SEMESTER WISE COURSE STRUCTURE

& EVALUATION SCHEME

MASTER OF TECHNOLOGYCHEMICAL ENGINEERING

(Effective from the session 2022-23 for new entrants)

DEPARTMENT OF CHEMICAL ENGINEERING HARCOURT

BUTLER TECHNICAL UNIVERSITYKANPUR

Chemical Engineering Department

OUR VISION

To emerge as a global leader in the areas of education and research in Chemical Engineering to handle the technological challenges in Chemical Engineering & Allied Field and catering the requirement of present and future stakeholders and society.

OUR MISSION

1. To provide state-of-art technical education to the undergraduate and post graduate students.
2. To create a conducive and supportive environment for the overall growth of our students.
3. To cultivate awareness of social responsibilities in students to serve the society.
4. To groom students with leadership skills helpful in Startups, professional ethics and accountability along with technical knowledge to face the changing needs of industry and environment.
5. To impart consultancy services to the Chemical and Allied industries of region, state and the country.

For PG

Programme Educational Outcomes (PEOs)

Post Graduates from our department will be able to

1. Independently conduct fundamental and applied research in industries and academia.
2. Work in a team for a multidisciplinary approach in problem solving for varied fields of chemical process industries.
3. Demonstrate good professional ethics and engineering judgment on the global, economical, environmental and social issues.

Programme Specific Outcomes (PSOs)

1. Identify, formulate and solve engineering problems in core chemical industry processes and R&D.
2. Undertake technical projects and consultancy in their chosen fields of specialization.
3. Contribute to the development of scientific and technical knowledge by effectively communicating the acquired knowledge and core competence among students, industry professionals, clients and society.

SEMESTER WISE COURSE STRUCTURE & EVALUATION SCHEME M. TECH. (CHEMICAL ENGINEERING) (FULL TIME PROGRAMME)

SEMESTER - I

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					CT	TA	Lab.	Total		
1	PCC	NCH 501	Advanced Chemical Engineering Thermodynamics	4 [3-1-0]	30	20	-	50	50	100
2	PCC	NCH 503	Advanced Chemical Reaction Engineering	4 [3-1-0]	30	20	-	50	50	100
3	PCC	NCH 505	Optimization of Chemical Processes	4 [3,1,0]	30	20	-	50	50	100
4	PCE	NCH 507 - 513	Elective - I	4 [3-1-0]	30	20	-	50	50	100
			Total Credits	**16**						

Elective - I [3-1-0]

NCH507	Artificial Intelligence in Chemical Engineering
NCH509	Advanced Mathematical Methods in Chemical Engg
NCH511	Safety Hazard and Risk Analysis
NCH513	Instrumental Methods of Analysis

SEMESTER - II

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					CT	TA	Lab.	Total		
1	PCC	NCH 502	Advanced Transport Phenomena	4 [3-1-0]	30	20	-	50	50	100
2	PCC	NCH 504	Advanced Separation Processes	4 [3,1,0]	30	20	-	50	50	100
3	PCC	NCH 506	Modeling And Simulation of Chemical Processes	4 [3,1,0]	30	20	-	50	50	100
4	PCE	NCH 508-514	Elective - II	4 [3,1,0]	30	20	-	50	50	100
			Total Credits	**16**						

Elective - II [3-1-0]

NCH 508	Statistical Design of Experiments
NCH 510	Nanomaterials in Science & Engineering
NCH 512	Design of Piping System for Chemical Plants
NCH 514	Water Pollution Monitoring and Control

SEMESTER - III

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					CT	TA	Lab.	Total		
1	PCC	NCH 601	Seminar	2 [0,0,4]	-	20	30	50	50	100
2	PCC	NCH 603	Industrial Training	2 [0,0,4]		50	-	50	50	100
3	PCC	NCH 605	Dissertation	12 [0,0,24]		50	-	50	50	100
			Total Credits	**16**						

SEMESTER - IV

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					CT	TA	Lab.	Total		
1	PCC	NCH 602	Dissertation	16 [0-0-32]	-	50	-	50	50	100
			Total Credits	**16**						

NCH 605 Dissertation will have Internal Evaluation while NCH 602 Dissertation will have External Evaluation**.**

SYLLABUS
M. TECH CHEMICAL ENGINEERING

NCH 501 ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS

Assessment:

Sessional: 50 marks

End Semester: 50 marks

L	T	P	C
3	**1**	**0**	**4**

Course Objectives: To learn advanced topics of classical thermodynamics with emphasis on basic concepts, laws, and thermodynamic relationships and to familiarize students with knowledge of advanced thermodynamics especially in chemical engineering related fields.

Course Outcomes:

Students completing the course will be able to

CO1	Perform Legendre transformation of Energy equation and derive Maxwell relations.	Understand, Apply,
CO2	Calculate phase equilibrium conditions (BUBL P, BUBL T, DEW T and DEW P) for non-ideal mixtures using the gamma-phi approach and Evaluate equilibrium constant and Gibbs free energy change of a chemical reaction by applying criterion of equilibrium.	Apply, Evaluate
CO3	Calculate the effect of curvature on thermodynamic properties such as vapour pressure and solubility.	Analyze, Evaluate
CO4	Calculate changes in U, H, and S for ideal gases, and also for non-ideal gases through the use of residual properties and colligative properties such as Boiling point elevation, freezing point depression.	Understand, Apply, Evaluate
CO5	Demonstrate introductory understanding to various concepts of statistical thermodynamics	Understand, Apply,

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	-	-	-	-	-	-	-	1
CO2	3	3	3	2	-	-	-	-	-	-	-	1
CO3	3	3	3	3	-	-	1	-	-	-	-	1
CO4	3	3	2	2	-	-	-	-	-	-	-	-
CO5	3	3	2	3	-	-	-	-	-	-	-	1
Avg	3	3	2.4	2.2	0	0	1	0	0	0	0	1

Module 1 (12 Lectures)

Introduction to Thermodynamics and statistical mechanics, Internal energy, First law of thermodynamics, Intensive and extensive properties Concept of entropy, Second law of thermodynamics: Extremum principles of Energy and Entropy., Legendre transforms of energy and reformulation of second law in terms of the Legendre transforms, Maxwell relations, Maximum work theorem.

Module 2 (10 Lectures)

Conditions of phase equilibrium and its applications, Gibbs Duhem relations, Gibbs phase rule, Conjugate variables, Criteria for stability and its implications. Chemical reactions: condition of equilibrium for a reaction mixture, Equilibrium constants, Heat of reaction Thermodynamics of fluid-fluid interfaces: Dividing surface, surface excess quantities, condition of equilibrium at interfaces, Kelvin equation, Gibbs adsorption isotherm, Thermodynamics of fluid-solid interfaces: condition of equilibrium with respect to dissolution and growth of solids.

Module 3 (8 Lectures)

Classical mechanics: Lagrangian formulation, Constants of motion, Hamilton's principle, and phase space, concept of statistical ensemble, Statistical independence of macroscopic bodies, Liouville equation, Measurements and ensemble averages. Micro-canonical, and Grand-canonical ensembles. Gibbs entropy formula and Boltzmann entropy formula, Partition functions, Fluctuations and stability.

Module 4 (5 Lectures)

Ideal gas: Analytical derivations of the partition functions of ideal gas in various ensembles and thermodynamic properties, Ideal solid: Analytical derivation of partition function, heat capacity, Non-ideal gases, Virial equation of state, Second virial coefficient, Liquids: Distribution functions, pair correlation function g(r) and experimental measurement of g(r) by diffraction, Mean-field theory and perturbation theory.

Module 5 (5 Lectures)

Dilute solutions and colligative properties: Derivation of Raoults law, Henry's law, Van'tHoff's formula for osmotic pressure. Boiling point elevation, freezing point depression Introductory Quantum Statistical mechanics: Schrödinger Wave equation, Degeneracy,Partition functions. Ideal gas of polyatomic particles, Molecular partition functions, Einsteinand Debye theory of perfect crystals.

Suggested Text Books

1. Herbert B. Callen, Thermodynamics and an Introduction to thermo statistics, John Wiley and Sons, 1985.
2. McQuarrie D. A. and Simon, J. D., Molecular Thermodynamics, Viva Books, Pvt. Ltd., 2004

Suggested Reference Books

1. David Chandler, Introduction to modern statistical mechanics, Oxford UniversityPress, 1987

NCH503 ADVANCED CHEMICAL REACTION ENGINEERING

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks End

Semester: 50 marks

Course Objectives: To learn the heterogeneous catalyzed reactions and the models involved in reactor design. To appreciate the importance of both external and internal transport effectsin gas-solid and liquid-solid systems.

Course Outcomes:

Students completing the course will be able to

CO1	Develop basic concepts involved in using reaction rate equations and kinetic constants for homogenous and heterogeneous reactions.	Understand, Apply,
CO2	Perform model discrimination and parameter estimation for heterogeneous catalytic reactions and Predict the role of temperature, concentration, and interphase mass transfer in the rate equations.	Apply, Evaluate
CO3	Derive design equations and perform calculations for various multiphase reactors	Analyse, Evaluate
CO4	Determine optimal reactor configurations and operating policies for systems involving multiple reactions	Understand, Apply, Evaluate
CO5	Perform analysis of falling film catalytic wall reactors, trickle bed reactors and chromatographic reactors.	Understand, Evaluate

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	3	-	-	-	-	-	-	-	1
CO2	3	3	2	2	-	-	-	-	-	-	-	-
CO3	3	3	2	3	-	-	-	-	-	-	-	-
CO4	3	3	1	3	-	-	-	-	-	-	-	-
CO5	3	3	2	3	-	-	-	-	-	-	-	-
Avg	3	3	1.8	2.8	0	0	0	0	0	0	0	1

Module 1 (6 Lectures)

Kinetics of heterogeneous catalytic reactions, rate equations, model discrimination and parameter estimation.

Module 2 (7 Lectures)

Deactivating catalysts, mechanisms of catalyst deactivation, the rate and performance equations, design.

Module 3 (7 Lectures)

Mass Transfer and Reaction in a packed bed, Stoichiometric table, Pressure drop in a Reactor, Ergun's equation, Flow through a packed bed.

Module 4 (10 Lectures)

Types of multiphase reactors, mass transfer reactors, mass transfer equations, Interfacial surface area, mass transfer between phases, multiphase reactor equations, equilibrium between phases, membrane reactors, falling film reactors, bubble column reactors.

Module 5 (10 Lectures)

Falling film catalytic wall reactor, trickle bed reactors, multiphase reactors with catalysts, other multiphase reactors, reactor-separator integration, catalytic distillation, chromatographic reactors, ironore refining, petroleum refinery.

Suggested Text Books

1. Levenspiel, O., Chemical Reaction Engineering, Wiley India, 1998.
2. Froment G. F. and Bischoff, K. B., Chemical Reactor Analysis and Design, John Wiley and Sons, 1979.

Suggested Reference Books

1. Fogler, H. S., Elements of Chemical Reaction Engineering, 2nd edition, Prentice-Hall, 2000.
2. Schmidt, Lanny D., The Engineering of Chemical Reactions, 2nd edition, Oxford University Press, 2010.

NCH 505 OPTIMIZATION OF CHEMICAL PROCESSES

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objective: To understand the concepts and origin of the different optimization methods. To get a broad picture of the various applications of optimization methods used in Chemical Engineering. Optimizes different methods in industry for design and production, both economically and efficiently.

Course Outcome:

Students completing the course will be able to

CO1	Demonstrate comprehensive understanding of various optimization techniques.	Understand
CO2	Formulate various process optimization problems.	Apply, Evaluate
CO3	Explain the need for optimization where optimal decisions need to be taken in the presence of trade-offs between two or more conflicting objectives.	Analyse, Evaluate
CO4	Implement the theory and applications of optimization techniquesin a comprehensive manner for solving linear and non-linear, geometric, dynamic, integer and stochastic programming techniques.	Understand, Apply,
CO5	Identify, formulate and solve a practical engineering problem of their interest by applying or modifying an optimization technique.	Understand, Apply, Evaluate

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	1	-	-	-	-	-	-	-
CO2	3	3	1	2	1	-	-	-	-	-	-	-
CO3	3	2	3	2	1	-	-	-	-	-	-	-
CO4	3	1	2	1	3	-	-	-	-	-	-	-
CO5	3	3	2	3	2	-	-	-	-	-	-	1
Avg	3	2.2	1.8	2	1.6	0	0	0	0	0	0	1

Module (7 Lectures)

Introduction to process optimization; formulation of various process optimization problems and their classification, Basic concepts of optimization-convex and concave functions, necessary and sufficient conditions for stationary points.

Module 2 (10 Lectures)

Optimization of one-dimensional functions, unconstrained multivariable optimization- direct search methods. Bracketing methods: Exhaustive search method, Bounding phase method

Region elimination methods: Interval halving method, Fibonacci search method, Golden section search method. Point-Estimation method: Successive quadratic estimation method.Indirect first order and second order method. Gradient-based methods: Newton-Raphsonmethod, Bisection method, Secant method, Cubic search method. Root-finding usingoptimization techniques.

Module 3 (7 Lectures)

Multivariable Optimization Algorithms: Optimality criteria, Unidirectional search, direct search methods: Evolutionary optimization method, simplex search method, Powell'sconjugate direction method. Gradient-based methods: Cauchy's (steepest descent) method, Newton's method. Constrained Optimization Algorithms: Kuhn-Tucker conditions, Transformation methods: Penalty function method, method of multipliers, Direct search for constraint minimization: Variable elimination method, complex search method.

Module 4 (6 Lectures)

Linear Programming: Graphical solution, Primal Simplex method, Artificial starting solution, Dual Simplex method, Primal-Dual relationship, Duality, Sensitivity analysis. Revised Simplex method.

Module 5 (10 Lectures)

Transportation Problem, Optimization of staged and discrete processes. Dynamic programming, Specialized & Nontraditional optimization techniques: Simulated annealing; Genetic algorithms; Differential evolution. Application of optimization in the design of separation process, chemical reactor and large-scale process plant.

Suggested Text books:

1. Edgar T. F., and Himmelblau, D. M., Optimization of Chemical Processes, Mc GrawHill, International editions, chemical engineering series, 1989.
2. G.S. Beveridge and R.S. Schechter, Optimization theory and practice, Mc GrawHill, New York, 1970.
3. Hamdy A. Taha, Operation Research, Pearson, 2008

Suggested Reference Books:

1. Rekllitis, G.V., Ravindran, A., and Ragdell, K.M., Engineering Optimization-Methods and Applications, John Wiley, New York, 1983.
2. Latest articles from journal

TCH 507 ARTIFICIAL INTELLIGENCE IN CHEMICAL ENGINEERING

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objectives: This course provides an in-depth understanding of the applications of Artificial Intelligence (AI) in the field of Chemical Engineering. It aims to equip M.Tech. Chemical Engineering students with the necessary knowledge and skills to leverage AI techniques for solving complex problems in process design, optimization, control, and data analysis. The course covers various AI algorithms and methodologies and explores their practical implementation in chemical engineering applications. Through lectures, case studies, and hands-on exercises, students will develop a strong foundation in AI concepts and gain practical experience in applying AI techniques to chemical engineering problems.

Course Outcomes:

Students completing the course will be able to

CO1	Introduce the fundamental concepts of Artificial Intelligence and its relevance to chemical engineering.	Remember, Understand
CO2	Familiarize students with various AI techniques and algorithms applicable to chemical engineering problems.	Understand, Apply
CO3	Develop an understanding of AI-driven modeling, optimization, control, and data analysis techniques.	Understand, Apply
CO4	Provide hands-on experience with implementing AI algorithms using software tools commonly used in the chemical engineering industry.	Apply, Evaluate, Create
CO5	Encourage critical thinking and problem-solving skills through the application of AI techniques to real-world chemical engineering scenarios.	Create, Design

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	3	-	-	-	-	-	1	2
CO2	3	3	3	2	3	-	-	-	-	-	1	2
CO3	3	2	2	3	2	-	-	-	-	-	1	2
CO4	3	3	2	2	2	-	-	-	-	-	-	2
CO5	3	3	2	3	3	-	-	-	-	-	-	2
Avg	3	2.8	2.2	2.4	2.4	0	0	0	0	0	1	2

Module 1 (8 Lectures)

Introduction to the field of Artificial Intelligence

Historical development and current trends in AI, Relevance of AI in chemical engineering applications, Understanding the basic concepts of machine learning, supervised, unsupervised, and reinforcement learning, Applications of machine learning in chemical engineering, Data preprocessing and feature engineering for AI applications, Introduction to statistical analysis for AI in chemical engineering, Software tools for AI in chemical engineering.

Module 2 (8 Lectures)

AI Techniques for Modeling and Simulation

Supervised learning algorithms: regression, classification, and ensemble methods, Unsupervised learning algorithms: clustering and dimensionality reduction, Neural networks and deep learning for modeling chemical processes, Model validation and performance evaluation techniques, Introduction to AI modeling software.

Module 3 (8 Lectures)

AI for Data Analysis and Predictive Modeling

Time-series analysis and forecasting using AI, Anomaly detection and fault diagnosis in chemical processes, AI-based predictive modeling for process performance and quality prediction, Handling big data in chemical engineering applications, Software tools for AI data analysis and predictive modeling.

Module 4 (8 Lectures)

AI in Process Safety and Sustainability

AI applications in hazard identification and risk assessment, Predictive maintenance and reliability analysis using AI, AI-driven approaches for energy efficiency and sustainability in chemical processes, Integration of AI techniques with safety management systems.

Module 5 (8 Lectures)

Case Studies and Practical Implementation

Analysis and discussion of case studies showcasing AI applications in chemical engineering.

Practical implementation of AI algorithms using software tools

Ethical considerations and challenges in AI implementation in chemical engineering

Suggested Text Books

1. Edgar, Thomas F., and Davis L. South. Artificial Intelligence in Chemical Engineering. Wiley, 2019.
2. Shmueli, G., and Bhushan G. Machine Learning for Chemical Engineering: Data Analysis, Modeling, and Prediction. Wiley, 2019.

Suggested Reference Books

1. Spiegel, M. R. Advanced Mathematics for Engineers and Scientists, SchaumOutline Series, McGraw Hill, 1971.
2. David M. Reklaitis and Ananth Y. Annaswamy, Data Driven Chemical Engineering, John Wiley & Sons, 2017.
3. Weifeng Z. and Huaixiu Z., Artificial Intelligence in Process Engineering by, Springer, 2019.

TCH 509 ADVANCED MATHEMATICAL METHODS IN CHEMICAL ENGINEERING

Assessment:

Sessional: 50 marks

End Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objectives: To give students an insight in various Chemical Engineering processes using advanced analytical methods and provide adequate background of Mathematics to deal with Chemical Engineering Problems, to understand research papers on relevant topics involving advanced Mathematics.

Course Outcomes:

Students completing the course will be able to

CO1	Solve problems of algebraic equations	Understand, Apply,
CO2	Solve problems of differential equations and simultaneous equations	Apply, Evaluate
CO3	Solve problems of partial differential equations	Analyse, Evaluate
CO4	Apply Frobinious method to solve Bessel equation	Apply, Evaluate, Create
CO5	Apply Frobinious method to solve hypergeometric equation	Apply, Evaluate

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	-	-	-	-	-	1	1
CO2	3	3	3	2	3	-	-	-	-	-	1	1
CO3	3	2	2	3	2	-	-	-	-	-	1	1
CO4	3	3	2	2	2	-	-	-	-	-	-	-
CO5	3	3	2	3	2	-	-	-	-	-	-	-
Avg	3	2.8	2.2	2.4	2.4	0	0	0	0	0	1	1

Module 1 (12 Lectures)

Ordinary Differential Equations, Separable equations, Equations made separable by change of variables, Homogeneous Equations, Equations with first order and first degree with linear coefficients, Exact equations, Linear equation of first order, Bernoulli’s equation, Other integrating factors, Integration of Exact equations, Equations of first order and higher degree, Clairaut’s equation, Singular solutions, Equations with missing terms, General properties of

Linear equations, Linear equations with constant coefficients, Determination of the complementary function, exponential functions, Determination of the particular integral, the Euler equation, Simultaneous Linear Differential equations.

Module 2 (6 Lectures)

Power series method, theory of the power series method, Legendre's equation, Legendre's Polynomials, Frobenius Method.

Module 3 (6 Lectures)

Bessel's equation, Bessel Functions Jv(x), Bessel Functions Jv(x) for any $v \geq 0$. Gamma Function, Solution J-v(x) of the Bessel Equation, Backbones of Bessel's Theory, Jv(x) with v= $\pm 1/2$, $\pm 3/2$, $\pm 5/2$.

Module 4 (8 Lectures)

Definition of matrix, some special definitions and operations involving matrices, Determinants, Theorems on determinants, Inverse of a matrix, Orthogonal and unitary matrix. Orthogonal vectors, System of linear equations, Systems on n equations with n unknowns, Cramer's Rule, Eigen values and Eigen vectors.

Module 5 (8 Lectures)

Partial Differential equations, some definitions involving partial differential equations, linear partial differential equations, some important partial differential equations, Method of solving boundary-value problems, General solutions, Separation of variables, Laplace transform nethods.

Suggested Text Books

3. Mickley, Reid and Sherwood, "Applied Mathematics in Chemical Engineering", Tata McGraw Hill, New Delhi (1981).
4. E. Kreyszig, "Advanced Engineering Mathematics", 8th edition, John Wiley and Sons (1999).

Suggested Reference Books

1. M. R. Spiegel, "Advanced Mathematics for Engineers and Scientists", Schaum Outline Series, McGraw Hill, (1971).

NCH 511 SAFETY HAZARD AND RISK ANALYSIS

Assessment:

Sessional: 50 marks End

Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objectives: The course is aimed to familiarize the students with the principles of industrial safety and standard safety procedures to be followed in chemical industries. On completion of the course, the students are expected to demonstrate a comprehensive understanding of various accident prevention techniques, hazard analysis techniques and legislations pertaining to safety in chemical industries.

Course Outcomes:

Students completing the course will be able to

CO1	Identify various types of hazards and risks in a chemical industry.	Understand, Remember
CO2	Perform risk analysis by applying various risk assessment techniques.	Apply, Evaluate
CO3	Identify various toxic substances, estimate their toxic limits and suggest protective techniques so that the exposure is within safe limits.	Analyse, Evaluate
CO4	Suggest proper ways of handling, transportation and storage of flammable liquids, gases, and toxic materials.	Understand, Evaluate
CO5	Perform disaster planning and management and prepare for any emergency situations.	Apply, Evaluate

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	1	-	-	-	-	-	-	-	1
CO2	3	2	1	1	-	-	-	-	-	2	-	1
CO3	3	2	3	2	1	-	-	-	-	-	-	-
CO4	3	2	2	2	1	-	-	-	-	-	-	-
CO5	3	1	2	2	2	-	-	-	2	-	-	1
Avg	3	1.6	1.8	1.6	0.8	0	0	0	0.4	0.4	0	0.6

Module 1 (6 Lectures)

Industrial safety, Industrial hygiene and safety aspects related to toxicity, noise, pressure, temperature, vibrations, radiation etc. Explosions including dust, vapor, cloud and mist explosion.

Module 2 (8 Lectures)

Elements of safety, safety aspects related to site, plant layout, process development and design stages, identification of hazards and its estimation, risk, risk analysis and assessment methods; fault free method, event free method, scope of risk assessment, controlling toxic chemicals and flammable materials.

Module 3 (8 Lectures)

Toxic substances and degree of toxicity, its estimation, their entry routes into human system, their doses and responses, control techniques for toxic substances exposure, use of respirators, ventilation systems.

Module 4 (9 Lectures)

Prevention of losses, pressure relief, provision for fire fighting, release of hazardous materials from tanks, pipes through holes and cracks, relief systems: types and location of relief's.

Module 5 (9 Lectures)

Handling, transportation and storage of flammable liquids, gases, and toxic materials and wastes, regulation and legislation, government role, risk management routines, emergency preparedness, disaster planning and management.

Suggested Text Books:

1. Daniel A. Crowl and Joseph F. Louvar, Chemical Process Safety: Fundamentals with applications, Prentice Hall, Inc, 1990.
2. F. P. Lee's, Loss prevention in the process Industries, Volume 1 and 2 Butterworth, 1983.
3. Hoboken, N. J., Guidelines for Chemical Process Quantitative Risk Analysis, Wiley-Interscience, 2000.

Suggested Reference Books:

1. R. W. King and J. Magid, Industrial Hazards and Safety Handbook, Butterworth, 1982.
2. G. L. Wells, Safety in Process Plant Design, John Wiley and Sons Inc., 1980.
3. Fawcett, H.H. and W.S. Wood, Safety and Accident Prevention in Chemical Operations, 2nd Edition, Wiley-Interscience, New York, 1982.

NCH 513 INSTRUMENTAL METHODS OF ANALYSIS

Assessment:

L	T	P	C
3	1	0	4

Sessional: 50 marks End

Semester: 50 marks

Course Objective:

This course introduces theoretical principles behind modern analytical instrumentation techniques and practical considerations, scope and limitations of each of them.

Course Outcomes:

Students completing the course will be able to

CO1	Select a suitable method for analysis of a given sample	Understand, Apply
CO2	Analyze the data obtained from any technique to infer meaningful results.	Apply, Evaluate
CO3	Identify the scope and limitations of various techniques.	Analyze, Evaluate
CO4	Identify sources of error in each technique and minimize the errors incurred in analysis.	Understand, Apply, Evaluate
CO5	Design the instrument for basic parameters testing.	Apply, Evaluate

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	-	-	-	-	-	-	-	-
CO2	3	2	1	1	-	-	-	-	-	-	-	-
CO3	3	2	3	2	3	-	-	-	-	-	-	-
CO4	3	3	2	2	3	-	-	-	-	-	-	-
CO5	3	3	3	3	2	-	-	-	-	-	-	-
Avg	3	2.6	2.2	1.8	2.75	0	0	0	0	0	0	0

Module 1 (9 Lectures)

Introduction to spectroscopic techniques, UV - Vis Spectrophotometry, Nephelometry,Turbidimetry, Reflectance Spectrometry, Fluorescence, Phosphorescence Spectrometry.

Module 2 (8 Lectures)

Flame Emission and Atomic Absorption Spectrometry, Electro thermal AAS, Hydride generation AAS and Flameless mercury analysis. Inductively Coupled Plasma Atomic Emission Analysis.

Module 3 (9 Lectures)

Infrared spectrometry, Introduction to X-Ray techniques, XRF. Introduction to NMRspectroscopy and mass spectrometry.

Module 4 (7 Lectures)

Electro analytical techniques: Potentiometry, Voltametry, Polarography Chromatographicanalysis: GC, LC

Module 5 (7 Lectures)

Chromatographic analysis, HPLC, Hyphenated techniques. Errors, statistical methods of data handling

Suggested Text Books:

1. H.Willard, L.L Meritt, J.A Dean and F.A.Settle: Instrumental Methods of Analysis, 6th Edition, CBS.
2. A.I.Vogel: Quantitative Inorganic Analysis, 5th Edition, ELBS.

Suggested Reference Books:

1. G.W. Ewing: Analytical Instrumentation Hand book, Marcell Dekker, New York, 1990.

NCH 502 ADVANCED TRANSPORT PHENOMENA

Assessment:

Sessional: 50 marks End

Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objective: The course will accustom the students with import topics in advanced transport phenomena (momentum, heat and mass transport). The focus will be to develop physical understanding of principles discussed and with emphasis on chemical engineering applications. In addition to the text, the student will be exposed to classic and current literature in the field.

Course Outcome:

Students completing the course will be able to

CO1	Set up and solve differential momentum, heat, and mass balances for 1-D steady state problems and quasi-steady-state problems occurring in laminar and turbulent flows in terms of vector and tensor fluxes.	Understand, Apply
CO2	Formulate conservation statements in heat, mass, and momentum at multiscale from microscopic to macroscopic in both steady and unsteady modes.	Apply, Evaluate
CO3	Analyze advanced transport problems in heat, mass, and momentum, both macroscopic and microscopic, formulate simultaneous energy and mass balances in chemical processes.	Analyse, Evaluate
CO4	Understanding of differential equation application in transport of heat, fluid and mass.	Understand, Evaluate
CO5	Conceptual understanding of heat, fluid and mass transfer.	Understand, Apply, Evaluate

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	-	-	-	-	-	-	-	-
CO2	3	2	1	1	-	-	-	-	-	-	-	-
CO3	3	3	3	2	3	-	-	-	-	-	-	-
CO4	3	3	3	2	3	-	-	-	-	-	-	-
CO5	3	3	3	3	2	-	-	-	-	-	-	-
Avg	3	2.8	2.4	1.8	2.75	0	0	0	0	0	0	0

Module 1 (6 Lectures)

Philosophy and fundamentals of three transport phenomena: Importance of transport phenomena; analogous nature of transfer process; basic concepts, conservation laws.

Molecular transport of momentum, Heat and mass, laws of molecular transport, Newton’s law of viscosity, Fourier law of heat conduction, and Fick’s law of diffusion. Transport coefficients – viscosity, thermal conductivity, and mass diffusivity. Estimation of transport coefficients and temperature / pressure dependence.

Module 2 (8 Lectures)

one dimensional transport in laminar flow (shell balance): Newtonian and non-Newtonian fluids, General method of shell balance approach to transfer problems; Choosing the shape of the shell; most common boundary conditions; momentum flux and velocity distribution for flow of Newtonian fluids in pipes, for flow of Newtonian fluids in planes, slits and annulus, Time derivatives, The equation of continuity, the equation of motion, the equations of changein curvilinear, co-ordinates, use of the equations of change to set up steady flow problems.

Module 3 (9 Lectures)

Unsteady state momentum transport, Flow near a wall suddenly set in motion, Momentum transport phenomena in turbulent flow. Definitions of friction factors, friction factor for flow in tubes, for flow around spheres, for packed bed column.

Module 4 (9 Lectures)

shell energy balance, boundary conditions, Heat conduction with an electrical heat source, Heat conduction in a cooling fin, heat conduction with exothermic reactions. Temperature distributions with more than one independent variables: Unsteady state heat conduction in solids, Boundary layer theory.

Module 5 (8 Lectures)

Definitions of concentrations, velocities & mass fluxes, Fick's law of diffusion, Temperature & pressure dependence of mass diffusivity, Maxwell’s law of diffusion. Shell mass balance, boundary conditions, diffusion through a stagnant gas film. Diffusion with heterogeneous chemical reaction, Diffusion with homogeneous chemical reaction, Diffusion in to a fallingliquid film.

Suggested Text Books:

1. R.B. Bird, W.E. Stewart and Lighfoot, E.W., Transport Phenomena, 2nd Edition. JohnWiley, 2002
2. Wilty J.R., Wilson, R.W. and Wicks, C.W., Fundamentals of Momentum Heat and Mass Transfer, 4th Edition, John Wiley, New York, 2001

Suggested Reference Books:

1. Christie J. Geankopolis,Transport Processes and Separation Process Principles 4th Edition. Printice-Hall, 2003
2. Brodkey, R.S. and Hershey H.C., Transport Phenomena – A Unified Approach, McGraw Hill, 1988

NCH 504 ADVANCED SEPARATION PROCESSES

L	T	P	C
3	**1**	**0**	**4**

Assessment:

Sessional: 50 marks End

Semester: 50 marks

Course Objectives: To learn the principle and technical concept of advanced separation processes. Create awareness among students with new and unconventional separation processes, Acquire sufficient knowledge in energy intensive processes for separation of components, Students will be equipped with the applications in Down-streaming processes

Course Outcome:

Students completing the course will be able to

CO1	Analyze multicomponent distillation using shortcut methods.	Understand, Apply
CO2	Calculate the enhancement factor for absorption with chemical reactions and estimate the effect of reversibility of chemical reaction on the mass transfer rate.	Apply, Evaluate
CO3	Select a suitable membrane for a given separation process and determine the effect of process variables on gas separation by membranes.	Analyze, Evaluate
CO4	Analyze the effect of process variables on Reverse osmosis membrane processes and Ultrafiltration membrane processes.	Analyze, Apply, Evaluate
CO5	Explain Supercritical fluid extraction, Supercritical fluid chromatography, and Supercritical fluid reactions.	Understand, Apply, Evaluate

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	2	-	-	-	-	-	-	-	-
CO2	3	3	1	1	-	-	-	-	-	-	-	-
CO3	3	2	1	2	-	-	-	-	-	-	-	-
CO4	3	2	2	2	2	-	-	-	-	-	-	-
CO5	3	1	3	3	2	-	-	-	-	-	-	-
Avg	3	1.8	1.6	2	0.8	0	0	0	0	0	0	0

Module 1 (5 Lectures)

Fundamentals of separation process, Review of Distillation, Multi component distillation –Bubble point and dew point calculations and Short cut methods, Azeotropic distillation; Extractive distillation; Molecular distillation; Reactive distillation

Module 2 (8 Lectures)

Absorption with chemical reaction; Enhancement factor; Simultaneous diffusion and chemical reaction near an interface – Film theory, Penetration theory, Surface renewal theory Surfactant based separation processes: Liquid membranes: fundamentals and modeling. , Micellar enhanced separation processes, Cloud point extraction.

Module 3 (8 Lectures)

Supercritical fluid extraction – Supercritical fluids, Phase equilibria, Industrial applications; Important supercritical processes – Decaffination of coffee, Extraction of oil from seeds, Residuum oil supercritical extraction (ROSE), Supercritical fluid chromatography, Supercritical fluid reactions etc. Centrifugal Separation processes chromatographic separation processes

Module 4 (10 Lectures)

Classification of membrane processes; Liquid permeation membrane processes or dialysis – Series resistance in membrane processes, Dialysis processes, Types of equipment for dialysis; Gas permeation membrane processes – Types of membranes and permeabilities for separation of gases, Types of equipment for gas permeation membrane processes (flat membranes, spiral-wound membranes, hollow-fibre membranes); Types of flow in gas permeation; Complete-mixing model, cross-flow model and countercurrent flow model for gas separation by membranes; Effect of processing variables on gas separation by membranes

Module 5 (9 Lectures)

Reverse osmosis membrane processes – Osmotic pressure of solution, flux equation, Typesof equipment and Complete mixing model; Effect of operating variables; Concentration polarization; Permeability constants

Ultrafiltration membrane processes – Types of equipment, flux equation, effects of processing variables

Suggested Text Books:

1. Geankoplis, C. J., Transport Processes and Unit Operations, Prentice-Hall of India Pvt. Ltd., New Delhi, 2000.
2. Sherwood, T. K., Pigford R. L., and Wilke, C.R., Mass Transfer, McGraw-Hill, New York, 1975.

Suggested Reference Books:

1. Treybal, R. E., Mass-Transfer Operations, McGraw-Hill, New York, 1980.
2. Latest articles from journals

NCH 506 MODELING AND SIMULATION OF CHEMICAL PROCESSES

Assessment: Sessional:

50 marks End Semester:

50 marks

L	T	P	C
3	1	0	4

Course Objective:

To give an overview of various methods of process modeling, different computational techniques for simulation. The focus shall be on the specific applications so that the studentcan take up modeling and simulation challenges in his profession.

Course Outcome:

CO1	Select the type of model to be used based on the problem. That is make a selection simple vs. rigorous model, lumped parameter vs. distributed parameter, Steady state vs. dynamic, Transport phenomena based vs. Statistical models.	Understand, Apply
CO2	Development of process models based on conservation principles and process data	Apply, Evaluate
CO3	Develop steady state models for various heat transfer and mass transfer equipment.	Apply, Evaluate
CO4	Develop mathematical models of Batch reactors, Continuous-stirred tank reactors and Plug-flow reactors	Understand, Apply,
CO5	Demonstrate the knowledge of various simulation packages and available numerical software libraries.	Understand, Apply, Evaluate

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	3	-	-	-	-	-	-	-	-
CO2	3	3	2	2	-	-	-	-	-	-	-	-
CO3	3	3	3	1	1	-	-	-	-	-	-	-
CO4	3	3	2	2	1	-	-	-	-	-	-	-
CO5	3	3	3	3	3	-	-	-	3	-	-	1
Avg	3	3	2.4	2.2	1	0	0	0	0.6	0	0	0.2

Module 1 (10 Lectures)

Fundamentals of mathematical modeling-Principles of formulations, Fundamental laws: Continuity equations, energy equation, equation of motion, transport equations, equation of state, equilibrium, chemical kinetics; Advantages and limitations of models and applicationsof 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; Concept of degree of freedom for steady state and unsteady state systems.

Module 2 (8 Lectures)

Mathematical models of heat-transfer equipments: Double pipe heat exchanger, Shell & tube heat exchangers, Evaporators, Fired heaters, Partial condensers

Module 3 (6 Lectures)

Mathematical models of mass-transfer equipments: Batch and continuous distillation columns, Reactive distillation columns, packed absorption columns, Dehumidifiers

Module 4 (8 Lectures)

Mathematical models of reactors: Batch reactors, Continuous-stirred tank reactors, Plug-flow reactors, Industrial reactors-Ammonia converter, Sulphuric acid converter, Methanol reactor, FCC reactor, Claus reactor, etc.

Module 5 (8 Lectures)

Numerical methods: Linear and non-linear simultaneous algebraic equations, Ordinary-differential equations-Initial-value problems & boundary-value problems, Partial-differential equations Different approaches to flow sheet simulation- Sequential modular approach, Simultaneous modular approach, Equation oriented approach; Review of thermodynamic procedures and physical property data banks.

Suggetsed Text Books:

1. Luyben, W. L., Process Modeling, Simulation, and Control for Chemical Engineering, 6th ed. McGraw-Hill Education, 2016.
2. Denn, M.M. Process Modelling, Wiley, New York, 1990.
3. Hussain Asghar, "Chemical Process Simulation", Wiley Eastern Ltd., New Delhi,1986.
4. Holland C.D. and Liapis, A.I. Computer Methods for Solving Dynamic SeparationProblems, McGraw Hill, 1983.

Suggested Reference Books:

1. Holland, C.D. Fundamentals of Modelling Separation Processes, Prentice Hall,1975.
2. Walas, S.M. Modelling with Differential Equations in Chemical Engineering,Butterworth, 1991.

NCH 508 STATISTICAL DESIGN OF EXPERIMENTS

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objectives: The aim of the course is to give competences in the field of applied statistical methods for work concerning planning and analysis of experiments, regression analysis, optimization of processes and multivariate analysis.

Course Outcome:

Students completing the course will be able to

CO1	Understand the importance of randomization and replication of experimental data set.	Understand, Apply
CO2	Estimate statistical variance and perform analysis of variance, regression analysis, correlation analysis on a given experimental data	Apply, Evaluate
CO3	Design full factorial and fractional factorial experiments and analyse the data	Analyse, Evaluate, Apply
CO4	Develop nested designs, block designs and response surface designs	Understand, Evaluate
CO5	Recognize what design was followed and perform the appropriate analysis given the description of how a set of data was collected.	Analyse, Apply, Evaluate

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	-	-	-	-	-	-	-
CO2	3	3	2	2	1	-	-	-	-	-	-	-
CO3	3	2	3	3	2	-	-	-	-	-	-	-
CO4	3	3	3	2	1	-	-	-	-	-	-	-
CO5	3	3	2	3	2	-	-	-	-	-	-	-
Avg	3	2.6	2.4	2.2	1.4	0	0	0	0	0	0	0

Module 1 (7 Lectures)

Introduction to statistics for engineers: Simplest discrete and continuous distributions, Statistical inference, Statistical estimation, tests and estimates on statistical variance,Analysis of variance, Regression analysis (Simple linear, multiple, polynomial, nonlinear), Correlation analysis (Correlation in linear regression, correlation in multiple linear regression)

Module 2 (8 Lectures)

Design and analysis of experiments: Introduction to design of experiments, Preliminaryexamination of subject of research, Screening experiments

Basic experiment-mathematical modeling: Full factorial experiments and fractional factorial experiments, Second-order rotatable design (Box-Wilson design).

Module 3 (9 Lectures)

Orthogonal second order design (Box Benken design), D-optimality, Bk-designs and Hartleys second order design.

Statistical analysis: Determination of experimental error, Significance of the regressioncoefficients, Lack of fit of regression models

Module 4 (7 Lectures)

Experimental optimization of research subject: Problem of optimization, Gradientoptimization method, canonical analysis of response surface.

Module 5 (9 Lectures)

Mixture design `composition-property: Screening design `composition-property', Simplex lattice design, Scheffe simplex lattice design, Simplex centroid design, Extreme vertices design, D-optimal design, Draper-Lawrence design, Factorial experiments with mixture, Full factorial combined with mixture design.

Suggested Text Books:

1. Z. R. Lazic, Design of experiments in chemical engineering: A practical guide, Wiley, 2005.

NCH 510 NANOMATERIALS IN SCIENCE & ENGINEERING

L	T	P	C
3	1	0	4

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objectives: • This course aims to provide a broad overview of fundamental principles and laws governing the properties at nanometer scale. Students will learn various top down and bottom up approaches for nanostructure synthesis and experimental techniques to characterize them. This course will also introduce various applications of nanotechnology in chemical engineering.

Course Outcomes:

Students completing the course will be able to

CO1	Describe the basic science behind the novel and superior properties of materials at the nanometer scale	Remember, Understand,
CO2	Demonstrate a comprehensive understanding of the state-of-the art nanofabrication methods	Understand, Apply
CO3	Compare and select suitable techniques for characterization of a given nanomaterial	Understand, Apply
CO4	Explain how nanotechnology can be put to use in varied areas of science and engineering	Apply, Analyze
CO5	Evaluate the impact of nanotechnology on society and environment. Evaluate current constraints such as regulatory, ethical, political, social and economic; when putting nanotechnology to use.	Understand, Apply, Evaluate, Analyze

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	1	3	1	-	-	-	-	-	1
CO2	3	3	1	1	2	-	-	-	-	-	-	1
CO3	3	3	3	2	3	-	-	-	-	-	-	1
CO4	3	2	1	2	3	-	-	-	-	-	-	-
CO5	3	2	3	3	2	-	-	-	-	-	-	3
Avg	3	2.2	1.8	1.8	2.6	1	0	0	0	0	0	1.5

Module 1 (6 hours): Introduction to Nanotechnology

Emergence and challenges, Nanomaterials and its classification, Properties of individual nanoparticles, Methods of synthesis, Reactivity of nanoparticles, List of stable carbon allotropes extended, Synthesis of carbon Bucky balls, Fullerenes, Metallo-fullerenes, solid C60, Nanotubes, Nanowires, Carbon nanostructures.

Module 2 (6 hours): Synthesis of Nanomaterials

Methods of synthesis of Nanomaterials: Bottom-up (building from molecular level) and Top-down (breakdown of bulk/microcrystalline materials) approaches. Manufacturing of nanoscale materials: Chemical vapor deposition of carbon nano tubes, Plasma deposition of ultra thin functional films on Nanomaterials, Solution based Synthesis of Nanoparticles, Vapour Phase Synthesis & Synthesis with framework, Nanolithography, Dip Pen Lithography. Artificially Layered Materials: Quantum Well, Quantum Dots.

Module 3 (6 hours): Characterization of Nanomaterials
Optical Microscopy, Electron Microscopy, Secondary electron scattering, Back scattering, Scanning Probe Microscopes, Focused Ion Beam Technique, X-ray imaging, Transmission Electron Microscope (TEM), Scanning Probe Microscope (SPM)- Atomic Force Microscope (AFM), Scanning Tunneling Microscope (STM).

Module 4 (6 hours): Classification of Nano-materials
Amorphous, Crystalline, microcrystalline, quasi-crystalline and nano-crystalline materials, Intermolecular forces, Aqueous, Biological, Van der-waal, Electro static, Double layer forces.

Module 5 (6 hours): Applications of Nano-materials
Nano biotechnology: Drug Delivery, Nanoclay, Nanocomposites, Surface coatings, Selfcleaning Materials, Hydrophobic Nanoparticles, Biological nanomaterials, Nano electronics, Nano machines & Nano devices, Nano hydrogel, Photocatalytic reactors, Nano clay Synthesis, Polymer nanocomposite, Waste Water Treatment, Societal, Health and Environmental Impacts, Introduction to industries which produces commercial nanomaterials.

Suggested Text Books

1. G. Louis Hornyak, Joydeep Dutta, Harry F. Tibbals and Anil K. Rao, Introduction to NanoScience, CRC Press of Taylor and Francis Group, 2008
2. Pools C.P. and Owens F.J., Introduction to Nanotechnology, Wiley-Interscience, 2003
3. G.Cao, Nanostructures and Nanomaterials, Synthesis, Properties and Applications, Imperial College Press, 2004.

Suggested Reference Books

1. Bhusan B., Springer Handbook of Nanotechnology, 4th Ed., 2017

NCH 512 DESIGN OF PIPING SYSTEM FOR CHEMICAL PLANTS

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objective: This course covers various aspects of designing a piping system fora chemical plant. This includes selection of the type, size and material of pipes and various fittings. Course also deals with piping layout and its installation.

Course Outcome:

Students completing the course will be able to

CO1	Calculate pressure drop for Newtonian & non-Newtonian fluids, incompressible & compressible fluids and two-phase flows.	Understand, Apply
CO2	Calculate economic pipe diameter and optimum insulation thickness for a given fluid flow.	Apply, Evaluate
CO3	Calculate stresses in a curved pipe line or in a bend.	Evaluate
CO4	Select proper type and material of joints, valves, bolts, gaskets and other fittings for a given fluid.	Understand, Apply, Evaluate
CO5	Design piping layout around a given equipment and for the whole plant.	Understand, Evaluate

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	-	-	-	-	-	-	-	1
CO2	3	3	2	2	-	-	-	-	-	-	-	1
CO3	3	3	3	3	1	-	-	-	-	-	-	1
CO4	3	2	1	2	2	-	-	-	-	-	-	1
CO5	3	2	1	3	2	-	-	-	-	-	-	1
Avg	3	2.6	1.8	2.4	1.5	0	0	0	0	0	0	1

Module 1 (6 Lectures)

Fundaments of fluid flow through pipes-Calculation of pressure drop for Newtonian & non-Newtonian fluids, incompressible & compressible fluids and two-phase flow.

Module 2 (7 Lectures)

Calculation of Economic pipe diameter, insulation thickness, equivalent length, Slurry transport and pipelines.

Module 3 (10 Lectures)

Engineering flow diagram, nomenclature and equipment elevation

Piping layout, line pressure drop, piping analysis, stress analysis of curved pipelines, yard piping, Piping codes, standards and specifications-ASME, ASTM, API.

Module 4 (9 Lectures)

Piping components-pipes, pipe ends, pipe fittings, end fittings, flanged joints, valves, valve codes and standards, valve classification, valve components, bolts, gaskets (fasteners and sealing elements)Piping materials-selection, cost and installation.

Module 5 (8 Lectures)

Design of heat exchanger piping, Thermosyphon reboiler piping, Pressure relief piping Steam tracing design, Thermowell design, Expansion loops and expansion joints Design of pipeline network-Pinch analysis Pipeline operation and maintenance-friction reduction, cleaning, coating, wear, leak detection, water hammer.

Selected Text Books:

1. Peter Smith, Fundamentals of piping design, Gulf Publishing House

Selected Reference Books:

1. Kellog, Design of pipeline systems

TCH 514 WATER POLLUTION MONITORING AND CONTROL

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks End

Semester: 50 marks

Course Objective:

To study methods of monitoring water pollution from various sources and characterize waste water based on its constituent pollutants. Learn ways to reduce BOD and COD and design a waste water treatment plant covering various physical, chemical and biological processes routinely used. Advanced treatment options utilizing ion exchange and membrane separation will also be covered. Students will be introduced to schemes for treatment of some typical industrial wastes from pulp and paper, sugar, distillery, dairy, fertilizer, refinery etc.

Course Outcome:

Students completing the course will be able to

CO1	Isolate specific sources of water pollution and monitor the levels so that they comply with minimum national standards.	Understand, Apply,
CO2	Design a waste water treatment plant for given reduction in BOD and COD.	Apply, Evaluate
CO3	Design plant for treatment and disposal of sludge.	Analyse, Evaluate
CO4	Select advanced treatment options based of waste water characteristics.	Understand, Apply,
CO5	Explain how the effluents from different industries are treated.	Understand, Apply, Evaluate

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	-	-	-	-	-	-	-	-
CO2	3	2	3	-	-	-	-	-	-	-	-	-
CO3	3	1	3	2	3	-	-	-	-	-	-	-
CO4	3	1	2	2	3	-	-	-	-	-	-	-
CO5	3	2	2	3	2	-	-	-	-	-	-	1
Avg	3	1.8	2.4	1.6	1.6	0	0	0	0	0	0	0.2

Module 1 (9 Lectures)

Water Pollutants, Effects, Monitoring and Quality standards: Pollution of water and soil, effect of pollutants on environment and health, monitoring water, pollution, water pollution laws and minimum national standards, monitoring, compliance with standards, Latest norms for effluent treatment.

Module 2 (8 Lectures)

Water Pollution Sources, Analysis and Methods of control: Water pollution sources and classification of water pollutants - Wastewater sampling and analysis. Treatment of water-pollution: BOD, COD of wastewater and its reduction – Fundamentals of Anaerobic digestion and Aerobic digestion.

Module 3 (8 Lectures)

Wastewater Treatment Plant Design: Physical unit operations: Screening, Flow equalization, sedimentation etc., Chemical Unit Processes: chemical precipitation, dis-infection, color removal by adsorption Biological unit processes: Aerobic suspended - growth treatment processes, aerobic attached growth treatment processes, anaerobic suspended - growth treatment processes, Anaerobic attached-growth treatment processes.

Module 4(7 Lectures)

Advanced Wastewater and Water Treatment: Carbon adsorption - Ion exchange- Membrane processes - Nutrient (nitrogen and phosphorus) removal - Design of plant for treatment and disposal of sludge.

Module 5 (8 Lectures)

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

Suggested Text Books:

1. C.S. Rao, "Environmental Pollution Control Engineering", Wiley 2nd Edition, New Age International Publishers, 2006.
2. S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill, New Delhi, 1985

Suggested Reference Books:

1. P. Sincero and G.A. Sincero, Environmental Engineering: A Design Approach Prentice Hall of India pvt Ltd, N.Delhi.1996
2. Tchbanoglous and F.L. Burton, Metcalf and Eddy’s Wastewater Treatment- Disposal And Reuse (Third Ed.), TMH publishing Co Ltd, N. Delhi