Partial Oxidations, Micro devices for Conversion of Gaseous Fuels to Syngas by Means of Steam Reforming

References:

1. Wolfgang Ehrfeld, Volker Hessel, Holger Löwe MicroreactorsNew Technology for Modern Chemistry © WILEY-VCH Verlag GmbH, D-69469 Weinheim (Federal Republic of Germany), 2000.
2. S.V.LuisandE.Garcia-Verdugo,ChemicalReactionsandProcessesunderFlow Conditions, University Jaume I/CSIC, Castello´n, Spain, The Royal Society of Chemistry 2010
3. Madhvanand N. Kashid, Albert Renken,and Lioubov Kiwi-Minsker, Microstructured Devices for Chemical Processing,Wiley-VCH VerlagGmbH &Co. KGaA,Boschstr ©201512,69469Weinheim,German.
4. Hessel,V.,Renken,A.,Schouten,J.C.,Yoshida,MicroProcessEngineering"A Comprehensive Handbook 2009, ISBN 978-3-527-31550-5.

Outcomes: Attheendofthiscourse,studentsareableto:

1. Studentswillunderstandtheroleofmicroflowchemistryandprocesstechnologyin chemical engineering.
2. Thestudentisexpectedtoobtainconsiderableinsightintovarioustypesofmicro reactors.

CH24C PROCESS PLANT DESIGN&FLOW SHEETING TOOLS

Instruction,hours/week:3 Credits:3 Assessment:40+60

Objectives:

1. Understandingofthescope,principles,norms,accountabilitiesandboundsof contemporary engineering practice in the specific discipline.
2. Applicationofestablishedengineeringmethodstocomplexengineeringproblem solving.
3. Applicationofsystematicengineeringsynthesisanddesignprocesses.

Unit-I: Introduction: Basic concepts: General design considerations, Process design development, Layout of plant items, Flow sheets and PI diagrams, Economic aspects and Optimum design, Practical considerations in design and engineering ethics, Degrees of freedom analysis in interconnected systems, Network analysis, PERT/CPM, Direct and Indirect costs, Optimum scheduling and crashing of activities.

Unit-II: Hierarchy of chemical process design; Nature of process synthesis and analysis; Developing a conceptual design and flow sheet synthesis. Synthesis of reaction-separation systems; Distillation sequencing; Energy targets. Heat integration of reactors, distillation columns, evaporators and driers; Process change for improved heat integration. Heat and mass exchange networks and network design.

Unit-III: Flow-sheeting:Synthesisofflowsheet:Propositionallogicandsemanticequations, Deduction theorem, Algorithmic flow sheet generation using P-graph theory, Sequencing of operating units, Feasibility and optimization of flow sheet using various algorithms viz, Solution Structure Generation (SSG), Maximal Structure Generation (MSG), Simplex, Branch-and-bound etc.

Unit-IV: Analysis of Cost estimation: Factors affecting Investment and production costs, Estimation of capital investment and total product costs, Interest, Time value of money, Taxes and Fixed charges, Salvage value, Methods of calculating depreciation, Profitability, Alternative investments and replacements.

Unit- V: Optimum Design and Design Strategy: Break-even analysis, Optimum production rates in plant operation, Optimum batch cycle time applied to evaporator and filter press, Economic pipe diameter, Optimum insulation thickness, Optimum cooling water flow rate and optimum distillation reflux ratio.

References:

1. Peters,M.A.andTimmerhaus,K.D.,PlantDesignandEconomicsforChemical Engineers, McGraw Hill (2003).

2. AnilKumar,ChemicalProcessSynthesisandEngineeringDesign,TataMcGrawHill (1982).

3. Ulrich,G.D.,AGuidetoChemicalEngineeringProcessDesignandEconomics,John Wiley & Sons (1984).

4. Perry,R.H.andGreen,D.,ChemicalEngineer'sHandbook,McGraw-Hill(1997).

Outcomes: Attheendofthiscourse,studentsareableto:

1. Analyze,synthesizeanddesignprocessesformanufacturingproductscommercially
2. Integrate and apply techniques and knowledge acquired in other courses such as thermodynamics,heatandmasstransfer,fluidmechanics,instrumentationandcontrol to design heat exchangers, plateand packed columns and engineering flow diagrams
3. Usecommercialflowsheetingsoftwaretosimulateprocessesanddesignprocess equipment
4. Recognizeeconomic,construction,safety,operabilityandotherdesignconstraints
5. Estimatefixedandworkingcapitalsandoperatingcostsforprocessplants