SYLLABI FOR MASTER OF ENGINEERING IN CHEMICAL ENGINEERING WITH SPECIALIZATION IN ENVIRONMENTAL ENGINEERING EXAMINATIONS 2016-2017

MASTER OF ENGINEERING IN CHEMICAL ENGINEERING WITH SPECIALIZATION IN ENVIRONMENTAL ENGINEERING

This ME will be extension of ME Chemical ongoing in the department. Students will be given option on the basis of merit of OCET / GATE for specialization in Environment Engineering . The student opting for this specialization will have to study one extra course in all three semesters with 12 extra credit.

SYLLABI FOR MASTER OF ENGINEERING IN CHEMICAL ENGINEERING WITH SPECIALIZATION IN ENVIRONMENTAL ENGINEERING EXAMINATIONS 2016-2017

SCHEME OF TEACHING AND EXAMINATION

Paper	Subject	Teaching Hrs. per Week				End Term	Mid Term	Total Marks
FIRST SEMESTER		L	T	P	C			
CHE 1.1	Mathematical Methods in Chemical Engineering	4	-	-	4	50	50	100
CHE 1.2	Fluid Mechanics	4	-	-	4	50	50	100
CHE 1.3	Mass Transfer	4	-	-	4	50	50	100
CHE 1.4	Chemical Engineering Thermodynamics	4	-	-	4	50	50	100
CHE 1.5	Transport Phenomena	4	-	-	4	50	50	100
	Total	20	-	-	20	250	250	500
CHE 1.6	Air Pollution Control Engineering	4	-	-	4	50	50	100
	Total	24	-	-	24	300	300	600

L: Lecture hours/Week
P: Practical Hours/Week
C: Number of Credits

Note: Mid Term include: Evaluation towards two minor tests (60% of the marks), Assignments (20% of the marks), Class surprise tests, presentations etc. (20% of the marks).

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EXAMINATIONS 2016-2017

SCHEME OF TEACHING AND EXAMINATION (2016-2017)

Paper	Subject	Teaching Hrs. per Week				End Term	Mid Term	Total Marks
SECOND SEMESTER		L	T	P	C			
CHE 2.1	Heat Transfer	4	-	-	4	50	50	100
CHE 2.2	Research Methodology	4	-	-	4	50	50	100
CHE 2.3	Chemical Reaction Engineering	4	-	-	4	50	50	100
CHE 2.4	Process Dynamics & Control	4	-	-	4	50	50	100
CHE 2.5	Process Modeling & Simulation	4	-	-	4	50	50	100
Practical								
CHE 2.6	Process Modeling & Simulation	-	-	2	1	-	25	25
CHE 2.7	Seminar	-	-	2	1	-	25	25
	Total	20	-	4	22	250	300	550
CHE 2.8	Solid Waste Management	4	-	-	4	50	50	100
	Total	24	-	4	26	300	350	650

Note: Allotment of project thesis will be done at the end of second semester and before summer vacation.

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SCHEME OF TEACHING AND EXAMINATION (2016-2017)

Paper	Subject	Teaching Hrs. per Week				End Term	Mid Term	Total Marks
THIRD SEMESTER		L	T	P	C			
CHE 3.1	Open Elective*	4	-	-	4	50	50	100
CHE 3.2	Elective**	4	-	-	4	50	50	100
CHE 3.3	Preliminary Thesis#	-	-	20	10	-	-	-
Total		8	-	20	18	100	100	200
CHE 3.4	Waste Water Treatment Technology	4	-	-	4	50	50	100
Total		12	-	20	22	150	150	300

#: *Preliminary thesis* will be evaluated on the basis of seminar presentations and discussions and the candidate shall be awarded 'S' grade i.e. satisfactory for continuation or else 'X' grade i.e. unsatisfactory.

Note: Students of Master of engineering in Chemical with specialization in Environmental Engineering will not be considered for industrial pollution control and abatement (CHE 3.2) and they will have to take some other elective (CHE 3.2)

*** List of Open Elective (CHE 3.1)**

1. Analytical Techniques
2. Project Management
3. Optimization Techniques
4. Safety & Hazards
5. Composite Materials

**** List of Elective (CHE 3.2)**

1. Industrial Pollution Control and Abatement
2. BioChemical Engineering
3. Polymer Chemistry & Characterization
4. Alternate Energy Technology
5. Macromolecular Hydrodynamics

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SCHEME OF TEACHING AND EXAMINATION (2016-2017)

Paper	Subject	Teaching Hrs. per Week				End Term	Mid Term	Total Marks
FOURTH SEMESTER		L	T	P	C			
CHE 4.1	Thesis	-	-	30	15	-	-	-
	Total	-	-	30	15	-	-	-

NOTE:
The student is required to make seminar presentation(s) of the results achieved before the submission of the thesis.

1. The Post Graduate Student Research Committee (PGRC) of the Institute will evaluate the Thesis. The constitution of the committee is as under:
    a. Chairperson of the institute/Nominee
    b. Professor of the institute
    c. Supervisor(s)
    d. External examiner
2. The PGRC will evaluate the final thesis based on an open house presentation by the student, which will be attended by the faculty members, PG students and other research scholars of the institute.
3. No marks are assigned to Preliminary Thesis and Thesis evaluation work. On successful completion and presentation of Research Seminars, the candidate will be awarded 'S' grade i.e. satisfactory or else 'X' grade i.e. unsatisfactory.
4. Requirement for the award of M.E (Chemical Engineering with specialization in Environmental Engineering) degree is 87 credits with minimum CGPA of 6.0 and successful completion of thesis work.

SYLLABI FOR MASTER OF ENGINEERING IN CHEMICAL ENGINEERING WITH SPECIALIZATION IN ENVIRONMENTAL ENGINEERING
EXAMINATIONS 2016-2017

FIRST SEMESTER

Paper Title: MATHEMATICAL METHODS IN CHEMICAL ENGINEERING (Theory)
Paper Code : CHE 1.1 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Numerical solutions of simultaneous and higher order differential equations: Runge-Kutta method, Picard's method. Approximate methods for B.V. problems: Finite difference method.
Approximate and numerical solutions of PDE's: Finite difference approximation to derivatives. Numerical solutions of elliptic equations (Laplace and Poisson's equations), Parabolic equations and Hyperbolic equations.
Integral Functions: Gamma functions, Beta functions, Elliptic integrals and functions and error functions.

SECTION-B

Solution methods for linear difference equations, complementary solutions and particular solutions. Nonlinear equations (Riccatic equations).
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.
Fourier Transforms: Introduction, fourier integrals, properties of fourier transforms, convolution theorem, Parseval's identity for F-transform, relation between fourier and laplace transforms, fourier transforms of the derivatives of a function. Applications to boundary value problems.

***Books Recommended*:**

1. Jain, R. K. & Iyengar, S. : Advanced Engg. Mathematics, 2nd Edition, Narosa Publishing House, New Delhi, 2003.
2. Grewal, B. S. : Higher Engineering Mathematics, Khanna Publishers, New Delhi, 41st Edition.
3. Kreyszig, Erwin : Advanced Engineering Mathematics, 8th Edition, Wiley Eastern, New Delhi, 2002.
4. Jain, R.K. : Numerical Solution of Differential Equations, 2nd Edition, Prentice Hall, 1987.
5. Mickley, H.S., Sherwood, T.K. and Reed, C.E. : Applied Mathematics in Chemical Engineering
6. Sastry, S.S. : Introductory Methods of Numerical Analysis

Paper Title: FLUID MECHANICS (Theory)
Paper Code : CHE 1.2 Max. Marks 50 Credits : 4 Time: 3 hours

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Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Dimensional Analysis: Buckingham, Pi-theorem, Rayleigh method, geometric, kinematic and dynamic similarity, scale up numerical problems on pumps, drag force and agitation.
Differential Equations of fluid flow: Continuity equation for one dimensional and three dimensional flows. Derivation of momentum equation for three dimensional flow in Cartesian coordinates.
Flow of non-viscous flows: Equation of motion (Euler equation) and its integration to obtain Bernoulli equation, velocity potential and irrotational flow. Streamlines and stream functions for two dimensional incompressible flow, two dimensional irrotational flow and flow net.
Laminar flow of viscous fluids: Effects of viscosity on flow, pressure gradient in steady uniform flow, use of momentum equations in cylindrical coordinates, velocity profiles in isothermal flow in circular tubes and annuli and friction factor relations. Flow in infinite parallel plates and shear stress. Velocity profiles in non-isothermal conditions.

SECTION-B

Turbulent flow of viscous fluids: Prandtl's mixing length theory, Reynolds equation for in compressible turbulent flow. Reynolds stresses, statistical theory of turbulence, intensity of turbulence, scale of turbulence, measurement of turbulence, hot wire anemometer and its use in turbulence parameters, isotropic and homogeneous turbulence.
Turbulent flow in closed conduits: Prandtl's power law of velocity distribution, logarithmic and universal velocity distribution equations for turbulent flow in smooth tubes. Friction factor for rough and smooth tubes, relationship of u^+ and y^+ to the friction factor and Reynolds number.

Flow of incompressible fluids past immersed bodies: Von-Karman integral momentum equation, boundary layer on immersed bodies, equation of two dimensional flow in the boundary layer, local and total drag coefficients. Transition from laminar to turbulent flow on the flat plate.

General Topics: (a) High velocity measurement techniques for fluids (b) Scale up techniques.

***Books Recommended*:**

1. Knudsen & Katz : Fluid Dynamics and Heat Transfer, McGraw Hill Book Co., 1974.
2. McCabe, Smith & Harriott : Unit Operations of Chemical Engineering, McGraw Hill Book Co., 1993.
3. Gupta, Santosh K. : Momentum Transfer Operations, Tata McGraw Hill, 1984.
4. Sissom, L. E. & Pitts, D.R. : Elements of Transport Phenomenon, McGraw Hill, 1972.
5. Nevers Noel de : Fluid Mechanics for Chemical Engineering, 2nd Edition, McGraw Hill Inc., 1991.

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EXAMINATIONS 2016-2017

Paper Title: MASS TRANSFER (Theory)
Paper Code : CHE 1.3 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

Section A

Fundamentals of Separation Processes; Basic definitions of relevant terms

Multicomponent distillation – Binary vapour-liquid equilibria, p-x-y diagrams, t-x-y diagrams, x-y diagrams, activity coefficients, relative volatility. Prediction of VLE by UNIFAC method.

Graphical methods for estimating stage requirements for binary systems for one feed, two feed, one feed and one side stream with constant relative volatility.
Analytical methods like Fensky and Underwood equations. Smoker equations and its applications. Methods of estimation of minimum reflux, optimized feed stage and minimum number of stages.
Supercritical fluid extraction – Supercritical fluids, Phase equilibria, Industrial applications; Important supercritical processes – Decaffination of coffee, Extraction of oil from seeds, Residuum oil supercritical extraction

Section B

Membrane Separation : Classification of membrane processes; Membrane Materials , Membrane Modules, Transport in Membranes, Dialysis and Electrodialysis, Reverse Osmosis , Gas Permeation, Pervaporation, Ultrafiltration, Microfiltration

Adsorption, Ion Exchange, and Chromatographic separation processes: Sorbents – Adsorbents, Ion Exchangers and Sorbents for Chromatography, Slurry Adsorption (Contact Filtration), Fixed-Bed Adsorption (Percolation), Thermal-Swing Adsorption, Pressure-Swing Adsorption, Continuous, Countercurrent Adsorption Systems, Simulated-Moving-Bed Systems, Ion-Exchange Cycle, Chromatographic Separations

Books Recommended

1. Smith, B. D.: Design of Equilibrium Stage Processes, McGraw Hill, N. Y., 1963
2. King, C J: Separation Processes, Tata McGraw Hill, New Delhi, 2nd Edition, 1982
3. Nath K: Membrane Separation Processes, pHI, New Delhi, 2011.

4. Seader, J. D., and Ernest J. Henley. *Separation Process Principles*. New York, NY: Wiley,
5. C.J.Geankoplis, Transport Processes and Unit Operations, Prentice-Hall of India Pvt. Ltd., New Delhi (2000).
6. T.K.Sherwood, R.L.Pigford and C.R.Wilke, Mass Transfer, McGraw-Hill, New York (1975).
7. R.E.Treybal, Mass-Transfer Operations, McGraw-Hill, New York (1980).

Paper Title: CHEMICAL ENGINEERING THERMODYNAMICS (Theory)
Paper Code : CHE 1.4 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Phase Equilibrium; Chemical potential, Gibbs Duhem equation & its applications, fugacity & activity, standard states, thermodynamic properties from volumetric data.
Intermolecular forces; Potential energy functions, electrostatic forces, polarizability & induced dipoles, hydrogen bonds.
Fugacities in gas and liquid mixtures, excess functions (Wohl's expansion, Wilson's equation, NRTL equation, UNIQUAC equation).

SECTION-B

Reaction equilibrium; Effect of temperature and pressure on reaction equilibrium constant, multi reaction equilibrium, multiphase equilibrium.
Vapor-liquid equilibrium; Applications of excess functions to binary mixtures, VLE plots for tertiary mixtures, estimation of activity coefficients.

Books Recommended:

1. Prausnitz, J. M. : Molecular Thermodynamics of Fluid Phase equilibrium, 2nd Edition, Prentice Hall Inc., Eaglewood Cliffs, N. J., 1986.
2. Smith, J. M., Van ness, H. C. & Abbott, M. M. : Chemical Engineering Thermodynamics, 6th Edition, McGraw-Hill Intl. Ed., 2001.
3. Narayanan, K. V. : A textbook of Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall India, 2001.
4. Kyle, B. G. : Chemical and Process Thermodynamics, 3rd Edition, Prentice Hall of India, 1999.

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Paper Title: TRANSPORT PHENOMENA (Theory)
Paper Code : CHE 1.5 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Instructions for the Paper setter: Total number of questions to be set = 08 with the following distributions:
Unit-I : 01 Unit-II : 02 , Unit-III : 02 , Unit-IV: 02 , Unit-V : 01. The students will be required to attempt 5 questions selecting at least 01 question each from Unit-II , Unit-III and Unit-IV, and at least one question from Unit-I and Unit-V

Unit-I

Introduction – Mechanism of molecular transport of momentum, heat and mass transfer. Flux equations –Newton's, Fourier's and Fick's laws. Similarities and differences, Non-Newtonian fluids, transport properties – estimation, temperature and pressure dependence, estimation of transport properties of binary gaseous mixtures.

(4 hrs)

Unit-II

Velocity distributions in laminar flow – shell momentum balances – Flow of falling film – flow of fluids through circular tubes, annulus and between parallel plates. Creeping flow around sphere – Drag calculations.

(8 hrs)

Unit-III

Temperature distributions in solids and in laminar flow – shell balances – Heat conduction with electrical, Nuclear, viscous and chemical heat source, Heat conduction through composite walls, and cooling fin.Forced convection and free convection.
Concentration distributions in solids and in laminar flow – shell mass balances, diffusion through a stagnant gas film, Diffusion with homogenous chemical reaction and heterogeneous chemical reaction. Diffusion into a falling liquid film – chemical reaction inside a porous catalyst.

(10 hrs)

Unit-IV

Equations of change for isothermal systems – Equation of continuity, Equation of Motion, Equations of change in curvilinear coordinates, use of equations of change to set up steady flow problems. Equations of change for non-isothermal systems – Equation of energy – use of equations of change to set up steady state flow problems. Equation of change for a binary mixture – Equation of continuity of a component in curvilinear coordinates.

(16 hrs)

Unit-V

Unsteady state problems in momentum, energy and Mass Transfer operations. Turbulence – Time smoothing of equations of change of momentum, energy and mass transfer. Eddy properties – Intensity of turbulence Reynolds stresses, Semi empirical expressions for turbulent – momentum – energy and mass fluxes.

(7 hrs)

***Books Recommended*:**

TEXT BOOKS

1. Bird, R.B., Stewart, W. E. and Lightfoot, E. N. : Transport Phenomena, 2nd Edition, John Wiley & Sons,
2002.
2. Brodkey, R.S. and Hershey, H.C. : Transport Phenomena: A Unified Approach, McGraw Hill Publications, 1988.

REFERENCE BOOKS

1. Beek, W.J., Muttzal, K.M.K. and Van Heuven, J.W. : Transport Phenomena, 2nd Edition, John Wiley & Sons.
2. Faghra, A. and Zhang, Y. : Transport Phenomena in Multiphase Systems, Academic Press.
3. Slattery, J.C. : Advanced Transport Phenomena, Cambridge University Press.

Paper Title: AIR POLLUTION CONTROL ENGINEERING (Theory)
Paper Code : CHE 1.6 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

Section A

Brief history about air pollution

Magnitude and effects of major and secondary air pollutants

Air quality and emission standards

Control Technologies:

Particulate control technology: Principles of Operation, Design Methodology and Considerations, Industrial applications and Problems encountered in the working of particulate control equipments: gravitational settling chambers, cyclone separators, gas filteration, electrostatic precipitators, particulate removal by scrubbing, adsorption of gaseous emissions

Air pollution control by combustion: thermal combustion, catalytic combustion

Control of sulfur dioxide emissions

Emission control of nitrogen oxides

Control of organic emissions

Air Pollution Meteorology: Atmospheric dispersion of air pollutants, temperature inversions, Estimation of pollutants by Gaussian plume model.

Section B

Automobile Emission Control:
Transport scenario and automobile pollution
Internal combustion engines,
Air pollutants from petrol engines,
Control technologies for spark ignition engines,
Nature of diesel emissions
Particulate matter in diesel engines
Control technologies for diesel engines
Alternative fuels as pollution reducers

Air Pollutants and Global climate:
Recent Focus on global warming and Greenhouse Gases Reduction,
Stratosphere ozone depletion and chloroflurocarbons.
Acid rain
Photochemical reactions

Books Recommended:

Rao, C.S., *Environmental Pollution Control Engineering*, New age international publishers, 2006

Davis M.L., Cornwall DA, *Introduction to environmentalEngg,* McGraw-Hill*,* Inc*1991*.

Heck, R.M. and Farrauto, R. J. *Catalytic Air Pollution Control: Commercial Technology.* Wiley-Interscience. 2002.

Ray, T.K. Air Pollution Control in Industries. Tech Books International, New Delhi (2 volumes). 2006.

Mudakavi J. R. *Principles and Practices of Air Pollution Control and Analysis,* I K International Publishing House Pvt. Ltd, 2010.

Perkins, H.C. Air Pollution, McGraw Hill. (1974)

Flagan RC, Seinfield J.H, *Fundamentals of Air Pollution Engineering.,* Prentice Hall, 1988

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SECOND SEMESTER

Paper Title: HEAT TRANSFER (Theory)
Paper Code : CHE 2.1 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Analysis of Convection Heat Transfer: Convection heat transfer, boundary layer fundamentals, conservation of mass, momentum and energy for laminar and flow over a flat plate, dimensionless Boundary – Layer equations & similarity parameters, dimensional analysis, integral equations of the laminar boundary layer, analysis between momentum and heat transfer over a flat surface; turbulent flow and turbulent boundary layers analysis, analysis for turbulent flow over a flat surface.
*Heat Transfer by Natural Convection***:** Natural convection, temperature a velocity distribution in thermal boundary layers, governing equations of mass, momentum and energy for natural convection past vertical plane surface, approximate integral boundary layer analysis for natural convection, working correlations for various shapes, natural convection from finned surface, natural convection in enclosed spaces, natural convection from finned surfaces, mixed free and forced convection.
*Forced convection Inside Tubes & Ducts***:** Analysis of laminar forced convection in long tube, correlations for laminar forced correction, analogy between heat and momentum transfer in turbulent flow, working correlations for turbulent forced convection, forced convection in noncircular sections.

SECTION-B

*Forced Convection over Exterior Surfaces***:** Flow over bluff bodies, local heat transfer coefficient distribution around cylinders, effect of various parameters on local heat transfer coefficient, heat transfer from tube bundles in cross-flow, heat transfer from non-circular sections.
Heat Transfer with phase change: Drop wise and film wise condensation, analysis of laminar film condensation on vertical surfaces, working correlations for various shapes, effects of non-condensable gases, vapor velocity, sub-cooling of condensate, super heating of vapor, orientation of tube on condensation heat transfer coefficient, condensation on tube bundles, turbulent film condensation.
Boiling heat transfer, Pool boiling, forced convective boiling in horizontal and vertical tubes, sub cooled pool boiling, bubble departure diameter, bubble frequency, nucleation sites, effect of various parameters on boiling heat transfer coefficient.
Heat transfer in fixed bed, heat transfer in fluidized bed, heat transfer in cyclone heat exchanger.

Heat transfer by combined conduction, convection and Radiation: Thermocouple lead error in surface temperature measurements, heat transfer from radiating fins, the flat plat solar collector, the heat pipe.

***Books Recommended*:**

1. Kays, W. M. & Crawford, M. E. : Convective Heat and Mass Transfer, 3rd Edition, McGraw Hill International Editions, 1993.
2. Frank Kreith & Mark S. Bohn : Principles of Heat Transfer, 6th Edition, Asian Books Private Limited, 2001.
3. Ghoshdastidar, P. S. : Heat Transfer, Oxford University Press, 2004.
4. J P Holman : Heat Transfer, 9th edition, Tata McGraw-Hill, New Delhi. 2008

Paper Title: RESEARCH METHODOLOGY (Theory)
Paper Code : CHE 2.2 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Introduction: Meaning, Features, Objectives/Motives & types of Research; Attributes of good Research, Research Methods and Research Methodology; Research Process, Significance of Research in Managerial decision making.
Research Design: Meaning, Characteristics and various concepts relating to research design and classification of research design, Importance.
Measurement and Scaling: Data Types Nominal, Ordinal and Ratio scale; scaling techniques.
Formulation of Hypothesis: Meaning, Characteristics and concepts relating to testing of Hypothesis (Parameter and statistic, Standard error, Level of significance, type-I and Type-II errors, Critical region, one tail and two tail tests); Procedure of testing Hypothesis. Numerical problems based on chi-square test and Ftest (variance ratio test only).
Data Collection: Sources of Data-Primary/Secondary Methods of collecting data; direct personal interview, indirect oral interview, information through local agencies, mailed questionnaire method, schedule sent through enumerators; questionnaire and its designing and characteristics of a good questionnaire.
Sampling Design: Meaning and need of Sampling, Probability and non-probability sampling design, simple random sampling, systematic sampling, stratified sampling, cluster sampling and convenience, judgement and quota sampling (non-probability), determination of sample size.

SECTION – B

Data Analysis & Interpretation: Introduction to Multivariate analysis- Multiple and partial correlation, multiple regression analysis (with two independent variables), specification of

regression models and estimation of parameters, interpretation of results. Analysis of Variance (ANOVA)-One way and Two way ANOVA. Introduction to discriminant analysis and Factor Analysis

Design of Experiments:
Objectives, strategies, Factorial experimental design, Designing engineering experiments, basic principles-replication, randomization, blocking, Guidelines for design of experiments.
Single Factor Experiment: Hypothesis testing, Analysis of Variance components (ANOVA) for fixed effect model; Total, treatment and error of squares, Degrees of freedom, Confidence interval; ANOVA for random effects model, Estimation of variance components, Model adequacy checking.
Two factor Factorial Design, Basic definitions and principles, main effect and interaction, response surface and contour plots, General arrangement for a two - factor factorial design; Models-Effects, means and regression, Hypothesis testing

Report writing: Style/format, contents and essential steps for report writing.
Suggested Readings:
1. K.N. Krishna SwamyAppaLyer Siva KumarM.Mathirajan: Management Research Methodology,Pearson Education, 2009
2. Ranjit Kumar:Research Methodology, Pearson Education 2009-02-20
3. Donald R. CooperPamela S. Schindler: Business Research Methods, Tata McGraw Hill
4. Michael Riley et.al: Researching & Writing dissertation in Business & Management, ThomsonLearning.
5. R. Pannerselvam: Research Methodology, Parentice Hall of India Limited.
6. R. Nandagopalet.al.:Research Methods in Business, ExcelBooks.
7. William G.Zikmund :Business Research Methods, Thomson South Western Publication
8. C.R. Kothari:Research Methodology-Methods &Techniques.
9. K.V. Rao:Research Methodoloty in Commerce &Management.

Paper Title: CHEMICAL REACTION ENGINEERING (Theory)
Paper Code : CHE 2.3 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Review of Fundamental Concepts of Mole Balances: Reaction rate, general mole balance equation. Mole balance on different reactor types: batch, CSTR and tubular reactors. Industrial reactors.

Conversion and Reactor Sizing: Design equations for isothermal batch and flow systems. Applications of design equations for CSTR and plug flow reactors, Reactors in series, space time and space velocity.

Rate Laws and Stoichiometry: Relative rates of reaction, rate constant, elementary reactions, nonelementary reactions, reversible reactions, batch system stoichiometric table, flow system stoichiometric table, volume change with reaction.

Isothermal Reactor Design: Design structure for isothermal reactors, scale-up of liquid phase batch reactor data to design of CSTR, tubular reactors.

Collection and Analysis of Rate Data: Differential method and integral method of rate analysis, method of half-lives, differential reactors. Evaluation of laboratory reactors: fixed bed, stirred batch reactor, stirred contained solids reactor, continuous-stirred tank reactor, straight-through transport reactor, recirculating transport reactor.

Multiple Reactions: Conditions for maximizing the desired product in parallel reactions. Maximizing the desired product in series reactions. Stoichiometric table using fractional conversion for multiple reactions.

Non-Isothermal Reactor Design: Energy balances: basic ideas about constant or mean and variable heat capacities, heat added to the reactor. Non-isothermal continuous flow reactors at steady state: application to the CSTR, adiabatic tubular reactor, steady state tubular reactor with heat exchange. Multiple steady states (MSS) in a CSTR.

SECTION-B

Catalysis and Catalytic Reactions: Steps in a catalytic reaction, synthesizing a rate law, mechanism and rate limiting steps, design of reactors for gas-solid reactions, heterogeneous data analysis for reactor design.

Diffusion and Reaction in Porous Catalysts: Molar flux, Fick's first law, binary diffusion, diffusion and reaction in spherical catalyst pellets, estimation of diffusion and reaction limited regimes.

Reactors for Catalytic Reactions: Fluidized reactors: information about suspended solid reactors, bubbling fluidized bed (BFB), K-L model for BFB and circulating fluidized beds (CFB). Slurry reactors: rate of gas absorption, transport to catalyst pellet, diffusion and reaction in catalyst pellet, rate law and determining the rate limiting step, slurry reactor design. Fixed bed catalytic reactor: mass transfer and reaction in packed bed.

Distribution of Residence Times for Chemical Reactors: General characteristics, measurement of RTD: pulse input and step tracer experiment.

Models for Non-Ideal Reactors: One parameter models: the tank-in-series model and the dispersion model. Two parameter models: real CSTR modeled with an exchange volume and real CSTR modeled using bypassing dead space.

***Books Recommended*:**

1. Fogler, H. S. : Elements of Chemical Reaction Engineering, 4th Edition, Pearson Prentice Hall, 2007.

2. Levenspiel, O. : Chemical Reaction Engineering, 3rd Edition,Wiley India Pvt Ltd.,2007.
3. Smith, J. M. : Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, 1981.

Paper Title: PROCESS DYNAMICS AND CONTROL (Theory)
Paper Code : CHE 2.4 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

A brief review of frequency response technique, Ziegler-Nichols controller tuning rules, Bode and Nyquist plots, Bode and Nyquist stability criterions, development of empirical models from frequency response data: Graphical methods for 1st order plus dead time and 2nd order plus dead time processes.
*Advanced Control Strategies***:**
Cascade control: Closed loop behavior and controller design for cascade control.
Feed forward control: Logic of feed forward control, designing of feed forward controllers, practical aspects on the design of feed forward controllers, feed forward-feed back control, ratio control.
Feed back control systems with large dead time: Smith Predictor scheme.
Selective Control Systems: Override control and Auctioneering control systems

SECTION-B

A brief review of the dynamic behavior of control systems, Stability of control systems by root locus method using P, PI and PID controllers, ¼ decay ratio criterion.
*Multivariable Control***:** State space representation of physical systems, transfer function matrix, interaction of control loops, relative gain array and selection of loops, design of non-interacting control loops: Decouplers.
*Model based control***:** Direct synthesis method (DSM)-controller design based on process model and desired closed loop transfer function. Internal Model Control: basic structure of IMC, design of internal model controller (IMC) and conventional feedback controller.
*Digital control***:** Introduction to direct digital control (DDC), sampling continuous signals and its reconstruction.

***Text Books Recommended*:**

1. Coughanowr, D. R. : Process Systems Analysis and Control, 2nd Edition, McGraw-Hill International Editions, Singapore, 1991.
2. Stephanopoulos, G. : Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall of India Private Limited, New Delhi, 2003.

Reference Books

3. Seborg, D. E., Edgar, T. F. & Mellichamp, D. A. : Process Dynamics and Control, John Wiley & Sons, Singapore, 2nd Edition, 2004.
4. Luyben, W.L. & Luyben M. L. : Essentials of Process Control, McGraw Hill, International Editions, Singapore, 1997.

Paper Title: PROCESS MODELLING AND SIMULATION (Theory)
Paper Code : CHE 2.5 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Introduction to mathematical modeling; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models – Simple vs. rigorous. Lumped parameter vs. distributed parameter; Steady state vs. dynamic, Transport phenomena based vs. Statistical, empirical vs analytical. Concept of degree of freedom analysis.

Review of numerical methods used for solution of; linear and non linear equations, ODE's and PDE.

Simple examples of process models; Models giving rise to nonlinear algebraic equation (NAE) systems, - steady state models of flash vessels, equilibrium staged processes distillation columns, absorbers, strippers, CSTR, heat exchangers, evaporators, etc.

SECTION-B

Unsteady state lumped systems: models giving rise to differential algebraic equations (DAE) with applications of laws of conservation of mass, momentum and energy. Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, Flash separation column, multistage batch and continuous distillation column, Absorption and Extraction columns.

Unsteady State Distributed Systems: Analysis of laminar flow in pipe, heat exchanger, packed columns, plug flow reactor, packed bed reactor, absorption and extraction in packed beds.

***Books Recommended*:**

TEXT BOOKS

1. Luyben, W.L. : Process Modeling Simulation and Control for Chemical Engineers, 2nd Edition, McGraw Hill Book Co., 1990.
2. Franks, R.G.E. : Mathematical Modeling in Chemical Engineering, John Wiley, 1967.
3. Ramirez, W. : Computational Methods in Process Simulatio, 2nd Edition, Buttersworths, N.Y.

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REFERENCE BOOKS

1. Jana, A.K. : Chemical Process Modeling and Computer Simulation, PHI, 2008.
2. Bequette, B.W. : Process Control: Modeling Design of Simulation, PHI.
3. Denn, M. : Process Modeling, Wiley, N.Y., 1990.

Paper Title: PROCESS MODELLING AND SIMULATION (Practical)
Paper Code : CHE 2.6 Max. Marks 25 Credits : 1

Practicals based on theory covered in Paper CHE 2.5.

Paper Title: SEMINAR (Practical)
Paper Code : CHE 2.7 Max. Marks 25 Credits : 1

Title: SOLID WASTE MANGEMENT
Paper Code : CHE 2.8 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

Section A

Waste generation, Need and requirements for management and planning Solid waste- types, generation trends, quality and quantity aspects

Review on types of solid waste – Municipal waste, urban , rural and industrial wastes, Special wastes- tyres, household hazardous wastes, demolition waste, domestic waste; sewage sludge and municipal waste; slaughterhouse waste; agricultural waste; Radioactive waste; Electronic wastes: Mining waste.

Integrated Solid waste Management; Solid waste characterization: ultimate and proximate analysis; Waste reduction at source, volume reduction Collection techniques. Transport of solid waste and its optimization, transfer stations

Management and disposal of Hazardous wastes and Biomedical waste.

Section B

Environmental Impact Assessment

Treatment and disposal techniques:

Open dumping ocean dumping

Landfill : sanitary landfilling methods, operation and design

Materials recovery/recycling; - Recycling of Aluminum, glass, plastic, paper etc

Biological waste treatment: Composting: aerobic and anaerobic composting, Vermiculture

Thermal treatment for volume reduction technologies: incineration gasification, pyrolysis, open burning etc

Books Recommended:

Rao, C.S., *Environmental Pollution Control Engineering*, New age international publishers, 2006

Davis M.L., Cornwall DA, *Introduction to environmentalEngg,* McGraw-Hill*,* Inc*1991*.

2. Tchobanogloas, G. *Integrated Solid Waste Management: Engineering, Principle and Management.* McGraw Hill, USA. 1993.

Noble, G. *Sanitary Landfill Design Handbook*. Technomic Westport Connecticut, USA. 1976.

Vesilind, P. A., Worrell, W. and Reinhart, D. *Solid Waste Engineering.* Brooks/Cole Thomson Learning Inc., USA. 2002.

Blackman, W.C. *Basic Hazardous Waste Management*. CRC Press, USA. 2001.

Acharya, D.B. and Singh, M. *Hospital Waste Management*. Minerva Press, Delhi. 2003.

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M. E. (CHEMICAL ENGINEERING)
THIRD SEMESTER

Paper Title: OPEN ELECTIVE (Theory)
Paper Code : CHE 3.1 Max. Marks 50 Credits : 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

1. ANALYTICAL TECHNIQUES

SECTION-A

Complexometric titrations: Complexes-formation constants; chelates – EDTA, Chelon Effect, EDTA equilibria, effect of pH on EDTA equilibria, EDTA titration curves, endpoint – detection and indicators; Importance of complexometric titrations.
Solvent Extraction: Distribution law, extraction process, factors effecting extraction, technique for extraction, quantitative treatment of solvent extraction equilibria, classification of solvent extraction systems. Advantages and applications of solvent extraction.

Chromatography: Introduction to chromatography, principles, classification of chromatographic techniques, thin layer and paper chromatography – principle and technique.
Column Chromatography – Factors affecting column efficiency and applications. Gas – liquid chromatography – theory, instrumentation and applications. HPLC – instrumentation, method, column efficiency and applications.

Thermoanalytical methods: Principle, classification of methods.
TGA – Instrumentation, factors affecting results and analysis of data. applications.
DTG – Instrumentation, analysis of data and applications.
DTA – Principle, Instrumentation and applications.

SECTION-B

IR Spectroscopy: Origin, rigid rotor model, harmonic oscillator model, principle, modes of vibrations of atoms in polyatomic molecules, instrumentation, selection rules, identification of organic compounds on the basis of infrared spectra.

UV-Vis Spectroscopy: Introduction, laws of absorption, origin of spectra, types of transitions, selection rules, identification of organic compounds using UV-VIS spectroscopy.
NMR: Principle, chemical shift, spin-spin coupling shift reagents, instrumentation, spectra and molecular structure, identification of organic compounds on the basis of NMR.

Electron Microscopy : Introduction to electron microscopy, classification of electron microscopy methods, Scanning electron microscopy , Instrumentation and applications. Scanning Tunnelling microscopy –Principle and comparison with SEM

Atomic force microscopy AFM- Principle Instrumentation and its basic application

2. ***Books Recommended*:**

1. Skoog, D. A. & West D. M. : Principles of Instrumental Analysis, 5th Edition, Saunders College Publishers, USA.
2. Skoog, D. A. & West D. M. : Fundamentals of Analytical Chemistry, 7th Edition, Saunders College Publishers, USA.
3. Willard, Meritt, Dean & Settle : Industrial Methods of Analysis, 7th Edition.
4. Galen W. Ewing. : Industrial Methods of Chemical Analysis, 5th Edition.
5. Silverstein R. M. & Webster F.X. : Spectrometric identification of Organic Compounds, 6th Edition, John Wiley and Sons, Inc., USA.

2. PROJECT MANAGEMENT

SECTION-A

Project Management: concept of project management, project management systems, responsibilities and qualities of a project manager, project management team-composition, functions and responsibilities, co-ordination procedures. Manpower planning; recruitment and selection job description, specification and evaluation, performance appraisal, basis of remuneration and incentives. Project Identification: Principles of project identification, importance of capital investment, decision making industrial policy resolution, industrial development and regulation act, supply and demand analysis, incentives for industrially backward areas and small scale industries, foreign collaboration and foreign exchange regulations. Appraisal criteria and selection of investment: Non discounting criteria, discounting criteria, appraisal and selection in practice.

SECTION-B

Feasibility studies: Preparation of techno-economic feasibility report, feasibility analysis technical economic, commercial and financial planning: Network analysis, PERT/CPM Bar chart.

Preconstruction Planning. Project Scheduling control and Monitoring: Resource Scheduling, manpower scheduling, multi project scheduling, cost scheduling, PERT/Cost scheduling optimisation, crash costing and updating and leveling of resources, Implementation of Project schedules. Financial Control: Budgeting and cost control, sources of long term funds for business, Planning and capital structure, problems of working capital management and liquidity.

***Books Recommended*:**

1. Prasanna Chandra : Project Preparation Appraisal Implementation, 3rd Edition, IIM Bangalore, McGraw Hill, 1987.
2. Kharbhanda, O.P. : Total Project Management, Gower Publishing Co. Ltd., England.
3. Choudhury : Project Management, Tata McGraw Hill, New Delhi,1988.
4. Rao Ramesh, K.S. : Fundamentals of Financial Management, Macmillan Publishing Co., New York, 1989.
5. Bansal, J.C. and Ghosh, B. : Project Management of Process Plants, Panjab University, 1985.

3. OPTIMIZATION TECHNIQUES

SECTION-A

Introduction to system analysis and Modelling with reference to chemical engineering problems. Differential Method for solving one and two variable problems, with and without constraints, application of Langranian Multiplier method, Linear Programming Modelling, Graphical method, Single Phase Simplex method, Two Phase Simplex method, Duality, Sensitivity analysis.

SECTION-B

Geometric Programming: as applied to chemical Engineering problems with degree to difficulty equal to zero and one , with and without constraints; Search Methods: Sequential Search method, Golden Section method, Dichotomous Search method; Introduction to Dynamic Programming as applied to discrete multistage problems like Cascade of CSTR, Train of Head exchangers etc.

***Books Recommended*:**

1. Baveridge and Schecheter : Optimisation Theory and Practice, Mc Graw Hill, 1971.
2. Asghar Hussain : Optimisation Techniques for Chemical Engineers, Mc Millan.
3. Hadley : Linear Programming.
4. Hadley : Non-Linear Programming.

4. SAFETY & HAZARDS

SECTION-A

Definitions, identifications, Classifications and assessment of various types of hazards in work-place environment. Protective and preventive measures in hazard control.

Toxic chemicals: Maximum allowable concentrations and other standards. Biological threshold limit values.

Mechanical and electrical hazards, personal protective equipments.

SECTION-B

Explosive and inflammable substances. Radioactive hazards. Fire prevention. Good housing keeping in industrial environment.

Standard safety procedures and disaster control. Indian legislation on safety and prevention of hazards and safety code.

Case study of typical hazardous industry.

***Books Recommended*:**

1. Wells, G.L. : Safety in process Plant Design.
2. Lees, F.P. : Loss Prevention in Process Industries.
3. Chanleft, E.T. : Environmental Protection.
4. Berthowex, P.M. and Rudd, D.E. : Strategy of Pollution control.

5. COMPOSITE MATERIALS

SECTION-A

Concepts underlying formation, characteristics and behavior of plastic-based composites such as fiber glass laminates, structural sandwiches, plywood and load-bearing adhesive joints. Typical components such as metals, glass, synthesis and natural adhesives, plastics, foams, wood, paper, fabrics and rubber.

SECTION-B

Correlation between adhesion principles and physical behavior,. Methods of design, analysis, fabrication and testing. Discuss failure mechanisms of chemical and mechanical types.

Paper Title: ELECTIVE (THEORY)
Paper Code : CHE 3.2 Max. Marks 50 Credits : 4, Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

1. INDUSTRIAL POLLUTION CONTROL AND ABATEMENT.

SECTION-A

Treatment Methods for water & waste **:** Sources and characterization of water pollution.
Primary Treatment: gravity separator, equalization tanks, Sedimentation, Flotation
Secondary Treatment – Design of : Upflow Anarerbic, Sludge Blanket (USAB) reactor, Activated Sludge process – Rotating Biological Contactors (RBC), Trickling Filters;
Natural Treatment - Wetland Systems, Waste Stabilization Ponds.
Tertiary Treatment systems: Disinfection etc.
Sludge and solid wastes treatment: Identification of hazardous wastes – disposal and waste minimization, waste management,

SECTION-B

Air Pollution Control : Air pollutants : Sources, effects, temperature inversions, plume behavior, characterization, stack height, Gaussian Plume design model, Measurement and emission estimates, Isokinetic Sampling.

Control methods: Particulate emission control methods, gravitational settling chambers, cyclone separators, Scrubbers fabric filters, ESP, wet scrubbers, control of Volatile Organic Compounds (VOC's) Control of SO_2, NO_X,

Others: Motor Vehicle Air Pollution Control, Global Waring, Indoor Air Pollution

Books & References

1. Air Pollution by Perkins
2. Air Pollution by Rao & Rock
3. Industrial Pollution Control by S.P.Mahajan
4. Air Pollution Control Engg. by N.D.Nevers
5. Disposal of Wastes Water by Eddy Mt Calf
6. "Environment Engg. & Science" by Sincero & Sincero
7. Introduction to Environment Engg. by – Davis and Cornwell

2. BIOCHEMICAL ENGINEERING
Syllabus same as for ME (Food Tech)

3. POLYMER CHEMISTRY & CHARACTERIZATION

SECTION-A

Chemical structure of monomers and polymers: Basic concepts and polymer nomenclature, classification of polymers, special features of polymer structure, Molecular weight and its distribution. Preparation of polymeric materials and their characterization. Fundamentals of chain and step growth polymerization, chemistry of organic radicals and ions, synthesis-structure-property relationships.

SECTION-B

Principle and instrumental details of techniques for polymer characterization and testing for molecular weight and its distribution, mechanical strength , tensile, compression, flexural, impact, torsion, electrical properties, optical properties, thermal properties, structure determination-NMR scanning election microscopy, etc.

***Books Recommended*:**

1. Collins, F.A., Bares.J. and Billmeyer, F.W : Experiments in Polymer Science, Wiley-Interscience, 1973.
2. Sorensen, W.R. and Cambell, T.W. : Preparative Methods of Polymer Chemistry, Interscience Publishers, N.Y., 1968.
3. Allan, P.W. : Techniques of Polymer Characterization, Butterworths Scientific Pub., London, 1959.
4. Hennike Jr., J.C. : Infrared Spectrometry of Industrial Polymers." Academic Press, 1967.
5. Kamp, F.G. : Characterization of Plastics by Physical Methods, Hanser Publishers, 1986.
6. Brown, R.P. : Handbook of Plastics Test method, Longman Scientific and Technical Pub., New York, 1988.
7. Ghosh, P. : Polymer Science and Technology, 2nd Edition, TMH, 2002.
8. Fried, J.R. : Polymer Science and Technology, PHI, 1995.
9. Williams, D.J. : Polymer Science and Engineering, Prentice Hall.

4. ALTERNATE ENERGY TECHNOLOGY

SECTION-A

Solar Energy Fundamentals, Solar Radiation Characteristics and Measurements. Low temperature energy collection, high temperature energy collection, solar thermal power generation systems, Domestic industrial and agricultural applications of solar energy,.

SECTION-B

Wind resource assessment, acrodynamic analysis and design of wind mills, interphasing of wind achines, geothermal energy and ocean thermal, thermal energy. Energy storage, Solar refrigeration and Air-conditioning, Energy Storage.

Books :

Solar Energy, G.N. Tewari, Narosa Publishing House, 2002
Solar energy, H.P. Garg & J. Prakash, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2000
Principles of Solar Engineering, D. Yoi Goswami, Frank Kreith, Jan. F. Kreider, Taylor and Francis, 2000
Energy Technology, S. Rao, Dr. B.B. Parulekar, Khanna Publisher, 2000.
Non Conventional Energy Sources, G.D. Rai, Khanna Publisher, 1997

5. MACROMOLECULAR HYDRODYNAMICS

SECTION-A

Types of flow, viscosity measurement, flow curve, zero-shear viscosity, activation energy of flow, effect of different parameters on viscosity; Boltzmann principle, Linear Viscoelastic models.

SECTION-B

Time-temperature superposition principle, WLF equation and its applications, master curve and its use, Flow of Non Newtonian fluids through pipes and channels.
Thermodynamics in Polymer Processing.

***Books Recommended*:**

1. Ferry, J.D. : Viscoelastic Properties of Polymers, Wiley, 1970.
2. Williams, D.J. : Polymer Science & Engineering, Prentice Hall.
3. Mcrum, N.G., Bucknall, C.P. and Bucknall, C.B. : Principles of Polymer Engineering, Oxford University Press, New York, 1988.
4. Williams, H.L. : Polymer Engineering, Elsevier, 1975.
5. Cheremisnoff, N. : Polymer Flow Engineering, Encyclopedia of Fluid Mechanics, Vol. 9, Culf Pub. Co., 1990.
6. Brydson, J.A. : Flow Properties of Polymer Melts, Iliffe, London, 1970.
7. Skelland, A.H.I. : Non- Newtonian Flow and Heat Transfer, John Wiley, 1967.

Paper Title: WASTE WATER TREATMENT TECHNOLOGY (Theory)
Paper Code : CHE 3.4 Max. Marks 50 Credits : 4 Time: 3 hours

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Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

Section A

Waste Water Generation, Types And Characteristics: Physical, chemical and biological water quality parameters

International And National Standards For Waste Water : In-stream Standards, Potable water Standards, Wastewater effluent Standards

Water and Waste Water Treatment Plants : Water Treatment Plants, Waste Water treatment Plants**,** Design Flow Rates and Parameters

Unit Operations, Processes And Design Of Primary Treatment: Coagulation and Flocculation, Sedimentation,Filtration, Ammonia Removal

Section B

Unit Operations, Processes And Design Of Aerobic And Anaerobic Digestion : Activated sludge processes: Design and applications, Trickling filter, Rotating Biological contractors , Anaerobic digestion and sludge

Unit Operations, Processes And Design Of Tertiary Treatment: Adsorption, Ion Exchange, Membrane Processes, microfiltration, Advanced Oxidation processes(homogenous and heterogenous)

Books Recommended

1. Peavy, H.S, Rowe D R Tchobanoglous G,. : Environmental Engineering (McGRAW – Hill International Editions)
2. Reynolds and Richard: Unit Operations and Processes in Environmental Engineering
3. Henry J G & Heinke G W: Environmental Science and Engineering (Second Addition)
4. Hammer & Hannes, Water and Wastewater Technology, PHI
5. Droste R L , Theory and Practice of water and wastewater Treatment, Wiley, India

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