CHEMICAL ENGINEERING DEPARTMENT

Syllabus
Academic Session 2020-21 onwards
SEMESTER V

Mass Transfer Operations

Lectures: 4 Periods/week — ***Sessional Marks: 30***
University Examination: 3 hours. — ***University Examination Marks: 70***

COURSE OBJECTIVE: The students will be able to understand the concepts of basic mass transfer operations involved in industrial processes as well as relate them to practical problems in everyday lives.

Unit 1 — **Lecture 10**

Introduction to mass transfer operations, Molecular mass transfer, Fick's law, Diffusivities, Differential equation for diffusion steady state equimolar counter diffusion, Diffusion of A through stagnant B for liquid or gases. Convective diffusion mass transfer coefficient, Diffusion between two phases, inter phase diffusion, Equilibrium; Equilibrium relation, two film theory, overall mass transfer coefficient, Diffusion of turbulent flow-eddy diffusion, Mixing length, Wetted wall column, Mass, heat and momentum transfer: Analogies, J_D factor.

Unit 2 — **Lectures 8**

Distillation: Vapor-liquid equilibrium and enthalpy concentration diagram, Principles of distillation, Principles of batch distillation, Flash distillation, Differential distillation, McCabe Thiele methods, Feed plate location and efficiency, Optimum reflux, Types of equipment , Bubble cap plate, Sieve plate, Valve tray, Packed tower, Packed columns: Concept of height evaluation to theoretical plate(HETP), NTU(Number of Transfer Units).

Unit 3 — **Lectures 6**

Gas absorption & stripping: Mechanism of absorption, Equilibrium relations, Operating line, Absorption factor, NTU & HTU, Column diameter, Gas absorption equipments: Plates and & Packed column, Packing materials, Capacity of packed towers, Special Case: Flooding in column.

Unit 4 — **Lecture 8**

Extraction: Solid-liquid extraction, Multistage counter counters operations, Number of equilibrium stages, Liquid –liquid extraction: Ternary liquid-liquid equilibrium, Batch and continuous liquid–liquid equilibrium, Batch and continuous liquid- liquid extraction, Stage calculations, Extraction with intermediate feed and reflux, Reflux, selectivity, Rate of extraction, Systems with complete immiscibility.

Unit 5 — **Lectures 8**

Drying: Equilibrium: Insoluble solids, soluble solids, soluble solid equilibrium, Critical, free, bound and unbound moisture content. Drying operation and mechanism, rates of batch drying and continuous drying, drying curve, direct dryers, indirect dryers, drying at high temperature and low temperature.

Text Book/Reference Books:

1. Mass Transfer Operations, Treybal Robert E., 3rd edition, International Edition, McGraw Hill.
2. Unit Operations of Chemcal Engineering, Warren L., McCabe, Julian C., Smith, Peter, Harriot, 7th edition, McGraw Hill.

Suggested Textbooks:

1. Treybal, R. E.: “Mass transfer Operations”, 3rd ed., McGraw-Hill, New York, 1980.
2. Unit Operations of Chemical Engineering, McCabe W.L., and Smith J.C. & Harriot, McGraw Hill Book Co., New York 1980, 5th Edition.

Reference books:

1. Geankpolis, C.J., Transport Processes and Separation Process Principles (Includes Unit Operations),Prentice Hall of India, New Delhi, 4th Edition, 2003.

2. Roman Zarzytci, Andrzai Chacuk, Absorption: Fundamentals and Application, Pergamon, Press, 1993.

Course Outcomes:

After completion of this course, the student will be able to:

CO1	Solve diffusion and diffusion related problems.
CO2	Estimate mass transfer coefficients for gas–liquid contacting systems.
CO3	Explain the humidification and dehumidification operations.
CO4	Estimate the rate of batch and continuous drying.
CO5	Apply design calculations of single and multiple effect evaporators.

Mapping of course outcomes with program specific outcomes:

Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	2	-	-	-	-	-	-	-
CO2	1	3	3	3	2	-	-	-	-	-	-	-
CO3	2	2	2	3	-	-	-	-	-	-	-	-
CO4	1	2	3	3	1	2	1	-	-	-	-	-
CO5	1	2	3	1	2	3	1	-	-	-	-	-

Chemical Reaction Engineering

Lectures: 4 Periods/week — ***Sessional Marks: 30***
University Examination: 3 hours. — ***University Examination Marks: 70***

Course objective

This course will provide students understand the kinetics of reaction engineering and provide basis for design of simple chemical reactors.

Unit – I **Lectures 8**

Classification of reactions, rate of reaction, Variable effecting the rate, reaction mechanism, order of reaction and its determination through different methods, collision and activated complex theory.

Unit-II **Lectures 8**

Classification of reactors: Concept of ideality. Development of design Equation for batch reactor, CSTR, and PFR, properties of ideal reactor.

Unit-III **Lectures 8**

Combination of reactors, reactors with recycles Yield and selectivity in multiple reactions. Multiple reactions in batch, CSTR and PFR. Autocatalytic reaction.

Unit-IV **Lectures 8**

Design of isothermal and non-isothermal batch, CSTR, PFR, optimum temperature progression, thermal characteristics of reactors.

Unit- V **Lectures 8**

Non-ideal reaction, evaluation of RTD characteristics, non-ideal models: axial dispersion model and tank in series model.

Course Outcomes:

After completion of this course, the student will be able to

CO1	Explain the basic concepts in reaction and reactor engineering.
CO2	Design performance equations of reactors.
CO3	Analyse Non-Isothermal operation in Ideal Reactors
CO4	Examine the Non-Ideal Behaviour of real reactor.

Mapping of course outcomes with program specific outcomes:

Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**1**	**1**	**1**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**
CO2	**3**	**3**	**3**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO3	**3**	**2**	**2**	**1**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO4	**3**	**3**	**2**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Suggested Reading:

1. Chemical Reaction Kinetics By J.M. Smith (3rd Edition Mc Graw Hill)
2. Chemical Reaction Theory an Introduction By K.G. Denbigh & K.G. Turner (2nd Edition United Press & ELBS 1972)
3. Chemical Kinetic and Reactor Engineering By G. Copper & GVJ jeffery`s (Prentice Hall 1972)
4. Chemical reaction engineering By O.Levenspiel (2nd Edition Willey Eastern, Singapore)
5. Chemical process Principal Part-III By Houghen Watsn & Ragatz [Kinetics & catalysis (2nd Edition asian publication House Bombay)]
6. Element of Chemical Reaction Engineering By Fogler ,H.S. (2nd edition Prentice Hall of India Pvt. Ltd. New Delhi 1999)

Solution Thermodynamics

Lectures: 4 Periods/week *Sessional Marks: 30*
University Examination: 3 hours. *University Examination Marks: 70*

Objective : To impart fundamental concepts of solution thermodynamics involving ideal and non – ideal systems and to compute phase and reaction equilibrium data.

Detailed Syllabus

Unit I **Lectures 8**

Equation of states, generalized correlations, acentric Factor, Calculation of thermodynamic properties using fugacity and fugacity coefficient and activity and activity coefficient, Excess properties of mixing, Gibbs Duhem equation and its correlation in terms of partial pressure.

Unit II **Lectures 8**

Phase Rule and Phase Equilibria: Phase rule, Claussius-Claypron equation, VLE calculation-Bubble Point, Dew Point, Dew point and flash calculation. Phase Equilibrium VLE.

UNIT III **Lectures 8**

Excess Free Energy: Concept of excess free energy of mixing and its Gibbs-Duhem equation, in relation to Raoult's Law, Henry's Law, Lewis Randle Rule and partial pressure.

UNIT IV **Lectures 8**

Gibbs/Duhem equation and its interacted form like, Porter Van Laar, Margules, Wilson and Redlich/Kister Equation. Excess function of non-ideal solution.

UNIT V **Lectures 8**

Chemical Equilibria: Criteria for Equilibrium, Equilibrium Constant and its dependence on temperature and pressure, Evaluation of equilibrium constant. Equilibrium conversion for single and multiple reaction systems, Phase rule for reacting substances.

TEXTBOOK

1. Introduction to Chemical Engineering Thermodynamics, Smith, J.M., Van Ness, H.C., and Abbott, M.M., 7th Edition, McGraw Hill.

Reference Books:

1. Chemical Engineering Thermodynamics, Y.V. C. Rao, Universities press.
2. A Textbook of Chemical Engineering Thermodynamics, K. V. Narayanan. Publisher, PHI Learning Pvt. Ltd., 2004.

Course outcomes (COs)

At the end of the course, the students will be able to:

CO1: Apply basic equation of states to calculation of state variables for a chemical process.

CO2: Determine the thermodynamic properties of gas mixture/solution and their correlation to standard equation.

CO3: Calculate Bubble-P&T, Dew P&T, Flash P&T in VLE for a binary and multi component systems.

CO4: Determine Equilibrium constant & composition of the chemical solution at given state conditions.

NUMERICAL METHODS IN CHEMICAL ENGINEERING

Lectures: 4 Periods/week	***Sessional Marks: 30***
University Examination: 3 hours.	***University Examination Marks:70***

Course Objective: To study the numerical+ analysis methods and their applications in solving chemical engineering problems.

Syllabus

UNIT I **Lectures 6**

Introduction, Approximation and Concept of Error & Error Analysis. Linear Algebraic Equations: Methods like Gauss elimination, LU decomposition and matrix inversion, Gauss-Siedel method, Chemical engineering problems involving solution of linear algebraic equations.

UNIT II **Lectures 7**

Root finding methods for solution on non-linear algebraic equations: Bisection, Newton-Raphson and Secant methods, Chemical engineering problems involving solution of non-linear equations.

Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression.

UNIT III **Lectures 10**

Numerical integration: Trapezoidal rule, Simpson's rule, integration with unequal segments, quadrature methods, Chemical engineering problems involving numerical differentiation and integration.

UNIT IV **Lectures 7**

Ordinary Differential Equations: Euler method, Runge-Kutta method, Adaptive Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems involving single, and a system of ODEs .

UNIT V **Lectures 5**

Introduction to Partial Differential Equations: Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method.

Course Outcomes:

After completion of this course, the student will be able to

CO1	**Solve linear and non linear equations using bisection and Newtons method.**
CO2	**Evaluate sets of linear equations.**
CO3	**Apply laplace equations to heat and mass transfer governing equations.**
CO4	**Understand linear and non linear regression techniques and to correlate with experimental data.**
CO5	**Solve initial and boundary value problems of ordinary differential equations.**

Mapping of course outcomes with program specific outcomes:

Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**2**	**2**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO2	**2**	**2**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO3	**2**	**2**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO4	**3**	**2**	**2**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO5	**2**	**1**	**2**	**1**	**2**							

Suggested Text Books

1. Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.

Suggested References Books

1.S.C. Chapra& R.P. Canale, "Numerical Methods for Engineers with Personal Computer Applications", McGraw Hill Book Company, 1985.

2. R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.

3. Atkinson, K. E., "An Introduction to Numerical Analysis", John Wiley & Sons, 1978.

4. Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

Mathematical Methods in Chemical Engineering

Teaching Scheme: ***Sessional Marks: 30***

Lectures: 3 periods/week ***University Examination Marks: 70***

University Examination: 3 hours

Course Objectives:

1. To impart the knowledge of partial differential equations.
2. To understand concept of probability and distributions.
3. To know the probable errors while using different techniques.
4. To understand model writing techniques.

Course Outcomes: At the end of the course, the students will be able to:

5. Understand the vectors and partial differential equations.
6. Understand probability and distributions
7. Estimate error analysis in different techniques.
8. Write model equations for numerical techniques for solution of ODE and PDEs.

UNIT 1 **Lectures 9**

Vector and tensor spaces; Metric,norm and inner products; orthonormalization; matrices, operators and transformations; eigen values and eigen vectors; Fredholm alternative, Rayleigh quotient and its application to chemical engineering systems; self adjoint and non self adjoint systems

UNIT 2 **Lectures 6**

Partial differential equations and their application in chemical engineering; Strum-louiville theory; Separation of variables and Fourier transformations.

UNIT 3 **Lectures 8**

Applications of Greens function for solution of ODE and PDEs in chemical engineering; Numericals techniques for solution of ODE and PDEs; Linear stability and limit cycles; Bifurcation theory; Secondary bifurcation and chaos.

UNIT 4 **Lectures 6**

Probability concepts and distributions, random variables, error analysis, point estimation and confidence intervals, hypothesis testing

UNIT 5 **Lectures 8**

Development of empirical chemical engineering models using regression techniques, design of experiments, process monitoring based on statistical quality control techniques, case studies

Text/Reference Books:

1. Pushpavnam, S., Mathematical Methods in Chemical engineering, Prentice Hall of India, New Delhi, IsBN-81-203-1262-7

Course outcome mapping with Programme outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	-	-	-	-	-	-	-	3
CO2	3	2	1	-	-	-	-	-	-	-	-	3
CO3	3	3	3	3	-	-	-	-	-	-	-	3
CO4	3	2	3	1	-	-	-	-	-	-	-	3

OPTIMIZATION OF CHEMICAL PROCESS

Lectures: 3 periods/week — *Sessional Marks: 30*
University Examination: 3 hrs. — *University Examination Marks: 70*

Course Objectives:-

1. To understand the different optimization techniques
2. To impart knowledge of linear programming's
3. To apply optimization techniques for the design of different equipment
4. To apply optimization techniques for the optimization of process parameters

UNIT – I: **[4L]**
Nature and Organization of optimization problems, fitting models to data, formulation of objective functions.

UNIT – III **[6L]**
Basic concepts of optimization, optimization of unconstrained function, one dimensional search.

UNIT – III: **[6L]**
Linear programming and applications.

UNIT – IV: **[10L]**
Optimization recovery of waste heat, shell and tube heat exchanger, evaporator design, liquid-liquid extraction process, optimal design of staged distillation column.

UNIT – V: **[10L]**
Optimal pipe diameter, optimal residence time for maximum yield in an ideal isothermal batch reactor, chemostat, optimization of a thermal cracker using linear programming.

Text Book:
1. Optimization of chemical process, T.F.Edgar and Himmelblau.D.M., McGraw Hill.

Reference Book:
Optimization: Theory and Applications, S.S.Rao, Wiley Eastran Ltd.

Course Outcomes: At the end of the course, the students will be able to:

1. Understand the basic concept of optimization.
2. Estimate the recovery of waste heat from shell and tube heat exchanger.
3. Write linear programing for various problems.
4. Design evaporator, liquid-liquid extraction process and stage distillation column.

Course outcome mapping with Programme outcomes:

	POs1	POs2	POs3	POs4	POs5	POs6	POs7	POs8	POs9	POs10	POs11	POs12
CO1	2	1	1	1	-	-	-	-	-	-	-	3
CO2	3	1	3	2	-	-	-	-	-	-	-	3
CO3	3	3	3	2	1	-	-	-	-	-	-	3
CO4	3	3	3	3	1	-	-	-	-	-	-	3

FLUIDIZATION ENGINEERING

Lectures: 3 Periods/week ***Sessional Marks: 30***

University Examination: 3 hours. ***University Examination Marks: 70***

Course Objectives:

To study the fluidization phenomena, fluidized bed regimes and models.

Course Outcomes:

The students will be able to:

1. understand the fluidization phenomena and operational regimes.
2. design various types of gas distributors for fluidized beds and determine effectiveness of gas mixing at the bottom region.
3. analyse fluidized bed behaviour with respect to the gas velocity.
4. develop and solve mathematical models of the fluidized bed.

UNIT I **Lectures 4**

Flow through packed beds-Ergun equation,

UNIT II **Lectures 12**

Phenomena of fluidization liquid like behavior of a fluidized bed, Types of fluidization- particulate and Aggregative fluidization Advantages and disadvantages of fluidization over packed beds and moving beds. Industrial applications. Minimum fluidization velocity, Terminal velocity and pressure drop in a fluidized bed.

UNIT III **Lectures 8**

Average particle size, sphericity, voidage, Expansion of liquid-solid fluidized bed, Richandson, Zaki equation, use of dimensional analysis

UNIT IV **Lectures 8**

Brief idea of the mechanism of gas-solid fluidization homogeneous & bubble phase, size of bubble, bubble velocity and its expansion.

UNIT V **Lectures 8**

1. Design of batch & continuous fluidizer for heat & mass Transfer, Entrainment & Elutriation- Entrainment at or above TDH, Entrainment below TDH
2. Semi fluidizations.

Text Books:

1. Fluidization Engineering, Kunii, Diazo and Octave Levenspiel (Chapters 1,2,3,4,7,9,10 and 12).

2. Fluidization, Max Leva (Chapters 2,3, and 7)

Reference Book:

1. Perry’s Chemical Engineers Hand Book, Perry Rober H, 7th edition, McGraw Hill

Environmental Engineering

Lectures: 3 Periods/week — *Sessional Marks: 30*
University Examination: 3 hours. — *University Examination Marks: 70*

Objective: Objective of this course is to understand the different environmental issues and its consequence on the ecosystem. Further, it has been introduced the technical solution of numerous pollutions such as air, water, soil, and noise pollution. It also addresses the solid waste issue of urban area.

Course Outcome (CO): At the end of the course, student will be able to

- CO1. Understand the different type of pollutions (air, water and noise) its consequence on eco-system.
- CO2. Evaluate the plum size, plum rise, COD, BOD and noise label.
- CO3. Identify the different control measures as well as treatment process of different pollutant.
- CO4. Explain the different type of chemical and biological treatment process.

Course Plan

UNIT I **(10 lectures)**
Air Pollution: Types of air Pollutants, Classification of Industries based on Pollutants, sources of air Pollutant, line source, point source and fumigate source, Atmospheric dispersion, Dispersion model, plume size, types of calculation of plume rise, calculation of concentration, Atmospheric salability Meteorology,

UNIT II **(5 lectures)**
Gaseous pollutant control technology, ESP, cyclone separation, victory scrubber, bag filters, Air Act.

UNIT III **(10 lectures)**
Water Pollution: Sources, criteria and standards, physical and chemical characteristics, Pre Primary, Secondary and Tertiary treatments of wastewater, sludge digestion and disposal, Advanced treatment processes, Disinfections, Typical Industrial treatment processes, Municipal waste waters treatment, Water act.

UNIT IV **(05 lectures)**
Noise Pollution: Definition ,measurement, effects and control

UNIT V **(05 lectures)**
Solid Waste: Classification of solid waste, collection, chemical and biological treatment, disposal of solid waste

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BOOKS RECOMMENDED

Mahajan S.P., “Pollution Control in Process Industries”, Tata McGraw Hill Inc., New Delhi, 2001.

Rao C.S., “Environmental Pollution Control Engineering”, 2nd Edition, Revised, Wiley Eastern Limited, India, 2006.

Bhatia S.C., “Environmental Pollution & Control in Chemical Process Industries”, Khanna Publications, Delhi, 2001.

Sawyer C.N., McCarty P.L. & Perkin G.F., “Chemistry for Environmental Engineering and Science”, McGraw-Hill, 5th ed., 2002

Relationship of COs to POs for Environmental Engineering

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	3	2	1	-	-	2	1	-	-	1	-	-
CO2.	3	3	2	2	-	2	2	-	-	-	-	-
CO3.	2	2	3	2	-	2	2	-	-	-	-	-
CO4.	3	3	3	1	-	1	3	-	-	-	-	-

Industrial Pollution Control

Teaching Scheme:

Lectures: 3 Periods/week ***Sessional Marks: 40***
University Examination: 3 hours. ***University Examination Marks: 60***

Objectives

1. To understand the importance of industrial pollution and its abatement
2. To study the underlying principles of industrial pollution control
3. To acquaint the students with case studies
4. Student should be able to design complete treatment system

Course Outcomes: At the end of the course, the student will be able to:

1. Recognize the causes and effects of environmental pollution
2. Analyze the mechanism of proliferation of pollution
3. Develop methods for pollution abatement and waste minimization
4. Design treatment methods for gas, liquid and solid wastes

Unit I **Lectures 8**

Industries & Environment

Industrial scenario in India - Industrial activity and Environment - Uses of Water by industry - Sources and types of industrial wastewater - Industrial wastewater and environmental impacts - Regulatory requirements for treatment of industrial wastewater - Industrial waste survey - Industrial wastewater generation rates, characterization and variables - Population equivalent - Toxicity of industrial effluents and Bioassay tests.

Unit II **Lectures 8**
Air Pollutant Abatement

Air pollutants scales of concentration, lapse rate and stability, plume behavior, dispersion of air pollutants, atmospheric dispersion equation and its solutions, Gaussian plume models. Air pollution control methods, Source correction methods, Design concepts for pollution abatement systems for particulates and gases. Such as gravity chambers, cyclone separators, filters, electrostatic precipitators, condensation, adsorption and absorption, thermal oxidation and biological processes.

Unit III **Lectures 8**

Waste water treatment processes

Design concepts for primary treatment, grid chambers and primary sedimentation basins, selection of treatment process flow diagram, elements of conceptual process design, design of thickner, biological treatment Bacterial population dynamics, kinetics of biological growth and its applications to biological treatment, process design relationships and analysis, determination of kinetic coefficients, activated sludge process. Design, trickling filter design considerations, advanced treatment processes, Study of environment pollution from process industries and their abatement: Fertilizer, paper and pulp, inorganic acids, petroleum and petrochemicals, recovery of materials from process effluents.

Unit IV **Lectures 8**

Solid waste and Hazardous waste management

Sources and classification, properties, public health aspects, Sanitary land fill design, Hazardous waste classification and rules, management strategies, Nuclear waste disposal Treatment methods – component separation, chemical and biological treatment, incineration, solidification and stabilization, and disposal methods, Latest Trends in solid waste management.

Unit V **Lectures 8**

Industrial Noise pollution Sources of noise pollution, characterization of noise pollution prevention& control of noise pollution, Factories Act 1948 for regulatory aspects of noise pollution.

References

1. Rao C.S., "Environmental Pollution Control Engineering", 2nd edition
2. Mahajan S.P., "Pollution Control in Process Industries".
3. Nemerow N.L., "Liquid waste of industry- theories, Practices and Treatment", Addison Wesley, New York, 1971
4. Weber W.J., "Physico-Chemical Processes for water quality control", Wiley Interscience New York, 1969
5. Strauss W., "Industrial Gas Cleaning", Pergamon, London, 1975
6. Stern A.C., "Air pollution", Volumes I to VI, academic Press, New York, 1968
7. Peterson and Gross. E Jr., "Hand Book of Noise Measurement", 7th Edn, 2003.
8. Antony Milne, "Noise Pollution: Impact and Counter Measures", David & Charles PLC, 2009.

SOLID WASTE MANAGEMENT

Lectures: 4 Periods/week — *Sessional Marks: 30*
University Examination: 3 hours. — *University Examination Marks: 70*

Course objective:

This course will give the idea about the solid waste management (SWM), equipment and processing technique for SWM, properties of municipal solid waste and disposal of SWM.

Module 1: Introduction **Lecture 8**

Philosophy and organization, Status of waste management, Computation an integrated waste management strategy. Evolution of solid waste management, Legislation and Government agencies

Module 2: Management **Lecture 8**

Planning solid waste management progress, Generation of solid waste, Onsite handling, Storage and processing, Transfer and transport, Processing techniques and equipment, Hazardous waste and their management, Process management issues, Planning, Recovery of resources conservation, Chemical and Biological methods.

Module 3: Properties of Municipal Solid Waste **Lecture 8**

State the Physical, Chemical and Biological properties, Describe associated considerations of Municipal Solid Waste (MSW)

Module 4: Disposal of solid waste **Lecture 8**

Land filling, Ocean disposing, Source reduction, Recycling, Incineration, Composting.

Module 5: Case studies on major industrial solid waste generation units **Lecture 8**

Coal fired, power plant, Textile industry, Brewery, Distillery, Oil refinery, radioactive generation units. Case studies on spills, Sludge lagooning and incineration.

Course outcome:

At the end of the course, the student will be able to

CO1: Idea about the solid waste management.

CO2: Outline sources, types and composition of solid waste with methods of handling, sampling and storage of solid waste

CO3: Select the appropriate method for solid waste collection, transportation, redistribution and disposal

CO4: Describe methods of disposal of hazardous solid waste.

Reference Book:

1. Solid Waste, Martell, 1975, John Wiley, NY.
2. Solid Waste, George Techobanuglour, H. Theisen and R. Eliassen.
3. Handbook of Solid Waste by Frank Krieth, 1996, McGraw Hill Inc. NY.

Water Pollution Control

UNIT I **Lectures 8**

Sources, criteria and standards, physical and chemical characteristics, Pre-Primary, Secondary and Tertiary treatments of wastewater, sludge digestion and disposal.

UNIT II **Lectures 9**

Wastewater characteristics; Wastewater treatment objectives, methods, and implementation considerations.

UNIT II **Lectures 8**

Principles of physical, chemical, and biological processes, that form the basis for wastewater and liquid hazardous waste treatment, such as chemical, biological, and thermal oxidation, carbon adsorption, ion-exchange, membrane processes, air and steam stripping, and chemical precipitation.

UNIT IV **Lectures 8**

Design of facilities for physical and chemical treatment; Design of facilities for treatment and disposal of sludge; Effluent disposal.
Water pollution legislation and regulation.

UNIT V **Lectures 9**

Schemes for treatment of some typical industrial wastes – pulp and paper, sugar, distillery, dairy, fertilizer, refinery etc.

BOOKS RECOMMENDED

Rao C.S., “Environmental Pollution Control Engineering”, 2nd Edition, Revised, Wiley Eastern Limited, India, 2006.