VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME & SYLLABUS OF TEACHING AND EXAMINATION
2015-2016

SEMESTER VI

CHEMICAL REACTION ENGINEERING-II (Common to CH & PC)					
Subject Codeklkjfkjoi923980289iorwerjejwkfm,m,.zb,bm,.z	:	15CH61	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	04	**Exam Hours**	:	03
Total No. of Lecture Hourasafgee3kjfajqoiotdmadwe9008904ioklsdms	:	50	**Exam Marks**	:	80
Credits	:	04			

Course Objectives:
The students will
1. Be able to understand and apply the principles of non-ideal flow in the design of reactor.
2. Be able to develop rate laws for heterogeneous reactions.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Taxonomy
Module 1 **Content**		
Basics of Non Ideal Flow: Importance & interpretation of RTD, C, E & F curves & Statistical interpretation. Dispersion model. Tanks in series model. Conversion in non- ideal flow reactors for simple systems.	10	L1,L2,L3
Module 2		
Introduction to Heterogeneous Systems: Rate equations, contacting patterns, fluid-particle non catalytic reactions, URC model, Spherical particles of unchanging size, shrinking spherical particles, determination of rate controlling steps. **Fluid-Fluid Non Catalytic Reactions:** Kinetic regimes for mass transfer and reaction; rate equations.	10	L2,L3,L4
Module 3		
Catalysis: Introduction to catalysis. Properties of catalysts. Estimation methods for catalytic properties. Promoters, inhibitors etc, Mechanism of catalysis. Rate equations for different rate controlling step. **Deactivation:** Deactivating catalyst. Mechanism, rate & performance equation.	10	L3,L4,L5
Module 4		
Solid Catalyzed Reactions: Heterogeneous reactions- Introduction, Kinetic regimes. Rate equation for surface kinetics. Pore diffusion resistance combined with surface kinetics. Thiele modulus and	10	L4,L5

enhancement factor, Porous catalyst particles. Heat effects during reaction.		
Module 5		
Solid Catalyzed Reactions (Contd.): Performance equations for reactors containing porous catalyst particles. Experimental methods for finding rates. Packed bed catalytic reactor & reactors with suspended solid catalyst. Fluidized reactors of various type. Gas-Liquid Reactors: Trickle bed, slurry reactors. Three phase fluidized bed.	10	L3,L4,L5

Course outcomes:

After studying this course, students will be able to:

1. Apply theoretical knowledge to distinguish between various RTD curves and predict the conversion from a non-ideal reactor using tracer information.
2. Acquire practical knowledge about design of reactors for non-catalytic and catalytic reactions.
3. Know the use of reactors for gas–liquid operations with and without chemical reaction.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Life - long Learning

TEXT BOOKS:

1. **ChemicalReactionEngineering,**OctaveLevenspiel,3Edition,JohnWiley&Sons, 2001.
2. **ChemicalEngineeringKinetics,**J.M.Smith,3rd Edition,McGrawHill.
3. **ElementsofChemicalReactionEngineering,**H.ScottFoggler,3rd Edition,PrenticeHall, 2001.

REFERENCE BOOKS:

1. **Chemical&CatalyticReactionEngineering,**JamesJ.Carberry,McGrawHill,1976

MASS TRANSFER OPERATIONS-II (Common to CH & PC)					
Subject Code	:	15CH62	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	04	**Exam Hours**	:	03
Total No. of Lecture Hours	:	50	**Exam Marks**	:	80
Credits	:	04			

Course Objectives:
The students will
1. Be able to understand different separation techniques.
2. Be able to design distillation column, absorber and calculations involved in liquid liquid extraction.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Taxonomy
Module 1 **Content**		
Gas Liquid Contacting Systems: Types, construction and working of plate and packed columns, types and properties of industrial packing's, plate efficiencies, HETP and HTU concepts. **Absorption:** Absorption.Solventselectionforabsorption.Materialbalanceandconceptof drivingforceandminimumsolventrates. Multistageabsorptioncolumns.DesignofPlate columns.Absorptionanddesorptionfactors.	10	L1,L2,L3
Module 2 **Content**		
PackedTowerAbsorption:Liquidphaseholdupandpressuredropinabsorptiontowers. Designofpackedtowers(processdesign-heightanddiameter).Multi-componentabsorption. Absorptionwithchemical reaction. **Distillation:**Introduction.Vapourliquidequilibria(T-x,y,P-x,y.H-x,yandx-ydiagramsfor binary mixtures). Relative volatility. Prediction of VLE from vapour pressure data using Raoult'slaw.VLEformulti-component systems.Non-idealsystems.Azeotropes.Immiscible systems.Steamdistillation**,**Flashandsimpledistillation.	10	L2,L3,L4
Module 3 **Content**		
Distillation (Contd.):.Multi-stage rectification column. Design using McCabe Thiele and Lewis-Sorelmethodsforbinarymixtures. **Distillation(Contd.):**Ponchon-Savaritmethod.IntroductiontoMulticomponentdistillation, Vacuum,molecular,extractiveand azeotropicdistillations.	10	L3,L4,L5
Module 4 **Content**		
Liquid-LiquidExtraction:Ternaryequilibrium.Solventselection.Singlestage.Multi-stage cross-current,counter-currentextraction.Equipmentforliquid-liquidextraction.	10	L3,L4, L5

Module 5	Content		
LeachingOperation: Equipmentforleaching.Preparationofsolidsforleaching .Equilibrium diagrams.Calculationof singlestage andmulti-stageleachingoperation.		10	L2,L3,L4

Course outcomes:

After studying this course, students will be able to:

1. Apply theoretical knowledge for separation of components.
2. Acquire practical knowledge about design of mass transfer equipment.
3. Differentiate various separation techniques.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Life - long Learning

TEXT BOOKS:

1. **MassTransferOperations**-RobertE Treybal,3rd Edition,McGrawHill,1981.
2. **UnitOperationsin ChemicalEngineering**-McCabe&Smith,6th Edition,McGrawHill,2001.

REFERENCE BOOKS:

1. **Chemical Engineering VolI, II, IV and V** - Coulson and Richardson, 4th Edition, PergamonPress,1998.
2. **IntroductiontoChemicalEngineering**-Badger&Banchero,TMH6thReprint1998.
3. **Principlesof UnitOperation**-Foust*et.al*.,2nd Edition,JohnWiley,1994.
4. **TransportProcessesandUnitOperation**-GeankoplisCJ,PrenticeHall(I),2000.
5. **AppliedProcessDesignforChemicalandPetrochemicalPlant**Ludwig,2nd Edition,Gulf Publishing,2002.

INDUSTRIAL POLLUTION CONTROL

Subject Code	:	15CH63	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	04	**Exam Hours**	:	03
Total No. of Lecture Hours	:	50	**Exam Marks**	:	80
Credits	:	04			

Course Objectives:
The students will
1. Be able to understand various concepts of water usage and importance.
2. Be able to understand about air, soil and noise pollution and its control.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating and L6 – Creating.

Modules	Teaching Hours	Blooms Taxonomy
Module 1 **Content**		
Introduction: Importanceofenvironmentformankind.Biosphereandlayersofatmosphere. Hydrologicalcycleandnutrientcycles.Typesofpollution. Damagesfromenvironmental pollution. Needofenvironmental legislationsandenvironmentalActsinIndia.Functions of centralandstatepollutioncontrolboards. **Sources,Sampling andAnalysis ofWastewater:**Waterresources.Originofwastewater. Evaluation, classificationandcharacterizationofwastewater. Physicalandchemical characteristics.BOD,CODandtheirimportance.Types ofwaterpollutants andtheireffects. Samplingandmethodsofanalysis.	10	L1,L2,L3
Module 2 **Content**		
WastewaterTreatment: Preliminary,primary,secondaryand tertiarytreatments of wastewater. Sludgetreatmentanddisposal.Advancedwastewatertreatment.Recoveryofmaterialsfrom processeffluents. **ApplicationsToIndustries:**Normsandstandardsoftreatedwater.Origin,characteristics,and treatment methodsintypical industries–petroleum refinery,pulpand paper,fertilizer,distillery, tannery,andtextileprocessing.	10	L2,L3,L4
Module 3 **Content**		
AirPollutionAspects: Natureofairpollution.Classificationofairpollutants.Sourcesofair pollutants.Airqualitycriteriaandstandards.Plumebehavioranddispersionofair pollutants. Effectsof airpollutiononhealth,vegetation,and materials.	10	L3,L4,L5
Module 4 **Content**		
Air Pollution Control: Sampling of pollutants. Methods of estimation of air pollutants. Automobile pollution.Controlmethodsforparticulatesandgaseouspollutants.Origin,control methods,andequipmentusedin typicalindustries – Thermalpowerplants,metallurgical industries,andcementindustries.	10	L4,L5, L6
Module 5 **Content**		

SolidWasteTreatment: Origin,Classificationandmicrobiology.Propertiesandtheirvariation. Engineered systemsforsolidwastemanagement–generation,onsitehandling,storage, collection,transferandtransport,composting,sanitarylandfilling. **NoiseControl:**Sourcesanddefinitions.Determinationofnoiselevels.Noisecontrolcriteria and noise exposure index. Administrative and engineering controls. Acoustic absorptive materials.	10	L3,L4,L5

Course outcomes:

After studying this course, students will be able to:

1. Apply, analyze and identify the environmental problems.
2. Acquire practical knowledge to plan strategies for control and reduce pollution.
3. Apply environmental management systems to industrial activities.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Life - long Learning
5. Collaborative and multidisciplinary work

TEXT BOOKS:

1. **EnvironmentalPollutionControlEngg,**C.S.Rao,2nd Edition,NewAgeInternational Reprint,2002.
2. **PollutionControlinProcessIndustries,**S.P.Mahajan,TataMcGrawHill,22nd Reprint, 1999.

REFERENCE BOOKS:

1. **PrinciplesandPracticesofAirPollutionControlandAnalysis,**J.R.Mudakavi,I.K. InternationalPublishingHomePvt.Ltd.,NewDelhi,2010.
2. **Air Pollution,**H.C.Perkins,McGrawHill,1974.
3. **SolidWasteManagement,**D.J.Hagery*et.al*.,VanNostrandReinhold,1973.
4. **IndustrialPollutionControlHandbook,**Lund,H.F.,6th Edition,Vol.1,McGrawHill, 1971.
5. **NoiseAbatement,**Duerden,Buttreworth,1970.
6. **IntroductiontoEnvironmentalEngg,**Davis.,3rdEdition,McGrawHill,1998.
7. **WasteWaterEngineeringTreatmentDisposalReuse,**Metcalf and Eddy,4th Edition,Tata McGrawHill,2003.
8. **EnvironmentalEngineering, G.N**. Pandey and G.C. Carney, Tata McGraw Hill, 11thReprint,2002.
9. **IntegratedSolidWasteManagement,**GeorgeTchobanoglous*etal*,2nd Edition,McGraw Hill&Co,1993.

PROCESS EQUIPMENT DESIGN AND DRAWING (Common to CH & PC)					
Subject Code	:	15CH64	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	04	**Exam Hours**	:	04

Total No. of Lecture Hours	:	50	**Exam Marks**	:	80
Credits	:	04			

Course Objectives:

The students will

1. Be able to understand advances and types in the design of heat and mass transfer equipment and its accessories.
2. Be able to develop modifications based on design.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Detailedchemicalengineeringprocessdesignofthefollowing equipment should be studied.Standardcodebooksaretobeused.Thedetailedproportionate drawings shallincludesectional frontview,fulltop/sideviewdependingonequipmentandmajorcomponents. 1. **Classwork:** Students areto design the equipment. They s h a l l alsobe trained to draw free hand proportionatesketches. 2.**FinalExamination:**Studentshavetoanswer anyoneofthetwoquestionsgiv enin theexamination.Aftercompletingthedesign,freehandproportionate sketchesaretobe drawnasrequired.	Teachin g Hours	Blooms Taxonom y
Content		
1.DoublepipeHeatexchanger 2.ShellandTubeHeatexchanger 3.Condensers–Horizontalandvertical 4.Evaporator–Singleeffect 5.Sieve TrayDistillationColumn 6.Packed BedAbsorptionColumn 7.RotaryDryer.	07 07 08 07 07 07 07	L1,L2,L3, L4,L5,L6

Course outcomes:

After studying this course, students will be able to:

1. Design and modify process equipment relating to heat and mass transfer.
2. Will handle process parameters to alter and design process Equipment.

Question Paper Pattern:

This question paper will have two questions. Each full question consists of 80 marks. Each full question will have sub questions covering design of the equipment and proportionate drawing Top view, front view and side view of equipment. The students will have to answer any one full question.

Note: ChemicalEngineersHandbook,Perry&Green,McGrawHill,1997.
IS2825,IS4503,B.I.S.,NewDelhi,1969 are permitted for exam and internal.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools

4. Life - long Learning
5. Collaborative and multidisciplinary work

TEXT BOOKS:

1. **ProcessEquipmentDesign-**M.V.Joshi,3rd Edn.,Macmillan&Co. India,Delhi, 1998.
2. **ProcessEquipmentDesign–VesselDesign,**Brownell&Young,JohnWilley,1959.
3. **Process Design of Equipment – Vol1,** S. D. Dawande, 3rd Edn, Central Techno Publications.2003.

REFERENCE BOOKS:

1. **ChemicalEngineersHandbook,**Perry&Green,7th Edn,McGrawHill,1997.
2. **PressureVesselCode–IS2825,**ISCode,B.I.S.,NewDelhi,1969.
3. **Flowof FluidsthroughValves,Fittings&Pipes**,CraneAmazon,2006.

ELECTROCHEMICAL TECHNOLOGY					
Subject Code	:	15CH651	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	03	**Exam Hours**	:	03
Total No. of Lecture Hours	:	40	**Exam Marks**	:	80

Credits	:	03

Course Objectives:
The students will
1. Be able to understand the operation of various types of electrochemical systems.
2. Be able to understand electrochemical corrosion of metals and corrosion protection methods.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules		Teaching Hours	Blooms Taxonomy
Module 1	**Content**		
IntroductionToTheoreticalAspects: Faradayslaws,mechanismofconductioninsolids, liquidsand gases andinionicmelts.Conductioninmetals andsemiconductors. Reversibleelectrodesandpotentials,electrodeprocessesandelectrodekinetics.		8	L1,L2,L3
Module 2	**Content**		
Varioustypesofoverpotentials.Polarisation. Butler-volmerforoneelectronandmuteelectronsteps.ModelsofelectricalDoublelayer.		8	L2,L3,L4
Module 3	**Content**		
Appliedaspects:Potentiometryandion-selectiveelectrodes.Polaroraphy.		8	L2,L3,L4
Module 4	**Content**		
Electrodedepositionofmetals andalloys. PrimaryandSecondaryFuelCells.		8	L1,L2,L3
Module 5	**Content**		
CorrosionAndItsPrevention: Electrowinning.Electroorganicandinorganicsynthesis(and sometypicalexamples).Environmentalelectrochemistry.Bio-electrochemistry**.**		8	L2,L3,L4

Course outcomes:
After studying this course, students will be able to:
1. Apply and control techniques for the electrochemical surface treatment of metals, such as plating and anodizing, with the aim of improving their properties.
2. Understand the mechanism of electrochemical corrosion of metals, use of appropriate design criteria and apply corrosion protection techniques in order to limit corrosion of metals.

Question Paper Pattern:
This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes
1. Critical Thinking
2. Problem solving

3. Use of modern tools
4. Life - long Learning

TEXT BOOKS:

1. **ModernElectrochemistry,**J.O.M.,Bockris&A.K.N.Reddy,Vol.1&2,Plenum,New York2002.
2. **IndustrialElectrochemicalProcesses,**A.Kuhn,Elsevier,Amsterdam,1971.

REFERENCE BOOKS:

1. **ElectroAnalyticalChemistry,**J.J.Lingane,Wiley, NewYork,1958.
2. **Electrochemistry,PrinciplesandApplications,**E.C.Potter,CleaverhumePress,London 1956.
3. **OrganicElectrochemistry,**M.M.Baizer,MarcelDekker,3rdEdition,NewYork,1991.

PETROCHEMICALS					
Subject Code	:	15CH652	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	03	**Exam Hours**	:	03
Total No. of Lecture Hours	:	40	**Exam Marks**	:	80
Credits	:	03			

Course Objectives:
The students will
1. Be able to understand the various types of Carbon compounds and their properties.
2. Be able to understand preparation of petrochemical compounds from different sources.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules		Teaching Hours	Blooms Taxonomy
Module 1	**Content**		
Definition of Petrochemicals: Petrochemical. Industries in India. Principal raw materials. Introductionto chemicalsfromC1,C2,C3 andC4 compounds. **ChemicalsfromC1Compounds:**Manufactureofmethanolandchloromethanes.Manufacture ofperchloroethylene.		8	L1,L2,L3
Module 2	**Content**		
ChemicalsfromC2Compounds: Ethyleneandacetylene,ethanol,polyethylene,ethylene dichloride,acetaldehyde,vinylchloride,ethyleneoxide,ethanolamines,vinylacetate,acetic acid.		8	L2,L3,L4
Module 3	**Content**		
Chemical from C3 Compounds: Isopropanol, acetone, lumen (isopropylbenzene), acrylonitrile,isoprene,polypropylene,epichlorohydrin,propyleneoxide.		8	L2,L3,L4
Module 4	**Content**		
Chemical from C4 Compounds: Butadiene dehydrogenation of butane (Houdry). Dehydrogenationof butylenes.Dehydrogenation-dehydrationofethanol.Steam crackingof hydrocarbons. **ChemicalsfromAromatics**:Primaryrawmaterial.Hydroalkylation.		8	L2,L3,L4
Module 5	**Content**		
Manufactureofphenol–5methods.Styrene–2methods.Phthalicanhydridemaleic anhydride, nitrobenzene,aniline. Manufactureofindustrialdyesbasedonpetroleumfeedstocks**.**		8	L2,L3,L5

Course outcomes:
After studying this course, students will be able to:
1. Differentiate varieties of carbon compounds and their properties.
2. Explain the mechanism of preparation of primary and secondary compounds.

Question Paper Pattern:
This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes
1. Critical Thinking
2. Problem solving

3. Use of modern tools
4. Life - long Learning

TEXT BOOKS:

1. **Petrochemicals,** B.K.BhaskarRao,CRC Press,1990.
2. **ChemicalsfromPetroleum,** A.L.Waddams,2nd Edition,ELBS, London,1970.

REFERENCE BOOKS:

1. **Dryden'sOutlinesofChemicalTechnology,** GopalRaoMand MarshallSittig,3rd Edition, East-WestPress,1997.
2. **ChemicalProcessIndustries,** 5thedition,ShreveandAustin,McGrawHill,1984.
3. **ChemicalTechnology,** G.N.Pandey,3rd Edition,VikasPublishingHousePvt.Ltd.,1977.
4. **ChemicalTechnology,** Mukhlyonov,MirPublications,1982.

FERMENTATION TECHNOLOGY					
Subject Code	:	15CH653	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	03	**Exam Hours**	:	03
Total No. of Lecture Hours	:	40	**Exam Marks**	:	80
Credits	:	03			

Course Objectives:

The students will

1. Be able to understand role of microorganisms in fermentation.
2. Be able to understand the various fermentation technologies used.
3. Be able to learn the production of important products through fermentation.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Taxonomy
Module 1 **Content**		
Introduction to fermentation & Microbial Growth Kinetics: History and development of fermentation, general requirements of the fermentation, range of fermentation processes, parts of a fermentation process- upstream and downstream processing, aerobic and anaerobic fermentation, solid state and submerged fermentation. Batch culture (Quantifying cell concentration, Growth patterns and Kinetics), Continuous culture, Comparison of batch and continuous cultures in industrial processes, Fed batch culture, Examples of use of fed batch cultures.	8	L1,L2,L3
Module 2 **Content**		
Isolation, preservation Pathways and improvement of industrial Microbes: Isolation, preservation Improvement of industrially important microorganisms, DNA techniques Induction, carbon catabolite repression, crab tree effect, feedback Inhibition and repression	8	L2,L3,L4
Module 3 **Content**		
Media, Sterilization inoculum for industrial fermentations: Introduction, Typical media, Energy sources, Carbon sources, Nitrogen sources, Buffers, Oxygen requirements, Antifoams, Medium optimization, Medium sterilization: The design of batch sterilization processes, The design of continuous sterilization processes, Sterilization of the fermenter, feeds and air, Filter sterilization The development of inocula for yeast , bacterial and fungal processes, The aseptic inoculation of plant fermenters	8	L2,L3,L4
Module 4 **Content**		
Aeration agitation & Design of fermenter: The oxygen requirements and supply of industrial fermentations, Determination of K_{La}, Factors affecting K_{La} values, balance between oxygen supply and demand, Basic function of a fermenter for microbial or animal cell culture, body construction,	8	L2,L3,L5

and various parts of a fermenter.			
Module 5	**Content**		
Important products through Fermentation: Organic acids: citric and acetic acid; enzymes: amylase, protease, lipase; antibiotics: penicillin; vitamins: vitB12; amino acids: lysine, Glutamic acid; organic solvents: ethanol, acetone butanol; alcoholic beverages: wine, beer; biomass: baker's yeast ; bio fertilizers; bio pesticides; bio surfactant; steroid transformation; biopolymers		8	L2,L3,L4

Course outcomes:

After studying this course, students will be able to:

1. Appreciate the use of microorganisms for the production of value added commodities.
2. Describe key industrial bioprocesses, from the traditional to the recently evolved.
3. Integrate biological and engineering principles involved in the production and recovery of commercial products.
4. Develop critical thinking skills and learn to employ a quantitative, scientific approach towards conversion of biological materials to value added products.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Life - long Learning

TEXT BOOKS:

1. **Biochemical Engineering,** Bailey &Ollis, McGraw Hill.

REFERENCE BOOKS:

1. **Principles of Fermentation Technology** – Stan bury P.F., Whitaker A, Hall S. J.
2. **Bioprocess Engineering: Basic concepts** – Shuler M.L., Kargi F. (PHI)

PULP AND PAPER TECHNOLOGY					
Subject Code	:	15CH654	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	03	**Exam Hours**	:	03
Total No. of Lecture Hours	:	40	**Exam Marks**	:	80
Credits	:	03			

Course Objectives:

The students will

1. Be able to understand the wood chemistry, basic pulp and papermaking processes from different raw materials.
2. Be acquainted with raw material characteristics, physical and mechanical concepts, nomenclature and procedures related to evaluating paper and paper board product properties
3. Be able to learn Chemical recovery systems and bleaching of mechanical pulps. Treatment of effluent.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Taxonomy
Module 1 **Content**		
WoodChemistry: Chemicalcomposition-cellulose,hemicellulose,lignin,woodextractives, rawmaterial.Qualityparametersunderevaluation.Yieldofrawmaterial. **Pulping:**Generalprinciple ofpulping.Typesof pulpingprocesses:mechanical,chemical,semi-chemical,sulphate process, Kraftprocess. Processcalculations. Rawmaterialutility requirements.Processflowsheetanddescription. Washingandbleaching.Commonunit operation.Woodtreatment,digestion,evaporation,dryingwithequipmentused.	8	L1,L2,L3
Module 2 **Content**		
TreatmentofPulp:Screening,washing,refining,thickeningofpulp.Bleaching-conventional andnon-conventionalbleachingtechniques. **PaperMaking:**Preliminaryoperationsonpulp.Beatingandrefiningofpulp.Non-fibrous materials. Fillers and loadingmaterial.Internalsizing.Wetand additivesurfacetreatment.Paper coloring.Surfacesizing.	8	L2,L3,L4
Module 3 **Content**		
Paper Drying and Finishing: Types of dryers. Calendaring. Reeling and winding.Paper machinedrives,cutting,windingand rewinding.Conversionofpapers.	8	L2,L3,L4
Module 4 **Content**		
PaperQualityofGrades: Differentgradesofpaperquality.Parametersandtheir evaluation. Saturationofpaper.Specialgradepapers.Recyclingof wastepapers.	8	L2,L3,L5
Module 5 **Content**		

SupportiveOperations: Chemicalrecovery– waterbalance,oxidation,evaporationofblack liquor,lime recovery.Qualitycontrolandsafetyaspects. **Environmental Aspects:** Effluent characteristics of pulp and paper industries. Treatment methods.	8	L2,L3,L5

Course outcomes:

After studying this course, students will be able to:

1. Apply the fundamental chemical principles of making pulp and paper in the industry.
2. Optimize pulping operations to achieve maximum pulp bleaching ability and strength properties.
3. Advice pulp and paper makers on how to control environmental pollution.
4. Identify requirements for process control and quality assurance in pulp and paper manufacturing processes.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Life - long Learning
5. Collaborative and multidisciplinary work

TEXT BOOKS:

1. **Pulpand PaperChemistryandTechnology**,Casey,J.P.,2nd Edition,InterScience,1960

REFERENCE BOOKS:

1. **Handbookof Pulp andPaperTechnology**,BrittK.W.,ReinholdPublicationCorp.,1964.
2. **Pulpand PaperScienceandTechnology**,LibbyC.E.Vol1to3,McGrawHill,1962.

FOOD TECHNOLOGY

Subject Code	:	15CH661	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	03	**Exam Hours**	:	03
Total No. of Lecture Hours	:	40	**Exam Marks**	:	80
Credits	:	03			

Course Objectives:

The students will

1. Be able to impart knowledge to the students about food processing and various unit operations involved in it, packaging, storing and preservation, food poisoning, food related hazards and safety.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 – Creating.

Modules	Teaching Hours	Blooms Taxonomy
Module 1 **Content**		
IntroductionandQualityAttributesofFood: Functionoffoods.Foodinrelationto health. Aimoffoodscienceandtechnology.Quality attributes–Appearancefactors,Texturalfactors, Flavorfactors.Visualandobjectively measurableattributes.Aromaoffoods–introductory ideas,formation,chemistryandanalysis.Taste–introductory ideas, formationandchemistry. Additionalquality;qualitystandards,qualitycontrol. Introduction tosensory evaluationof foodsandbeverages. **ModernTrendsInFoodScience:**Biotechnologyinfood.Biofortification,Nutraceuticals. Organic foods.Lowcostnutrientsupplements.Packagingoffoods andnutritionlabeling.Careers in foodscience andfoodindustries.	8	L1,L2,L3
Module 2 **Content**		
FormationandChemistryofFood: Carbohydrates.Proteins.Lipids.Vitamins.Minerals. Water.Biotin.Choline.Phytochemicals. **FoodProcessingandPreservation:**Fooddeterioration– Causes.Aimsandobjectivesof preservationandprocessing. Unitoperationsinprocessing.Differentmethodsoffood preservation– lowtemperature,hightemperature, preservatives,osmoticpressure,dehydrations. foodirradiation;processingandpreservations ofmilkanddairy,vegetablesandfruits,cereals, legumesandnuts,meatandmeatproducts, fatsandoils,beverages,sugars,sweeteners,honey andconfectionary,saltandspices.	8	L2,L3,L4
Module 3 **Content**		
EnzymaticandNon-EnzymaticReactionsDuringStorages: Introduction toenzymes.Nature andfunction ofenzymes.Classificationofenzymes.Hydrolases– Esterace,amylases,pecticenzymes.Proteases.Oxidoreductases – phenolases,glucoseoxidase,catalose,peroxidase, lipoxygenase,xantineoxidase.Immobilizedenzymes.Usesandsuggesteduseso	8	L2,L3,L4

fenzymein foodprocessing.Non-enzymaticreactions.			
Module 4	**Content**		
FoodAdditives: Introduction andneedforfoodadditives.Typesofadditives–antioxidants, chelating agents,coloring agents,curingagents,emulsions,flavorsandflavorenhancers,flavor improvers,humectantsandantichokingagents,leavening agents,nutrientsupplements, non-nutritivesweeteners,pHcontrolagents.Preservatives – typesandapplications.Stabilizersand thickeners,other additives.Additivesandfoodsafety. **FoodContaminationandAdulteration:**Typesofadulterantsandcontaminants.Intentional adulterants. Metallic contamination.Incidentaladulterants. Natureandeffects.Food lawsand standards		8	L2,L3,L5
Module 5	**Content**		
Environmental ConcernsAndFoodSafety: Waterinfoodproduction.Propertiesand requirementsofprocessing water.Environmentalconcerns–solidwastedisposal,wastewater properties,wastewatertreatment.Safetyhazardsandrisks.Foodrelatedhazards. Processingand handling.Cleaningandsanitizing.		8	L2,L3,L5

Course outcomes:

After studying this course, students will be able to:

1. Explain the various causes of food deterioration and food poisoning.
2. Identify appropriate processing, preservation, and packaging method.
3. Analyze product quality and effect of processing technique on it.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools

TEXT BOOKS:

1. **FoodScience,**B.Srilakshmi,4th Edn,NewAge International,2007.
2.**Foods:FactsandPrinciples,**N.ShakuntalaManayandM.Shadaksharamurthy,NewAge Publishers,2005.

REFERENCE BOOKS:

1.**IntroductiontoFoodScience,**RickParker,ThomsanDetmer,2001.
2.**FoodProcessingandPreservation,**G.SubbulakshmiandShobhaA.Udupi,NewAge International,2001.
3.**FoodScience,**NormanN.PotterandJosephH.Hotchkin,1st Edition,AviPublishingCo, 1968.
4.**Principlesof FoodChemistry,**JohnMDeMan,3rd Edition,Springer,1999

SUGAR TECHNOLOGY					
Subject Code	:	15CH662	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	03	**Exam Hours**	:	03
Total No. of Lecture Hours	:	40	**Exam Marks**	:	80
Credits	:	03			

Course Objectives:

The students will

1. Be able to understand scenario of India Sugar industry.
2. Be acquainted with raw material characteristics, physical and chemical properties.
3. Be able to learn methods and analyze products and byproducts.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Taxonomy
Module 1 **Content**		
SugarIndustry InIndia: Chemicalandphysicalpropertiesofsucroseandreducing sugars. Sourcesforsucrose. Formationof sucroseplants.Non-sugarcompoundsof sugarcane.Inorganic constituentsofsugarcanejuicesandsugarsanalyticalmethodsusedinsugarindustry. **Purification**: Chemical technologyof thepurification process. Fundamental reactions and physicalchemistry aspectsofclarification,liming,sulphitationandcarbonation process. Filtrationofsugarjuice.	8	L1,L2,L3
Module 2 **Content**		
Evaporation: Evaporationofsugarjuice.Heattransferinevaporations. Evaporationequipment andauxiliaries. **Evaporation(Contd..):**Methodsofobtainingsteam,andqualityofsteam.Steameconomy. Chemistryoftheevaporationprocess.	8	L2,L3,L4
Module 3 **Content**		
Crystallography: Solubilityofsucrose.Nucleationinsupersaturatedsolutions–kineticsand growthofcrystallization.Chemistryofcrystallization.Controlmethodsandequipmentinsugarcrystallization,technologyofsugar crystallization.Evaporationandcirculationinvacuumpans.	8	L2,L3,L4
Module 4 **Content**		
Centrifugation: Theoryofthecentrifugalprocess,centrifugaloperation.	8	L2,L3,L5
Module 5 **Content**		
Centrifugation: Engineeringprinciplesofsugarcentrifugalandthecentrifugalequipmentand auxiliaries. Productionoffinal molassesand molasses'sutilization.Gradingof sugar.	8	L2,L3,L5

Course outcomes:

After studying this course, students will be able to:

1. Apply the fundamentals in production of Sugar.
2. Evaluate the yield of the sugar based on different raw materials.
3. Grade sugar and byproducts.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Life - long Learning
5. Collaborative and multidisciplinary work

TEXT BOOKS:

1. **PrinciplesofSugarTechnology,**HoningP.,Vol.ItoIII,ElsevierPublishingCompany,1953.
2. **IntroductiontoCaneSugarTechnology,**Jenkinos.G.H,Elsevier,1966.

REFERENCE BOOKS:

1. **HandbookofCaneSugarTechnology,**MathurR.B.L,2nd Edition,OxfordandI.B.H. PublishingCo.,1997.
2. **HandbookofSugars,**Pancoast,H.M,andJunk,W.R.,2nd Edition,AVIPublishingCo. Inc.,Connecticut,1981.

PETROCHEMICAL ENGINEERING					
Subject Code	:	15CH663	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	03	**Exam Hours**	:	03
Total No. of Lecture Hours	:	40	**Exam Marks**	:	80
Credits	:	03			

Course Objectives:

The students will

1. Be able to study the Prospects, Growth, Economy related to Petrochemical Industry.
2. Be able to study various feed stocks employed.
3. Be able to study heat & mass transfer operations related to Petrochemical Industry.
4. Be able to study reactors employed and engineering problems encountered at Petrochemical Industry.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Taxonomy
Module 1 **Content**		
Introduction: The growth of petrochemical industry, Global & Indian scenario, Feed stocks for Petrochemicals, Natural gas Refinery gasses, Sources, Composition of natural gas, Properties, Storage Heating value and flammability limits of natural gas. Refinement of Natural Gas: Acid gas removal: Metal oxide process, Slurry process, Amine process, Carbonate washing process, Sulphur recovery process. Dehydration, Technology of Liquefied Natural Gas	8	L1,L2,L3
Module 2 **Content**		
CRACKING: Thermal, Catalytic, Product distribution, Steam cracking, Thermodynamics of Steam cracking of Natural gas, Naphtha and Heavy distillates, Products of steam cracking, Production of Hydrogen, Synthesis gas, Methanol, Reaction features. Reactors for steam cracking. Engineering Problems associated	8	L2,L3,L4
Module 3 **Content**		
Thermo dynamical and Technological principles involved in Alkylation, Oxidation, Nitration Hydrolysis processes employed at petrochemical industry.	8	L2,L3,L4
Module 4 **Content**		
Thermo dynamical and Technological principles involved in Sulphonation, Sulfation and Isomerization processes employed at petrochemical industry	8	L2,L3,L5
Module 5 **Content**		
Petro Chemicals from Aromatics: Feed stocks, Hydro alkylation. Thermodynamics, Kinetics Rectors features Product distribution Engg. Problems associated	8	L2,L3,L5

Course outcomes:

After studying this course, students will be able to:

1. Explain the various technologies of petrochemicalengg.
2. Evaluate the thermo dynamical and kinetic aspects.
3. Explain the various engineering problems associated with petrochemical industries.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Life - long Learning
5. Collaborative and multidisciplinary work

TEXT BOOKS:

1. Bhaskara Rao, B.K., "A Text on Petrochemicals", Khanna Publishers, 2000.
2. SukumarMaiti, "Introduction to Petrochemicals", 2nd Edition, Oxford and IBH Publishers, 2002.
3. Dryden, C.E., "Outlines of Chemical Technology", 2nd Edition, Affiliated East-West press, 1993

REFERENCE BOOKS:

1. Margaret Wells, "Handbook of Petrochemicals and Processes", 2nd Edition, Ash Gate Publishing Limited, 2002.
2. Sami Matar, and Lewis F. Hatch., "Chemistry of Petrochemical Processes", 2nd Edition, Gulf Publishing Company, 2000.

POLYMER AND PLASTIC ENGINEERING					
Subject Code	:	15CH664	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	03	**Exam Hours**	:	03
Total No. of Lecture Hours	:	40	**Exam Marks**	:	80
Credits	:	03			

Course Objectives:

The students will

1. Be able to understand the basics of polymers, sources, structure, properties.
2. Be able to understand plastics, manufacturing aspects, properties and uses.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Taxonomy
Module 1 **Content**		
Polymer Basics– classifications based on occurrence, types, process, and end uses. Polymerization Kinetics and mechanism of free radical, cationic, anionic, living polymers and coordination polymerization– Ziegler Natta catalysts, monometallic mechanism, stereo regular polymerization, chain transfer reaction and constant.	8	L1,L2,L3
Module 2 **Content**		
STRUCTURE, PROPERTIES AND REACTION OF POLYMERS Functionality,tactility of polymer, microstructure, chemical and geometrical structure, ladder,Star and telechelic polymers, interpenetrating networks-Polymers-crystalline amorphous nature, Crystallizability-effect on properties. Reactions of polymer molecules with specific groups OH, CHO, C=O, COOH and $–NH_2$ and polymer–cross linking, cyclisation–polymer degradation,thermal,Mechanical, photo and radiation. Properties of Polymers.	8	L2,L3,L4
Module 3 **Content**		
BIO AND INORGANIC POLYMERS Naturally occurring polymers, starch, proteins, cellulose, Derivatives of cellulose polymers, Rayon, cellophane, cellulose acetate, butyrate and nitrate , ethyl cellulose, carboxy methyl Cellulose-preparation, properties, application organometallic polymers, co-ordination polymers, Polyamides, Inorganic polymers- phosphorous and nitrogen containing polymers, silicones, Hybrid polymers.	8	L2,L3,L4
Module 4 **Content**		
PLASTICS: Feed stocks, Classifications, Resins, Plastics Natural & Synthetic, Code Identification. Olefins synthesis and production of LDPE, HDPE, CPE, homo& copolymers. Polypropylenes& polypropylenes	8	L2,L3,L5

Module 5	**Content**		
ENGINEERING PLASTICS: Acrylics, Polyamides, Poly-tetrafluoroethylene, feed stocks, Synthesis Processing & Applications		8	L2,L3,L5

Course outcomes:

After studying this course, students will be able to:

1. Apply the fundamentals in reactions of polymers.
2. Differentiate types of polymers based on application.
3. Apply knowledge of plastics and its properties in engineering applications.

Question Paper Pattern:

This question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Life - long Learning
5. Collaborative and multidisciplinary work

TEXT BOOKS:

1. **F.W. Billmayer**, Text Book of Polymer Science, 3rd edition, John Wiley and sons, New York, 2002.
2. **R.J. Young**, Introduction to Polymers, Chapman and Hall Ltd., London, 1999.

REFERENCE BOOKS:

1. **Gorge Odeon** – Principles of Polymerization, 4th edition, McGraw Hill Book Company, New York. 2004.
2. **PremamoyGhosh**," Polymer Science and Technology, 2nd edition, McGraw-Hill Publishing Company Limited, New Delhi, 2003.
3. **V.R. Gowarikar**, Polymer Science, New Age International Pvt. Ltd Publishers, 2010.
4. **M G Aurora, M Singh**, Introduction to Polymer Science Amol Publications.

CHEMICAL REACTION ENGINEERING LABORATORY					
Subject Code	:	15CHL67	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	1I + 2P	**Exam Hours**	:	03
Total No. of Lecture Hours	:	42	**Exam Marks**	:	80
Credits	:	02			

Course Objectives:

Students will

1. Experimentally verify the principles and working of Reactors studied in theory.
2. Carry out experiment and make observations for various parameters.
3. Study and use various Reactors for determining rate constant and conversion.
4. Evaluate the data and compare with reported literature.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

The following experiments are to be carried out; the data are to be analyzed based on the theoretical aspects, and recorded with comments.	Blooms Level
1. Batch Reactor	L4,L5
2. Isothermal plug flow reactor	L4,L5
3. Mixed flow reactor	L4,L5
4. Semi batch reactor	L4,L5
5. Heterogeneous catalytic Reactor	L4,L5
6. Segregated flow reactor	L4,L5
7. Adiabatic Reactor	L4,L5
8. Packed bed Reactor	L3,L4,L5
9. RTD Studies in Tubular Reactor	L3,L4,L5
10. Effect of temperature on Rate of reaction	L4,L5
11. Bio Chemical Reaction (Batch)	L4,L5
12. Enzyme catalyzed reactions in batch reactor	L4,L5
13. RTD Studies in mixed flow reactor	L4,L5
14. Sono-chemical reactor	L4,L5
15. Photochemical reactor	L4,L5

Course outcomes:

After studying this course, students will be able to:

1. Apply theoretical knowledge of various types of reactors.
2. Acquire practical knowledge of reactors.
3. Know the use of skills in handling various reactors.

Conduct of Practical Examination:

1. Minimum of 10 experiments are to be conducted and all 10experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes

1. Critical Thinking
2. Usages of Modern Tools
3. Collaborative and Multidisciplinary Work
4. Life Long Learning
5. Independent and Reflective Learning

TEXT BOOKS:

1. **ChemicalReactionEngineering,**OctaveLevenspiel,3Edition,JohnWiley&Sons, 2001.
2. **ChemicalEngineeringKinetics,**J.M.Smith,3rd Edition,McGrawHill.
3. **ElementsofChemicalReactionEngineering,**H.ScottFoggler,3rd Edition,PrenticeHall, 2001.

REFERENCE BOOKS:

1. **Chemical&CatalyticReactionEngineering,**JamesJ.Carberry,McGrawHill,1976

MASS TRANSFER OPERATIONS LABORATORY					
Subject Code	:	15CHL68	**IA Marks**	:	20
No. of Lecture Hrs/Week	:	1I + 2P	**Exam Hours**	:	03
Total No. of Lecture Hours	:	42	**Exam Marks**	:	80
Credits	:	02			

Course Objectives:

Students will

1. Experimentally verify the mass transferconcepts studied in theory.
2. Carry out experiment and make observations for various mass transfer equipment.
3. Study the effect of mass transfer coefficients in design of equipment.
4. Evaluate the performance characteristic for different mass transfer cases.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

The following experiments are to be carried out; the data are to be analyzed based on the theoretical aspects, and recorded with comments.	Blooms Level
1. Diffusion of organic vapours in air	L3,L4,L5
2. Simple Distillation	L3,L4,L5
3. Packed column/ plate column distillation	L3,L4,L5
4. Steam distillation	L3,L4,L5
5. Solid – liquid leaching	L3,L4,L5
6. Surface evaporation	L3,L4,L5
7. Tray dryer	L3,L4,L5
8. Adsorption studies	L3,L4,L5
9. Liquid-liquid/Vapour –liquid equilibrium	L3,L4,L5
10. Liquid extraction – (cross current: 1 and 2 or 3 stage)	L3,L4,L5
11. Hold up studies in packed columns	L3,L4,L5
12. Rotary/ vacuum dryers	L3,L4,L5
13. Wetted wall column	L3,L4,L5
14. Cooling tower	L3,L4,L5
15. Solid dissolution	L3,L4,L5
16. Gel-electrophoresis	L3,L4,L5

Course outcomes:

After studying this course, students will be able to:

1. Apply theoretical knowledge of various mass transfer equipment.
2. Acquire practical knowledge of mass Transfer Equipment.
3. Know the handling of Mass transfer operations.

Conduct of Practical Examination:

1. Minimum of 10 experiments are to be conducted and all 10experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes

1. Critical Thinking
2. Usages of Modern Tools
3. Collaborative and Multidisciplinary Work
4. Life Long Learning
5. Independent and Reflective Learning

TEXT BOOKS:

1. **MassTransferOperations-**RobertE Treybal,3rdEdition,McGrawHill,1981.
2. **UnitOperationsin ChemicalEngineering**-McCabe&Smith,6th Edition,McGraw Hill,2001.

REFERENCE BOOKS:

1. **Chemical Engineering VolI, II, IV and V -** Coulson and Richardson, 4th Edition, PergamonPress,1998.
2. **TransportProcessesandUnitOperation-**GeankoplisCJ,PrenticeHall(I),2000.