MECM 101 - SEPARATION PROCESSES

UNIT- I

Mechanisms of Mass Transport, steady and molecular diffusion, Equimolar counter diffusion, Diffusion asa Mass flux, Thermal Diffusion, Multicomponent gas phase system: Molar Flux in terms of effective diffusivity,Maxwells law of Diffusion, Diffusivities in solids liquids, gases. Steady state molecular diffusion in fluids at rest and in laminar flow, Unsteady State Diffusion.

UNIT - II

Mass transfer in turbulent flow- eddy diffusion and prandtl mizing length,Mass Trasfer through a phase boundry Two film theory, Penetration Theory The Film Penetration theory,Surface Renewal theory,Diffusion in Liquids. Velocity in Mass Transfer. Mass Transfer in Turbulent Flow:Renolds Analogy,Chilton Colburn Analogy

UNIT - III

Boundry Layer: Introduction, Momentum Equation , The Turbulent Boundary Layer: The turbulent portion, The laminar sub layer,Boundary Layer Theory applied applied to a pipe flow: Entry Conditions,Application of the Boundary layer theory.

UNIT – IV

Principle of membranes separation process, classification characterization & preparation of membrane,membranes modulus &application ,liquid membranes and industrial application.

UNIT - V

Ternary and multicomponent system fractionation theories: Multicomponent Mixture: Equilibrium Data,Feed and Product Composition, Light and Heavy key components,Calaulation of a number of plates required for a given separation, Minimum Reflux Ratio,No of Plates at total reflux, Relation bet Reflux ratio and no of plates. Brief Description about Azeotropic and Extractive distillation.

REFERENCE BOOK

1. Coulson &Richardson Volume 1, Edition 6(Chemical Engineering)
2. Coulson &Richardson Volume 2, Edition 6(Chemical Engineering)
3. B.K. Datta. “Separation process Technology“
4. J.D. Seader “Separation process principles” Second Edition
5. Nath K. Membrance separation Technology PHI

MECM 102 - ADVANCED TRANSPORT PHENOMENON

UNIT-I

Velocity distribution in laminar flow The equations of change for isothermal flow: creeping flow around a solid sphere Equations of continuity, equation of motion, the equation of mechanical energy, application of Navier-Stokes equation to solve problems like falling film,flow in a tube, shape and surface of a rotating fluid.

Unit-II

Velocity distribution in turbulent flow, microscopic balance for isothermal system macroscopic balance for non isothermal system.

UNIT-III

Temperature distribution in solids and in laminar flow , The equations of change for nonisothermal flow:Equations of energy, ,use of equations of change to set up steady state heat transferproblems,

UNIT – IV

Temperature distribution in turbulent flow energy transport by radiation. Temperature fluctuations and the time smoothed temperature . time smoothing energy equation semi empirical expression for the turbulent energy flux.

UNIT-V

Concentration distribution in solid and in laminar flow The equations of change for multi component systems: Concentration distribution in turbulent flow macroscopic balance for multicomponent system.

REFERENCE BOOKS:

1. Transport Phenomena R.B.Bird, W.E.Stewart and E.N.Lightfoot, Wiley international Edition, NewYork 2002.
2. Advanced transport Phenomena, J.C. Slattery Cambridge series in Chemical Engg., 1999.
3. Transport Processes And Unit Operations-Geankoplis

MECM 103- REACTOR DESIGN

UNIT-I
Models for Non-Ideal flow Reactors: Two- parameter models- Real CSTR modeled using bypass and dead space, real CSTR modeled as two CSTR interchange, testing a model and determining its parameters.

UNIT-II
Catalysis and catalytic reactors: Design of reactors for gas solid reactions. Heterogeneous data analysis for reactor design; catalyst deactivation – Types of Deactivation, Moving bed Reactors,Packed Bed Catalytic Reactor, Reactors with Suspended Solid Catalyst.

UNIT-III
External diffusion effects on heterogeneous reactions- External resistance to mass Transfer: Mass transfer coefficient, mass transfer to a single particle, mass transfer limited reactions in packed beds, The Shrinking Core Model.

UNIT-IV
Introduction of Heterogeneous Reactions, Diffusion and reaction in porous catalysts- Diffusion andreaction in spherical Catalyst pellets, internal effectiveness factor, Falsified Kinetics, Overall effectiveness factor.G/L Reactions on Solid Catalyst: Trickle Beds, SlurryReactors, Fluidized Bed Reactors.

UNIT-V
Non- isothermal reactor design- energy balance, nonisothermal adiabatic , CSTR, PFR, low,reactors at steady state, equilibrium conversion; multiple steady states- ignition- extinction curve.

UNIT-VI
Distribution of residence times for chemical reactors- ResidenceTime Distribution (RTD) Function, Measurement of the RTD, and Characteristics of the RTD, RTD in Ideal Reactors,Zero-Parameter Models, RTD and Multiple Reactions.

REFERENCE BOOKS:
1. Octave Levenspiel, “Chemical Reaction Engineering”, Wiley Eastern University, 3rd Edition New Delhi (2001).
2. Fogler, H.S., “Elements of chemical reaction engineering”, Prentice Hall, 4th Ed. New Jersey (1986).
3. Lannyd. Schmidt, “The Engineering of Chemical Reaction”, University of Minnesota.
4. Stanley M. Walas, “ Chemical Reaction Engineering Handbook Of solved Problems”, University of Kansas, Lawrence.

MECM 104- ADVANCED HEAT TRANSFER

UNIT-I

General equation of change for energy. heat conduction equation in cylindrical coordinate,spherical coordinates. Heat conduction through a hollow cylinder. Critical thickness of insulation.

UNIT-II

Steady and unsteady state conduction is one, two and three dimensional cases. Finite difference method in steady and unsteady conduction. Two dimension steady state heat conduction in rectangular plates and semi infinite plates. Transient heat conduction in solid with finite conduction and convective resistance.

UNIT-III

Forced Convection: Laminar flow over flat plate Momentum equations of hydrodynamic boundary layer over a flat plate. Blasius solution of laminar boundary layer flows. Laminar and turbulent flow over a flat plate, turbulent flow in tube, cylinder and sphere. Analytical and semi analytical solutions.

Free convectionMomentum and energy equations for laminar free convection heat transfer on a flat plate. Equations for velocity and temperature in vertical and horizontal planes for cylinders and spheres.

UNIT-IV

Radiation heat transfer concepts. Angle factor calculation. Network method of analysis of radiation exchange. Radiation calculation through gas and vapors.

UNIT - V

Design of compact heat exchanges, Heat transfer due to boiling liquefied metal heat transfer. Heat exchanger effectiveness and number of transfer unit.

REFERENCES BOOKS:

1. Process Heat Transfer, D.Q. Kern
2. Heat Transfer J.P. Holman
3. Heat and mass transfer R.K. Rajput
4. Fundamental of engineering heat and mass transfer. R.C.Sachdeva

MECM105 - PROCESS MODELLING AND SIMULATION

UNIT-I

Introduction to modeling, a systematic approach to model building, classification of models.Conservation principles, thermodynamic principles of process systems.

UNIT-II

Development of steady state and dynamic lumped and distributed parameter models based onfirst principles.

UNIT-III

Development of grey box models. Empirical model building. Statistical model calibration and validation. Population balance models. Examples.Solution strategies for lumped parameter models. Stiff differential equations.

UNIT-IV

Solutionmethods for initial value and boundary value problems. Euler's method. R-K methodshooting method, finite difference methods. Solving the problems using matlab library package.

UNIT-V

Solution strategies for distributed parameter models. Solving parabolic, elliptic andhyperbolic partial differential equations. Finite element and finite volume methods.

REFERENCES:

1. K. M. Hangos and I. T. Cameron, "Process Modelling and Model Analysis",Academic Press.
2. W.L. Luyben, "Process Modelling, Simulation and Control for Chemical Engineers",2nd Edn., McGraw Hill Book Co., New York.
3. W. F. Ramirez, "Computational Methods for Process Simulation", 2nd ed.,Butterworths.
4. Mark E. Davis, "Numerical Methods and Modelling for Chemical Engineers", John Wiley & Sons.
5. Singiresu S. Rao, "Applied Numerical Methods for Engineers and Scientists" Prentice Hall, Upper Saddle River, NJ.

MECM201-PROCESS PLANT OPTIMIZATION TECHNIQUES

UNIT- I

Introduction to optimization and its scope in chemical process design, Developing Models for Optimization, Formulation of objective function, Optimization Theory and Methods:Basicconcept of optimization of Unconstrained Function,One dimensionalsearch, Unconstrained Multivariable optimization.

UNIT- II

Linear programming and Applications, Simplex Method,Nonlinear programming with constraints, quadratic programming, successive quadratic programming.

UNIT- III

Mixed integer programming, Optimization in large scale plant design and operation, integrated planning, scheduling and control in the process industries.

UNIT- IV

Application of optimization:Heat transfer and Energy conservation, SeparationProcess, Fluid flow system, chemical reaction design and operation.

UNIT- V

Optimization and Functions of a Complex Variable and Numerical Analysis:Gauss siedal method, Gauss elimination method, Eulers Method, Modified Euler Method and Runga-Kutta Method for Ordinary Differential Equations, Tranzoidal Rule and Simpson's 1/3 and 3/8 Rules.

REFERENCE BOOKS

1. Optimization of the Chemical Process Edgar, Himmelblau, Lasden.
2.Numerical Methods in Engineering and Science Dr B.S Garewal
3. Optimization theory and practice, G.S. Beveridge and R.S.Schechter, McGraw Hill, Newyork.
4. Engineering Optimization-Methods and Applications, Reklaitis,G.V., Ravindran, A., and Ragsdell,K.M., John Wiley, New York

MECM 202 -COMPUTER AIDED DESIGN FOR PROCESS EQUIPMENTS

UNIT- I

General design consideration, Optimum design, Property estimation, Material and Energy balance, introduction to special software for steady and dynamic simulation of chemical engineering systems

UNIT- II

Computer aided design of heat transfer equipment. Design of double heat exchangers, shell and tube heat exchangers, condensers and evaporators.

UNIT- III

Computer aided design of mass transfer equipment. Design of mass transfer equipments: Design of distillation column, Absorption tower bothplate as well as packed type

UNIT- IV

Computer aided design of chemical reactors, Batch reactor, continuous stirred tank reactor and Plug flow reactor.

UNIT- V

Interactive computer graphics and drafting Simulation software, spread sheeting,Flowsheeting software, Integrated software system, development of software programs.

REFERENCES

1. Bruce A Finlayson “Introduction to Chemical Engineering Computing”, Wiley Student Edition.
2. James M. Douglas “Conceptual Design of Chemical Processes”, McGraw Hill, New York.
3. M.S Peter and K.D. Timmerhaus, R.E West, “Plant design and economics for chemical engineers”, McGraw Hill
4. B.C. Bhattacharyya and C.M. Narayanan, “Computer Aided Design of Chemical Process Equipment", New Central Book Agency (P) Ltd., New Delhi.
5. Robert G. Squires,“Computer Applications in chemical Engineering: Process Design & simulation”
6. Alexandre C. Dimian, “Integrated Design and Simulation of Chemical Processes”, Elsevier.
7. B. Wayne Bequette, “Process Dynamics: Modeling, Analysis and Simulation”, Prentice Hall International Series.

MECM 203 - ADVANCED PROCESS DYNAMICS & CONTROL

UNIT-I

Review of first and higher order systems, closed and open loop response. Dynamic behavior,stability analysis and design of feedback controllers and Cohen-Coon controller tuning. Control valve types linear, equal percentage and quick opening valve. Design of valves.

UNIT-II

Frequency response analysis, design of control system, Controller tuning and process identification. Zigler-Nichols tuning methods, Bode-Nyquist Plots, Bode stability Criterion,Nyquist stability Criterion. Feedback Control of systems with large dead time or inverse response.

UNIT-III

Control systems with multiple loops, Advance control techniques cascade, selective and split – Range control, feed forward and ratio control, adaptive and inferential control systems.

UNIT- IV

Synthesis of alternative control configurations for MIMIO processes. Interaction and Decoupling of control loops, RGA and the selection of loops .Design of non-interacting control loops.Design of control systems for complete plants.Tuning of multivariable controllers.

UNIT-V

Sample Data Controllers: Basic review of Z transforms, Response of discrete systems to various inputs. Open and closed loop response to step, impulse and sinusoidal inputs, closed loop response of discrete systems. Design of digital feed back controllers. Introduction to control of non-linear systems

REFERENCE BOOKS

1. 'Process Systems analysis and Control', D.R. Coughanour, Mc.Graw Hill, II Edition, 1991.
2. 'Process Dynamics and Control', D.E.Seborg, T.F.Edger, and D.A.Millichamp, John Wiley and Sons, II Edition, 2004.
3. 'Principle and Practice of Automatic Process Control', C.A.Smith and A.B.Corripio, John Wiley and Sons, 1985.
4. 'Process Modelling Simulation and Control for Chemical Engineers', W.L.Luyben, McGraw Hill, II Edition, 1990.
5. Chemical Process Control – Theory and Practice', Stephanopoulous, Prentice Hall of India Ltd.1984.
6. Process control: Modeling, Design and simulation, B.Wayne Bequette PHI, 2003.
7. Chemical Process Control " An Introduction to theory & Practices, Stephanopoulos, PHI.
8. Process Dynamics, Modeling and Control, Babatunde O, W. Harmon Ray, Oxford University Press.
9. Process Dynamics and control. D.E. Seborg, T.F. Edgar, D.A. Mellichamp Wiley.

MECM 204 - PRODUCTIVITY AND MANAGEMENT'

UNIT- I

Introduction to operations research – Development of operational research, definition,characteristics, scopes, opportunity and operation research in problem solving. Limitations of operational research and applications. Differences between manufacturing and serviceoperations.

UNIT- II

Model, types of model, constructing model and deriving solution from model, operations research model in practices, computer software for operational research. Approach of the assignment model, models with price Breaks, with Restrictions.

UNIT- III

Duality theory, Primal Dual relationships in formulation and their solutions, Sensitivity Analysis,Dual Simplex Method. Transportation problem – Formulation, Optimal solution, unbalanced transportation problem.

UNIT- IV

Optimization- Techniques, planning and control models (Network techniques), deterministic case. Maximization and Minimization problem – Development and construction. PERT and CPM analysis Difference between CPM and PERT.

UNIT- V

Analysis for operations management, cost data for operations management – Break even analysis, investment analysis

REFERENCE BOOKS

J.K.Sharma Operations Research Theory & Applications
Pream Kumar Gupta, D.S. Hira, Operations Research
J.K Sharma Operations Research Theory and Application

MECM205- INDUSTRIAL POLLUTION CONTROL

UNIT-I

Major problems and pollution in environment, Environmental gradients, Tolerance and adaptation, Environmental laws and Provisions, Guidelines for pollution and health aspects for different industries, environmental impact assessment, environmental auditing

UNIT- II

Problems concerned to air pollution and its effects, meteorological aspects of air pollution,chemical and photochemical reactions in atmosphere, Principles and designing of air pollution controlling and abating instruments, Mitigating measures

UNIT-III

Sources of water pollution and standards for waterfor different purposes, water treatment, effect of waste water on ecology Noise pollution, its measurement and mitigating measures

UNIT-IV

Sources and classification of solid waste, properties of solid waste, transportation and treatment of MSW and ISW (Industrial Solid Waste), Hazardous waste, its storage and treatment

UNIT-V

Basic concepts of LCA, Waste minimization by reuse and recycling, Case study for different industries for waste minimization and environmental perspectives.

REFERENCES:

1. Environmental Engineering, Gerard Keily; Tata McGraw Hill Pub.
2. C. S. Rao, Environmental Pollution Control Engineering; New Age International Publishers
3. H.S.Peavy, D.R.Rowe and George Tchobanoglous, Environmental Engineering; McGraw Hill International

MECM-301(A) DATA BASE FOR PROCESS PLANT DESIGN

UNIT-I

Shell and Tube Heat Exchanger Design: 1-2 parallel –counter flow: Shell and Tube Exchanger, Flow arrangements for increased heat recovery, Calculations for Process conditions.

UNIT-II

Multiple Effect Chemical Evaporation: Calculations of Chemical Evaporators, Solution of industrial problems: concentration of cane sugar liquors – forward feed, Evaporation of paper pulp waste liquors – backward feed, caustic soda concentration – forced circulation evaporators.

UNIT-III

Vaporizers and Reboilers: Vaporizing processes, Reboiler arrangements, Classification of vaporizing exchangers, Heat flux and temperature difference Limitations, Relation between maximum flux and maximum film coefficient,

UNIT-IV

Towers: Introduction, Contacting Devices, Choice between Packed Columns and Plate columns,Tower Packings, Choice of plate types, Transfer unit calculations, Column diameter. Packed Towers: Introduction, Type and Size of Packings, Flooding, Pressure Drop, Foam, Holdup,Degree of Wetting, Column Diameter, Height of Packing,

UNIT-V

Introduction, Sieve Trays: Tower Diameter, Plate Spacing, Entrainment, Weepage, Tray Layout,Valve trays: Flooding and Entrainment, Tray Spacing, Foaming Tray type, Tray diameter and Lay out, Hydraulic Parameters.

REFERENCE BOOK:

1. Process Heat Transfer by D.Q.Kern, Mc Graw Hill Co., 1997.
2. Process Plant Design by Backhurst and Harker Amercian ElservierPub.Co., Heinmann Chemical Engineering Series, 1973.
3. Process Equipment Design by M.V.Joshi, McMillan India,1996.
4. Coulson and Richardson Chemical Engineering Volume 6 Pergamon Press.

MECM -301(B) BIOCHEMICAL ENGINEERING

UNIT-I
Introduction to microbiology: Biophysics and the cell doctrine, the structure of cells, important cell types,from nucleotides to RNA and DNA, amino acids into proteins.

UNIT-II
Kinetics of enzyme catalyzed reaction: the enzyme substrate complex and enzyme action, simple enzyme kinetics with one and two substrates, other patterns of substrate concentration dependence, modulation and regulation of enzyme activity, other influences on enzyme activity.

UNIT-III
Immobilized enzyme technology: enzyme immobilization, industrial processes, utilization and regeneration of cofactors. Immobilized enzyme kinetics: effect of external mass transfer resistance, analysis of intra particlediffusion and reaction.

UNIT-IV
Kinetics of cellular growth in batch and continuous culture, models for cellular growth – unstructured,structured and cybernetic models. Thermal death kinetics of cells and spores

UNIT-V
Introduction to metabolic pathways, biosynthesis, transport across cell membranes, end products ofmetabolism, stoichiometry of cell growth and product formation.

UNIT- VI
Transport phenomena in bioprocess systems: Gas-liquid mass transfer in cellular systems,determination ofoxygen transfer rates, overall kLa' estimates and power requirements for sparged and agitated vessels, scaling of mass transfer equipment, heat transfer.

REFERENCE
1. Biochemical engineering fundamentals by J.E.Bailey and D.F.Ollis, 2nd Ed,1986,McGraw Hill.
2. Bioprocess Engineering by Michael L. Shuler and Fikret Kargi, 2nd edition, Pearson education education
3. Biochemical engineering by James M.Lee – Prentice-Hall-1992.
4. Biochemical engineering by Aiba, Humphrey and Mells, academic press.
5. Bioprocess engineering principles, Pauline M. Doran, Academic Press.
6. Biochemical Engineering, H.W. Blanch and D.S. Clark, Marcel Dekker, 1997

MECM -301(C) NANOTECHNOLOGY IN CHEMICAL ENGINEERING

UNIT- I

Nano materials and nano composites: Introduction, surface of nanoparticles, thermal phenomena, surface energy-general considerations, phase transitions, thermodynamics, heat capacity of nano particles, Phase transformations of nanoparticles, nanoparticle Structure fluctuations.

UNIT- II

Gas Phase Synthesis of Nanoparticle: Fundamental considerations, inert gas condensation,physical and chemical vaporsynthesis, laser ablation, Microwave plasma process, flame aerosolprocess, coated particle synthesis of nano particles, sol-gel and Hydrothermal processes,freeze drying attrition, Chemical vapor deposition methods for producing nano particles.

UNIT- III

Properties of nano particles:
a) Magnetic properties: super paramagnetic properties, applications, exchange coupled magnetic nano materials.
b) Optical properties: quantum confinement, quantum dots and other lumophores, metallic and semiconducting nano particles, special luminescent nano particles, electroluminescence,electrochromic and photochromic materials, magneto-optic applications.

UNIT- IV

Electrical properties: electrical conductivity in nano-rods andnanotubes, Photoconductivity of nano-rods, electrical conductivity of nano composites.Mechanical Properties: General considerations, influence ofgrain size, sintering temperature,super plasticity, filled polymer composites, nano fluids and applications of nano fluids.

UNIT- V

Carbon Nanotubes: nano rods and nano plates, Layeredstructures, compounds with layers structures, nano tubes and nanorods from materials other than carbon.Thin films: Kinetic theory of gasses, concepts vacuum, Thermal evaporation, sputtering, ion implantation concepts in nanomaterial science.

REFERENCE BOOKS

1. Nano Materials & Introduction to Synthesis, Properties &Application. Dieter Vollath, Wiley VCH 2006.
2. Handbook of nanophase and nanostructured materials Vol1,2,3,4 Zhong Lin Wang, Yi Liu and Ze Zhang, Academic-Plenum Pblisher, 2002.
3. Nano technology, Richard booker, Earl Baysen Wiley Cheamtech, 2005.
4. Nano Materials, A.K. Bandyopadhyay New Age International Publishers, 2008 .

MECM -302 (A) DESIGN OF PIPING SYSTEMS FOR CHEMICAL PLANTS

UNIT-I

Fundaments of fluid flow through pipes-Calculation of pressure drop for Newtonian & non-Newtonian fluids, incompressible & compressible fluids and two-phase flow, Calculation of economic pipe diameter, insulation thickness, equivalent length, Slurry transport and pipelines

UNIT-II

Engineering flow diagram, nomenclature and equipment elevation Piping layout, line pressure drop, piping analysis, stress analysis of curved pipelines, yard piping

UNIT-III

Piping codes, standards and specifications-ASME, ASTM, API Piping components-pipes, pipe ends, pipe fittings, end fittings, flanged joints, valves, valve codes and standards, valve classification, valve components, bolts, gaskets (fasteners and sealing elements)

UNIT-IV

Piping materials-selection, cost and installation Design of heat exchanger piping, Thermosyphon reboiler piping, Pressure relief piping Steam tracing design, Thermowell design, Expansion loops and expansion joints

UNIT-V

Design of pipeline network-Pinch analysis Pipeline operation and maintenance-friction reduction, cleaning, coating, wear, leak detection, water hammer

REFERENCES

1. Peter Smith, Fundamentals of piping design, Gulf Publishing HouseKellog, Design of pipeline systems
2. Sahu, Handbook of Piping Design

Grading IIIrd Semester w.e.f.2011-12

MECM 302-(B) ENERGY MANAGEMENT

UNIT-I

Introduction to sources of Energy : Solar Energy, WindEnergy , Bio Mass , Chemical Energy,Magneto hydro dynamics, Geothermal, Ocean Energy, Nuclear Energy. Present usage levels.

UNIT-II

Solar Energy: Solar Radiation and its measurements, solar energy collectors: Flat plate collectors, concentrating collectors, Storage of Solar energy techniques: Thermal storage, Latent heat storage, Electrical, Chemical Storage, Mechanical Energy storage, solar pond.

UNIT-III

Energy from Biomass: Solid, liquid and gaseous biofuels conversion Techniques: Anaerobic digestion, Fermentation, Chemical reduction, Liquefaction, gasification, Hydrogenation and oil extraction. Bio gas generation: Factors affecting biodigestion for Biomass, energy audit,energy conservation & reuse.

UNIT-IV

Chemical Energy Sources : Fuel Cell : Operation of afuel cell, Classification of fuel cells ,Advantages and disadvantages of a fuel cell, conversion efficiency of a fuel cell, Polarization in fuel cells Hydrogen Energy: Hydrogen production methods: Electrolysis, Thermo-Chemical methods, Fossil Fuel methods.

UNIT- V

Electrochemical Energy Conversion & Storage:EMF, reversible cells and irreversible cells,reversible electrodes, free energy changes and emf in cells, effect of cell temperature on batteries, derivation of number of electrons involved in a cell reactions, constant power, effect of battery design. Primary batteries, secondary batteries – lead acid, nickel cadmium, nickel metal hydride, silver oxide zinc system, energy management in chemical process plants

REFERENCE BOOKS

1. Culp, A, " Principles of Energy Conversion" MCGraw Hill,1979.
2. G.D. Rai, " Energy Sourses" , Khanna Publishers, 2008.
3. Mr. Barak, "Electrochemical Power sources", I.E.E. series Peter Peregrinus Ltd. Steverage,U.K 1980, reprint 1997.
4. Linden D and Thomas B.Reddy, "Hand Book on Batteries and Fuel Cell", McGraw Hill Book Co.,New York, 3rd Edition, 2002.
5. J.P. Gabano, "Lithium Batteries", Academic Press, London, 1983.

MECM-302(C) FLUIDIZATION

ENGINEERINGUNIT-I
INTRODUCTION
The fluidized state, Nature of hydro dynamic suspension particle-particle forces, species of fluidization, Regimization of the fluidized state, operating models for fluidizations systems,Application of fluidization systems.

UNIT-II
HYDRODYNAMICS OF FLUIDIZATION SYSTEMS
General bed behavior pressure drop, Flow regimes, Incipient fluidization, pressure fluctuations,phase hold ups, Measurement techniques, Empircial correlations for soilds holdup, iquid holdup and gas holdup, Flow models - generalized wake model, structural wake model and other important models.

UNIT -III
SOLIDS MIXING AND SEGREGATION
Phase juxtaposition operation shifts, Reversal points, Degree of segregation, Mixing segregation equilibrium, Generalized fluidization of poly disperse systems, liquid phase mixing and gas phase mixing.

UNIT-IV
HEAT AND MASS TRANSFER FLUIDIZATION SYSTEMS
Mass transfer - gas-liquid mass transfer, Liquid soild mass transfer and wall to bed mass transfer,Heat transfer - column wall - to - bed heat transfer, Immersed vertical cylinder-to-bed heat transfer, Immersed horizontal cylinder to-bed heat transfer.

UNIT-V
MISCELLANEOUS SYSTEMS
Conical fluidized bed, Moving bed, Slurry bubble columns, Turbulent bed contactor, Two phase and three phase inverse fluidized bed, Draft tube systems, Semi fluidized bed systems, Annular systems, typical applications, Geldart's classification for power assessment, Powder characterization and modeling by bed collapsing.

REFERENCES:
1. Gas-Liquid-Solid Fluidization Engineering, Liang-Shih Fan, Butterworths, 1989.
2. Fluidization Idealized and Bubbleless, with Applications, Mosoon Kwauk, Science Press,1992.
3. Fluidization Engineering, O. Levenspiel and D. Kunii, John Wiley, 1972.