SHIVAJI UNIVERSITY, KOLHAPUR.

Proposed Syllabus For Part-I Sem-I
M.E. (Chemical Engineering), w.e.f. Academic Year 2014-2015

Sr. No.	Name of the Subject	Teaching Scheme		Examination			Total Marks
		L	T/P	T/W	TP	ORAL	
1	Advanced Momentum and Heat Transfer	03	01	25	100	---	125
2	Advanced Chemical Engineering Thermodynamics	03	01	25	100	---	125
3	Process Modeling in Chemical Engineering	03	01	25	100	---	125
4	Elective I	03	01	25	100	---	125
5	Elective-II	03	01	25	100	---	125
6	Advanced Computational Laboratory	---	02	25	---	25	50
7	*Seminar-I	---	02	25	---	---	25
Total		15	09	175	500	25	700

Sr. No	**ELECTIVE-I**	**Sr. No**	**ELECTIVE-II**
1	Nano-Technology	1	Catalysis and Surface Phenomena
2	Green Technology	2	Bioprocess Engineering
3	Pharmaceutical Biotechnology	3	Materials Engineering
4	---	4	Process and Equipment Design

M.E. (Chemical Engineering), Part:-I Sem.-II

Sr. No.	Name of the Subject	Teaching Scheme		Examination			Total Marks
		L	T/P	T/W	TP	ORAL	
1	Advanced Mass Transfer	03	01	25	100	---	125
2	Modern Reaction Engineering	03	01	25	100	---	125
3	Chemical Process Control	03	01	25	100	---	125
4	Elective-III	03	01	25	100	--	125
5	Elective-IV	03	01	25	100	---	125
6	Analytical Laboratory	---	02	25	---	25	50
7	*Seminar-II	---	02	25	---	---	25
8	Comprehensive Viva	---	----	----	----	50	50
Total		15	09	175	500	75	750

Sr. No	ELECTIVE-III	Sr. No	ELECTIVE-IV
1	Computational Fluid Dynamics'	1	Project Management
2	Energy Engineering	2	Advance Separation techniques
3	Research Methodology	3	Downstream Process Technology
4	---	4	Operational research

M.E. (Chemical Engineering), Part:-II, Sem.-III

Sr. No.	Name of the Subject	Teaching Scheme		Examination			Total Marks
		L	T/P	T/W	TP	ORAL	
1	Inplant Training	--	--	50	--	--	50
2	*** Dissertation Phase-I	-	05	50	--	50	100
Total		--	05	100	--	50	150

M.E. (Chemical Engineering), Part:-II, Sem.-IV

Sr. No.	Name of the Subject	Teaching Scheme		Examination			Total Marks
		L	T/P	T/W	TP	ORAL	
1	*** Dissertation Phase II	-	05	100	-	100	200

* For Seminar I, II, work load will be for One batch of 09 (Nine) students.

** Open Elective-
Students can take any subject from other Discipline being conducted in the same Institute and with the consent of their guide.

*** For Dissertation phase I and Dissertation phase II, work load will be for one student.

B
Accredited By NAAC

SHIVAJI UNIVERSITY, KOLHAPUR.

Revised Syllabus of

(M.E. Chemical Engineering Part –I & II)

To be introduced from the academic year 2014-15

(i.e. from July 2014) Onwards

(Subject to the modifications will be made from time to time)

Shivaji University, Kolhapur

M.E. (CHEMICAL ENGINEERING) PART-I

1. Advanced Momentum and Heat Transfer

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit- I

Basic Concepts: Forces and tresses, stress tensor properties constitutive equation.

Boundary Layer Flow: Boundary layer equations, separation of BL, Blasius solution for flat state, properties of BL equation, Similarity solutions, Momentum integral equations.

Unit- II

Turbulent Flow: Reynolds equation for turbulent flow, velocity distribution for flow in pipe. Statistical theory of turbulence. Effect of wall roughness, drag reduction etc.

Non-Newtonian Fluids: Rheological behavior of non-Newtonian fluids, laminar flow in cylindrical tubes, laminar flow between parallel plates, laminar flow in annuli. Generalized relationship for power law model.

Unit-III

Agitation And Mixing: Agitation of liquids, Mixing mechanisms (Laminar mixing, Turbulent mixing), Circulation, Velocities in stirred tanks. Flow patterns in stirred tanks, Power consumptions in stirred vessels, mixing equipments.

Multiphase Flow: Two phase gas vapor liquid flow, horizontal and vertical flow of gas-liquids, liquids, gas-solid mixtures, slip and hold up effect, phase separation and settling behavior, analysis of stratified and bubble flow, formation of bubbles and drops and their size distribution and hold up in different flow system, momentum and energy relations.

Motion In The Fluidized Bed: Conditions for fluidization, behavior of the fluidized, minimum fluidization velocity, different types of fluidization, particulate fluidization, bubbling fluidization, semi-fluidization, mixing and segregation in fluidized bed, application of fluidization.

REFERENCES:

1. "The Flow of Complex Mixture in Pipes" by Govier and Aziz.
2. "Chemical Engineering" by Coulson and Richardson, Volume I.

Section-II

Unit-I

Introduction: Brief Introduction to different modes of heat transfer; Conduction: General heat conduction Equation-Initial and Boundary conditions, Steady State Heat Transfer, Transient heat conduction; Lumped system analysis, heat transfer analogies, heat transfer to liquid metals.

Turbulent Forced Convective Heat Transfer: Momentum and energy equations - turbulent boundary layer heat transfer – mixing length concept - turbulence model, Heat pipe.

Unit-II

Heat Transfer In Two Phase Systems: Mechanism of nucleation pool boiling and flow boiling, heat transfer regimes and low maps. Condensation: Basic process, on planner surface, inside and over pipe of pure and multicomponent vapors. Heat transfer in paced bed and fluidized beds. Overall pressure drop and void calculation methods. Flow regims in two phase flow. Drift flux model, annular flow, critical flow, flow instabilities, homogeneous flow, and separated flow.

Non-Newtonian Flow Heat Transfer: Comparative study of Newtonian and non-Newtonian fluid in context with heat transfer, Newtonian and non-Newtonian heat transfer in circular tube, coils and other configuration, Non-Newtonian heat transfer in PFR, CSTR. Generalised relationship of power law fluid, forced convection heat transfer to Bingham plastic and power law fluid in circular conduits.

Unit-III

Mechanisms of heat transfer in packed, fluidized and moving bed rector, heat transfer in dilute phase transport, application of basic heat equation in a design use of heat transfer in furnaces, pipe still, thermo siphoning and other industries.

Heat Transfer Augmentation: Active and passive techniques, rough surface, swirl flow generation and compound augmentation. Compact heat exchangers.

References:

1. D.G. Knudsan and D. L. Katz. Fluid Dynamics and Heat transfer. Mc-Graw Hill, 1958
2. H. P. Skelland "Non Newtonian flow and Heat transfer" John Wiley 1867
3. Hewitt G F, Shires G L, Bott T R, Process heat transfer CRC process (NY) 1994
4. HArison & Davidson, Fluidization Engg, Mc-Graw Hill, 1968

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2. Advanced Chemical Engineering Thermodynamics

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit-I

Detailed review of thermodynamics laws and basic concepts : Concepts of entropy, Specifications of the equilibrium state, Intensive and extensive variables, Equations of state, Enthalpy, Gibbs free energy and other important thermodynamic properties.

Unit-II

Equilibrium and Stability in one component systems : The criteria for equilibrium , Stability of thermodynamic system, Phase equilibria: Applications of equilibrium and stability criteria to the equations of state. The molar Gibbs free energy and fugacity of a pure component. Specifications of the equilibrium thermodynamics state of system of several phases. The gibbs phase rule for one component system. Thermodynamic properties of phase transitions Problems.

Unit-III

The Thermodynamic of Multi Component Mixtures : The thermodynamic description of mixtures. The partial molar gibbs free energy and the generalized Gibbs – Duhem equation. A

notation for chemical reactions. The equations on change for a multicomponent system. The heat of reaction and convection for the thermodynamic properties of reacting mixtures. The specification of the equilibrium. Thermodynamic state for a multicomponent multi phase system. The Gibbs phase rule Problems.

Unit-IV

The estimation of the Gibbs free energy and fugasity of a component in mixture : The ideal gas mixture , The partial molar mixture properties. The fugasity of a species in gaseous, liquid and solid mixtures. Several correlative liquid mixture (activity coefficient) models Problems. Vapor liquid equilibrium using activity coefficient models, problems.

Unit-V

Chemical equilibrium and the balance equations for chemically reacting systems : Chemical equilibrium in a single phase system, Heterogeneous chemical reactions, Chemical equilibrium when several reactions occur in single phase, the balance equation for a tank type chemical reactors, a balance equation for a tubular reactor, overall reactor balance equations, problems.

Unit-VI

Introduction to Statistical thermodynamics : Classical and quantum mechanics , the canonical ensemble, other ensembles and fluctuations, microstates, macrostates and thermodynamic probability , Physical models, Boltzmann statistics, Fremi-Dirac stastics and Bose – Einstein stastics,Ideal monoatomic gas and diatomic gas, Partition function, Phase space, Equipartition of energy.

Text Books :

1) Chemical Engineering Thermodynamics – Stanlay Sandler IInd edition Wiley graham in chemical engineering.

References :

1) Introduction to Chemical Engineering Thermodynamics : J.M. Smith, H.C.Vanness McGraw Hill International book company.
2) The Principles of Chemical Equillibrium , Kenneth Denbiegh , Cambridge University Press.
3) Chemical Process Principles – Part II (IInd Edition) O.A.Hougen,K.M.Watson R.A.Rogatz.
4) Chemical Engineering Thermodynamics – B.F.Dodge McGraw Hill
5) Statistical Thermodynamics
6) Thermodynamics – by J.P.Holman IVth edition McGraw Hill Inter.
7) Statistical thermodynamics- M.C.Gupta Wiley Eastern Ltd.

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3. Process Modeling in Chemical Engineering

Teaching Scheme:		**Examination Scheme:**
Lectures	**: 3Hours per week**	**Theory Paper : 100 Marks**
Tutorial	**: 1Hour per week**	**Term Work : 25 Marks**

Unit-I

Introduction to dynamic models: Mass balance equation - Balancing procedure, Case studies: CSTR, Tubular reactor, Coffee percolator, Total mass balance – Case Studies: Tank drainage, Component balances - Case Studies: Waste holding tank, Energy balance- Heating in a filling tank, Parallel reaction in a semi continuous reactor with large temperature difference, Momentum balances – Dimensionless model equations, CSTR, Gas liquid mass transfer in a continuous reactor**.**

Modeling of stage wise processes: Reactor Configurations, Generalized model description, Heat transfer to and from reactors, Steam heating in jacket, Dynamics of the metal jacket walls, Batch reactor – Constant volume, Semi - batch reactor, CSTR - Constant volume CSTR, CSTR cascade, bubble column reactor, Reactor stability.

Unit-II

Mass transfer models: such as liquid-liquid extraction, distillation, Multicomponent separation, multi component steam distillation, absorber- stage wise absorption, steady state gas absorption with heat effects, evaporator**.**

Model Discrimination And Parameter Estimation: Rate equations, Linear and non-linear regression analysis, Design of experiments, Factorial, Central, fractional design, Evolutionary operation techniques, Case studies.

Unit-III

Lumped and distributed system: Distributed system- Counter current heat exchanger, Flasher design, Condensation, Definition of lumped parameter model**.** Mathematical models of heat-transfer equipments: Shell & tube heat exchangers, Evaporators, Fired heaters, Partial condensers. Plug flow reactor, Plug flow reactor contactors, Liquid –liquid extraction column dynamics .

Unit-IV

Flow sheet simulation : Process flow sheet simulation; Process and information matrix, Recycle calculation sequence; Materials and Energy balance computation using modular approach; Process analysis, Process variables, selection, Equipment selection.

Unit-V

Dynamic simulation: Dynamic simulation of Reactors, distillation column, Absorbers, evaporators and crystallizes, introduction to simulation packages like GPSS, CSMP.

Unit-VI

Process Simulators: Introduction to professional simulator like Aspen.Hysys and Mathematical tools like MATLAB, Introduction to SIMULINK and Poly Math etc.

Application Of Optimization: Heat transfer and energy conservation, Separation techniques, Fluid flow systems, Chemical Reactor design.

Reference Books:

1. C. L. Smith, R. L. Pike and P. W. Murill, “Formulation Optimization of Mathematical odels”,

International Text, Pennsylvania, 1970.
2.. John Ingham, Irving, J. Dunn, Elmar, Heinzle Jiri, E. Prenosil, "Chemical Engineering Dynamics", VCH Publishers Inc., New York, 1974.
3. Roger G. E. Franks, "Modeling and Simulation in Chemical Engineer", Wiley Inter Science, New York, 1972.
4. R. W. Gaikwad, Dr. Dhirendra, "Process Modeling and Simulation", Central Techno Publications, Nagpur, 2003.
5. Edgar, T.F. and D.M. Himmelblau - " Optimization of Chemical Processes ", McGraw Hill BookCo., New York, 1989.
6. Lubeyn W.L. "Process Modeling, Simulation and Control Engineering ", McGraw Hill Book Co., New York, 1990.
7. Chemical Engineering Tutorial Numerical methods, Chemical Engineering, August 17, October 26, 1987 Feb. 15, April 25, July 18, Nov. 21, 1988, July 14, 1989.
8. Chemical Engineering Tutorial Statistics for Chemical Engineers, Chemical Engineering., July 23, 1985, Feb. 3, April 14, June 23, Sept. 1, 1986.

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4. Elective-I

4.1 Nanotechnology

Teaching Scheme:		**Examination Scheme:**
Lectures	**: 3Hours per week**	**Theory Paper : 100 Marks**
Tutorial	**: 1Hour per week**	**Term Work : 25 Marks**

Unit-I

Introduction to Nanotechnology: History, Importance of Nanoscales, Fundamental concepts(Bottom-up and Top-down processes).

Unit-II

Application of Nanotechnology.

Unit-III

Nanomaterials: Fundamental concept of nanomaterial, Materials used in nanotechnology, carbon nanotubes-properties

Unit-IV

Synthesis, Purification, Application of Nanomaterials.

Unit-V

Recent Advances in Nanotechnology

Unit-VI

Intellectual property rights on Nanotechnology: Importance of IP Protection, copy rights and trade secrets

Reference Books:

1.“Principles of Nanotechnology” , Phani umar
2.”Nanomaterials”,Vishwanathan
3.”The Nanoscope” Encyclopedia of Nanoscience and NanotechnologyVol I to Vol 6, Edited by Dr.Parag Diwan and Ashish Bharadwaj

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4.2 Green Technology

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit I

Introduction to Organic Chemistry /Analytical Chemistry /Basic Chemical Engineering

Unit II

Introduction to Green Chemistry: Principles of Green Chemistry, Reasons for Green Chemistry (resource minimisation, waste minimisation, concepts), Green reactions solvent free reactions, Catalyzed (heterogeneous/homogeneous) reactions, MW/ Ultrasound mediated reactions, Bio catalysts etc

Unit III

Introduction to Pharmaceutical Process Chemistry: Introduction to process chemistry, the difference between synthesis and process,

Unit-IV

Rote design, Route optimization, DOE

Unit-V

Role of Analytical Chemistry in Process Chemistry Role of Process Safety in Process Chemistry: TH classification, MSDS, Thermal Hazards, Waste segregation and disposal.

Unit-VI

Scale-up aspects including PE in Process Chemistry: Case Studies; New Initiatives : Micro reactors.

References:

[1] James H.Clarke & Duncan Maacquarrie, Handbook of Green Chemistry and Technology, Wiley-Blackwell; 1 edition (2002)
[2] Paul T.Anastas and John C. Warner, Green Chemistry: Theory and Practice, Oxford University Press, USA (2000)
[3] M.Lancaster, Green Chemistry (Paperback), Royal Society of Chemistry; 1 edition (2002)
[4] Stanley E.Manahan, Green Chemistry and the Ten Commandments of Sustainability, 2nd ed (Paperback), ChemChar Research Inc (2005)
[5] Albert Matlack, Introduction to Green Chemistry (Hardcover), CRC Press; 1 edition (2001)
[6] Kenneth M.Doxsee and James Hutchison Green Organic Chemistry: Strategies, Tools,

and Laboratory Experiments (Paperback), Brooks Cole; 1 edition (May 7, 2003)
[7] Green Chemistry in the Pharmaceutical Industry, Peter Dunn (Editor), Andrew Wells (Editor), Michael T. Williams (Editor), Wiley-VCH (2010)
[8] Handbook of Green Chemistry – Green Solvents (Hardcover), Walter Leitner (Editor), Philip G. Jessop (Editor), Chao-Jun Li (Editor), Peter Wasserscheid (Editor), Annegret Stark (Editor), Paul T. Anastas, Wiley-VCH (2010)

4.3 Pharmaceutical Biotechnology

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit-I

Drug Development in Pharmaceutical Process- Production of pharmaceuticals by genetically engineered cells (hormones, interferrons) - Microbial transformation for production of important pharmaceuticals (steroids and semi-synthetic antibiotics)

Unit-II

Techniques for development of new generation antibioticsl,Protein engineering, drug design, drug targeting.

Unit-III

Disease Diagnosis and Therapy,ELISA and hybridoma technology,DNA vaccine,Gene Therapy, Toxicogenomics.

Unit-IV

Proteomics in Drug Development,Role of Proteomics in Drug Developmen.

Unit-V

Diagnosis of disease by Proteomics,Separation and identification techniques for protein analysis,Development of antibody based protein assay for diagnosis.

Unit-VI

Diagnosis and Kit Development,Use of enzymes in clinical diagnosis, Use of biosensors for rapid clinical analysis,Diagnostic kit development for microanalysis.

References:

1. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (ed), Concepts in Biotechnology, University
Press, 1996
2. Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London

5. Elective-II

5.1 Catalysis and Surface Phenomena

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit-I

Introduction of Catalysis : Classification of Catalysis - Homogeneous, Heterogeneous, Biocatalysts, Preparation of catalysis - Laboratory Techniques, Industrial methods, Transition models, Dual functional catalysts, Zeolites, Enzymes, Solid Catalysts, Powder Catalysts, Pellets, Composition, Active ingredients, Supportive materials, Catalysts activation.

Unit-II

Catalysts Characterization: Surface area measurements, BET Theory, Pore size distribution, Porosimetry Chemisorption techniques, Static and dynamic methods, Crystallography and surface analysis techniques, XRD, XPS, ESCA, ESR, NMR, Raman and Masbauar spectroscopies, Surface acidity and toxicity, Activity, Life time, Bulk density, Thermal stability etc.

Unit-III

Theories of Catalysts: Crystal structure and its defects, Geometric and electronic factors, Analysis of transition model catalysis, Chemistry and thermodynamics of adsorption, Adsorption isotherms - Langmuir model, Tempkin model, Freundich model, Elovich equation, Langmiur Hinshel - wood model, Rideal - Eely mechanism, Reversible - irreversible mono and bimolecular reactions with and without inerts, Determination of rate controlling steps, Inhibition, parameter estimation.

Unit-IV

Mass and Heat Transport in Porous Catalysts : Internal and external transport, fixed bed, Fluidized bed reactors, Effect of internal transport on selectivity. Effectiveness factor and Thiele modulus.

Unit-V

Catalyst Deactivation : Poisons, sintering of catalysts, Pore mouth plugging and uniform poisoning models, Kinetics of deactivation, Catalyst regeneration.

Unit-VI

Industrial Catalysis : Industrial catalysts preparation methods, Typical industrial catalytic processes, Case studies, Catalytic deactivation prevention methods, New techniques for catalyst characterization, Overall study.

References:

1. Emmett, P.H. - “Catalysis Vol. I and II, Reinhold Corp.", New York, 1954.

2. Smith, J.M. - “Chemical Engineering Kinetics ", McGraw Hill, 1971.
3. Thomas and Thomas - “Introduction to Heterogeneous Catalysts ", Academic Press, London 1967.

5.2 BIOPROCESS ENGINEERING

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit-I

Review of fundamentals of microbiology and biochemistry. Bioprocess principles: Kinetics of biomass production. Substrate utilization and product formation.

Unit-II

Batch and continuous cultures. Fed batch culture introduction. Fermentation processes. General requirements of fermentation processes.

Unit-III

An overview of aerobic and anaerobic fermentation processes. Examples of simple and complex media. Design and usage of commercial media for industrial fermentation. Thermal death kinetics of microorganisms. Heat sterilizations of liquid media. Filter stabilizations of liquid media and air.

Unit-IV

Enzyme technology- Microbial metabolism enzymes classification and properties. Applied enzyme catalysis-kinetics of enzyme catalytic reaction. Metabolic pathways. Protein synthesis in cells. Bioreactor design and operations. Selection scale up operations of bioreactors.

Unit-V

Mass transfer in heterogeneous biochemical reaction systems. Oxygen transfer rates and coefficients. Role of aeration and agitation in oxygen transfer. Heat transfer processes in biological systems. Recovery and purification of products.

Unit-VI

Introduction to instrumentation and process control in bioprocesses. Measurement of physical and chemical parameters in bioreactors. Monitoring and control of dissolved oxygen, pH, Impeller speed and temperature in a stirred fermenter.

Text books:

1. M. L. Shuler, F. Kargi. Bioprocess engineering. 2nd edition. PHI. New Delhi. 2002.
2. J. E. Bailey, D. F. Ollis. Biochemical engineering. 2nd edition. Mc Graw Hill Publication co. NY. 1985.
3. Pauline M. Doran, Bioprocess Engineering Principles, Academic Press, 2001

5.3 Material Engineering

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit-I

Engg. requirement of materials, atomic bonding, atomic arrangements, structural imperfections and atom movements, electronic structures & process binary alloys and equilibrium diagrams.

Unit-II

metallic phases and their properties, phase transformations in iron carbon system.

Unit-III

heat treatment, surface hardening, case hardening metals and their alloys, organic materials & their properties, ceramic phases and their properties, multiphase materials, reactions within solid materials.

Unit-IV

modification of properties through change in microstructure, corrosion, oxidation, thermal stability, radiation damage, composite materials .

Unit-V

Crystallography, X-Ray Diffraction Methods, Reitveld Refinement, Neutron Diffraction, XRay absorption, XRay Fluorescence spectroscopy, Electron Diffraction- diffraction pattern in specific modes.

Unit-VI

LEED and RHEED, Electron Optics, Electron Microscopy-Transmission and Scanning Electron Microscopy, STM and AFM, Compositional analysis employing AES, ESCA and Electron Probe Microanalysis.

Reference Books

1. James F. Shackelford, Introduction to Materials Science for Engineers, 7th Edition, Pearson Prentice Hall (2009)
2. W. D. Callister, Fundamentls of Materials Science and Engineering, Wiley (2007)
3. C. Kittle, Introductin to Solid State Physics, Wiley (2007)
4. R. W. Cahn and P. Haasen, Physical Metallurgy, North Holland (1996)
5. Bradley D. Fahlman Materials Chemistry, Kindle Edition 2008).
6. B.D.Cullity ElementS of X-ray Diffraction Addision Wesely Reading Mass 1978.
7. David D. Brandon and Wayne D. Kaplan Microstructural Characterization of Materials wiley
8. Dawn Bonnel Scanning Probe Microscopy and Spectroscopy: Theory, Techniques, and Applications 2000.
9. C. Julian Chen Introduction to Scanning Tunneling Microscopy Monographs on the Physics and Chemistry of Materials.

5.4 Process and Equipment design

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit-I

Shell and Tube Heat exchanger: Classification, Shell and Tube side Heat Transfer Coefficients, Pressure drop, Fouling, Baffles, Passes Tubes Tube Sheet, Effectiveness, of Heat exchanger, Heat Exchangers sizing For Heating or Cooling in agitated vessel, Heat exchangers and their Suitability, Jacketed Batch Reactor Heating, Air Cooled Heat exchanger, optimum Cooling water Temp, Mechanical Design Of Shell and Tube Heat exchanger, Differential Expansions and Thermal Stress in Heat exchanger.

Unit-II

Heat Exchange equipment: Plate Heat Exchanger, Fired Heater Design Consideration, Heater Efficiency, Heat Regenerator, Thermic Fluid Heating System Design Consideration, Cooling Tower Design Consideration, Cooling Water Blow Down, Cooling Water Corrosion, Crossed flow indused Draft Cooling Tower , Evaporation, Single and Multiple Effect forward and Backward Feed Evaporators.

Unit-III

Reactor: Reactor Classification, Design Equation for Batch PFR and CSTR, Fluidized Bed Reactor, Scale Up.

Unit-IV

Separation Equipment and Distillation column: Classifications of Separator, Design Procedure For Gas Liquid Separator Oil Water Separator, Decanter, Gravity Separators, Centrifugal Separators Gas Cleaning Equipment: Cyclone Separator, Electrostatic Precipitator, Granular Bed Filter, Hydro-cyclone,Method For Calculating No Of Trays, No of plates at Total Reflux, Plate column or Packed Column, Types of Plate, Entrainment, Minimum No of Plates, Pressure Drop Calculation, Packed Column.

Unit-V

Drying equipment: Common Terms In drying, Drying Rate, Performance of Continuous Dryer, Drying Equipments: Rotary Dryers, Turbo Dryers, Drum Dryers, Spray Dryer, Solvent Dryer, Fluidized Bed Dryer, Insipient Fluidization Velocity.

Unit-VI

Pipe line: Pipe Thickness, Pipe diameter, Condensate Piping, Pipe Support, Design of Pipeline for Natural Gas, Transportation of Crude oil, Pipe Line in Sea Water, Pipeline Design on Fluid Dynamics Parameters.

References:

1. Process Design Of Equipments Vol.-1, 4th Edn by Dr.S.D.Dwande, Denett & Company Publication 2011
2. Process Design Of Equipments Vol.-2, 4th Edn by Dr.S.D.Dwande, Denett & Company Publication 2012
3. Introduction to Process Engineering and Design 4th Reprint 2011, S.B.Thakore, B.I.Bhatt, Tata Mc. Graw Hill, Eduction Pvt. Ltd,Delhi

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M.E. (Chemical Engineering), Part:-I Practical
6. Advance Computational Laboratory

Practical – 2hrs.
Term Work – 25 Marks

Unit-I

SCILAB:

Scilab Basics: Common Operators, Common Functions, Special Constants, The Command Line, Data Structures, Strings, Saving and Loading Variables

Dealing with Matrices: Entering Matrices, Calculating Sums, Subscripts, The Colon Operator, Simple Matrix Generation, Concatenation, Deleting Rows and Columns, Matrix Inverse and Solving Linear Systems, Entry-wise operations, Matrix Size

Plotting Graphs: 2D Graphs, 3D Surfaces

Unit-II

MATLAB:

Working with the MATLAB User Interface

Reading data from file, Saving and loading variables, Plotting data, Customizing plots, Calculating statistics and best-fit line, Exporting graphics for use in other applications

Variables and Expressions

This chapter introduces the concept of entering MATLAB commands. Creating and accessing data in variables is emphasized. Entering commands, Creating variables, Getting help, Accessing and modifying values in variables, Creating character variables

Analysis and Visualization with Vectors: Calculations with vectors, Plotting vectors, Basic plot options, Annotating plots.

M.E. (Chemical Engineering), Part:-I

7. Seminar I

Teaching Scheme:	**Examination Scheme:**
Practical: 2 Hours per week	**Term Work: 25 Marks**

Seminar-I should be based on the literature survey on any topic relevant to Chemical Engineering (should be helpful for selecting a probable title of dissertation). Each student has to prepare a write up of about 25 pages of "A4" size sheets and submit it in duplicate as the term work.

The student has to deliver a seminar talk in front of the faculty members of the department and his classmates. The faculty members, based on the quality of the work and preparation and understanding of the candidate, shall do an assessment of the seminar internally – jointly.

M.E. (Chemical Engineering), Sem.-II

1. Advanced Mass transfer Syllabus

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit-I

Physical-Chemical Phenomena: Diffusivity and mechanism, Diffusion dispersion, Diffusivity measurements and prediction in non- electrolytes and electrolytes, solubility of gases in liquids, Interphase mass transfer in two phase and multi component system.

Unit-II

Mass transfer with Chemical reaction: Fluid-fluid reactions involving diffusion transfer, application of mass transfer to reacting systems Residence time distribution analysis, mass transfer coefficients, determination and prediction in dispersed multiphase contractors under the conditions of free forced convection, prediction of mean drop or bubble size of dispersion.

Unit-III

Capacity and efficiency of contacting devices, energy requirements of separation process.

Unit-IV

Multicomponent distillation: Mass transfer models, Binary distillation in tray columns, Multicomponent distillation tray column, Distillation in packed column –Non-equilibrium models, solving the model equations, Design studies of Depropanizer, Extractive distillation, Reactive distillation , cryogenic distillation and molecular distillation.

Unit-V

Adsorption, Ion exchange and chromatography: Adsorption, equilibrium considerations, pure gas adsorption, liquid adsorption, Ion exchange equilibrium, equilibrium in chromatography, Kinetic and transport considerations, external and internal transport, mass transfer in ion exchange and chromatography.

Unit-VI

Extraction: Supercritical fluid extraction, Supercritical fluid, phase equilibria, industrial applications, residuum oil Supercritical process – decaffeination of coffee, extraction of oil from seeds, residual oil Supercritical application (ROSE), Supercritical fluid chromatography.

References:-

1. "Separation process" by J. Sieder and Henley, Wiley publishers, 1998
2. "Chemical Engineering Handbook" by Perry, Mc Graw Hill
3. "Unit operation in Chemical Engineering" 6^{TH} edition, McCabe Smith , Mc Graw Hill

4. "Mass Transfer Operations" by Trebyal, , Mc Graw Hill
5. "Transport Separations and Unit Operations" 3rd edition ,G.J.Geankoplis,Prentice Hall,NJ,1993
6. "Seperation process" by C.Judson King,Mc Graw Hill,1982
7. "Distillation" ,Matther Van Winkle, Mc Graw Hill, Book Company, NY

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2. Modern Reaction Engineering

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit I:

A brief review of Chemical kinetics and Ideal reactor.

Unit- II:

Non Ideal flow and mixing: Mixing concept, RTD, Response measurement, segregated flow model, Dispersion model, Tank in Series model, recycle rector model, analysis non ideal reactor.

Unit- III:

Heterogeneous reaction: Classification, Rate Controlling step, globale rate of reaction.

Unit- IV:

Fluid-solid Non Catalytic reaction: Sinking core model, untreated core model, kinetics of non catalytic reaction for spherical and cylindrical solid particles, Contacting patterns, Reactor design.

Unit- V:

Fluid-Fluid Reaction: Gas-liquid reaction, practical ability of film theory, kinetic regime identification, kinetics of fluid-fluid reaction, Contacting patterns, Reactor design.

Unit- VI:

Catalysis and Catalytic reaction: Classification of catalysis, surface area measurement, BET theory, pore size distribution, adsorption, adsorption isotherm, Internal and External transport in pore catalyst, effectiveness factor and their modules, Effect of internal transport on selectivity, Catalyst deactivation, poison,Sintering of catalyst, and uniform posing model, Mechanism and kinetics of deactivation, catalyst regeneration.

Design of heterogeneous catalyst: Isothermal and adiabatic fixed bed reactors, non-isothermal, non-adiabatic fixed bed reactor, Introduction to multiphase reactor design, two phase fluidized bed model, slurry reactor model, trickle bed reactor model.

References:

1. Octave Levanspeil, Chemicaal Reaction Engineering,Jhon Wiley, London
2. S.M.Walas, Reaction Kinetics for Chemical Engineers, Mc Graw Hill, New Yark
3. J.M.Smith, Chemical Reaction Kinetics, Mc Graw Hill,1981
4. Bischott and Fromment, Chemical Reactor Design and analysis,Wesley-1982
5. Fogler H.S, Ellement of Chemical Reaction engineering,prantice-hall1986

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3. Chemical Process Control

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit-I

Introduction To Feed Back Control: Concept of feedback Control, Types of feedback Controllers, Measuring Devises, Transmission Lines, Final Control Elements.

Dynamic Behavior Of Feedback Control System: Block Diagram and closed looped response, effect of P Control, I Control, D Control, and Composite Control Action on response of a controlled process.

Unit-II

Stability Analysis Of Feedback System: Notion of Stability, the characteristics equation, Routh –Hurwitz Criterion for stability, Root locus analysis.

Design Of Feedback Controller: Outline of Design Problem, Simple Performance Criteria, Time integral performance criteria, Select the type of feedback Controller, Controller tuning.

Unit-III

Frequency Response Analysis Of Linear Process: Response of First Order System to Sinusoidal input, frequency response characteristics of a general linear system, Bode Diagram, Nyquist Plots.

Design Of Feedback Control System Using Frequency Response Technique Bode Stability Criteria, Gain and Phase Margin, Ziegler- Nicholas Tuning Techniques, Nyquist Stability Criteria.

Unit-IV

Feed Back Control Of System With Large Dead Time Or Inverse Response : Processes with Large dead time, Dead Time compensation, Control of System with Inverse response.

Control System With Multiple Loop: Cascade Control, Selective Control System, Split Range Control.

Unit-V

Feed Forward And Ratio Control: Logic of Feed Forward Control, Problem of Designing feed forward controllers, Prctical Aspect on Design of Feed forward controllers, Feed forward- Feed Back Control, Ratio Control.

Adaptive and Inferential control system: Adaptive Control, Inferential Control **Introduction To Plant Wide Control:**Plant Wide Control issues, Hypothetical plant for Plant wide control Studies, Internal Feedback of Material and Energy, Interaction of Plant Design and control system design.

Unit-VI

Plant Wide Control System Design: Procedures for Designs of Plant wide control systems, A

Systematic procedure for plant wide control system design, Case studies: The Reactor Flash Unit Plant, Effect of Control Structure on Closed looped performance.

Digital Process Control System: Hard ware and Software, Distributed Digital Control System, Analog and Digital Signals and Data transfer, Microprocessors and Digital Hardware in Process Control, Software Organization.

References:

1. Chemical Process Control An Introduction To Theory And Practice- George Stephanopolous, Prentice Hall Of India , New Delhi 2003
2. Process Dynamics And Control, Dale E Seborg, Yhomas F Edgar, Duncan A, Mellichamp-Wiley India 2006
3. Process Control Modeling, Design And Simulation, B.Wayne Beqnette, Prentice Hall Of India, New Delhi 2004

M.E. (Chemical Engineering), Sem.-II

4. Elective-III

4.1 COMPUTATIONAL FLUID DYNAMICS

Teaching Scheme:		**Examination Scheme:**
Lectures	**: 3Hours per week**	**Theory Paper : 100 Marks**
Tutorial	**: 1Hour per week**	**Term Work : 25 Marks**

Unit-I

Governing Differential Equation And Finite Difference Method :

Classification, Initial and Boundary conditions – Initial and Boundary Value problems – Finite difference method, Central, Forward, Backward difference.

Unit-II

Uniform and non uniform Grids, Numerical Errors, Grid Independence Test.

Unit-III

Conduction Heat Transfer

Steady one-dimensional conduction, two and three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems.

Unit-IV

Incompressible Fluid Flow

Governing Equations, Stream Function – Verticity method, Determination of pressure for viscous flow, SIMPLE Procedure of Patankar and Spalding, Computation of Boundary layer flow, finite difference approach.

Unit-V

Convection Heat Transfer And Fem

Steady One-Dimensional and Two-Dimensional Convection – diffusion, Unsteady one-

dimensional convection – diffusion, Unsteady two-dimensional convection –Diffusion – Introduction to finite element method – solution of steady heat conduction by FEM – Incompressible flow – simulation by FEM.

Unit-VI

Turbulence Models

Algebraic Models – One equation model, K – ϵ Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes.

Reference Books:

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
2. Ghoshdasdidar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw-Hill Publishing Company Ltd., 1998.
3. Subas, V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.
4. Taylor, C and Hughes, J.B. "Finite Element Programming of the Navier-Stokes Equation", Pineridge Press Limited, U.K., 1981.
5. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., "Computational fluid USA,1984.
6. Fletcher, C.A.J. "Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques, Springer – Verlag, 1987.
7. Fletcher, C.A.J. "Computational Techniques for fluid Dynamics 2" Specific Techniques for Different Flow Categories, Springer – Verlag, 1987.
8. Bose, T.X., "Numerical Fluid Dynamics" Narosa Publishing House, 1997.

4.2 Energy Engineering

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit-I

Energy, units of energy, conversion factors, general classification of energy, Historical Events, Energy requirement of Society in Past and Present situation, World energy resources and energy consumption, Indian energy resources and energy consumption, energy crisis, energy alternatives, future possibilities of energy need and availability, electrical energy from conventional energy resources, internal combustion engines, steam turbines, gas turbines, hydroturbines (thermodynamic cycles not included).

Unit-II

Nuclear reactors, thermal, hydel and nuclear power plants (process outlines only), efficiency, merits and demerits of the above power plants, combined cycle power plants, fluidized bed

combustion, small hydropower.

Unit-III

Solar energy, solar thermal systems, flat plate collectors, focusing collectors, solar water heating, solar cooing, solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar photovoltaic systems, solar cells, solar photovoltaic power generation, solar energy application in India, energy plantations, wind energy, types of windmills, types of wind rotors,

Unit-IV

Darrieus rotor and Gravian rotar, wind electric power generation, wind power in India, economics of wind farm, ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion, geothermal energy.

Unit-V

Biomass energy resources, thermochemical and biochemical methods of biomass conversion, combustion, gasification, pyrolysis, biogas production, ethanol, fuel cells, alkaline fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, solid polymer electrolyte fuel cell, magneto hydro dynamics, open cycle and closed cycle systems, magneto hydro dynamic power generation, energy storage routes like thermal energy storage, chemical, mechanical storage, electrical storage.

Unit-VI

Energy conservation in chemical process plants, energy audit energy saving in heat exchangers, distillation columns, dryers, ovens and furnaces and boilers, steam economy in chemical plants, energy conservation in petroleum, fertilizer and steel industry, cogeneration, pinch technology, recycling for energy saving, electrical energy conservation in chemical process plants, environmental aspects of energy use.

References:

1. Goldmberg J., Johansson, Reddy A.K.N. & Williams R.H., Energy for a Sustainable World, John Wiley
2. Bansal N.K., Kleeman M. & Meliss M., Renewable Energy Sources & Conversion Tech., Tata McGraw Hill
3. Sukhatme S.P., Solar Energy, Tata McGraw Hill
4. Mittal K.M., Non-Conventional Energy Systems, Wheeler Pub.
5. Venkataswarlu D., Chemical Technology, I, S. Chand
6. Pandey G.N., A Text Book on Energy System and Engineering, Vikas Pub.
7. Rao S. & Parulekar B.B., Energy Technology, Khanna Pub.
8. Rai G.D., Non-Conventional Energy Sources, Khanna Pub.
9. Nagpal G.R., Power Plant Engineering, Khanna Pub.

TEXT BOOKS:

1. Power Plant Engineering, P. K. Nag Tata McGraw Hill 2nd edn 2001.
2. Power Plant Engineering, Domakundawar, Dhanpath Rai sons. 2003

4.3 Research Methodology

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit-I - Objectives and types of research: Motivation and objectives – Research methods *vs* Methodology. Types of research– Descriptive *vs*. Analytical, Applied *vs*. Fundamental, Quantitative *vs*. Qualitative, Conceptual *vs*. Empirical.

Unit-II - Research Formulation – Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem – Literature review – Primary and secondary sources – reviews, treatise, monographs-patents – web as a source – searching the web - Critical literature review – Identifying gap areas from literature review - Development of working hypothesis.

Unit-III - Research design and methods – Research design – Basic Principles- Need of research design — Features of good design – Important concepts relating to research design – Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan - Exploration, Description, Diagnosis,and Experimentation. Determining experimental and sample designs.

Unit-IV - Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection – Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation.

Unit-V - Reporting and thesis writing – Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables - Bibliography, referencing and footnotes - Oral presentation – Planning – Preparation – Practice – Making presentation – Use of visual aids - Importance of effective communication.

Unit-VI - Application of results and ethics - Environmental impacts - Ethical issues - ethical committees - Commercialization – Copy right – royalty - Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights – Reproduction of published material – Plagiarism - Citation and acknowledgement - Reproducibility and accountability.

REFERENCES

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.

2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
5. Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing.

M.E. (Chemical Engineering), Sem.-II
5. Elective-IV
5.1 Project Management

Teaching Scheme:		Examination Scheme:
Lectures	: 3Hours per week	Theory Paper : 100 Marks
Tutorial	: 1Hour per week	Term Work : 25 Marks

Unit I: Project Management growth

Concept and Definition , General System Management, Project management, Resistance to Change, System programmed, Project product vs project management a definition focus of success, Face of failure, Project life cycle, Project management methodologies, Corporate culture.

Unit II: Organizational structure

Introduction, organizational work flow, Traditional organization, Developing work , integration position, Project coordinator, Projected organization , Matrix structure, Strong weak balanced matrix, Project management Expertise, Studying tips for the PMF (Project Management Certificate Exam)

Unit III : Organizing and staffing the project office and team

The staffing environment, Selecting the project manager,Skill requirement for project and programme manager, Organizational staffing progress,The project office, Project organizational chart.

Unit IV : management function

Controlling, Directing ,Project Authority, Interpersonal life cycle, leadership in a project management environment, life cycle leadership, organizational impact ,employee manager problem, management pit falls, Communication, Human behavior education, Management policies and procedure.

Unit V: Special Topic

Performance measurement, Financial compensation and rewards, Critical Issues with rewarding project team, mega Project, Morality, Ethics and corporate culture, Professional responsibility, Internal Prternership , External Prternership, Training and education, Integrated project team , Virtual project team, Break through Project.

Unit VI: Project Graphics:
Customer reporting, Bar chart, Presentation technique, Logic diagram/ Net working.

Cost Control
Understanding Control, The operating Cycle, Cost amount codes, Budgets, The Earned Value Management System, Variance and Earned Value, The Lost Base done, The lost overrun dilemma, Recording material Lost, Material Accounting Criteria, Cost Controll Problem.

Text Book:
A system Approach to planning, Scheduling, Controlling, by harolad Kerzner 10th Ed Willy

References:

1. project Management Theory and Practices Crary L Richardsion, CRC press, Taylor and Franas Group, boca ration London, new yark
2. Project Management for Engineer business, technology 4th Ed, Jhon M Nicholas, herman Stegn.

5.2 **Modern Separation Process**

Teaching Scheme:		**Examination Scheme:**
Lectures	**: 3Hours per week**	**Theory Paper : 100 Marks**
Tutorial	**: 1Hour per week**	**Term Work : 25 Marks**

Unit I : General
Review of Conventional process, recent advances in separation technique based on size, surface properties ionic properties and other special characteristics of substance.

Unit II: Filtration
Process Concept, Theory and Equipment used in Cross flow filtration , Cross flow electro filtration, duel functional filtration surface based solid- liquid separation involving stead liquid , Sirofloc filter.

Unit III: Membrane filtration
Types and choice of membranes, Plates and frame, tubular, Spherial wounded and hollow fibre membrane, reactor and their relative merits , commercial, pilot plant, and labortary membranes, Permeates involving analysis, reverse osmosis, nano filtration, ultrafiltration, microfiltration and donan analysis, economics of membrane operation, cevanic membrane.

Unit IV: Separation by Adsorption technique
Mechanism, Choice and type of adsorbent, normal adsorption technique, affinity chromatography, and immune chromatography, types of equipment and commercial processes, recent advance and processes, Economics.

Unit V: Ionic Separation:
Controlling factor, application, type of equipment used in electrophoresis, dielectrophoresis, ion

exchange chromatography, and electro-dialysis, commercial processes.

Unit VI: Other technique:
Separation Involving lyophilisation, pervaporation and permeation technique for solid, liquid, and gases, industrial variables and examples, zone melting, add crystallization, other separation processes, supercritical fluid extraction, oil spillage management.

References:

1. Lacey R.E and S. loaeb, industrial processing with membrane, wiely ,new yark-1972
2. King C.J, Separation processes, Tata Mc-Graw –hill publication Co. ltd-1982
3. Schoew, HM, New Chemical Engineering Separation technique, future science publisher 1972
4. Ronald W. Ronssel, Hand book of process Technology, wily new York 1987

5.3 Down Stream Processing

Teaching Scheme:		**Examination Scheme:**
Lectures	**: 3Hours per week**	**Theory Paper : 100 Marks**
Tutorial	**: 1Hour per week**	**Term Work : 25 Marks**

Unit I
Requirement of Downstream Processing : Basic concepts of separation Technology, Overview of a bioprocess including upstream and downstream processing, Importance of downstream processing in biotechnology, characteristics of biological molecules, New Separation process in modern biotechnology; Separation characteristics of proteins and enzymes – size, stability & other biological properties; Selection of purification methodologies, Characteristics of fermentation broth & its pretreatment.

Unit II
Biomass Removal and Disruption: Biomass removal and disruption: Cell disruption by Mechanical and non mechanical methods, Chemical lysis, Enzymatic lysis, physical methods, Sonication, Types of Homogenizers, Centrifugation; Sedimentation; Flocculation.

Unit III
Product Isolation: Liquid - liquid extractions, Precipitation (salt, pH, organic solvent, high molecular weight polymer). Separation of particulate by filtration, Rotary Vacuum Filtration, Centrifugation & Ultracentrifugation (Batch, continuous, basket), settling, sedimentation, decanting; Electrophoresis.

Unit IV
Membrane Based Separation: Membrane based purification: Microfiltration, Ultrafiltration, Reverse osmosis (UF and RO); Dialysis; Electrodialysis; Diafiltration; Pervaporation; Perstraction, Biotechnological application, Structure and characteristics of membranes; Liquid membranes; Supported liquid membrane; Membrane reactors.

Unit- V
Separation by Adsorption and Chromatography: Types of adsorption; adsorbents types, their preparation and properties, Types of adsorption isotherms and their importance; Chromatography: general theory, partition coefficients, zone spreading, resolution and plate height concept and

other chromatographic terms and parameters; chromatographic method selection; selection of matrix; separation based on size, charge, hydrophobicity and affinity: Gel filtration, Ion exchange chromatography, Affinity chromatography, IMAC chromatography; Covalent chromatography; Reverse phase chromatography (RPC) and hydrophobic interaction chromatography (HIC), HPLC, role of HPLC in protein characterization; Chromatofocussing; Polishing of Bioproducts by Crystallization of small and large molecules, drying and Formulations.

Unit- VI

Case Studies : Baker's yeast, Ethanol, Power alcohol, Citric acid, Intracellular proteins, Penicillin, Streptomycin, Insulin, Casein, interferon, Large scale separation and purification of *E.coli*, yeast, Recombinant products.

References:

1. E L V Harris and S. Angal, Protein Purification Methods, Ed. IRL Press at Oxford University Press, 1989.
2. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, Wiley- Interscience Publication, 1988.
3. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, Mc-Graw Hill, Inc., 1986.
4. Seperation, Recovery and Purification in Biotechnology, Aenjo J.A. and J.Hong
5. Priniciples of fermentation technology" by P F Stanbury and A Whitaker, Pergamon press (1984)
6. Comprehensive Biotechnology" Vol.2 Ed.: M. Moo-Young (1985)
7. Biotreatment, Downstream Processing and Modeling" (Advances in Biochemical Engineering /Biotechnology, Vol 56) by T. Schepler et al, Springer Verlag
8. Chromatographic and Membrane Processes in Biotechnology" by C.A. Costa and J.S. Cabral, Kluwer, Academic Publisher
9. Downstream Processing" by J.P. Hamel, J.B. Hunter and S.K. Sikdar, American Chemical Society
10. Protein Purification" by M.R. Ladisch, R.C. Wilson, C.C. Painton and S.E. Builder, American Chemical society ,Verlag
11. Protein purification: Principle and practice, third edition, Robert k. Scopes, Springer, editor: Charles R. Cantor

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5.4. Operation Research

Teaching Scheme:		**Examination Scheme:**
Lectures	**: 3Hours per week**	**Theory Paper : 100 Marks**
Tutorial	**: 1Hour per week**	**Term Work : 25 Marks**

UNIT I

Introduction to Operations Research: Basics definition, scope, objectives, phases, models and limitations of Operations Research. Linear Programming Problem – Formulation of LPP,

Graphical solution of LPP. Simplex Method, Artificial variables, big-M method, two-phase method, degeneracy and unbound solutions.

UNIT II

Transportation Problem. Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method.

UNIT III

Assignment model. Formulation. Hungarian method for optimal solution. Solving unbalanced problem. Traveling salesman problem and assignment problem.

UNIT IV

Sequencing models. Solution of Sequencing Problem – Processing n Jobs through 2 Machines – Processing n Jobs through 3 Machines – Processing 2 Jobs through m machines – Processing n Jobs through m Machines.

UNIT V

Dynamic programming. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.

UNIT VI

Games Theory. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.

UNIT VII

Replacement Models. Replacement of Items that Deteriorate whose maintenance costs increase with time without change in the money value. Replacement of items that fail suddenly: individual replacement policy, group replacement policy.

Inventory models. Inventory costs. Models with deterministic demand – model (a) demand rate uniform and production rate infinite, model (b) demand rate non-uniform and production rate infinite, model (c) demand rate uniform and production rate finite.

TEXT BOOKS:

1. P. Sankara Iyer, "Operations Research", Tata McGraw-Hill, 2008.
2. A.M. Natarajan, P. Balasubramani, A. Tamilarasi, "Operations Research", Pearson Education, 2005.

REFERENCE BOOKS:

1. J K Sharma., "Operations Research Theory & Applications , 3e", Macmillan India Ltd, 2007.
2. P. K. Gupta and D. S. Hira, "Operations Research", S. Chand & co., 2007.

3. J K Sharma., "Operations Research, Problems and Solutions, 3e", Macmillan India Ltd.
4. N.V.S. Raju, "Operations Research", HI-TECH, 2002.

M.E. (Chemical Engineering), Sem.-II (Practical)

6. Analytical Laboratory

Practical – 2hrs.

Term Work – 25 Marks

1. Analysis Of Given Sample by using Gas Chromatography
2. Detail study and Analysis of High Performance Liquid Chromatography (HPLC)
3. Instrument Exploration :Scanning Electron Microscopy (SEM)
4. Measurement , analyze, and discussion of three different types of Sample via Thermogravimetric Analysis, or TGA
5. Determination of the amount of carbon monoxide in exhaust samples by FTIR spectroscopy
6. Spectrophotometry: Absorption spectra and the use of light absorption to measure concentration
7. Analysis by using Gel Electrophoresis

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7. Seminar- II

Teaching Scheme:	**Examination Scheme:**
Practical: 2 Hours per week	**Term Work : 25 Marks**

Seminar II shall be based on tentative topic of dissertation such as review paper on some specific well defined area/ specialized stream of Chemical Engineering. Each student has to prepare a write up of about 25-30 pages of "A4" size sheets and submit it in IEEE format in duplicate as the term work.

The student has to deliver a seminar talk in front of the teachers of the department and his classmates. The teachers based on the quality of work and preparation and understanding of the candidates, shall do an assessment of the seminar internally. Some marks should be reserved for the attendance of a student in the seminars of other students.

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8. Comprehensive Viva

Examination scheme

Oral: 50 Marks

The students have to prepare on all subjects which they have studied In I^{ST} and II^{nd} Semesters the viva will be conducted by the External/Internal Examiner jointly and their appointments will be made by university. The in-depth knowledge, preparation and subjects understanding will be assessed by the Examiners.

ME Chemical Engineering
Part II Sem III

1. In-plant Training

Examination scheme:
Term work: 50 marks

The student has to prepare the report of training undergone in the industry during vacation after semester II. It shall include the brief details of assignment completed by the candidate and general observation and analysis. The identified areas for undertaking the dissertation work shall form part of report. The term work marks be based on report and departmental oral exams. The training should be of minimum two weeks from reputed industries and certificate of the same should be part of report

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ME Chemical Engineering
Part II and IV - Semester- III and IV
Dissertation

Phase- I	**Phase-II**
Practical-5	**Practical-5**
Term Work-100	**Term Work-100**

The objective of dissertation is to give the student opportunity to demonstrate his/her assimilation of knowledge in a wider spectrum of the chosen field of specialization by Appling it to solve a specific problem gaining experience and confidence. This may involve analysis, Synthesis, Design development, Construction, testing of a product or a system, generation of a new concept, idea, method technique, innovation, improvement etc.

Each student shall take up dissertation in the area of his/ her specialization and pursue the work under the guidance of faculty. One full semester is allotted for dissertation and at the end of semester he/ she shall submit a thesis.

The thesis should embody the result of scholarly work in a specialized area. It should exhibit Candidates knowledge of a recognized technique of investigation and critical evaluation and be presented in an organized and systematic way.
