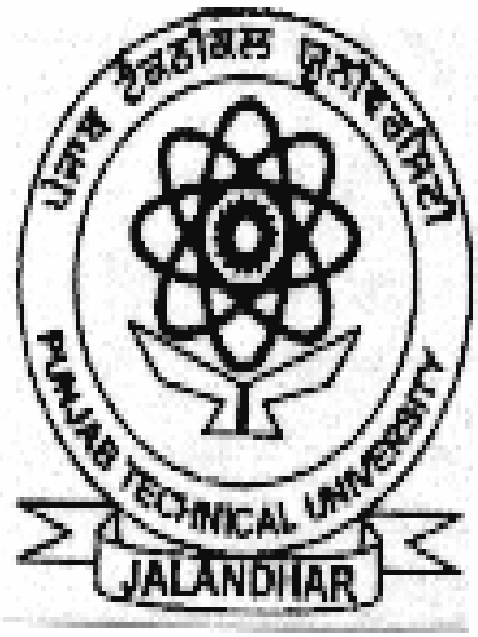
TEACHING SCHEDULE & STUDY SCHEME

M. TECH. PROGRAMME

(Chemical Engineering)



PUNJAB TCHHNICAL UNIVERSITY, JALANDHAR

August, 2004

DETAILED SYLLABUS AND OTHER CONDITIONS FOR THE PROPOSED COURSE

M.TECH. CHEMICAL ENGINEERING

Schedule of Teaching **Schedule of Examination**

Lecture	Tutorials (per weak)	Total		Time (Hrs)	Theory Marks	Sessional Marks	Viva	Total
4	0	4	All theory subjects	3	100	50		150
			Seminars			100		100
			Dissertation			Satisfactory/ Non	Satisfactory	

SEMESTER -I

CH- 501	Mathematical Methods in Chemical Engineering
CH- 502	Fluid Mechanics
CH- 503	Mass Transfer Theory

SEMESTER -II

CH- 504	Chemical Engg. Thermodynamics
CH- 505	Environmental Engg.

SEMESTER –III

CH- 506	Advanced Heat Transfer
CH- 507	Chemical Reaction Engg.
CH-	Elective -I

SEMESTER –IV

CH- 512	Process Dynamics & Control
CH-	Elective -II

SEMESTER -V

CH- 517	Statistical Methods for Data Treatment
CH- 518	Process Modelling and Simulation(Lab.)
CH- 519	Graduate Seminar

SEMESTER – VI

CH- 500	Dissertation

LIST OF ELECTIVES

ELECTIVE- I

CH- 508	Multi Component Distillation
CH- 509	Adsorption Engg.
CH- 510	Refrigeration Engg.
CH- 511	Advanced Polymer Science & Engineering

ELECTIVE- II

CH- 513	Colloid and Surface Chemistry
CH- 514	Corrosion Engg.
CH- 515	Bio Mass Utilization
CH- 516	Advanced Energy Technology

CH-501 Mathematical Methods in Chemical Engg.

Finite element analysis

Introduction to integral formulation of boundary value problems using variational methods, least square methods, Galerkin's method, one dimensional linear elements with examples. Element matrices using Galerkin's formulation.

Operation Research:

Duality theorem: Revised simple method

Transportation methods:

Introduction to the transportation model, Matrix terminology, Formulation and solution of transportation using various methods**.**

Assignment model:

Introduction to assignment model, Matrix Terminology, Comparison with Transportation model , Mathematical formulation and solution of assignment models.

Sequencing Models:

Introduction to sequencing models, processing of two jobs, through two machines, the travelling salesmen problem, Minimal path problem.

Z- Transforms:

Introduction, some standard Z- Transforms, linearity property, damping rule, some standard results, shifting rules, initial and final value theorems, convolution theorem, evaluation of inverse transforms, applications to difference equations.

Books Recommended:

1. Segarlind, L.J. **:** Applied finite element Analysis, John Wiley**.**

2. Zeinkiwicz, Q.C. **:** The finite element methods in Engineering Science, Mcgraw Hill.

3. Hunber K.H **:** A finite element method in Engineering, John Wiley

4. Church, C. Ashoff,R. & Arnoff, E. **:** Introduction to Operation Research, John Wiley & sons, Inc. New York

5. Taha, H. **:** Operation Research – an introduction, Macmillian Publishing Company, New York.

6. Stamblin, J & Steves, jr **:** Operation research – a fundamental approach Mcgraw Hill, Koga Kusha Ltd, Tok**.**

7. Hira D.S & Gupta P.K **:** Operations Research S.Chand & Co. , New Delhi

8. B.S.Grewal **:** Higher engg mathematics, Khanna publishers, New Delhi

CH-502 Fluid Mechanics

Dimensional Analysis: Buckingham Pi theorem, Reyleighs method, Geometric Kinematic and dynamic similarity, scale up numerical problems on pumps, drag force and agitation.

Differential equation of fluid flow: Continuity equation for one-dimensional and three-dimensional flow. Deviation of momentum equation(Navier- stokes equation) for three dimensional flow.

Flow of non- Viscous flows: Equation of motion (Euler equation) and its integration to obtain Bernoulli's equation, velocity potential and irrotational flow, streamlines and stream functions for two dimensional incompressible flow, two dimensional irrotational flow and flow nets.

Laminar flow of viscous fluids: Effect of viscosity on flow, pressure gradient in steady uniform flow, poseuille,s equation and friction factor, Reynolds number, Velocity profile in isothermal flow in circular tubes and annuli, and friction factor relation. Flow in infinite parallel plates and shear stress.

Turbulent flow of viscous fluids: Prantyl mixing length theory, Reynolds equation for in compressible flow. Reynold stresses, Statistical theory of turbulence. Measurement of turbulence, hot wire anemometer and its use in turbulence parameters.

Flow in compressible fluid passed immersed bodies: Von- Karman integral momentum equation, boundry layer on immersed bodies, equation of two dimensional flow in boundary layer, local and total drag coefficient. Transition from laminar to turbulent flow on the flat plate.

Pumping and piping: pumps for pumping all types of liquid/slurries their design consideration. Process plant piping, piping network and design.

General topics:

(a) Non Newtonian flow in lamina flow.
(b) Velocity measurement techniques for fluids.

Books Recommended:

1) Knudsen & Katz: fluid dynamic and heat transfer: Mc Graw Hill Book Co., 1974
2) Mc Cabe, Smith and Harriot, Unit operations of chemical Engg, Mc Graw Hill Book Co., 1993
3) Gupta Santosh K. , momentum transfer operations, Tata McGraw Hill
4) Sissen, L.E., Pitts D.R., Elements of transport phenomenon, McGraw Hill. 1972
5) Nevers Noel de, fluid mechanics for chemical Engg, 2nd edition, Mc Graw Hill, 1991
6) Streeter V.L., Fluid mechanics Mc Graw Hill

CH- 503 Mass Transfer Theory

General methods of solution of problem in unsteady- state molecular diffusion in isotropic media. Derivation of equations of unsteady- state diffusion for typical cases of mass-transfer in infinite semi- infinite and finite plane media and in spherical and cylindrical media.

Mechanism of turbulent diffusion in fluids: applications of the concept of boundary layers theory and of analogies of momentum heat and mass transfer to turbulent range diffusional phenomena. A theoretical treatment of interrelation ship of mass transfer coefficient and heat transfer coefficient.

Interphase diffusional phenomena: steady state and unsteady state theories of diffusion in two phase systems, significance of hydrodynamic factor in mass transfer between two phases in relative motion.

Mass transfer with Chemical Reaction: Diffusion reaction equations, slow reactions, fast reactions, transition from low to fast reaction, problems in practice.

Books Recommended:

1) Treybal, R.E.; Mass transfer operations , Mc Graw Hill international edition.
2) Bennett, C.O., & J.E.Myers: Momentum, Heat & Mass transfer , Mc Graw Hill international editions
3) Scharge, R.W. : A theoretical steady of interphase Mass transfer, Columbia University Press, New York, 1953.

CH-504 Chemical Engg. Thermodynamics

1. Review & Applications of Laws of Thermodynamics and other basic concepts.
Thermodynamic Properties:
Inter-relationship of properties; Equations of States; Law of corresponding states with practical examples; Maxwell's relations; Mathmatics of property changes, Jacobian Method.
Solution Thermodynamics
Fundamental property Relation, Chemical Potential as a Criterion for Phase Equilibria, Partial Properties , Ideal – Gas Mixtures, Fugacity and Fugacity Coefficient for a pure Species and species in solution, generalized correlations for the fugacity coefficient, the Ideal Solution, Excess Properties, Behaviour of Excess Properties of Liquid mixtures; Liquid – Phase Properties from VLE data; Models for the Excess Gibbs Energy; Property Changes of mixing; Heat effects of Mixing Processes; Molecular basis for Mixture Behaviour.
Thermodynamic Properties and VLE from Equations of State:
The nature of equllibrium, The Phase Rule, The Gamma/ Phi Formulation of VLE, Dewpoint and Bubblepoint Calculations, Flash Calculations; solute(1)/ solvent(2) systems; properties of Fluids from the Various Equations of State; VLE from Cubic Equations of State.
Phase Equilibria
Equilibrium and Stability; Liquid/ Liquid Eqilibrium(LLE), Vapour/ Liquid/ Liquid Equilibrium(VLLE); Solid/ Liquid Eqilibrium(SLE); Solid/ Vapour Equilibrium(SVE); VLE by Molecular Simulation
Chemical- Reaction Equilibria
The Reaction Coordinate; Application of Equilibrium Criteria to Chemical Reactions; The Standard Gibbs Energy Change and the Equillibrium Constants; Effect of Temperature on the Equilibrium Constant; Evaluation of Equilibrium Constants; Relation of equilibrium constants to composition; Equillibrium Conversions for single Reactions; Phase rule & Duhem's Theorem for reacting systems; multireaction equilibria.
Introduction to irreversible thermodynamics .

BOOKS RECMMONDED

1. Smith, J.M.& Van Ness, H.C. : Introduction to Chemiocal Engg. Thermodynamics McGraw Hill, Fourth Edition, 1987.
2. Prausnitz, T.Z. Lichtonthaler R.N. and de Azevedro E.G. : Molecular dynamics of fluid phase liquibria, Englewood Cliff, N.Z. Prentice Hall, Second Ed., 1986.
3. Kennethenbigh : The Principles of Chemical Equilibrium, Cambridge University press, Fourth Edition,1981
4. Balzhiser, Samules : Chemical Engg. Thermodynamics, Prentice Hall. 1972.
5. Chao,K.C.& Greenkorn, R.A. : Thermodymanics of fluids,Marcel Dekker, 1975

CH-505 ENVIRONMENTAL ENGINEERING

Air Pollution :

1. Inter- relation ship between energy and pollution global warning . effect of change in climate on eco- systems and world economy , clean and green technologies, pollution by automobiles and aircrafts.
2. Source of pollution and emission inventors, effects of air po9llutanta on human being and plant life, methods of reducing pollutants emissions.
3. Metrological aspects of air pollution, inversion, types of plumes and their behavior and different atmospheric stability conditions , plume dispersion, Gaussian model, buoyant plumes (Temperature profile of earth's atmosphere and its role in air pollution)
4. Types of smogs , photo- Chemical and Classical , fog, mist aerosol diffusion coefficient , air quality and emission standards.
5. Particulate matter as air pollutant , it's sources and effects, it's removal equipments: setting chambers , cyclone , electrostatic precipitators filter bags, venture scrubbers- their advantages and disadvantages and selection of equipments Types of cyclones; Stairmand design of cyclones, grade efficiency curves , pressue drop measurement.
6. Removal of Sox and Nox from stack gases (mainly from thermal plants and chemical industries)

Water Pollution

7. Types of water pollutants, their sources and effects (mainly from chemical industry)
8. Primary, Secondary and tertiary treatment of waste water, thickening of sludge, activated sludge process, sludge processes, sludge digester. Treatment of low POD and BOD waste waters. Trickling filters their working and design , some tertiary treatment methods.

Solid Pollution

9. Characterisation of Solid waste.
10. Disposal of solid waste.
11. Solid waste management, Reuse of Solid waste materials, Recovery of materials & metals, Conversion into useful products

BOOKS RECOMMENDED

1. Henry C. Perkins , Air pollution , McGraw Hill Book Co. N.Y. 1974.
2. Raw, M.N. and Rao, H.V.N. Air Pollution, Tata McGraw Hill. 1989.
3. Mahajan, S.P. Pollution control in process Industries, Tata McGraw Hill. 1991
4. Metcalf (Ed) , Waste Water Engineering, Tata McGraw Hill.(2^{nd} Ed.) 1990
5. Hodges, L., Environmental Pollution, (2^{nd}) Ed. Holt Rinechart and Wiosteon, 1997

CH- 506 ADVANCED HEAT TRANSFER

Application of Dimensional Analysis to Convection Problems

Heat Transfer in closed conduits : Heat Transfer in Laminar Tube Flow, Turbulent flow in a Tube, Heat Transfer in High Speed Flow.

Natural Convection Heat Transfer : Free Convection Heat Transfer on a Vertical Flat Plate, Empirical Relations for Free Convection , Free Convection from Vertical Planes and Cylinders, Free Convection from Horizontal Cylinders, Free Convection from Inclined Surfaces, Non- Newtonian Fluids, Simplified Equations for Air, Free Convection from Spheres, Free Convection in Enclosed Spaces, Combined Free and Forced Convection,

Analogies Between Momentum Heat and Mass Transfer

Heat Transfer in Packed Fluidized Beds

Condensation and Boiling Heat Transfer: Condensation Heat Transfer Heat trnafer Phenomena, The Condensation Number, Film Condensation Inside Horizontal Tubes, Boiling Heat Transfer, Simplified Relations for Boiling Heat Transfer with Water.

BOOKS RECOMMENDED :

1. Holman, J.P. : Heat Transfer, McGraw Hill , New York, 1997
2. Chapman, A.J. : Heat Transfer, Macmillan Publishing Co. NewYork
3. Kays, W. M. & Crawford, M.E. : Convective Heat and Mass Transfer, McGraw Hill, New York.

CH -507 CHEMICAL REACTION ENGINEERING

Review of fundamental concepts in kinetics, design equation for single and multiple reactions in isothermal batch, semi – batch, stirred tank and plug –flow reactors .

Temperature and PF pressure Effects on the reaction rates . Optimum temperature progression Design Equation for Non- isothermal Reactors . Reactors stability and special reference to C.S.T.R.

Introduction to optimization of Chemical Reactors.

Non – ideality in reactors: Its effects on conversion and one parameter models for non – ideal flow, Multi parameter models for real reactors, Mixing of fluids in reactors and its effect on chemical conversion, Characterization of micro and macro mixing.

Kinetics and its application to design of isothermal fixed bed and fluidized reactors for fluid- solid catalytic reactions. Catalyst deactivation. One dimensional; and two dimensional models for non – isothermals, non- adiabatic fixed- bed reactors . design of Slurry and trickle – bed reactors. Design of slurry and trickle bed reactors.

BOOKS RECOMMENDED

1. Fogler , H.S. : Elements of Chemical Reaction Engineering , Second Edition , Prentice Hall of India (1992)
2. Levenspiel , O : Chemical Reaction Engineering , Second Edition, Wiley Estorn Ltd.
3. Smith, J.M. : Chemical Reaction Kinetics & Reactor Design, John Wiley & Sons,1997.
4. Denbigh, K. G. & Turnewr, J.C. R. : Chemical Reactor Theory – An Introduction, Third Edition, Cambridge University Press, 1984.
5. Hill Jr. C.G. : An introduction to Chemical engineering Kinetics & Reactor design, John Wiley & Sons 1997.

ELECTIVE – I

CH-508 MULTI-COMPONENT DISTILLATION

Binary Vapour – liquid Equilibria: P-x- y diagram, T-x-y diagram, X-y diagram, Nonideal Vapour – Liquid Equilibrium : Activity Coefficient (Various Correlation), K- Factor, Relative Volatility.

Different methods of flash vaporization calculations including empirical co-relations, Analytical (Fensky, Underwood & Smoker equations) and graphical methods for calculation of stage requirement for binary and multi-component systems for constant and varying flow rates for varying relative volatilities for complex columns involving multiple feeds , side streams , open stream and like , for other special cases.

Methods for estimation of minimum reflux requirements, optimum, feed stage locations and minimum number of stages. Extractive and Azeotropic distillations, general considerations for the choice of separating agents and methods of calculations.

Unsteady state distillation , single and multistage processes , effect of column hold up, Contacting efficiencies in distillation, different methods for estimation of efficiencies , effect of liquid mixing.

Distillation trays , Hydraulic and other design considerations.

BOOKS RECOMMENDED

1. Treybal, R.E. :Mass Transfer Operations, McGraw Hill International Editions.

2. McCabe & Smith : Unit Operations of Chemical Engineering, McGraw Hill International Editions.

ELECTIVE – I

CH- 509 ADSORPTION ENGG.

Adsorption vs distillation, Selectivity's, Practical Adsorbents, Zeolites, Commercial Molecular Sieve Adsorbent.

Physical adsorption and the characterization of Process Adsorbents: Forces and Energies of Adsorption Theoretical Calculation of Heat of Adsorption at low coverage , Monolayer and Multilayer Adsorption , Capillary Condensation , Mercury Porosimetry Characterization of Zeolites

Thermodynamics of Adsorption : Classical Equilibrium Relationship, Thermodynamics of an Adsorbed Phase, Derivation of Isotherm equations from the Gibbs Equation, Adsorption of Mixtures, Statistical Thermodynamic Approach.

Correlation , Analysis and Prediction of Adsorption Equilibrium: Localized adsorption, Mobile Adsorption, General Thermodynamics Correlation -- Heats of adsorption , Entropy and Heat Capacities , Adsorption of Mixture, Adsorption from the Liquid Phase.

BOOKS RECOMMENDED

1. Ruthiver, Douglas M., Wiley- Inter Science Publication .
2. Treybal , Robent E , McGraw Hill International Edition .
3. Hill, T.L. Introduction to Statistical Thermodynamics, Addison Weslay, Reading Mass, 1960.
4. Young , D.M. and Crowell , A.D. , Physical Adsorption of Gases , Butterwortts, London, 1962.
5. Holland , C. D. and Lrapis A.I. Computer Methods for solvin Dynamic Separation Problems McGraw- Hill, New York, 1983.

ELECTIVE - I

CH- 510 REFRIGERATION ENGG.

Introduction and Basic Concepts: Introduction; Various Methods of Refrigeration; Unit of Refrigeration and Coefficient of Performance; Carnot Refrigeration Cycle; Difference between Heat Engine, Refrigerator and Heat Pump

Vapour Compression Refrigeration Systems: Carnot Vapour Compression Cycle; Simple Vapour Compression System; Wet Compression Versus Dry Compression; Expansion Process; Simple Vapour Compression Cycle; Ewing's Method for Suction State with respect to Maximum COP; Use of p-h Chart; Effect of Condenser Pressure, Evaporator Pressure, Super Heating of Refrigerant Vapour before Suction And Sub cooling of Refrigerant Before Expansion on Performance of Vapour Compression Cycle; Actual Vapour Compression Cycle

Multi-Pressure Vapour Compression Systems: Multi-Pressure Vapour Compression Systems in Industrial Refrigeration; Multistage Vapour Compression Systems; Necessity of Multistage Vapour Compression System; Optimum Inter-stage Pressure; Removal of Flash Gas; Inter-cooling; Multistage Vapour Compression Systems with Multi-Evaporators ,Multi-Compressors with or without Flash Gas Removal and Flash Gas Inter-cooling; Cascade Refrigeration System

Vapour Absorption Refrigeration System: Principle of Vapour Absorption Refrigeration System; Comparison of Vapour Absorption Refrigeration System with Vapour Compression Refrigeration System; Aqua-Ammonia Vapour Absorption Refrigeration System; Temperature-Concentration Diagram; Temperature-Enthalpy Diagram; Lithium-Bromide Water-Vapour Absorption Refrigeration System; Three Fluid Absorption Refrigeration System; Multi-Stage Vapour Absorption System

Refrigerants: Primary and Secondary Refrigerants; Halocarbon Compounds; Inorganic Compounds; Hydrocarbons; Azeotropes; Nomenclature of Refrigerants; Thermodynamic, Chemical and Physical Properties of Refrigerants; Common Refrigerants; Environmental Aspects of Refrigerants; Alternative Refrigerants; Comparative Study of Refrigerants

Refrigeration Equipments: Compressors; Condensers; Evaporators; Expansion Devices; Selection of Capillary Tube; Drier, Receiver, Oil Separator and Electric Controls

Low Temperature Refrigeration: Applications; Joule-Thomson Coefficient and Irreversible Expansion of Gases; Liquification of Gases, Linde or Linde-Hampson System; Claude Liquification System; Helium Liquification; Refrigeration System for Solid CO_2; Magnetic Cooling

Non-Conventional Methods of Refrigeration: Steam Jet Refrigeration; Vortex Tube Refrigeration; Pulse Tube Refrigeration; Thermo-Electric Refrigeration

BOOKS RECOMMENDED	***Author***	***Publisher***
(1) Principles of Refrigeration	Dossat John	Wiley & Sons
(2) Mechanical Refrigeration	Sparks & Dillo	McGrawHill
(3) Refrigeration & Air-Conditioning	W.P. Stoecker	McGrawHill
(4) Refrigeration & Air-Conditioning	Jordan & Priester	Prentice Hall
(5) Air-Conditioning & Refrigeration	Jennings & Lewis	International Text Book Company
(6) Refrigeration & Air-Conditioning	C.P. Arora	Tata McGrawHill
(7) Refrigeration & Air-Conditioning	Manohar Prasad	Wiley Eastern
(8) Refrigeration & Air-Conditioning	Arora & Doam-kundwar	Dhanpat Rai & Company
(9) Refrigeration & Air-Conditioning	P.L.Ballani	Khanna Publisher

ELECTIVE - I

CH-511 Advanced Polymer Science & Engg.

Introductory Survey: Definition and Concept of polymers, Classification of polymers, Structure- Properties relationship, configuration and conformation, solubility parameter ,intrinsic viscosity , diffusion and permeability in polymers, crystallization from melt, Kinetics of crystallization , Theory of glass transition.

Polymerization: Step polymerization (Carothers equation, reactivity of functional groups, kinetics of step polymerization), accessibility of functional groups in polymerization reaction, cross linking technology, distribution of molecular weight in bi-function polymerization, prediction & practical consideration of gel point; Free Radical polymerization (Kinetics rate & nature), Determination of absolute rate constant; Nature of termination and its effect on distribution on molecular weight; auto-acceleration & its kinetic study ; Process condition ; Relation between chain length & D.P.; Thermodynamic Consideration ; Living Polymers ; Ionic Chain Polymer ; Comparison between Radical and ionic polymerisation ; Cationic co-polymerization of C-C bond; Anionic polymers of C-C double bond; co-polymerization; kinetics of copolymers; monomers reactivity ratio; significance of co-polymerization ; block & graft copolymers; copolymer composition ; kinetics of stereo regular polymerization ; detailed study of kinetics & mechanism of polymerisation involving Ziegler Natta catalysts & metallocene catalysts ; ring opening polymerization ; group transfer polymerisation :detailed study of kinetics & mechanism of formation of inorganic polymers .

Techniques of polymers: Design criterion of polymerisation system; brief introduction & comparison of various techniques of polymerisation; bulk polymerisation; solution polymerisation (description of process, effect of process, parameter of polymerisation kinetics and distribution on molecular weight of polymers) emulsion polymerisation; (description of process, effect of process parameter on polymerisation kinetics and distribution on molecular weight of polymers); inverse emulsion polymerisation (description of process , effect of process parameter on polymerisation kinetics and distribution on molecular weight of polymers) ; suspension polymerisation (description of process , effect of process parameter on polymerisation kinetics and distribution on molecular weight of polymers).

BOOKS RECOMMENDED

1. 'Polymer Science & Technology' by Premamoy Ghosh Tata McGraw Hill.
2. ' Outlines of Polymers Technology' by Sinha PHI.
3. ' Poly Science' by Joel R Fried PHI.
4. ' Poly Science' by Billimeyar Jr.
5. 'Principles of Polymerisation' by G. Odian.
6. 'Momentum Heat & Mass to fundamentals, by Kcssler, DI publication by Decker.

CH-512 PROCESS DYNAMICS & CONTROL

Review of fundamental concepts of First Order and Higher Order Systems, Physical Examples of systems of different order systems. Linear Closed-Loop Systems: Concepts of control systems, controllers and Final Control Elements, Concepts of Block Diagrams.

Stability : Concept of Stability, Routh Test for Stability, Concepts of Root Locus & their plotting.

Frequency Response : Introduction to Frequency Response. Control System Design by Frequency Response.

Process Applications : Advanced Control Strategies. Controller Tuning and Process identification, Theoretical analysis of Complex Processes.

State – Space Methods : State-Space Representation of Physical Systems, Transfer Function Matrix, Multivariable Control.

Non-linear Control : Examples of Non-linear Systems. Methods of Phase-plane Analysis, The Describing Function Technique.

BOOKS RECOMMENDED :

1. Coughanowr D. R. : Process Systems Analysis and Control. McGraw Hill International Edition.
2. Eckman, D.P. : Automatic Process Control, New York, Wiley.
3. Smith, C.A. and Corripio : Principles and Practice of Automatic Process Control, New York, Wiley.

Elective-II

CH-516 ADVANCED ENERGY TECHNOLOGY

Energy Classification, Sources, Utilization, Economics and Terminology

Important Sources of Energy : Biomass Fuels, Fossil Fuels, Nuclear Fuels, Soar Energy.

Production of Thermal Energy : Conversion of Mechanical Energy, Electrical Energy, Electromagnetic Energy, Chemical Energy and Nuclear Energy.

Fossil – Fuel System : Fluid Moving System, Combustion Methods and System, Stream Generation.

Nuclear Power Reactor System

Production of Energy from Biomass : Gasification, Pyrolysis and Combustion Technology.

Energy Storage : Storage of Mechanical, Electrical, Chemical, Nuclear and Thermal Energy.

BOOKS RECOMMENDED :

1. Archie W. Culp. Jr. : Principles of Energy Conversion, Mc Graw Hill Inc. Publication, Second Edition, 1991.
2. Albert Binger, Technical Director, Scientific Research Councillor, Post Box No. 350, Kingstone 6, Jamaica.
3. Armando Caccres, Cemat Apartado Postal 1160, Gutamala City, Gautamala.
4. Naksitte Convattanachai Dept. of Mechanical Engg. Faculty of Engg. Prince of Songkla University, Haadyai, Songkla, Thailand.
5. Samir Sarkar; Fuel and Combustion.

CH-517 STATISTICAL METHODS FOR DATA TREATMENT

1. Introduction : Modern Statistics. The Role of Scientists and Engineers in Quality Improvement.
2. Treatment of Data : Pareto Diagrams and Dot Diagrams. Frequency Distributions. Graphs of Frequency Distributions. Stem-and-Leaf Displays, Descriptive Measures. Quartiles and other percentiles. The calculations of mean and variance.
3. Sampling Distributions : Populations and Samples : The sampling distribution of the Mean; The Sampling Distribution of the Variance.
4. The Mean, Median Mode and Other Measures of Central Tendency.
5. The Standard Deviation and other Measures of Dispersions.
6. Elementary Probability Theory : Definition of Probability. Conditional Probability, Independent and Dependent Events, Mutually Exclusive Events, Probability Distribution. Relation between population, sample, mean and Variance combinational Analysis, Fundamental n Permutation Combination, Stirling's Approximation to n!, Relation of Probability to Point Set Theory.
7. Proportions : Estimations of Proportions, Bayesian Estimation, Hypothesis concerning one proportion, Hypothesis concerning several Proportions, The Analysis of r x c tables, Goodness of Fit.
8. Non Parametric Test : The Sign Test, Rank-Sum Tests, Tests of Randomness. The Kolmogorov-Smirnov Test.
9. Curve Fitting : The Method of Least Squares, Curvilinear Regression, Multiple Regression, Checking the Adequacy of the Model, Correlation, Multiple Linear Regression.
10. Analysis of Variance : Some General Principles, Completely Randomised Design, Randomised Block Designs, Multiple Comparisons, Some Further Experimental Designs. Analysis of Covariance.
11. Factorial experimentation : Two-factor Experiments, Multifactor Experiments, 2" Factorial Experiments, The Graphic Presentation of 2^2 and 2^3 Experiments.
12. Application to Reliability and Life Testing : Reliability, Failure Time Distribution, The Exponential Model in Reliability, The Exponential Model in Life Testing. The Weibull Model in Life Testing. The Weibull Model in Life Testing.

Books Recommended :

1. Irwin R. Miller. John E. Freund. Richard Johnson, Probability and Statistics for Engineers; Fourth Edition. Prentice Hall of India Pvt. Ltd., New Delhi.
2. Shaum's Outline of Theory and Problems of STATISTICS Second Edition in 81 Units by Murrav R. Sptegel.
3. Gupta, S. P. Statistical Methods; Sultan Chand & Sons Educational Publishers, New Delhi.
4. Trivedi, S. K. Probability & Statistic with Reliability, Quecing and Computer Science Application; Prentice Hall of India Pvt. Ltd., New Delhi.
5. Eugene L. Grant : Richard S. Leuvenworth : Statistical Quality Control, Seventh Edition, Mc Graw Hill Publishing Company Ltd., New Delhi.