Passed in the Senate meeting held on 19/07/2008

B.Tech.-IV (CHEMICAL) 7th SEMESTER SCHEME FOR TEACHING AND EXAMINATION

CS: Core Subject ES: Elective Subject (from Department)

Sr. No.	Course	Code	Credits	Teaching Scheme Hours per Week			Examination Scheme						Total Marks
							Theory				Practicals		
				L	Tu	Pr	Hr	Sessional	Tu	End Sem	Sessional	End Sem	
1	Chemical Reaction Engineering-II (CS-1)	CH 401	3	3	0	0	2	50	---	50	---	---	100
2	Instrumentation and Process Control (CS-2)	CH 403	5	3	1	2	2	50	25	50	20	30	175
3	Process Equipment Design and Drawing (CS-3)	CH 405	5	3	1	2	2	50	25	50	20	30	175
4	Transport Phenomena (CS-4)	CH 407	4	3	1	0	2	50	25	50	---	---	125
5	ES-1**		3	3	0	0	2	50	---	50	---	---	100
6	Seminar	CH 409	1	0	0	2	---	---	---	---	20	30	50
7	Project Preliminaries	CH 411	2	0	0	4	---	---	---	---	40	60	100
8	Training	CH 413	1	0	0	0	---	---	---	---	---	50	50
	TOTAL		24	15	3	10		250	75	250	100	200	875
Total contact hours per week = 28			**Total Credit = 24**							**Total marks = 875**			

B.Tech.-IV (CHEMICAL) 8th SEMESTER SCHEME FOR TEACHING AND EXAMINATION

Sr. No.	Course	Code	Credits	Teaching Scheme Hours per Week			Examination Scheme						Total Marks
							Theory				Practicals		
				L	Tu	Pr	Hr	Sessional	Tu	End Sem	Sessional	End Sem	
1	Chemical Engineering Plant Design and Economics (CS-1)	CH 402	3	3	0	0	2	50	---	50	---	---	100
2	Chemical Systems Modeling (CS-2)	CH 404	3	3	0	0	2	50	---	50	---	---	100
3	Computer Aided Design in Chemical Engineering (CS-3)	CH 406	5	3	1	2	2	50	25	50	20	30	175
4	Safety and Pollution Control in Chemical Process Industries (CS-4)	CH 408	4	3	0	2	2	50	---	50	20	30	150
5	ES-2**		3	3	0	0	2	50	---	50	---	---	100
6	Project	CH 412	4	0	0	8	---	---	---	---	80	120	200
	TOTAL		22	15	1	12		250	25	250	120	180	825
Total contact hours per week = 28			**Total Credit = 22**							**Total marks = 825**			

**** Students have to opt for one subject from each Elective Subjects Group-1 & 2 as listed below:**

ES: Elective Subjects (Group-1)#	**ES: Elective Subjects (Group-2)#**
CH 415: Fundamentals of Biochemical Engineering	CH 414: Advances in Chemical Engineering
CH 417: Fundamentals of Colloid and Interface Science	CH 416: Catalysis and Reactor Design
CH 419: Fundamentals of Rheology of Materials	CH 418: Fluidization Engineering
CH 421: Industrial Waste Management and Control	CH 422: Introduction to Nanotechnology in Chemical Engineering
CH 423: Reaction Engineering for Pollution Prevention	CH 424: New Separation Techniques
CH 425: Sustainability and Green Chemistry	CH 426: Numerical Techniques and Optimization in Engineering
	CH **428**:Chemical Process Design

Electives are offered subject to the availability of the faculty members and their current research interest

B. Tech. IV (CH) Semester-VII	L	T	P	C
CH 401: CHEMICAL REACTION ENGINEERING - II	3	0	0	3

- **INTRODUCTION TO RTD** **(03 Hours)**
  Non ideal flow in reactors, RTD of fluid in reactors, Age distribution, F curve, C curve and E curve, Intensity Function, Effects of RTD on performance of Chemical Process Equipment

- **KINETICS AND DESIGN FOR NONCATALYSED HETEROGENEOUS SYSTEM (06 Hours)**
  Selection of a model, Determination of rate controlling step, Application to design, Application to fluidized bed,

- **FLUID- FLUID REACTIONS** **(05 Hours)**
  The rate equation, Kinetic regimes for mass transfer and reaction, fast reaction, intermediate reaction, slow reaction, Slurry reaction kinetics, Application to design

- **FLUID SOLID NON-CATALYTIC REACTIONS** **(06 Hours)**
  Particles of single size, plug flow of solids, Mixture of particles of different and unchanging sizes, mixed flow of particles of a single unchanging size,

- **CATALYTIC REACTORS** **(06 Hours)**
  ion kinetics, External and Internal Diffusional Resistances, Effects of Heat Generation/Absorption, Effectiveness Factors, Fixed Bed, Fluid Bed, Trickle bed, Slurry Reactors,

- **CATALYSIS** **(05 Hours)**
  Typical Catalysts used in chemical processes, Catalyst Characterizations, Catalyst Deactivation and Regeneration, Metal recovery from the Spent Catalysts

- **ZEOLITE CATALYSTS** **(05 Hours)**
  Applications, Rise of Acidity, Modifications, Shape Selectivity

- **ENVIRONMENTAL CATALYSIS** **(03 Hours)**
  Importance, Applications

- **MONOLITHIC REACTORS** **(03 Hours)**
  Configurations, Preparation, Hydrodynamics and Applications, Accelerated Deactivation of catalysts, Laboratory reactors, Oscillatory motion of reactants in catalyst pores, Microreactors.

- **INDUSTRIAL CASE STUDIES ON CATALYSIS AND CATALYTIC REACTORS** **(03 Hours)**

(Total Contact Time: 45 Hours)

BOOKS RECOMMENDED:

1. Fogler H.S., "Elements of Chemical Reaction Engineering", 4th Ed., Prentice Hall, NJ, 2006.
2. Levenspiel O., "Chemical Reaction Engineering", 3rd Ed., John Wiley & Sons, Singapore, 1998.
3. Smith J. M., "Chemical Engineering Kinetics", 3rd Edition, McGraw Hill, N Y, 1981.
4. Davis M.E., Davis R.J., "Fundamentals of Chemical Reaction Engineering", McGraw-Hill, New York,2003.
5. Froment G.F., Bischoff K.B., "Chemical Reactor Analysis and Design", 2nd Ed., John Wiley & Sons, Singapore, 1990.

B. Tech. IV (CH), Semester – VII	L	T	P	C
CH 403: INSTRUMENTATION AND PROCESS CONTROL	**3**	**1**	**2**	**5**

- **INTRODUCTION** **(02 Hours)**
  Steady and unsteady state design equation for an agitated heated tank. Introduction to P, PI, PID controls.

- **DYNAMICS OF FIRST ORDER SYSTEMS** **(04 Hours)**
  Dynamics of first order systems subjected to various disturbances like step, ramp, impulse & sinusoidal e.g. liquid level tanks, mixing process, thermometer etc. response of first order system in series.

- **DYNAMICS OF SECOND ORDER SYSTEMS** **(06 Hours)**
  Dynamics of second order systems subjected to various disturbances like step, impulse, sinusoidal.

- **LINEAR CLOSE LOOP SYSTEM** **(03 Hours)**
  Linear close loop system, Servo and Regulator problem.

- **CLOSED LOOP TRANSFER FUNCTION** **(05 Hours)**
  Closed loop transfer function, block diagrams for various simple systems, Transient response of the control system.

- **STABILITY OF CONTROL SYSTEM** **(04 Hours)**
  Stability of control system, Routh test criterion, Concept of Root Locus, frequency analysis, Bode diagrams for simple order system (first order system, second order system, P, PI, PD controllers)

- **ADVANCED CONTROL** **(05 Hours)**
  Cascade Control, Feed forward Control, Ratio control, Split Range Control, Auctioneering Control and Multivariable Control.

- **CONTROLLERS AND CONTROL ELEMENTS** **(02 Hours)**
  Controller, control elements, control valves.

- **DISTRIBUTED CONTROL SYSTEM** **(02 Hours)**
  Distributed control system (DCS), Programmable Logical Control System (PLC).

- **FLOW, LEVEL, PRESSURE AND TEMPERATURE MESUREMENT** **(04 Hours)**
  Construction, working principle, selection criteria and application of the measurement devices

- **LOGIC STRUCTURE, COMBINATIONAL LOGICS** **(03 Hours)**

- **KARNAUGH MAPS, ASSEMBLY LANGUAGE PROGRAMMING** **(02 Hours)**

- **SENSOR AND TRANSDUCER, INSTRUCTION PANELS,INTERFACE** **(03 Hours)**

(Total Contact Time: 45 Hours)

PRACTICALS:

1. Dynamics of First Order Liquid Level System.
2. Dynamics of Non Interacting Tanks.
3. Simulation of Heat Exchanger
4. Simulation of Catalytic Reformer
5. Simulation of Binary Distillation
6. Study of Temperature Control Trainer
7. Study of Pressure Control Trainer
8. Study of Flow Control Trainer
9. Study of Level Control Trainer
10. Dissolved Oxygen Meter
11. Thermocouple Calibration

BOOKS RECOMMENDED:

1. Coughanowr D.R., "Process Systems Analysis and Control", 2nd Ed., McGraw-Hill, New York, 1991.
2. Stephanopoulos G., "Chemical Process Control", Prentice-Hall of India, New Delhi, 2001.
3. Luben W.L., Luben M.L., "Essentials of Process Control", McGraw-Hill, New York, 1997.
4. Kopell L.B., Coughanowr D.R., "Process Systems Analysis and Control", McGraw-Hill, New York, 1986.
5. Eckman D.P., "Industrial Instrumentation", Dhanpat Rai and Sons, New Delhi**,** 1999.
6. Morris M. M., Kime C.R., "Logic and Computer Design Fundamentals", Prentice-all, PLACE2000.
7. Considine D.M., "Process Industrial Instruments and Control Handbook", McGraw-Hill, New York, 2001.

B. Tech. IV (CH) Semester - VII **L T P C**
CH 405 : PROCESS EQUIPMENT DESIGN & DRAWING **3 1 2 5**

- **INTRODUCTION (02 Hours)**
  Introduction to Chemical Engineering Design, Process design, Mechanical aspects of process equipment design, General design procedure, Equipment classifications, Design codes and standards (IS, ASTM and BS)

- **CRITERIA IN VESSEL DESIGN (03 Hours)**
  Properties of materials, Material of construction for various equipments and services, Material specifications, Fabrication techniques

- **DESIGN OF PRESSURE VESSELS (12 Hours)**
  Design of pressure vessels under internal pressure, Construction features, Pressure vessel code, Design of shell, various types of heads, nozzles, flanges for pressure vessel, Design and construction features of thick-walled pressure vessels, Various types of jackets and coils for reactors, Auxiliary process vessels

- **SUPPORTS FOR VESSELS (04 Hours)**
  Design consideration for supports for process equipments, Design of brackets support, leg support skirt, support, saddle support.

- **DESIGN OF STORAGE VESSEL (03 Hours)**
  Storage of nonvolatile and volatile liquids and gases, Codes for storage vessel design, Bottom, Roof and Shell designs.

- **DESIGN OF VESSELS UNDER EXTERNAL PRESSURE (03 Hours)**
  Design criteria for external design pressure, vessels operated under vacuum, Use of stiffeners, Design of covers, pipes and tubes

- **DESIGN OF HEAT EXCHANGERS (08 Hours)**
  Types of heat exchangers, Selection criteria, Design of heat exchangers- shell, tube, baffles, closures, channels, tube sheets etc.

- **DESIGN OF DISTILLATION AND ABSORPTION COLUMNS (08 Hours)**
  Basic features of tall vertical equipments/ towers, Towers/Column Internal, Design of tower shell and internals, supports etc.

- **PROCESS HAZARDS & SAFETY, MEASURES IN EQUIPMENT DESIGN (02 Hours)**
  Equipment testing, Analysis of hazards, Pressure relief devices. Safety measures in process equipment design

(Total contact time: 45 hours)

PRACTICALS

1. Design & drawing of Pressure Vessels
2. Design & drawing of Heat Exchangers
3. Design & drawing of Distillation Columns
4. Design & drawing of Reactors
5. Design & drawing of Storage Vessels
6. Design & drawing of specific equipments: Evaporators/ Crystallizers/ Dryers, etc.
7. Sketches of equipment accessories such as covers for pressure vessels, flanges, flange facing, supports, roofs for storage vessel, jackets, coils, tube sheet for heat exchangers, baffles in head exchangers, trays for distillation columns, packing for distillation towers, liquid distributors etc.
8. AutoCAD: Flange, Hub, 3-D Pressure vessel, 3-D Flange

BOOKS RECOMMENDED:

1. Joshi M.V., Mahajani V.V., "Process Equipment Design", 3rd Ed., MacMillan, Delhi, 1996.
2. IS Code: 2825 (1969).
3. Bhattacharyya B.C., "Introduction to Chemical Equipment Design: Mechanical Aspects", 5th Ed., CBS Publishers, New Delhi, 2008.
4. Soares C., "Process Engineering Equipment Handbook", McGraw-Hill, New York, 2002.
5. Cheremisinoff N.P., "Handbook of Chemical Processing Equipment", Butterworth Heinemann, Oxford, 2000.
6. Coulson & Richardson's Chemical Engineering, Vol. 6, 4th Ed., Elesevier, New Delhi, 2006.
7. Kern D.Q., "Process Heat Transfer", McGraw-Hill, New York, 1965.
8. Brownell L.E., Young E.H., "Process Equipment Design", Wiley Eastern, Delhi, 1977.
9. Branan C.R., "Rules of Thumb for Chemical Engineers", 4th Ed., Elsevier, Oxford, 2005.

B. Tech. IV (CH), Semester –VII	L	T	P	C
CH 407: TRANSPORT PHENOMENA	**3**	**1**	**0**	**4**

- **INTRODUCTION** **(01 Hour)**

- **TRANSPORT BY MOLECULAR MOTION** **(14 Hours)**
  Momentum transport by viscosity and momentum-flux. Energy transport by thermal conductivity and heat-flux. Mass transport by diffusivity and mass-flux.

- **TRANSPORT IN ONE DIMENSION (SHELL BALANCE METHODS)** **(17 Hours)**
  Shell momentum balances and velocity distributions. Shell energy balances and temperature distributions. Shell mass balances and concentration distributions.

- **USE OF GENERAL TRANSPORT EQUATIONS** **(6 Hours)**
  Equations of change and their use in momentum transport (isothermal).

- **VELOCITY DISTRIBUTIONS IN TURBULENT FLOW** **(1 Hour)**
  Comparisons of laminar and turbulent flows. Time-smoothed equations of change for incompressible fluids.

- **INTERPHASE TRANSPORT IN ISOTHERMAL SYSTEMS** **(04 Hours)**
  Friction factors for flow in tubes, flow around spheres, and packed columns.

- **MACROSCOPIC BALANCES FOR ISOTHERMAL FLOW SYSTEMS** **(02 Hours)**
  Macroscopic mass balance for steady and unsteady-state problems.

(Total contact hours : 45)

BOOKS RECOMMENDED:

1. Bird R.B., Stewart W.E., Lightfoot E.N., "Transport Phenomena", 1st & 2nd Eds., John Wiley & Sons, Singapore, 1960 & 2002.
2. Thomson, W.J., "Introduction to Transport Phenomena" Pearson Education Asia, Singapore, 2000.
3. Brodkey R.S. and Hershey H.C., "Transport Phenomena: A Unified Approach" McGraw-Hill, New York, 1988.
4. Plawsky J.L., "Transport Phenomena Fundamentals", Marcel Dekker, New York, 2001.
5. Slattery J.C., Sagis L., Oh E-S., "Interfacial Transport Phenomena", 2nd Ed., Springer, New York, 2007.

B. Tech. IV (CH), Semester-VIII	L	T	P	C
CH 402: CHEM. ENGG. PLANT DESIGN AND ECONOMICS	**3**	**0**	**0**	**3**

- **INTRODUCTION (02 Hours)**
  Basic consideration in chem. Engg. plant design, project identification, preliminary techno-economic feasibility.
  .
- **PROCESS DESIGN ASPECTS (04 Hours)**
  Selection of process, factors affecting process selection, types of flow diagrams.
- **SELECTION OF PROCESS EQUIPMENT (02 Hours)**
  Standard versus special equipment, materials of construction, selection criteria etc.
- **PROCESS AUXILIARIES (04 Hours)**
  Piping design, layout, support for piping insulation, types of valves, process control & instrumentation control system design.
- **PROCESS UTILITIES (06 Hours)**
  Process water, boiler feed water, water treatment & disposal, steam, oil heating system, chilling plant, compressed air and vacuum system.
- **PLANT LOCATION AND LAYOUT (04 Hours)**
  Factors affecting plant location, use of scale models.
- **COST ESTIMATION (06 Hours)**
  Factors involved in project cost estimation, total fixed & working capital, types & methods of estimation of total capital investment, estimation of total product cost, factors involved.
- **DEPRECIATION (03 Hours)**
  Types and methods of determination, evaluation.
- **PROFITABILITY (04 Hours)**
  Alternative investment & replacement methods for profitability evaluation, economic consideration in process and equipment design, inventory control.
- **OPTIMUM DESIGN (02 Hours)**
  General products rates in plant operation, optimum conditions etc.
- **PRODUCTION, PLANNING, SCHEDULING AND CONTROL (08 Hours)**
  Introduction, PERTS & CPM

(Total contact time: 45 hours)

BOOKS RECOMMENDED:

1. Peters M.S., Timmerhaus, K.D., "Plant Design and Economics for Chemical Engineers", 4th Ed., McGraw-Hill, Singapore, 1991.
2. Vilbrant F.C., Dryden, C.E., "Chemical Engineering and Plant Design", 4th Ed., McGraw-Hill, New York, 1959.
3. Pant J.C. "CPM and PERT with Linear Programming", Jain Brothers, New Delhi, 1986.
4. Davis, G.S, "Chemical Engineering Economics and Decision Analysis", CENDC, I.I.T., Madras, 1981.
5. Holland, F.A., Watson, F.A and Wilkinson, J.K., "Introduction to Process Economics", Wiley, New York, 1974.

B. Tech. IV (CH), Semester – VIII	L	T	P	C
CH 404: CHEMICAL SYSTEMS MODELING	**3**	**0**	**0**	**3**

- **INTRODUCTION** **(3 hours)**
  Physical and mathematical modeling, Principles of similarity, Independent variables, Dependent variables, Parameters and boundary conditions.

- **SOLUTIONS OF THE MODEL EQUATIONS** **(15 hours)**
  Laplace Transforms: Thermometer systems, mixing tanks, fixed bed reactor formulation. Partial differential equations and finite differences, Numerical Methods: Direct solutions of linear equations, roots of nonlinear equations.

- **MATHEMATICAL MODELING OF CHEMICAL ENGINEERING SYSTEM** **(8 hours)**
  Principle of formulations, Mathematical consistency of model, Continuity equations, Component continuity equations, Energy equations, Equations of motion, Transport equations, Equilibrium, Chemical Kinetics with examples.

- **APPLICATIONS IN CHEMICAL ENGINEERING SYSTEMS** **(12 hours)**
  Single, Two and n-stage extraction steady state mass transfer processes. Unsteady state formulation of a single stage extraction, Steady state heat conduction through hollow cylindrical pipe using various boundary condition, Unsteady process of steam heating of a liquid, Heat transfer through extended surface, Steady state counter current cooling of a tank diffusion with Chemical Reaction in a turbulent reactor, Batch distillation, pH systems etc.

- **TREATMENT OF EXPERIMENTAL RESULTS** **(3 hours)**
  Curve fitting, Numerical differentiation and integration etc

- **INDUSTRIAL SIMULATORS** **(4 hours)**
  Introduction and applications

(**Total contact time: 45 hours**)

BOOKS RECOMMENDED

1. Mickley H. S., Sherwood T. S., Reed C. E., "Application of Mathematical Modeling in Chemical Engineering", Tata-McGraw-Hill, New Delhi, 2002.
2. Jensen V.G., Jeffreys G.V., "Mathematical Methods in Chemical Engineering", 2nd Ed., Academic Press, London, 1978.
3. Salariya R. S., "Numerical Methods", Tata-McGraw Hill, New Delhi, 2002.
4. Lubyen W. L., "Process Modeling, Simulation and Control for Chemical Engineers", 2nd Ed., McGraw-Hill, New York, 1989.
5. Pushpavanam S., "Mathematical Methods in Chemical Engineering", Prentice-Hall of India, New Delhi, 2001.

B. Tech. IV (CH), Semester –VIII	L	T	P	C
CH 406: CAD IN CHEMICAL ENGINEERING	**3**	**1**	**2**	**5**

- **INTRODUCTION (3 hours)**
  Introduction to Computer aided design in chemical engineering, Mathematical modeling, Steady state and dynamic Simulation, Process simulation program (ASPEN PLUS).

- **CAD IN CHEMICAL PROCESSES (4 hours)**
  Computer aided design of chemical process equipment's, concepts of modular design, optimum design, parameter optimization etc.

- **COMPUTER AIDED FLOW SHEETING (6 hours)**
  Spread sheeting, Process synthesis, Flow sheeting software, Equation solution with recycle.

- **INPUT OUTPUT STRUCTURE (4 hours)**
  Decision for the input output structure, Flow sheet alternatives: guidelines, Number of product streams, Gas recycle and purge.

- **APPLICATION OF CAD IN HEAT EXCHANGER NETWORK DESIGN (8 hours)**
  Pinch technology, Heat integration, and Optimum number of heat exchanger.

- **APPLICATION OF CAD IN HEAT INTEGRATION OF DISTILLATION COLUMN(8 hours)**
  Characteristics, Appropriate placement of column, Distillation across pinch, Grand composite curve, Design of simple distillation column to improve heat integration.

- **APPLICATION OF CAD IN HEAT INTEGRATION OF REACTORS (6 hours)**
  Characteristics, Adiabatic operations, Indirect heat transfer, Appropriate placement of reactors.

- **APPLICATIONS OF CAD IN OTHER AREAS (6 hours)**
  Neural network, Artificial neural network, Knowledge based system etc

(Total contact time: 45 hours)

PRACTICALS

1. Simulation by ASPEN PLUS for Single distillation column
2. Simulation by ASPEN PLUS for REDFRAC
3. Simulation by ASPEN PLUS for Heat Exchanger
4. Simulation by ASPEN PLUS for Reactors (CSTR, PFR Etc)
5. Simulation by ASPEN PLUS for Cumin Production system
6. Simulation by ASPEN PLUS for Plant Optimization
7. Simulation by ASPEN PLUS for Property Estimation
8. Simulation by ASPEN PLUS for Methanol- Water System

BOOKS RECOMMENDED

1. Sinnott R. K., "Coulson & Richardson's Chemical Engineering", Vol. 6, 4th Ed., Elsevier, 2005.
2. Edgar T. F., Himmelblau D. M., Lasdon L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw-Hill, New York, 2001.
3. Smith R., "Chemical Process Design", McGraw-Hill, New York, 2000.
4. Biegler L. T., Grossmann E. I., Westerberg A. W., " Systematic Methods of Chemical Process Design", Prentice-Hall , New Jersey, 1997.
5. Douglas J., "Conceptual Design of Chemical Processes", McGraw-Hill, New York, 1989.

B. Tech. IV (CH), Semester - VIII	L	T	P	C
CH 408: SAFETY AND POLLUTION CONTROL IN CHEMICAL PROCESS INDUSTRIES	3	-	2	4

- **ENVIRONMENTAL AND POLLUTION IN CHEMICAL INDUSTRIES** **(02 Hours)**
  Definitions, scope and importance, need for public awareness, sources of pollution from Chemical industries
- **ENVIRONMENTAL LAWS AND STANDARDS** **(03 Hours)**
  Laws related to solid, liquid and gases effluents, standards and legislations, Health and environmental effects, case studies for specific industries like petrochemicals, fertilizers, desalination, petroleum refining.
- **POLLUTION PREVENTION THROUGH PROCESS MODIFICATION** **(10 Hours)**
  Recovery of by-products, Energy recovery, Waste utilization and recycle and reuse and waste generation minimization
- **AIR POLLUTION CONTROL** **(05 Hours)**
  Air pollution control through mechanical separation, adsorption, etc.
- **WATER POLLUTION CONTROL** **(05 Hours)**
  Water pollution control by physical, chemical and biochemical methods.
- **DESIGN OF CONTROL EQUIPMENT AND SYSTEMS** **(06 Hours)**
  Designs to prevent fires and explosions, fire triangles, fault tree analysis, case studies
- **SOLID WASTE TREATMENT AND DISPOSAL** **(04 Hours)**
  Types of solid waste, generation, onsite handling, storage & processing, Disposal techniques, recovery of resources, conversion products and energy.
- **SAFETY IN CHEMICAL PROCESS INDUSTRIES** **(10 Hours)**
  Safety and loss prevention, safety systems, Hazardus properties of chemicals, characterization of chemical processes, the nature and impact of chemical plant accidents, occupational safety and industrial hygiene, Toxicology, toxic release, case studies

(Total contact time: 45 hours)

PRACTICALS

1. Determination of Dissolved Oxygen (DO)
2. Determination of Biochemical Oxygen Demand (BOD)
3. Determination of Chemical Oxygen Demand (COD)
4. Determination of Oil and Grease
5. Determination of Alkalinity
6. Determination of Acidity
7. Determination of Chloride Ion Concentration
8. Determinations of Total Suspended Solids (TSS)
9. Calorific value
10. Sampling Programs
11. Atomic Absorption Spectrophotometer Method

BOOKS RECOMMENDED:

1. Crowl D. A., Louvar J. F., "Chemical Process Safety", Prantice-Hall, 2nd Ed., New York, 2002.
2. Metcalf & Eddy, "Waste Water Engineering: Treatment, Disposal and Reuse", Tata-McGraw-Hill, New Delhi, 2002.
3. MaCarty S., "Chemistry for Environmental Engineering", Tata-McGraw-Hill, New Delhi, 2004.
4. Rao C.S., Environmental Engineering, Wiley Eastern Limited, New Delhi, 1995.
5. Sanders R E., "Chemical Process Safety", Butterworth-Heinemann, New Delhi, 2005.
6. Masters G.M., "Introduction to Environmental Engineering and Science", Prentice-Hall, New Delhi, 1997.