GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140503
Semester – IV
Subject Name: Heat Transfer

Type of course: Professional core course

Prerequisite: A good understanding regarding basic modes of heat transfer viz. conduction, convection and radiation with governing laws underlying this heat transport mechanisms. Mathematical background is also essential in this respect

Rationale: Heat transfer is a necessary process in virtually all forms of energy generation and use; from coal fired to nuclear power stations, from automobile engines to rocket motors, from refrigerating cold stores to air conditioning space vehicles. This subject is intended to make students aware about mechanisms involved in heat transfer process in many of aforementioned applications. This ultimately will enable the students to design the equipments for heat process viz., shell and tube heat exchangers, evaporators, condensers.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Introduction:** Overview of applications of heat transfer in different fields of engineering, modes of heat transfer- conduction, convection and radiation, heat transfer with and without change of phase. **Conduction:** Mechanism of heat conduction, Fourier's law, thermal conductivity of solids, liquids and gases, effect of temperature on thermal conductivity, General heat conduction equation in Cartesian coordinates, Boundary conditions, Formulation of heat transfer problems without generation of heat, Conduction through systems of constant thermal conductivity :- conduction through plane, cylindrical and spherical wall, combined boundary condition systems (conduction-convection systems), conduction through composite slab, cylindrical and spherical shells. Electrical analogy to heat flow, Critical and Optimum thickness of Insulation. Unsteady State heat Conduction	12
2	**Convection:** Mechanism, thermal and velocity boundary layers, boundary layer thickness, relationship between hydrodynamic and thermal boundary layer thickness for flow over flat plates, the convective heat transfer coefficient, reference temperatures, thermal boundary layers for the cases of flow over a flat plate and flow through pipe, dimensionless numbers in heat	12

	transfer and their significance. **Forced Convection:** General methods for estimation of convection heat transfer coefficient, Correlation equations for heat transfer in laminar and turbulent flow for external and internal flows for constant heat flux and wall temperature conditions- flow in a circular tube Analogy between momentum and heat transfer: Development of Reynold's and Prandtl analogy. Overview of Colburn and Von-A **Natural Convection:** Dimensional analysis, natural convection from vertical and horizontal surfaces under laminar and turbulent conditions for plates, cylinders, physical significance of Grashoff and Rayleigh numbers.	
3	**Heat transfer by radiation:** Introduction- theories of radiation, electromagnetic spectrum, thermal radiation, spectral emissive power, surface emission- total emissive power, emissivity. Radiative properties, Emission, irradiation, absorptivity, reflectivity and transmissitivity. Concept of black and grey body, radiation intensity, Laws of black body radiation, non-black surfaces- Grey, white and real surface, radiation between black surfaces and gray surfaces	**6**
4	**Heat Exchangers:** Classification of heat exchangers: Classification according to transfer processes, number of passes, surface compactness, construction features, flow arrangements, heat transfer mechanisms. Shell and tube heat exchanger, fouling, concept of overall heat transfer coefficient, LMTD, correction factor for LMTD, Sizing and rating problem using LMTD method in parallel flow, counter flow exchanger, cross flow and multi-pass heat exchangers, Temperature – distance plots for different flow arrangements in single and multi-pass heat exchangers. Determination of area, length, number of tubes required for a given duty in different configurations using LMTD method of analysis. Concept of Effectiveness- NTU method, definition of effectiveness, effectiveness NTU relations for single pass exchangers in counter-flow and parallel flow configurations. Double pipe heat exchangers: - construction, various steps for the design of double pipe heat exchangers. Plate and spiral heat exchangers, Condensers	**12**
5	**Boiling and Condensation:** Pool boiling - Boiling curve, hysteresis in the boiling curve, mechanism of nucleate boiling, Forced convection boiling - Brief over view of internal forced convection boiling. Condensation: Physical mechanisms, types of condensation, factors affecting condensation.	**8**
6	**Evaporation:** Principle of Evaporation, types of evaporators- their construction and operation, Natural circulation evaporators, short tube vertical or calendria type evaporators, basket type vertical evaporators, long tube vertical evaporators, forced circulation evaporators, falling film evaporators, climbing or rising film evaporators, agitated thin film evaporators, the plate evaporator. Single effect and multiple effect evaporators, Performance of evaporators, capacity and economy of evaporators, Overall heat transfer coefficient, effect of liquid head and boiling point elevation. Material and energy balances for single effect evaporator and the calculations on single effect evaporator. Multiple effect evaporators, Energy Balance.	**10**

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140503
Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**15**	**20**	**10**	**10**	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Kern D Q, Process Heat Transfer, McGraw Hill Book Co. (1997).
2. Binay. K. Dutta, "Heat Transfer Principles and applications" Prentice Hall of India
3. Coulson J M and Richardson J F, Chemical Engineering Volume 1, Pergamon Press (1999).
4. Holman J. P, "Heat Transfer", McGrawHill.
5. Ozisik M. N, "Heat Transfer - A Basic Approach", McGraw-Hill.
6. Incropera F. P. and DeWitt D. P, "Introduction to Heat Transfer". John Wiley & Sons.
7. Sachdeva R.C, "Fundamentals of Engineering Heat and Mass transfer", New Age International, India
8. Rao Y.V.C, "Heat Transfer", University Press, India
9. Cengel A. Yunnus. "Heat Transfer – A Practical Approach", McGraw Hill
10. Geankopolis C J, Transport Processes and Separation Process Principles, Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
11. Kothandaraman C.P, "Heat and Mass Transfer Data Book" New Age International, India
12. Ramesh K. Shah and Dušan P. Sekulic, Fundamentals of Heat Exchanger Design, John Wiley & Sons, Inc. 2003

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To identify different different modes of heat transfer and understand basic mechanism of conduction.	22
CO-2	To explain heat transfer under different convective regimes.	22
CO-3	To predict extent of heat flow by radiation through grey, white and real surfaces.	12
CO-4	To analyze heat transfer through different types of heat exchangers used for various applications	18

CO-5	To describe industrial applications and regimes involved in boiling and condensation	12
CO-6	To categorize different types of evaporators with their performance evaluation and to analyze material and energy balance for single and multi-effect systems	14

List of Experiments: (Minimum 10 experiments need to be performed)

1. Determination of thermal conductivity of insulating powder
2. Determination of thermal conductivity of given metal rod
3. Determination of heat transfer coefficient by natural convection
4. Determination of heat transfer coefficient by forced convection
5. Determination of overall heat transfer coefficient for counter flow in laminar regime in double pipe heat exchanger
6. Determination of overall heat transfer coefficient of shell and tube heat exchanger
7. Heat Transfer in Composite walls- Determination of effective thermal conductivity and overall resistance
8. Determination of overall heat transfer coefficient and efficiency in finned tube heat exchanger
9. Determination of overall heat transfer coefficient and efficiency in plate type heat exchanger
10. Determination of heat transfer coefficient in turbulent flow regime in a double pipe heat exchanger
11. Determination of Stephan boltzmann constant experimentally.
12. Determination of economy and capacity of open pan evaporator.
13. Determination of economy and capacity of multiple effect evaporator

Major Equipments

Thermal conductivity measurement apparatus, stefan boltzmann apparatus, composite wall apparatus, emissivity apparatus, lagged pipe apparatus, various heat exchange equipment like shell and tube heat exchanger, plate type heat exchanger, open pan evaporator, multi effect evaporator etc.

List of Open Source Software/learning website :

Reference to NPTEL lectures can be made for a better understanding regarding heat transfer under different conditions.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140507
Semester –IV
Subject Name: Chemical Engineering Thermodynamics-II

Type of course: Professional Core Course

Prerequisite: Chemical Engineering Thermodynamics-I

Rationale: This subject introduces the concepts of fugacity, activity coefficient and other important thermodynamic properties and its evolution for pure components and solutions. Starting with ideal gas mixtures and ideal solutions, the concepts of bubble and dew points are introduced to enable flash calculations and design of process components. Subsequently, various levels of non-ideality and complexity are introduced. The course also provides fundamental insight into the underlying thermodynamic principles of phase equilibria and reaction equilibria to solve complex problems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	1	0	4	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**PHASE EQUILIBRIA:** **VAPOUR/LIQUID EQUILIBRIUM (VLE):** Introduction, The Nature of Equilibrium, The Phase Rule; Duhem's Theorem, VLE-Qualitative Behaviour, Azeotropic Mixtures, Retrograde condensation, Simple Models for Vapour/Liquid Equilibrium ,Raoult's Law, Dewpoint and Bubblepoint Calucations with Raoult's Law , Henry's law, VLE by Modified Raoult's Law, VLE from K-Value Correlations, Flash Calculations, The Gamma / Phi Formulation of VLE, An introduction to Equilibrium and stability, liquid- liquid equilibrium (LLE), solid-liquid equilibrium, Vapor-Liquid-liquid equilibrium (VLLE), Solid-Liquid equilibrium (SLE), Solid-Vapor equilibrium (SVE) etc..	15
2	**SOLUTION THERMODYNAMICS:** **THEORY** Fundamental Property Relation, The Chemical Potential as a Criterion for Phase Equilibria, Partial Properties, Equations Relating Molar and Partial Molar Properties , The Partial Molar Gibbs Energy and the Generalized Gibbs-Duhem Equation, Partial Properties in Binary Solutions, Relations among Partial Properties, The Ideal Gas Mixture model, The Partial Molar Gibbs Energy and Fugacity, Fugacity and Fugacity Coefficient: Pure Species and for Species in Solution ,The Ideal Solution Model , The Lewis/Randall	18

	Rule , Excess Properties , The Excess Gibbs energy and activity coefficient, nature of excess property **APPLICATIONS** Liquid-Phase Properties from VLE Data ,Composition Dependence of Liquid- Phase Fugacities for Species in a Binary Solution, Excess Gibbs Energy, Data Reduction, Thermodynamic Consistency by Integral or Area Test Method, Models for the Excess Gibbs Energy, Margules Equations, VanLaar Equations, Local Composition Models such as NRTL Equation, UNIQUAC Equation, UNIFAC Method	
3	**CHEMICAL REACTION EQUILIBRIA:** The reaction coordinates, Application of equilibrium criteria to chemical reactions, The standard Gibbs free energy change and the equilibrium constant, Effect temperature on equilibrium constant, Evaluation of the equilibrium constant, Relation of equilibrium constant to composition for gas phase and liquid phase reactions, calculation of equilibrium conversion for single reaction, The phase rule and Duhem's theorem for reacting systems, introduction to multi-reaction equilibria	12

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
7	28	28	7	0	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. Smith J.M, Van Ness H.C., Abbott M. M, "Introduction to Chemical Engineering Thermodynamics", the McGraw Hill Companies, Inc., USA, 7th Ed., 2005.
2. Elliot J. R. and Lira C.T., "Introductory Chemical Engineering Thermodynamics", Prentice Hall, 1999.
3. Hougen O.A., Watson K.M., and Ragatz R.A., "Chemical Process Principles Part,II" Thermodynamics, John Wiley 1970.
4. Perry's chemical engineers handbook, 7th edition, McGraw,Hill, USA, 2000.
5. K.V.Narayanan "A Text book of chemical Engineering thermodynamics", Prentice Hall of India
6. Stanley I. Sandler, "Chemical, Biochemical and Engineering Thermodynamics", Wiley India Pvt. Ltd., 4th ed., 2007.
7. B.G. Kyle,"Chemical Process Thermodynamics", 2nd Edn., Prentice Hall of India Pvt.Ltd., New Delhi, 2000.
8. J.M.Prausnitz, R.N. Litchtenthaler, Molecular thermodynamics of fluid phase Equilibria, 3rd Edition,Prentice Hall.
9. Stanley M. Walas, Phase-Equilibria in Chemical Engineering,Wiley India Private Limited

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140507

Course Outcomes:

Students should be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Explain fundamentals of Solution thermodynamics, phase equilibria and reaction equilibria.	10
CO-2	Apply fundamental property relations to find thermodynamic properties of solutions	15
CO-3	Calculate maximum extent of separation possible under prevailing operating conditions for various multiphase multi component systems	30
CO-4	Determine thermodynamic properties like fugacity, activity coefficients, constants of model equations etc.. for solutions	20
CO-5	Determine equilibrium conversions of reaction systems and its dependence on various operating parameters	25

List of Tutorials: Numericals/problems based on topics of each theme of content.

Major Equipment: None

List of Open Source Software/learning website:
1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can refer to the CDs which are available with some reference books for the solution of problems using softwares. Students can develop their own programs for the solutions of problems.
3. XSEOS–an Open Software for Chemical Engineering Thermodynamics

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140508
Semester – IV
Subject Name: Unit Processes & Chemical Technology

Type of course: Basic Science**.**

Prerequisite: Basic Organic and Inorganic Chemistry

Rationale: Chemical Unit Processes is essential for chemical engineering as it gives an overview of all chemical process industries.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Pr/Viva (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Contents:

Sr. No.	Topics	Teaching Hrs.
1	**Mechanisms and recent advances of following unit processes:** Alkylation and Acylation, e.g. alkylation of benzene, phenols, etc. Halogenation, e.g. chlorination of toluene, Nitration and Sulfonation, e.g. nitration, sulfonation of benzene, etc. Hydrogenation and Reductive Alkylations, e.g. hydrogenation of nitrobenzene, reductive alkylation reactions of anilines, Oxidation, e.g. oxidation of xylenes, etc.	06
2	**Sulphur, Sulphuric acid & Fertilizer Industries:** Mining and manufacturing of Sulphur, Manufacture of Sulphuric acid by DCDA process and its applications. Sulphur trioxide, Sodium Sulphate, Sodium Thiosulphate, Manufacturing technologies & associated Engineering problems. Introduction to Fertilizer industries, manufacturing processes of Ammonia, Urea, Nitric acid, Phosphoric acid their uses and applications, major engineering problems, NPK fertilizer.	10
3	**Chlor-alkali and Heavy Inorganic industry:** Manufacturing of Caustic Soda and Chlorine by membrane cell, mercury & diaphragm process, Manufacturing of Sodium Bicarbonate.	04
4	**Dye & its Intermediates, Paints and Pigment Industries:** Classification of Dyes according to its Constitution and Application, Introduction to Disperse, Reactive, Azo, Anthraquinone & Vat dyes, Manufacturing Processes of Chrome blue black, H-acid, Koch acid, Vinyl sulphone, Vat dyes. Introduction to Paints classification & its constituents, PVC of Paints, Different types of pigments such as white, blue, red, yellow, green, brown. Introduction to Varnishes, Solvent & Thinners & Industrial Coatings.	08

5	**Drugs and Pharmaceuticals:** Classification of various drugs and pharmaceuticals, Introduction of Antibiotics, Manufacturing of penicillin, Introduction of vitamins, Manufacturing processes of Aspirin, Vitamin-D, B-12, & C (Ascorbic acid), Introduction to Barbital & Phenol Barbital.	06
6	**Sugar & Fermentation Industries:** Manufacturing of Sugar. Fermentation, Industrial Alcohol, Absolute Alcohol, Beers, Wines and Liquors, Manufacturing of Butyl Alcohol & Citric acid by fermentation.	05
7	**Cement & Ceramic Industries:** Cement & Its types, Settling & Hardening of Cement, Cement manufacturing by wet & dry process. Introduction to Ceramic Industry, Manufacturing of Building bricks, Refractory & its types.	06
8	**Introduction to pulp and paper industries:** Pulp manufacturing by Kraft process, Difference between sulphate & sulphite process, Manufacturing of Paper.	04
9	**Petroleum Refinery and Petrochemicals:** Introduction to basics of refinery, Important properties of petroleum products, Processing of petroleum and treatment techniques, cracking etc. Introduction of C1, C2, C3, Petrochemical aromatics and polymers.	08

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	**15**	**20**	**05**	**05**	**05**

Legends: R: Remembrance; U: Understanding; A: Application; N: Analyze; E: Evaluate; C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Dryden, C. E. "Outlines of Chemical Technology" (Edited and Revised by M. Gopala Rao and M. Sittig) East West Press. Pvt. Ltd, New Delhi, 3 rd Edition (1997).
2. Austin G. T. Shreve's Chemical Process Industries", 5th Edition, McGraw Hill (1984).
3. B K. Sharma, "Industrial Chemistry (Including Chemical Engineering)" Krishna Publishing House.
4. James A Kent, "Riegel's Handbook of Industrial Chemistry" Springer Publication.
5. A H Patel, "Industrial Microbiology" Trinity Press, Laxmi Publication Pvt Ltd.
6. M Gopala Rao, Marshall Sittig, "Outlines of Chemical Technology" Affiliated East West Press (Pvt) Ltd.
7. Encyclopedia of Industrial Chemistry ,Ullmann, VCH, 1996.
8. Industrial Organic Chemistry ,Weissermel K &Arpe H.J., Weinheim, 1978.
9. Pandey G.N., "A Text Book of Chemical Technology", Volume 1 and 2, Vikas Publications11. B. S. Mitchell.

10. An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.

11. Kirk and othmer ,"Encyclopedia of Chemical Technology", III Edition.
12. Srikumar Koyikkal,"Chemical Process Technology and Simulation", PHI Learning Ltd (2013).
13. Unit Process by G H Groggins.

Course Outcome:

Sr. No.	CO Statements	Marks % Weightage
1.	Develop fundamental understanding of the process carried out in chemical industry.	**30%**
2.	Explain the basic reaction steps involved in the production of various grades of products.	**21%**
3.	Construct process flow diagrams for different chemical manufacturing plants.	**28%**
4.	Predict all possible trouble shootings arise in chemical plants.	**7%**
5.	To review the practical importance and relevance of process takes place in chemical industry.	**7%**
6.	Resolve all technological and economical problems arise in the chemical manufacturing plants.	**7%**

LIST OF PRACTICALS: (Minimum 10 need to be performed)

Sr. No.	List of Experiments
1.	To prepare soap in the laboratory and carry out its cost analysis.
2.	To determine saponification value of oil sample
3.	To prepare detergent in the laboratory and to carry out its cost analysis.
4.	To determine the acid value of the given sample of oil.
5.	To prepare hydrated lime from the given calcium carbonate powder
6.	To prepare caustic soda by chemical method.
7.	To synthesis aspirin from salicylic acid.
8.	Preparation of phenyl azo – β – Naphthol from aniline.
9.	Preparation of disperse dye.
10.	To prepare mordant yellow dye.
11.	Preparation of fast green o dye.
12.	Preparation of nitro benzene from benzene.
13.	To study Alcohol Fermentation by Saccharomyces cereviceae (Baker's Yeast).
14.	Fermentative production of citric acid using the fungi Aspergillus niger.

Reference Books:

1. Vogel's Textbook of Practical Organic Chemistry by Hannaford, Smith &Tatchell, Publisher: Elbs with Longman
2. Vogel's textbook of Quantitative/ Qualitative Chemical Analysis, by Arthur I Vogel, Revised by Jeffery et al, Publisher: Addison Wesley,Longman Ltd, England
3. Engineering Vogel's Textbook of Quantitative Chemical Analysis by Jeffery. G H Publisher: Addison Wesley Longman/Pearson Education Asia.

Major Equipment:

1. Laboratory Oven, Stirrer Hot Plate, Hot plates.

2. Electronic Balance.

List of Open Source Software/learning website:

NPTEL, World Wide Web, etc.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140509
Semester – IV
Subject Name: Pollution control & Safety Management

Type of course: Humanities and social science

Prerequisite: Basic Concepts of chemistry and environmental science.

Rationale: This course is intended to familiarize students with the concepts of various traditional and modern pollution control methods along with identifying various pollutants and prevalent industrial laws and acts pertaining to safety, health and environment under Indian context. This course would enable students to identify and assess hazards in any stage of operation, to quantify and manage them as well.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Impact of man on the environment; ecological systems and pollution, hydrologic and nutrient cycles. Various types of environmental pollution in general and in chemical and allied industry in particular, sources and causes of environmental pollution, effect of pollution on environment.	5
2	Air pollution: Classification and properties of air pollutants, Emission sources, behavior and fate of air pollutants with special reference to chemical reactions in atmosphere, reactions at the earth's surface, photochemical smog etc., air pollution meteorology (generation, transportation and dispersion of air pollutants). Outlines of industrial air pollution control and particulate control equipment: selection, design and performance analysis; cyclone separator, fabric filters, gravity settling chambers, ESPs, wet scrubbers. Control of gaseous emissions Stack sampling and analysis of air pollutants.	7
3	Water pollution: sources and classification of water pollutants, Physico-chemical characterization of wastewater, water quality standards, Industrial water pollution management: Wastewater treatment processes; Pretreatment, primary and secondary treatment processes. Advanced wastewater treatment processes. Design of sedimentation tanks and biological treatment processes.	6
4	Solid waste management: sources and classification, public health aspects, methods of collection, potential methods of disposal: sanitary landfill, incineration, composting, recovery and recycling.	4

5	Introduction to Material Safety Data Sheet (MSDS), Sources of exposure, exposure evaluation, exposure-hazard control, Fire and explosion: types of fire, detonation and deflagration, UVCE and BLEVE, Regulatory bodies and regulations; Safety by design-sizing of specific devices such as, safety release valves, vents, flare systems; Instrumentation for safety - specific devices such as alarms, interlocks, shutdown systems, Hazard Identification Checklist procedure, Preliminary hazard analysis, What if analysis, Failure mode effect analysis, Hazard and operability (HAZOP) studies, Hazard analysis techniques: Fault tree analysis, Event tree analysis, General outline of DOW index.	**7**
6	Rules, regulations, laws etc. regarding environmental protection, pollution prevention and control, waste disposal etc. Standards and legislation EIA, EIS and EMP. Air and water pollution management through waste minimization. Industrial air pollution management, Role of government, semi/quasi govt. and voluntary organizations. Industries Factory act, concept of energy audit, environment Audit.	**7**
7	Safe industrial practices, Development of safety movement, Need for safety-general introduction, historical background and growth of safety science, basic concepts of safety audit	4
8	Concept of Cleaner Production(CP), End of Pipe Solution, Good House Keeping checklist, CP Methodology, Barriers and Drivers in cleaner production, Principles of sustainable developments, Principles of green chemistry, atom economy, waste prevention and minimization of waste generation.	**5**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	7	0	0

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Environmental Pollution Control Engineering by C.S.Rao, New Age International Publishers, New Delhi.

2. Wastewater Engineering: Treatment & Reuse by Metcalf and Eddy, McGraw Hill Publication

3. Pollution control in process industries, S P Mahajan, Tata McGraw Hill Publishing Company, New Delhi

4. Safety and Accident Management in the Chemical Process Industries Ed. by H. Heinmann, M. Dekker3Instrumental Methods of Analysis, B. K. Sharma, Goel Publishing house.

5. .HAZOP and HAZAN by Trevor Kletz, 4th Edition, Institution of Chemical Engineers, IChemE, UK

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

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the impact of engineering solutions in a global and societal context	20
CO-2	To uunderstand and apply appropriate control and preventive measures for different types of pollution	35
CO-3	To identify major process and health hazards and apply hazard analysis techniques for risk assessment	20
CO-4	To acquire knowledge about the various environmental and safety standards and legislations	25

List of Open Source Software/learning website:

Preparation of power-point slides, which include videos, animations, Pictures, graphics for better understanding theory – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus of Advanced analytical techniques is covered.

Suggested list of experiments to be performed (At least 10 experiments are to be given)

1. Characterization of a given sample of wastewater by determining its pH, conductivity, TDS, TSS.
2. To find out the quantity of Dissolved Oxygen (DO) present in the given water sample by Winkler's Method.
3. Determination of acidity, alkalinity & hardness of a given sample of water or wastewater.
4. To determine Biochemical Oxygen Demand (BOD) exerted by the given wastewater sample.
5. To find out Chemical Oxygen Demand (COD) of the given wastewater sample.
6. Determination of total residual chlorine in a given water sample.
7. To determine the color intensity of the dye contaminated wastewater using spectrophotometer.
8. To determine the ion exchange capacity of a given cation or anion exchanger.
9. Study of adsorption of dye from aqueous solution on any adsorbent (e.g. activated carbon) and examine the validity of (i) Freundlich isotherm and (ii) Langmuir iostherm

10. Determination of composition of volatile organic compounds dissolved in water by using (i) Refractometer or (ii) Karl-Fisher Apparatus.
11. Determination of efficiency of cyclone separator for separation of dust particles from mixtures.
12. Analysis of SOx and NOx compounds present in gaseous mixture using GC or any other techniques.
13. Separation of mixture of dyes using thin layer chromatography.
14. Separation of metallic ions by paper chromatography.
15. Characterization of municipal solid waste (physical and chemical).
16. To study the quality of a sample of water collected or provided.
17. To make an audit of the electrical energy consumption by various household appliances.
18. Preparation/compilation and study of MSDS of certain chemicals used in your laboratory.
19. Demonstration of portable fire extinguisher and other personal protective equipments used in the laboratories.

List of Open Source Software/learning website: Software:

PollutionTech - Air Pollution Control Software

Safety Management Software, MSDS Software, CSafe, DR software's ChemGes, Periscope¬ software, MAUS OHS Planning software (Occupational, Health & Safety Planner), CINTELLATE

Students can refer to video lectures available on the websites including NPTEL

Students can refer to the CDs which are available with some reference books for the solution of problems using softwares.

Students can develop their own programs for the solutions of problems.

Websites: www.safetyforlife.com.au , SmartOHS.com.au

https://www.cpcb.nic.in/PollutionControlLaw.pdf

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140510
Semester – IV
Subject Name: Numerical methods in chemical engineering

Type of course: Core Professional course

Prerequisite: Algebra

Rationale: It is necessary for Chemical Engineering students to solve complex problem.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	1	0	4	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Approximations and Errors:** Types of Errors, Significant figures, Accuracy of Numbers, Precision, Error Propagation, Applications in Chemical Engineering	3
2	**Solution of Algebraic and Transcendental Equations:** Basic Properties of Equations, Relations between Roots and Coefficients, Descartes Rule of Sign, Synthetic Division of a Polynomial by a Linear Expression, Bracketing Methods (Bisection, Secant, Method of False Position or Regula Falsi, etc.), Convergence of Iterative Methods, Newton-Raphson Method, Newton-Raphson Method for Non Linear Equations in Two Variables (Numericals based on application in chemical engineering)	8
3	**Solution of Linear Equations:** Mathematical Background, Matrix inversion, Gauss Elimination, Gauss-Jordan Method, Gauss-Seidel Iteration Method, Jacobi's Method, Gauss-Seidel Method, Eigen Value Problem (Numericals based on application in chemical engineering)	7
4	**Curve Fitting** Method of Least Squares, Fitting a Straight Line and a Polynomial, Fitting a Non-linear Function, Fitting Geometric and Exponential Curves, Fitting a Hyperbola, a Trigonometric Function, etc (Numericals based on application in chemical engineering)	7
5	**Finite Differences & Interpolation:** Finite Differences: Forward, Backward and Divided Differences Table, Central Differences, Newton's Forward, Backward and Divided Differences Interpolation Formula, Interpolation Polynomials, Lagrange Interpolation Formula, Inverse Interpolation (Numericals based on application in chemical engineering)	6
6	**Numerical Differentiation & Integration:** Differentiation Formula based on Tabulator at Equal and Unequal Intervals, Newton-Cotes	6

	Integration Formulas, Trapezoidal Rule and Simpson's 1/3 and 3/8 Rule (Numericals based on application in chemical engineering)	
7	**Ordinary Differential Equations :** Taylor's Series and Euler's Method, Modifications and Improvements in Euler's Method, Runge-Kutta 2nd Order & 4th Order Methods, Milne's Predictor-Corrector Methods, Boundary Value Problems (Numericals based on application in chemical engineering)	**8**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
17	**18**	**10**	**11**	**7**	**7**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. S C Chapra and R P Canale, Numerical Methods for Engineers, McGraw Hill International Edition.
2. S S Shastry, Introductory Methods of Numerical Analysis, Prentice Hall of India.
3. B S Grewal, Numerical Methods in Engineering & Science, Khanna Publishers.
4. M K Jain, S R K Iyengar and R K Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Find accuracy of numbers, errors and propagation of errors.	25
CO-2	Differentiate types of equation based on linearity and order	25
CO-3	Find the root of linear, non-linear and linear algebraic equations	15
CO-4	Analyze and solve finite difference-interpolation and numerical integration problems.	15
CO-5	Arrange the data and find out coefficient of equation for curve fitting	10
CO-6	Compare variety of numerical methods for solving ordinary differential equation	10