Bansilal Ramnath Agarwal Charitable Trust's

Vishwakarma Institute of Technology

(An Autonomous Institute affiliated to Savitribai Phule Pune University)

Structure & Syllabus of

B. Tech. (Chemical Engineering)

Pattern 'B18/C18/D18'

Effective from Academic Year 2018-19

Prepared by: - Board of Studies, Chemical Engineering

Approved by: - Academic Board, Vishwakarma Institute of Technology, Pune

Signed by

Chairman -BOS **Chairman – Academic Board**

Vision of the Institute

To be globally acclaimed Institute in Technical Education and Research for holistic Socio-economic development

Mission of the Institute

1. To endure that 100% students are employable in Industry, Higher studies, Become Entrepreneurs, Civil/Defense Services / Government Jobs and other areas like Sports and Theatre.

2. To strengthen Academic Practices in terms of Curriculum, Pedagogy, Assessment and Faculty Competence.

3. Promote Research Culture amongst Students and Faculty through Projects and Consultancy.

4 To make students Socially Responsible Citizen.

Vision of the Department

To achieve excellence in chemical engineering education and research"

Mission of the Department

1. To impart quality education preparing students for careers in conventional chemical engineering as well as niche areas such as advanced materials, environmental, biochemical and energy systems engineering.

2. To create a vibrant research environment for carrying out multidisciplinary research in collaboration with organizations of national and international repute.

3. To inculcate entrepreneurship and managerial skills with effective industry – institute interaction.

4. To foster holistic development of students and contribute to the society by addressing social, economic and environmental aspects

Program Educational Objectives (PEOs)

Graduates of the B. Tech. chemical engineering program should be able to utilize the expertise gained from the program to:

1. Pursue industrial and research careers in a global environment.

2. Successfully undergo a postgraduate program.

3. Contribute to multidisciplinary fields such as food and biotechnology, nanotechnology and advanced materials, energy and environmental engineering, product design etc.

4. Demonstrate a zeal for life-long learning.

5. Function effectively in teams, displaying ethical conduct.

Program Outcomes

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Engineering Graduates will be able to:

1. Work in chemical engineering organizations demonstrating expertise in conventional chemical engineering design and operations.

2. Work in diverse, multidisciplinary fields such as biotechnology, nanotechnology, food, energy, environmental, product designs etc.

Pattern ‘B18’

Second Year BTech Chemical Engineering

Academic Year 2018-19

Content

Title: Course Structure **FF653**

Branch: Chemical Engineering **Year: Second Year** **Academic Year: 2018-19**
Semesters: III **Module:III** **Pattern: B-18**

Sr. No.	Subject Code	Subject Name	Teaching Scheme (Hrs/Week)		Examination scheme						Credits
			Theory	Lab	CA		MSE	ESA		Total	
					HA	LAB		ESE	VIVA		
1	CH2001	Fluid Flow Operation	3	2	10	30	10	30	20	100	4
2	CH2003	Process Calculations	3	2	10	30	10	30	20	100	4
3	CH2005	Chemical Engineering Thermodynamics	3	2	10	30	10	30	20	100	4
4	CH2061	Physical and Organic Chemistry	3	2	10	30	10	30	20	100	4
5	CH2009	Differential Equations	2		20		30	30	20	100	2
6	CH2079	Engineering Design and Development 1	2	4						100	4
Total											22

Abbreviations Used			
CA	**Continuous Assessment**	**ESE**	**End Semester Examination**
HA	**Home Assignment**	**ESA**	**End Semester Assessment**
MSE	**Mid Semester Examination**		

CH2001:: FLUID FLOW OPERATIONS

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20 Hours)**

Fluids and properties of fluids, Newton's law of viscosity, rheological classification of fluids, types of flow, lines to describe the flow. The basic equation of fluid statics, pressure-depth relationship, pressure forces on surfaces, pressure measurements, pressure measuring devices. Mass, momentum and energy balance equations, venturi meter, orifice meter, pitot tube for velocity measurement, variable area meter. Fundamental dimension of quantities, dimensional homogeneity , Reyleigh's method and Buckingham's π method.

Section 2: **(20 Hours)**

Concept of hydrodynamic boundary layer, growth over a flat plate, change in nature of boundary layer, and different thicknesses of boundary layer, drag on flat plate, coefficient of drag and its variation, hydrodynamic, thermal and concentration boundary layers. Shell balance based solutions for laminar flow through circular tube (Hagen Poiseuelle equation), on inclined plane, Darcy-Weisbach equation, friction factor chart, **i**ntroduction to turbulence Minor losses and major losses in pipes, concept of equivalent pipe, series and parallel pipe systems, different pipe fittings and valves, transportation of fluids, pumps, blowers and compressors.

List of Practical:

Minimum 6 experiments from the following list to be performed:

1. Determination of viscosity of liquids
2. Pressure measurements by manometers
3. Reynolds experiment
4. Verification of Bernoulli principle
5. Calibration of venturimeter
6. Calibration of orificemeter
7. Calibration of rotameter
8. Friction in flow through pipes
9. Characteristics of centrifugal pump
10. Minor losses in pipes

List of Project Areas:

Minimum 1 Project from list to be completed:

1. Flow measurement
2. Laminar flow systems
3. Turbulent flow systems
4. Applications of Governing Equations of Fluid Flow
5. Transportation of Fluids
6. Pumps, blowers and compressors

Text Books:

1. Warren Lee McCabe, Julian Smith, Peter Harriott ; Unit Operations in Chemical Engineering., 7th edition, McGraw Hill Publications
2. Bansal R.K.; A Textbook of Fluid Mechanics and Hydraulic Machines., 9th edition, Laxmi Publications (P) Ltd
3. Coulson J.M. and Richardson J.F.; Chemical Engineering Vol. 2, Pergamon Press, 5th ed.

Reference Books:

1. Den M.M.; Process Fluid Mechanics; 1980., Prentice Hall
2. Yunus A.Cengel and John M. Cimbala.; Fluid Mechanics-Fundamentals and Applications; 3rd edition, Tata McGraw Hill

Course Outcomes:

The student will be able to –

1. Determine various properties and flow behaviors. **(2)**
2. Select and use manometers for pressure measurement. **(2)**
3. Solve fluid flow problems by using conservation equations of mass, momentum, and energy. **(4)**
4. Develop correlations using dimensional analysis. **(3)**
5. Design the pipe size and flow meters requirements under laminar and turbulent flow conditions. **(4)**
6. Determine the power requirements of pumping and transportation of fluids. **(5)**

CH2003:: PROCESS CALCULATIONS

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20 Hours)**

Dimensions and Units, Significance Unit conversions of mass, energy and pressure chemical calculations including mole, equivalent weight, solids, liquids, solutions and their properties, properties of gases. Non ideal calculations, for gas and liquid mixtures, Process flow sheet, Concept, Material balance calculations, Material balance of unit operations such as distillation, crystallization. Recycling, bypass and purge operations, material balance of unsteady state processes, Mass balance with chemical reactions, single, multiple reactions, excess and limiting reactants, conversion, yield and selectivity. Material balance with recycle, bypass and purge operation. Material balance of unsteady state processes with chemical reaction.

Section 2: **(20 Hours)**

Sensible heat changes in gases, liquids and solids, latent heat of phase change,Enthalpy changes in pure substances and their mixtures, Heat of solutions, Heat of crystallisation, energy balance of unit operations, Standard heat of formation and combustion, effect of temperature on heat of formation and Heat of reaction. Energy balance unit processes, Psychometric calculations, calculations for n number of reactions, simultaneous material and energy balance, adiabatic flame temperature calculations. combustion of fuels and combustion calculations. Application of spreadsheet software in process calculations.

List of Lab experiments:
Minimum 6 experiments from the following list to be performed:

1. Conversion of units
2. Material balance on unit process
3. Material balance on unit operation
4. Energy balance on unit operation
5. Energy balance on unit process
6. Recycle without chemical reaction on unit operation
7. Recycle with chemical reaction on unit operation
8. Finding standard heat of formation from data
9. Finding adiabatic flame temperature from data
10. Fuel and combustion calculations with data

List of Project areas
Minimum 1 Project from list to be completed:

1. Preparation of block diagram and process flow sheet.
2. Material balances of process; steady state.
3. Energy balances of process; steady state.
4. Combine material and energy balance.

5. Unsteady state material balance.
6. Psychometric calculations.

Text Books:

1. Bhatt B. I. and Thakore S. M.; Stoichiometry, Tata McGraw-Hill Publication, Fifth Edition, 2010 .
2. Himmelblau D. M.; Basic Principles and Calculations in Chemical Engineering , Tata McGraw-Hill Publication, 7^{th} Edition, 1997.

Reference Books:

1. Hougen O. A. and Watson K. M.; Chemical Process Principles (Part I), CBS Publishers New Delhi, 2^{nd} Edition, 2001.

Course Outcomes:

The student will be able to –

1. Determine the quantities of chemicals in different mode i.e. moles and equivalent mass and able to convert various physical quantities in different unit systems. **(2)**
2. Formulate analyse and solve steady state and unsteady state material balances for unit operations and unit processes. **(3)**
3. Make material balances for recycling, by-passing and purging operations. **(3)**
4. Perform energy balances for unit operations. **(4)**
5. Perform energy balances for unit processes. **(4)**
6. Perform Psychrometric calculations, non ideal calculations for gaseous and liquid mixtures, combustion calculations and solve complex chemical problems. **(5)**

CH2005:: CHEMICAL ENGINEERING THERMODYNAMICS

Credits: 4 **Teaching Scheme: 03(TH) + 02(LAB) Hours / Week**

Section 1: **(20 Hours)**
Properties of Fluids and Solution Thermodynamics: The fundamental property relations for homogeneous phases, Maxwell relationships, relations between thermodynamic properties, residual properties, residual properties by equations of state, thermodynamic diagrams. Single phase mixtures and solutions; ideal solutions; partial molar properties; chemical potential, effect of temperature and pressure on chemical potential, fugacity and fugacity Coefficient – pure species and species in solution, activity and activity coefficient, ideal solution model. Non-ideal solutions; excess properties; generalized correlation for fugacity coefficient, activity coefficient models, Gibbs-Duhem equation; criteria for thermodynamic equilibrium; models for the excess Gibbs energy, property changes of mixing

Section 2: **(20 Hours)**
Phase Equilibria and Chemical Reaction Equilibria: The nature of equilibrium, criteria of phase equilibrium, Phase rule, Duhem's Theorem, Introduction to VLE, Raoult's law, VLE by modified Raoult's law, dew point and bubble point calculations, flash calculations, determine whether azeotrope exist. Equilibrium and stability, Introduction to liquid -liquid equilibrium (LLE). The reaction coordinates criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant, effect of temperature on equilibrium constant, evaluation of the equilibrium constant, relation of equilibrium constant to composition, calculation of equilibrium conversion for single reaction. Phase rule and Duhem's theorem for reacting systems.

List of Practical:
Minimum 6 experiments from the following list to be performed:
1. To determine thermodynamic properties like internal energy, enthalpy for pure fluids
2. To determine fugacity, activity and activity coefficient
3. To determine thermodynamic properties of solution
4. To determine excess property of solution
5. To determine property changes of mixing of solution
6. To carry out flash calculation for binary system
7. To generate VLE data
8. To generate LLE data
9. To determine equilibrium constant for chemical reactions
10. Case Study of chemical plant

List of Project areas:
Minimum 1 Project from list to be completed:
1. Analysis of system containing pure fluids/solution.
2. Verification of experimental data
3. Bubble point and dew point calculation for binary system

4. Analysis of phase equilibria
5. Determination of azeotrope formation
6. Analysis of chemical reaction equilibria
7. Solid liquid equilibrium (SLE) and/or solid vapor equilibrium (SVE).

Text Books:

1. Smith J. M., Van Ness H. C., Abbott M. M.; Introduction to Chemical Engineering Thermodynamics, Seventh Edition, McGraw-Hill
2. Narayanan K. V.; A Textbook of Chemical Engineering Thermodynamics, Third Edition, Prentice-Hall of India Pvt. Ltd.

Reference Books:

1. Kyle B. G.; Chemical and Process Thermodynamics, Third Edition, Prentice Hall, New Jersey
2. Sandler S. I.; Chemical and Engineering Thermodynamics, Third edition, John Wiley, New York
3. Hougen O. A., Watson K. M., Ragatz R. A.; Chemical Process Principles Part II, Thermodynamics, John Wiley 1970
4. Reid R., Praunitz J., Sherwood T.; The Properties of Gases and Liquids, Third edition, McGraw-Hill, New York

Course Outcomes:

The student will be able to –

1. Estimate thermodynamic properties of pure substances in gas or liquid state. **(3)**
2. Estimate important thermodynamic properties of ideal and real mixtures of gases and liquids. **(4)**
3. Solve simple and complex chemical engineering problems using thermodynamic concepts, data and models. **(4)**
4. Apply criteria of phase equilibria for vapour liquid system and generate VLE data. **(4)**
5. Analyze phase equilibria involving vapor and/or liquid and/or solid. **(5)**
6. Analyze chemical reaction equilibria and use standard heats and free energies of formation to evaluate equilibrium constants and determine equilibrium. **(5)**

CH2061:: PHYSICAL & ORGANIC CHEMISTRY

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (PROJ/LAB) Hours / Week**

Section 1: **(20 Hours)**

Physical Chemistry: Kinetics: The rates of chemical reactions- experimental techniques. Chemical Kinetics: steady state approximation, integrated rate laws. The temperature dependence of reaction rates. Numerical on reaction rates. Surface Chemistry and Enzyme Catalysis: Adsorption and Chemisorptions, adsorption isotherms (Langmuir, Freundlich, B.E.T.), Chemisorptions and Catalysis. Thermodynamics-I**:** First law of thermodynamics-basic terms, Volumetric properties of pure fluids- PVT behavior of pure substances, virial equation of state, the ideal gas, application of virial equations. Thermodynamics-II: Heat effects, latent heat of pure substances, standard heat of reaction, standard heat of formation, temperature dependence of ΔH°, Second law of thermodynamics, entropy, entropy changes of an ideal gas, Third law of thermodynamics.
Electrochemistry**:** Equilibrium properties of electrolyte, Electrode potentials and applications, Electrochemical and Electro-analytical techniques, Bio electrochemistry.

Section2: **(20 Hours)**

Organic Chemistry: Electronic structure and Bonding, Acids and bases, Acidity and basicity of organic compounds, pKa and pK_b terms. Basics of Chemical Safety Engineering, Chemical Hygiene and Material Handling. Formation of Aliphatic Carbon-Carbon Bonds: Base Catalyzed Reactions, Formation of Aliphatic Carbon-Carbon Bonds: Acid Catalyzed Reactions, Electrophilic Aromatic Substitution, Nucleophilic Aromatic Substitution, Molecular Rearrangements, Free-Radical Reactions. Formation of Aliphatic Carbon-Nitrogen Bonds, Aromatic Diazonium Salts, Organometallic Reagents. Stereochemistry: Basic concepts of Stereochemistry, conformational isomerism of ethane, propane, butane, cyclohexane. Optical isomerism. Resolution and diastereoselectivity. Heterocyclic compounds: Structure and synthesis. Synthesis of Some Naturally Occurring Compounds. Instrumental method of analysis of chemicals. Methods for investigation of mechanism. Spectrophotometric analytical tools study. Introduction to biocatalysis & biotransformation. Retrosynthetic biocatalysis, Enzymes in functional group transformation

List of Lab experiments:
Minimum 6 experiments from the following list to be performed:
Physical Chemistry (any three)-

1. Study of adsorption of acetic acid on activated charcoal from solution.
2. To standardize $Na_2S_2O_3$ solution by preparing $K_2Cr_2O_7$ and to estimate percentage of Cu from brass.
3. To study the effect of concentration of the reactants on the rate of hydrolysis of an ester and study of kinetics of the reaction.
4. Determination of strength of HCl solution by titrating against NaOH using P^H metry.
5. Calculation of Heat of reaction using calorimeter.

Organic Estimations (any one)-

6. Determination of the amount of glucose in the solution by hypoiodite method.
7. Determination of the amount of acetamide in the solution.

Organic preparations (any two)-

8. Oxidation of an organic compound using oxidizing agent- Theory explanation, and analysis of product.
9. Synthesis of p-nitroacetanilide from acetanilide– Theory explanation, and analysis of product.
10. Methyl orange- Theory explanation and analysis of product.

List of Project areas:

Minimum 1 Project from list to be completed:

1. Project on kinetics of chemical reaction determination.
2. Project on waste water treatment.
3. Project on organic compound preparation and analysis.
4. Project on extraction of organic compounds.
5. Project on alternate method determination of organic compound synthesis.
6. Project on biocatalyst application for different chemical processes.

Text Books:

1. Principles of Physical Chemistry, B. H. Puri and L.R Sharma.; 7th Edition S. Chand Company, New Delhi, 1994.
2. Physical Chemistry, G. M Barrow.; 6th Edition, Tata McGraw Hill, 1998.
3. Instrumental method of analysis, B.K.Sharma; Goel Publishing House, 1995.
4. Organic Chemistry, J.Clayden, N.Greeves, S.Warren, P, Wothers;Oxford University Press.

Reference Books:

1. Physical Chemistry, D.P Julio; P.W Atkins; 8th edition, Oxford University Press, 2006.
2. Introduction to Chemical Engineering Thermodynamics, J.M. Smith, H.C Van Ness, M.M. Abbot;. 7th Edition, Tata McGraw Hill, 2005.
3. Organic Synthesis, The Disconnection Approach, S.Warren; John Wiley, 2004.
4. Principles of Organic Synthesis', J.M. Coxon, R.O.C.Norman; '3rd edition Blackie Academic and Professional, 1993.

Course Outcomes:

The student will be able to –

1. Find out the rate of chemical reaction and different kinetic parameters e.g. order or reaction, michaelis menten kinetics and rate constant etc. **(2)**
2. Get adsorption isotherms and its study e.g. surface area determination Find out the structure and catalytic properties of metals etc. **(3)**
3. Find out different thermodynamic parameters of chemical. Calculation and application of virial equation to calculate volumetric parameters. **(3)**

4. To select the reagents and physical and chemical conditions to carry out the desired reaction. **(4)**
5. Get the stereo chemical structure and optical activity of organic compounds, synthesis mechanism of heterocyclic compounds and spectrophotochemical behavior of organic compounds. **(4)**
6. Find out the effect of solvents on the reaction rate, the product formation and synthesis mechanism of some natural compounds. **(4)**

CH2009:: DIFFERENTIAL EQUATIONS

Credits: 02 **Teaching Scheme: 02 Hours / Week**

Section 1 **(15 Hours)**

Introduction to ODEs **:** Intro. and Basic concepts: Separable DE and numerical, Second and higher order DE , Second order homogeneous DE with const coefficients, Case of complex roots and exponential functions and numerical , Euler - Cauchy Eq. and numerical, Revision of analytical methods and Basics of numerical solutions of DE, System of DE, Euler's Method and RK-4 Method. Engineering Applications of ODEs : Engineering Applications of DE: Analysis of chemical drainage from a storage tank, Analysis of Compound diffusion, Simultaneous reactions in PFR, Temp and Conc analysis for a non-isothermal batch reaction ,Other Engineering Applications: Simulating transient current for RLC Circuit (Electrical Engg.), Motion of a damped spring-mass system (Mechanical Engg.), Conduction in heated plane surface (Aerospace Engg.), Deflection of sailboat mast (Environmental Engg.).

Section 2 **(15 Hours)**

Introduction to Partial Differential Equations: Intro and basic concepts of PDEs, Steady-state problems with dirichlet boundary conditions (Elliptic equation) ,Steady-state problems with derivative and irregular boundaries, Control volume approach and numerical, Space-time variable problems (Parabolic equations) and Numerical, Basics of numerical solutions of PDEs, Central difference and Crank-Nicolson's Method. Engineering Applications of Partial Differential Equations :Temperature of a heated plate with dirichlet boundary conditions, Temperature of a heated plate with irregular boundary, Explicit and implicit solution for 1-D heat conduction problem, Heated plate with insulate edge and irregular boundary, Crank-Nicolson solution to the heat conduction equation

Text Books:

1. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley and sons, inc. 2007
2. Advanced Engineering Mathematics, Michael D. Greenberg, Prentice Hall International publishers, 2008
3. Higher Engineering Mathematics, B.S. Grewal, Khanna Publishers, 2014.

Reference Books:

1. Advanced Engineering Mathematics, Alan Jeffrey, Academic Press, 2000.
2. Advanced Engineering Mathematics, Dennis G. Zill and Michael R. Cullen, Narosa
3. Publishing House, 2010.
4. Advanced Engineering Mathematics, C. Ray Wylie, Louis C Barrett R, McGraw- Hill Book Company.

Course Outcomes:

The student will be able to –

1. Employ basic analytical and numerical methods for solution of ODEs. **(2)**
2. Apply ODEs to chemical processes and engineering applications. **(3)**
3. Employ basic analytical and numerical methods for solution of PDEs. **(4)**
4. Apply PDEs to chemical processes and engineering applications. **(4)**

CH2079 :: ENGINEERING DESIGN AND DEVELOPMENT 1

Credits: 4 **Teaching Scheme: 02 (TH) + 04 (LAB) Hours / Week**

A project will be carried out in the following domain to approach societal needs and technology related to chemical engineering to be applied to execute the project and various tools will be used to analyze the results.

Domain

a. Healthcare
b. Agriculture
c. Defense
d. Education
e. Water and Sanitation
f. Clean Energy
g. Sustainable and Smart City
h. Responsible Consumption
i. Climate
j. Poverty and Hunger
k. Others

A detailed literature survey is carried out and plan for experimental/theoretical work is made. Students may also undertake industry visit to understand application of chemical engineering knowledge for projects related to manufacturing, synthesis, design and development, product testing etc.
Design and fabrication of experimental set up and/or development of model with use of relevant computer programs can be carried out. Analysis of experimental results and/or verification of theoretical model is to be reported.
The group of students is required to choose the domain and topic of project in consultation with the Guide.
A technical report is required to be submitted at the end of the term and a presentation will be given by students based on the same. Modern audio-visual techniques may be used at the time of presentation.

Course Outcomes:
The student will be able to –
1. Apply chemical engineering knowledge. **(2)**
2. Work in a team. **(1)**
3. Approach and execute a practical problem given in a project **(3)**
4. Carry out research and development work. **(3)**
5. Design equipments or process for chemical engineering plants **(4)**
6. Apply written, oral, and graphical communication in technical and non-technical environment. **(3)**

Title: Course Structure **FF No. 653**
Branch: Chemical Engineering **Year: Second Year** **Academic Year: 2018-19**
Semesters: IV **Module: IV** **Pattern: B-18**

Sr. No	Subject Code	Subject Name	Teaching Scheme (Hrs/Week)		Examination scheme						Credits
			Theory	Lab	CA		MSE	ESA		Total	
					HA	LAB		ESE	VIVA		
1	CH2062	Heat Transfer	3	2	10	30	10	30	20	100	4
2	CH2004	Mass Transfer Operation	3	2	10	30	10	30	20	100	4
3	CH2006	Chemical Reaction Kinetics	3	2	10	30	10	30	20	100	4
4	CH2008	Chemical Technology	3	2	10	30	10	30	20	100	4
5	CH2010	Numerical Methods for Chemical Engineering	2		20		30	30	20		2
6	CH2078	Engineering Design and Development 2	2	2							4
7	CH2084	PD1									
8	CH2074	GP2									
Total											22

Abbreviations Used			
CA	**Continuous Assessment**	**ESE**	**End Semester Examination**
HA	**Home Assignment**	**ESA**	**End Semester Assessment**
MSE	**Mid Semester Examination**		

CH2062:: HEAT TRANSFER

Credits: 04 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20 Hours)**

Introduction to heat transfer, heat transfer mechanisms: conduction, convection and radiation heat transfer, conduction heat transfer law, Steady state heat conduction through composite slab, cylinder, sphere, critical thickness of insulation, unsteady state heat conduction: Lump heat parameter model, dimensional analysis : Rayleigh's and Buckingham's method, Newton's law of cooling, heat transfer correlations in natural and forced convection systems, Thermal Boundary layer, Heat transfer from extended surfaces/fins, Boiling Heat Transfer, condensation Heat Transfer, Nusselt's theory, condensation on vertical/horizontal plate and cylinder, condensation on bank of horizontal tubes.

Section2: **(20 Hours)**

Emission from the surface, Concept of black, real and gray surface, Laws of black body radiation, Directional nature of thermal radiation, concept of solid angle and intensity, concept of diffuse surface, Kirchhoff's law. Heat transfer by radiation between two black surface elements, Concept of shape factor, Classification of heat exchangers, flow arrangements, Concept of overall heat transfer coefficient, fouling factor, concept of LMTD, effectiveness-NTU method for heat exchanger design, selection of heat exchangers, concept of condensers and design, concept of furnace and design, concept of reboiler and design, concept of evaporation, performance evaluation of tubular evaporators: capacity and economy, boiling point elevation, type of evaporators, single and multiple effect evaporation, material and energy balance calculations, preliminary evaporator design, heat Transfer to Agitated tanks.

List of Practicals:

1. Determination of thermal conductivity of insulating powder
2. Determination of thermal conductivity of composite wall
3. Determination of thermal conductivity of a metal rod and to study effect of temperature onits thermal conductivity.
4. Determination of heat transfer coefficient for convection heat transfer
5. Determination of efficiency temperature distribution along the fin in natural convection
6. Determination of efficiency temperature distribution along the fin in forced convection
7. Verification of Stefan-Boltzmann constant
8. Determination of emissivity of a nonblack surface
9. Determination critical heat flux in pool boiling

10. Analysis of heat exchangers performance in double pipe heat exchanger

List of Project areas:

1. Design of heat exchangers.
2. Design of evaporators.
3. Design of boiler.
4. Review on recent trends in heat exchangers.
5. Review on recent trends in evaporators.
6. Furnace design

Text Books:

1. Cengel Y. A.; Heat Transfer: A Practical Approach; 4th Edition; McGraw Hill Education(India) Private Limited
2. Sukhatme S.P.; A Textbook on Heat Transfer; 4th Edition; Universities Press.

Reference Books:

1. Incropera F. P., DeWitt D. P., Bergman T. L., Lavine A. S.; Fundamentals of Heat and Mass Transfer; 7th Edition; John Wiley and Sons
2. Kern D.Q.; Process Heat Transfer; 1st Edition; Tata McGraw Hill
3. McCabe W.L., Smith J.C., Harriott P.; Unit Operations of Chemical Engineering; 7th edition; McGraw Hill

Course Outcomes:

The student will be able to –

1. Distinguish between mechanisms of heat transfer and derive basic heat transfer equations from first principles. **(2)**
2. Solve convection heat transfer problems using empirical correlations. **(3)**
3. Solve boiling and condensation problems using empirical correlations. **(3)**
4. Solve radiative heat transfer problems. **(3)**
5. Design simple heat exchangers and condensers. **(5)**
6. Design evaporators, furnaces and reboilers. **(4)**

CH2004:: MASS TRANSFER OPERATIONS

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (PROJ/LAB) Hours / Week**

Section 1 **(20 Hours)**

Introduction to Mass Transfer Operations. Molecular Diffusion in gases and liquids, diffusivities of gases and liquids, types of diffusion, Fick's and Maxwell law of diffusion, Measurement of liquid-phase diffusion coefficient, Concept of diffusivity, diffusivity of liquids, Eddy diffusion, film theory, penetration theory, surface renewal theory, Steady state diffusion. mass transfer coefficients, mass, heat and momentum transfer analogies. ; Interphase mass transfer, local two phase mass transfer, overall mass-transfer coefficient, average overall coefficient, steady state, Continuous co-current and counter current – bubble columns, Liquid dispersal equipments – Venturi scrubbers, wetted wall columns. Gas processes, cascades, batch processes, Stages and mass transfer rates. Gas-liquid operations and Equipment for Mass Transfer, Overall mass transfer coefficient, Gas dispersal equipment dispersed Sparged vessels – flow of gas velocity problems based on aeration tank as a time for sparging Gas hold up. Liquid hold up – determination of interfacial area based on hold up and MTC. Tray tower Verses packed tower.

Section 2 **(20 Hours)**

Gas Absorption: Mechanism of gas absorption, equilibrium in gas absorption, choice of solvent, Countercurrent multistage operation, Non-isothermal operation, absorption in wetted wall columns, values of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculation of height of packed and spray tower. Absorption in tray towers, absorption and stripping factors, calculation of number of trays for absorption Tray efficiencies, absorption with chemical reaction. ; Humidification, Dehumidification Principles, vapor-liquid equilibrium, enthalpy of pure substances, wet bulb temperature relation, Lewis relation, Psychometric chart, methods of humidification and dehumidification, cooling tower design – HTU, NTU concept, calculation of height of cooling tower.; Drying, equilibrium in drying, type of moisture binding, mechanism of batch drying, continuous drying, time required for drying, mechanism of moisture movement in solid, Design principles of tray dryer, rotary dryer, spray dryer. Spray dryer, fluidized bed and spouted bed dryer, pneumatic dryer and vacuum dryer. Crystallization: Theory of crystallization and design.

List of lab Practical:

1. Study diffusion of liquid into a gas in a vertical pipe and calculate mass transfer coefficient.
2. Study steady state diffusion of acetone in air and calculate diffusivity.
3. To study characteristics of tray dryer and calculate rate of drying.
4. To study steady state molecular diffusion of acetic acid through water and determine diffusivity.
5. To determine efficiency of rotary dryer.
6. To study characteristics of cooling tower for efficiency and relative cooling.
7. To calculate mass transfer coefficient for absorption of CO_2 into NaOH solution.
8. To determine mass transfer coefficient for air-water system during humidification and de-humidification process.
9. To study crystallization to find yield.
10. Any two experiments from above syllabus using virtual lab.

List of Project areas

1. Design of dryer
2. Design of absorber
3. Design of cooling tower
4. Design of crystallizer
5. Data analysis of diffusion of liquid into gas
6. Data analysis of diffusion of liquid into liquid

Text Books:

1. Treybal, R.E;Mass Transfer Operations, 4th Edition, McGraw Hill.
2. McCabe, W. L.; Smith, J. C.; Harriett, .;Unit Operations of Chemical Engineering, 4th Edition, McGraw- Hill.

Reference Books:

1. Datta B. K., Principles of Mass Transfer and Separation Processes, 1st Edition, Prantice Hall.
2. Perry, Robert H.; Green, Don W.; Perry's Chemical Engineer's Handbook; 6th Edition, McGrawHill, 1984.
3. Coulson J. M.; Richardson, J. F.; Chemical Engineering – Vol. I & II; 6 th Edition, Butterworth- Heinemann.

Course Outcomes:

The student will be able to

1. Apply principles of diffusion to separation and purification processes and calculate mass transfer flux and estimate mass transfer coefficient and diffusivity for gas-liquid and liquid-liquid system. **(2)**
2. Select and design appropriate gas-liquid contacting devices. **(3)**
3. Select and design gas absorption and stripping column. **(4)**
4. Calculate mass transfer coefficient for humidification and dehumidification and design cooling tower. **(4)**
5. Calculate rate of drying and Select proper dryer, and find batch time for batch drier and design rotary drier for given requirement. **(4)**
6. Comprehend crystallization system and fundamental of design. **(4)**

CH2006:: CHEMICAL REACTION KINETICS

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20 Hours)**

Homogeneous reaction kinetics and design of Ideal reactors; Irreversible and reversible reactions-Elementary and non elementary reactions, Stoichiometry, Fractional conversion. Rate of reaction based on all components of the reaction and their interrelation. Law of mass action, Rate Constant-Based on thermodynamic activity, partial pressure, mole fraction and concentration of the reaction components and their interrelation, Temperature dependency of rate Constant - Arrhenious law, Transition state theory and collision theory.

Batch reactor concept- Constant volume Batch reactor system; Design equation for zero, first, Second irreversible and reversible reactions, graphical interpretation of these equations and their limitations, Variable volume Batch reactors. Design equation for first and second order irreversible and reversible reactions, Graphical interpretation of their limitations

Multiple reactions- Stoichiometry and Rate equations for series and parallel reactions. Ideal reactors- Concept of ideality, Types of flow reactors and their differences, Design equation for plug flow reactor and CSTR.

Section 2: **(20 Hours)**

Multiple reactor systems and Temperature and Pressure Effects; Multiple reactor systems- Size comparison of reactors, Optimum size determination, Staging of reactors, Reactors in series and parallel, Performance of infinite number of back mix reactors in series, Back mix and plug flow reactors of different sizes in series and their optimum way of staging;

Recycle reactors- Optimum recycle ratio for auto-catalytic (recycle) reactors Yield and selectivity, Parallel reactions Requirements for high yield, best operating condition for mixed and plug flow reactors, Series reactions,

Effect of temperature and pressure- Equilibrium Conversion, Optimum temperature progression, Adiabatic and non adiabatic operations, Temperature and conversion profiles for exothermic and endothermic reactions

List of lab/Project areas:

1. To calculate value of rate constant 'k' for the saponificaton of ethyl acetate with NaOH in batch reactor – I (Where M=1)
2. To calculate value of rate constant 'k' for the saponificaton of ethyl acetate with NaOH in batch reactor – II (Where M=2)
3. To calculate value of rate constant 'k' for the saponificaton of ethyl acetate with NaOH in straight tube, coli Bent Tube reactor and PFR
4. To calculate value of rate constant 'k' for the saponificaton of ethyl acetate with NaOH in mixed flow reactor.

5. To calculate value of rate constant 'k' for the saponificaton of ethyl acetate with NaOH in mixed flow reactors in series.
6. Verification of Arrhenius law
7. Semi batch Reactor Addition of NaOH in Ethyl acetate, Utilization of POLYMATHS for finding Behavior of products with respective of time.
8. Semi batch Reactor Addition of NaOH in Ethyl acetate, Utilization of POLYMATHS for finding Behavior of products with respective of time.
9. To determine τ Optimum for multiple parallel reactions
10. Study of a chemical process based on multiple reactions

Project area: (any one)

1. Utilization of POLYMATHS for finding behavior of products with respective of time in reactors
2. Effect of reactor types on product distribution for multiple reactions.
3. To generate temperature conversion profiles for exothermic and endothermic reactions
4. Design of ideal reactors
5. Design of recycle reactor
6. Performance of adiabatic plug flow reactor

Text Books:

3. Levenspiel, O., 'Chemical Reaction Engineering', 3rd. edition, John Wiley& Sons, 2001.
4. Fogler, H. S., 'Elements of Chemical Reaction Engineering', 3rd Ed., PHI, 2002.

Reference Books:

1. Walas, S. M., 'Reaction Kinetics for Chemical Engineers', McGraw Hill, 1959.
2. Smith, J.M., 'Chemical Engineering Kinetics', 3rd ed., McGraw Hill, 1987.

Course Outcomes:

The student will be able to –

1. Develop rate expressions from elementary and non elementary step mechanisms using steady-state and quasi-equilibrium approximations. **(2)**

2. Determine rate expressions by analyzing reactor data including integral and differential analysis on constant and variable volume systems. **(3)**

3. Design ideal reactors i.e. plug flow and CSTR for first and second order reversible and irreversible, constant and variable volume systems. **(3)**

4. Select and size isothermal reactors for series and/or parallel systems of reactions and product distribution for multiple reactions. **(4)**

5. Quantitatively predict the performance of common chemical reactors in various combinations. **(4)**

6. generate temperature and conversion profiles for exothermic and endothermic reactions. **(5)**

CH2008:: CHEMICAL TECHNOLOGY

Credits: 04 **Teaching Scheme: 03 (TH) + 02 (PROJ) Hours / Week**

Section 1: **(20 hours)**

Basic Concepts: Theory of Unit operations and industrial equipment and systems used in large scale plants; Unit processes, Development of flow diagram, schematic representation and application for unit operations and unit processes. Study the selection and process specific applications knowing available industrial equipment and plant accessories. Chlor-Alkali Industry *:* Chlor-alkali chart and importance of chlor-alkali industry, manufacturing processes process economics, and plants in India and a few examples of latest technology used in other nations; Manufacturing of soda ash, caustic soda, chlorine and engineering problems. Membrane cell, mercury cell diaphragm cell processes and electrolytic cell processes and flowsheets. Nitrogen industry : Role of nitrogen in fertilizers, manufacturing of ammonia, nitric acid, urea, the above study must involves different routes adopted, limitations, advantages and disadvantages of the process; steam-reforming process technology. Coal gasification technologies (Fixed bed (Lurgi Process), Fluidised bed (Winkler Process)

Section 2: **(20 hours)**

Sulfur and Sugar Industry*:* Importance, manufacturing of sulfur by Frasch process, technology for the manufacturing of sulfuric acid. Sugar Industry: Manufacture of sugar and engineering problems associated, Dextrin and starch derivatives. detailed study and comparison between chamber and DCDA processes; process economics. Phosphorus and Paper Pulp Industry*:* Importance, manufacturing of super phosphate, triple super phosphate, phosphoric acid, electro thermal processes and NPK fertilizers, production of pulp, engineering problems involved, paper manufacturing from pulp, and comparison of methods of manufacturing. Petroleum and polymer industry **:** Overview of refinery process, Crude multicomponent distillation, Cracking, Reforming, polymerization industries (polyethylene, polypropylene, PVC and polyester synthetic fibers).

List of Laboratory experiments

1. Drawing process flow diagram for reactor and distillation column with different combination of gas, liquid, solid reactants, endothermic, exothermic reactions, high low pressure system.
2. Literature review on synthesis of Chemical Products.
3. Market review for given chemical product.
4. Report writing on the chemical plant in Latex including literature, market survey, raw material handling, packing etc.
5. Industrial visit to Chemical Plant.
6. Preparing material safety data sheet for Chemical Product
7. Preparing OSHA sheets

8. Waste treatment methods in Chemical Industry
9. Heating arrangements/cooling arrangements in Chemical Industry
10. Systems for obtaining vacuums in Chemical industry

List of project:

1. Draw process flow diagram, process utility diagram, P & ID diagram, complete floorwise digram, (individual process to individual student) for the processes of Chemical Technology.
2. Basic material and Energy Balance of Chemical Plant
3. Find breakeven point for the New Chemical Plant.
4. Pinch Analysis for Chemical Plant
6. Complete Hazop study of Chemical Plant

Textbooks:

1. 'Dryden Outline of Chemical. Technology', Rao, M. Gopala, , 3rd Edition, East West Publishers, 1997.
2. 'Shreve's Chemical Process Industries', Austin, George T., 5th Edition, McGraw-Hill, 1984.

Reference Books:

1. 'Chemical Process Design and Integration', Smith, R., 3rd Edition, Wiley, 2005.
2. 'Unit Processes in Organic Synthesis', Groggins, P.H., 3rd Edition, McGraw-Hill Book Co., 1958.

Course Outcomes:

The student will be able to –

1. Apply process fundamentals of chemical technology in process industries. **(2)**
2. Apply knowledge of chemical technology in unit operations and unit processes happening in chemical industry. **(3)**
3. Develop process flow sheets for production of specific chemical product. **(4)**
4. Comprehend reaction temperature, pressure condition and heat network in process flowsheet. (**3)**
5. Analyze different process for same product based on economics, effluent treatment, social aspects. **(3)**
6. Explain Petroleum refinery operation and supplementary processes. **(3)**

CH2010::NUMERICAL METHODS FOR CHEMICAL ENGINEERING

Credits: 2 **Teaching Scheme: 02 (TH) Hours / Week**

Section 1: **(15 Hours)**

System of Linear Equation: Introduction to modeling, Matrix algebra**,** Systems of linear equation using Eigen values and Eigen vector, multiple ODE, steady state analysis, *Statistical Data Analysis:* Least square method, curve fitting and Regression (linear, multiple linear, polynomial and nonlinear), Interpolation. Numerical Analysis I *:* Root finding methods for algebraic equations :- False position method, Newton-Raphson method), Bisection method, Secant method, Trapezoidal rule, Simpson's 1/3 rule, integration with unequal segments, Simpson's 3/8 rule

Section2: **(15 Hours)**

Numerical Analysis II: Properties of finite methods (stability, convergence etc.) Finite difference method, elliptical and parabolic equations, Laplace equation, solution techniques, boundary conditions ,explicit and implicit method. Optimization: Basic concept of optimization and formulation, Nature of optimization problem (constraints and unconstraint), Liner programming by simplex method. Unconstraint Optimization problem: Global and local optimization, Region of convex or concave, Indirect methods (Newton's Method).

Text Books:

1. Chapra, S.C.; Canale, R.P., "Numerical Methods for Engineers", 4th Edition, Tata-McGraw Hill Publications, 2002.
2. Edger, T. F.; Himmelblau, D. M., "Optimization of chemical processes", McGraw-Hill, 2nd Edition, 2001.
3. R.B. Bird, W.E. Stewart and E.W. Lightfoot, "Transport Phenomena", John Wiley,

Reference Books:

1. Rice, R.G.; Do, D.D., "Applied Mathematics and Modeling for Chemical Engineers", John Wiley and Sons, 1995.
2. Jenson, V.G.; Jeffreys, G. V., "Mathematical Methods in Chemical Engineering", 2nd Edition, Academic Press, 1997.
3. Mickley, H. S.; Shewrwood, T. S.; Reed, C. E., "Applied Mathematics in Chemical Engineering", McGraw-Hill, 1957.
4. Riggs, James B., "An Introduction to Numerical Methods for Chemical Engineers", 2nd Edition, Texas Tech University Press, 1994.
5. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and sons, inc.

Course Outcomes:

The student will be able to –

1. Solve different Chemical engineering problems by using matrix **(3)**
2. Do statically data analysis. **(5)**
3. Solve different Chemical engineering problems using numerical methods. **(4)**
4. Solve different elliptical and parabolic equations. **(5)**
5. Solve industrial problems by using linear optimization techniques. **(5)**

CH2078 :: ENGINEERING DESIGN AND DEVELOPMENT 2

Credits: 4 **Teaching Scheme: 02 (TH) + 04 (LAB) Hours / Week**

A project will be carried out in the following domain to approach societal needs and technology related to chemical engineering to be applied to execute the project and various tools will be used to analyze the results.

Domain

l. Healthcare
m. Agriculture
n. Defense
o. Education
p. Water and Sanitation
q. Clean Energy
r. Sustainable and Smart City
s. Responsible Consumption
t. Climate
u. Poverty and Hunger
v. Others

A detailed literature survey is carried out and plan for experimental/theoretical work is made. Students may also undertake industry visit to understand application of chemical engineering knowledge for projects related to manufacturing, synthesis, design and development, product testing etc.
Design and fabrication of experimental set up and/or development of model with use of relevant computer programs can be carried out. Analysis of experimental results and/or verification of theoretical model is to be reported.
The group of students is required to choose the domain and topic of project in consultation with the Guide.
A technical report is required to be submitted at the end of the term and a presentation will be given by students based on the same. Modern audio-visual techniques may be used at the time of presentation.

Course Outcomes:
The student will be able to –
1. Apply chemical engineering knowledge. **(2)**
2. Work in a team. **(1)**
3. Approach and execute a practical problem given in a project **(3)**
4. Carry out research and development work. **(3)**
5. Design equipments or process for chemical engineering plants **(4)**
6. Apply written, oral, and graphical communication in technical and non-technical environment. **(3)**

Pattern ‘C18’

Third Year BTech Chemical Engineering

Academic Year 2018-19

Content

FF: 653

Title: Course Structure **Branch: Chemical Engineering**
Year: Third Year B. Tech. **Academic Year: 2018-19** **Semesters: V**
Module: V **Pattern: C-18**

Sr. No.	Subject Code	Subject Name	Teaching Scheme (Hrs/Week)		Examination scheme						Credits
			Theory	Lab	CA		MSE	ESA		Total	
					HA	LAB		ESE	VIVA		
1	CH3063	Chemical Engineering Mathematics	3	2	10	30	10	30	20	100	4
2	CH3061	Mechanical Operations	3	2	10	30	10	30	20	100	4
3	CH3065	Mass Transfer Operations	3	2	10	30	10	30	20	100	4
4	CH3067	Chemical Reaction Kinetics	3	2	10	30	10	30	20	100	4
5	CH3079	Engineering Design and Development 1 (EDD1)	2	4							4
6	CH3089	Seminar									1
Total											21

Abbreviations Used			
CA	**Continuous Assessment**	**ESE**	**End Semester Examination**
HA	**Home Assignment**	**ESA**	**End Semester Assessment**
MSE	**Mid Semester Examination**		

CH3063:: CHEMICAL ENGINEERING MATHEMATICS

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20Hours)**

System of Linear Equation

Introduction to modeling, Matrix algebra**,** Systems of linear equation using Eigen values and Eigen vector, multiple ODE, Sylvester formulae, steady state analysis, Gauss Siedel method.

Statistical Data Analysis

Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions. Least square method, curve fitting and Regression (linear, multiple linear, polynomial and nonlinear), Interpolation.

Numerical Analysis I

Root finding methods for algebraic equations :-False position method, Newton-Raphson method), Bisection method, Secant method, RK methods, Trapezoidal rule, Simpson's 1/3 rule, integration with unequal segments, Simpson's 3/8 rule

Section2: **(20Hours)**

Numerical Analysis II

Properties of finite methods (stability, convergence etc.) Finite difference method, elliptical and parabolic equations, Laplace equation, solution techniques, boundary conditions, explicit and implicit method,), Finite Volume method, Crank-Nicholson method, Introduction to Finite Element Methods.

Optimization

Basic concept of optimization and formulation, Nature of optimization problem (constraints and unconstraint), Liner programming by simplex method. Unconstraint Optimization problem: Global and local optimization, Region of convex or concave, Indirect methods (Newton's Method), Direct Methods (Region elimination method, Golden section method), Quasi-Newton's Method, Secant Method, Polynomial approximation (Quadratic and Cubic).

Tensor Analysis

Types of tensors, applications of tensors, other coordinate sytems**,** Curvilinear orthogonal system e.g. Expression in these co-ordinate systems for second order tensor such as velocity gradient, Newton's law of viscosity in tensorial form in Cartesian coordinates

List of Practicals:

Minimum 6 experiments from the following list to be performed:

1. To determine eigen vector & eigen value.
2. To solve multiple ODE.
3. To solve chemical engineering problems with matrix.
4. To solve differential equations with numerical methods.
5. To find out integration with numerical methods.
6. To find out area under the curves with numerical methods.
7. To solve elliptical equations with numerical methods.

8. To solve parabolic equations with numerical methods.
9. To solve chemical engineering problems with linear programming.
10. To study various tensors.

List of Project areas:
Minimum 1 Project from list to be completed:

1. Statistical data analysis
2. Root finding methods,
3. Numerical differentiation & Integration
4. Numerical methods for Finite difference
5. Optimization
6. Tensor analysis

Text Books:

1. Chapra, S.C.; Canale, R.P., "Numerical Methods for Engineers", 4th Edition, Tata-McGraw Hill Publications, 2002.
2. Edger, T. F.; Himmelblau, D. M., "Optimization of chemical processes", McGraw-Hill, 2nd Edition, 2001.
3. R.B. Bird, W.E. Stewart and E.W. Lightfoot, "Transport Phenomena", John Wiley,

Reference Books:

1. Rice, R.G.; Do, D.D., "Applied Mathematics and Modeling for Chemical Engineers", John Wiley and Sons, 1995.
2. Jenson, V.G.; Jeffreys, G. V., "Mathematical Methods in Chemical Engineering", 2nd Edition, Academic Press, 1997.
3. Mickley, H. S.; Shewrwood, T. S.; Reed, C. E., "Applied Mathematics in Chemical Engineering", McGraw-Hill, 1957.
4. Riggs, James B., "An Introduction to Numerical Methods for Chemical Engineers", 2nd Edition, Texas Tech University Press, 1994.
5. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and sons, inc.

Course Outcomes:

The student will be able to –

1. Solve different Chemical engineering problems by using matrix. **(3)**
2. Do statically data analysis. **(5)**
3. Solve different Chemical engineering problems using numerical methods. **(4)**
4. Solve different elliptical and parabolic equations. **(5)**
5. Solve industrial problems by using linear optimization techniques. **(5)**
6. Describe concept and applications of tensors. **(5)**

CH3061:: MECHANICAL OPERATIONS

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section I: **(20Hours)**

Relevance of fluid and particle mechanics, Particle size and shape, Mixtures of particles, Characterization of solid particles, Relationship among shape factors and particle dimensions; Specific surface area; Measurement of surface area, mixing of solids, size reduction, industrial screening equipment, crushing efficiency, open circuit and closed circuit grinding, size reduction equipments, Nucleation and growth of particles, solid storage, characteristics of Bulk solids, different operations for solid separation from gases and liquid- Froth flotation, magnetic separator, fiber and fabric filter, electrostatic precipitators, cyclone separator, hydrocyclone, Mineral jig, scrubbers, centrifuges, centrifugal clarifier, necessity of mixing and agitation in chemical industries, calculation of power requirement of mixing equipment, solid – Solid Mixing, agitator selection, Conveyors: design, calculation of Screw conveyors, Belt Conveyors, Chain and Flight conveyors, bucket elevators, pneumatic conveyors**,** mixing equipment of pastes and viscous material, mixing equipment of free flowing solids.

Section 2: **(20Hours)**

Filter media and filter aids, classification of filtration, pressure drop through filter cake, filter medium resistance, specific cake resistance, continuous filtration, washing and dewatering of filter cakes, centrifugal filtration, filtration equipments, motion of particles in liquid, drag force, drag coefficients, gravity settling method, terminal velocity, stoke's law, free settling, sink and float method, differential settling, Sedimentation and thickening: Batch sedimentation, equipments for sedimentation, kynch theory of sedimentation, calculation of area and depth of continuous thickeners, Flow around immersed bodies: Concept of drag, boundary layer separation, skin and form drag, drag correlations, flow through packed beds, Void fraction, superficial velocity, channeling, Ergun equation and its derivation, Kozeny Carman equation, Darcy's law and permeability, characteristics of fluidized systems, minimum fluidization velocity, types of fluidization, applications of fluidization technique, spouted beds and fixed bed

List of Practicals:
Minimum 6 experiments from the following list to be performed:

1. Properties of solids: To determine Avg. Particle size, Specific surface of mixture and No. of particles in the mixture.
2. Screening: To determine the effectiveness of screen.
3. Sedimentation: To determine area of thickener by conducting batch sedimentation test.
4. Ball mill: To determine crushing law constant (by using Rittingers law, Bonds law and Kicks law).
5. Jaw Crusher: To determine crushing law constant (by using Rittingers law, Bonds law and Kicks law).

6. Vacuum Leaf Filter: To determine filter medium resistance and cake resistance by using vacuum leaf filter.
7. Cyclone Separator: To determine efficiency of cyclone separator.
8. Froth Flotation: To determine separation efficiency using froth flotation.
9. Fluidization: To determine minimum fluidization velocity and verify with Ergun Equation.
10. Drag Coefficient: To determine terminal settling velocity and compare with theoretical settling velocity.

List of Project areas:
Minimum 1 Project from list to be completed:

1. A project on design of filtration process
2. A project on design of sedimentation process.
3. A project on design of fluidization process.
4. A project on design of conveyor belt.
5. A project on recent trends in filtration.
6. A project on plant design of STP or ETP plant.

Text Books:

1. McCabe W. L. and Smith J. C.; Unit Operations of Chemical Engineering; McGraw Publications, 5th Edition.
2. Coulson J.M. and Richardson J.F.; Chemical Engineering Vol. 2, Pergamon Press, 5th ed., 2002.

Reference Books:

1. Badger W. L. and Banchero J. T.; Introduction to Chemical Engineering; McGraw Hill Publications, 1997.
2. Foust A.S.; Principles of Unit Operations; John Wiley and Sons, 1965.
3. Stanley Walas, Butterworth-Heinemann; Chemical Process Equipment Selection and Design; 1990.

Course Outcomes:
The student will be able to –
1. Recognize basic principle of particle size measurement and select suitable size reduction equipment. **(2)**
2. Select suitable solid-solid, solid-fluid separation technique and storage tank. **(3)**
3. Select suitable solid conveying system and solid-solid mixing process. **(3)**
4. Describe concept of filtration and design filtration unit. **(5)**
5. Describe concept of sedimentation and design sedimentation unit. **(4)**
6. Describe concept of flow through packed bed and design fluidized bed. **(4)**

CH3065:: MASS TRANSFER OPERATIONS

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20Hours)**

Introduction to Mass Transfer and Molecular Diffusion: Introduction to Mass Transfer Operations. Molecular Diffusion in gases and liquids, diffusivities of gases and liquids, types of diffusion, Fick's and Maxwell law of diffusion, Measurement of liquid-phase diffusion coefficient, Concept of diffusivity, diffusivity of liquids, Eddy diffusion, film theory, penetration theory, surface renewal theory, Steady state diffusion. mass transfer coefficients, Mass, heat and momentum transfer analogies. ; Interphase mass transfer, local two phase mass transfer, overall mass-transfer coefficient, average overall coefficient, steady state co-current and countercurrent processes, Continuous co-current and counter current processes, cascades, batch processes, Stages and mass transfer rates. Gas-liquid operations and Equipment for Mass Transfer, Overall mass transfer coefficient, Gas dispersal equipments – bubble columns, Liquid dispersal equipments – Venturi scrubbers, wetted wall columns. Gas dispersed Sparged vessels – flow of gas velocity problems based on aeration tank as a time for sparging Gas hold up. Liquid hold up – determination of interfacial area based on hold up and MTC. Tray tower versus packed tower.

Section 2: **(20Hours)**

Gas Absorption: Mechanism of gas absorption, equilibrium in gas absorption, choice of solvent, Countercurrent multistage operation, Non-isothermal operation, absorption in wetted wall columns, values of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculation of height of packed and spray tower. Absorption in tray towers, absorption and stripping factors, calculation of number of trays for absorption Tray efficiencies, absorption with chemical reaction. ; Humidification, Dehumidification Principles, vapour-liquid equilibria, enthalpy of pure substances, wet bulb temperature relation, Lewis relation, Psychrometric chart, methods of humidification and dehumidification, cooling tower design – HTU, NTU concept, calculation of height of cooling tower.; Drying and *Liquid-liquid extraction*: Principles, equilibrium in drying, type of moisture binding, mechanism of batch drying, continuous drying, time required for drying, mechanism of moisture movement in solid, Design principles of tray dryer, rotary dryer, spray dryer. Spray dryer, fluidized bed and spouted bed dryer, pneumatic dryer and vacuum dryer. Crystallisation- Theory and design.

List of lab Practical:
Minimum 6 experiments from the following list to be performed:

1. Study diffusion of liquid into a gas in a vertical pipe and calculate mass transfer coefficient.
2. Study steady state diffusion of acetone in air and calculate diffusivity.
3. To study characteristics of tray dryer and calculate rate of drying.
4. To study steady state molecular diffusion of acetic acid through water and determine diffusivity.
5. To determine efficiency of rotary dryer.
6. To study characteristics of cooling tower for efficiency and relative cooling.
7. To calculate mass transfer coefficient for absorption of CO_2 into NaOH solution.

8. To determine mass transfer coefficient for air-water system during humidification and de-humidification process.
9. To study crystallization to find yield.
10. Any two experiments from above syllabus using virtual lab.

List of Project areas
Minimum 1 Project from list to be completed:

1. Design of dryer
2. Design of absorber
3. Design of cooling tower
4. Design of crystallizer
5. Data analysis of diffision of liquid into gas
6. Data analysis of difusion of liquid into liquid

Text Books:
1. Treybal, R.E;Mass Transfer Operations, 4th Edition, McGraw Hill.
2. McCabe, W. L.; Smith, J. C.; Harriett, .;Unit Operations of Chemical Engineering, 4th Edition, McGraw- Hill.

Reference Books:
1. Datta B. K., Principles of Mass Transfer and Separation Processes, 1st Edition, Prantice Hall.
2. Perry, Robert H.; Green, Don W.; Perry's Chemical Engineer's Handbook; 6th Edition, McGrawHill, 1984.
3. Coulson J. M.; Richardson, J. F.; Chemical Engineering – Vol. I & II; 6 th Edition, Butterworth-Heinemann.

Course Outcomes:
The student will be able to
1. Apply principles of diffusion to separation and purification processes and calculate mass transfer flux and estimate mass transfer coefficient and diffusivity for gas-liquid and liquid-liquid system. **(2)**
2. Select and design appropriate gas-liquid contacting devices. **(3)**
3. Select and design gas absorption and stripping column. **(4)**
4. Calculate mass transfer coefficient for humidification and dehumidification and design cooling tower. **(4)**
5. Calculate rate of drying and Select proper dryer, and find batch time for batch drier and design rotary drier for given requirement. **(4)**
6. Comprehend crystallization system and fundamental of design. **(4)**

CH3067:: CHEMICAL REACTION KINETICS

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20Hours)**

Homogeneous reaction kinetics and design of Ideal reactors

Irreversible and reversible reactions- Elementary and non elementary reactions, Stoichiometry, Fractional conversion. Rate of reaction based on all components of the reaction and their interrelation. Law of mass action, Rate Constant-Based on thermodynamic activity, partial pressure, mole fraction and concentration of the reaction components and their interrelation, Temperature dependency of rate Constant - Arrhenius law, Transition state theory and collision theory.

Batch reactor concept- Constant volume Batch reactor system; Design equation for zero, first, Second irreversible and reversible reactions, graphical interpretation of these equations and their limitations, Variable volume Batch reactors. Design equation for first and second order irreversible and reversible reactions, Graphical interpretation of their limitations

Multiple reactions- Stoichiometry and rate equations for series and parallel reactions. Ideal reactors- Concept of ideality, Types of flow reactors and their differences, Design equation for plug flow reactor and CSTR.

Section 2: **(20Hours)**

Multiple reactor systems and Temperature and Pressure Effects

Multiple reactor systems- Size comparison of reactors, Optimum size determination, Staging of reactors, Reactors in series and parallel, Performance of infinite number of back mix reactors in series, Back mix and plug flow reactors of different sizes in series and their optimum way of staging;

Recycle reactors- Optimum recycle ratio for auto-catalytic (recycle) reactors Yield and selectivity, Parallel reactions Requirements for high yield, best operating condition for mixed and plug flow reactors, Series reactions,

Effect of temperature and pressure- Equilibrium Conversion, Optimum temperature progression, Adiabatic and non adiabatic operations, Temperature and conversion profiles for exothermic and endothermic reactions

List of lab Experiments:

Minimum 6 experiments from the following list to be performed:

1. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in batch reactor – I (Where M=1)
2. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in batch reactor – II (Where M=2)
3. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in straight tube, coli Bent Tube reactor and PFR
4. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in mixed flow reactor.
5. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in mixed flow reactors in series.

6. Verification of Arrhenius law
7. Semi batch Reactor Addition of NaOH in Ethyl acetate, Utilization of POLYMATHS for finding Behavior of products with respective of time.
8. Study the effect of various combination of reactors on conversion
9. To determine τ Optimum for multiple parallel reactions
10. Study of a chemical process based on multiple reactions

Project areas:
Minimum 1 Project from list to be completed:

1. Utilization of POLYMATHS for finding behavior of products with respective of time in reactors
2. Effect of reactor types on product distribution for multiple reactions.
3. To generate temperature conversion profiles for exothermic and endothermic reactions
4. Design of ideal reactors
5. Design of recycle reactor
6. Performance of adiabatic plug flow reactor

Text Books:

1. Levenspiel, O., ‘Chemical Reaction Engineering’, 3rd. edition, John Wiley& Sons, 2001.
2. Fogler, H. S., ‘Elements of Chemical Reaction Engineering’, 3rd Ed., PHI, 2002.

Reference Books:

1. Walas, S. M., ‘Reaction Kinetics for Chemical Engineers’, McGraw Hill, 1959.
2. Smith, J.M., ‘Chemical Engineering Kinetics’, 3rd ed., McGraw Hill, 1987.

Course Outcomes:

The student will be able to –

1. Develop rate expressions from elementary and non elementary step mechanisms using steady-state and quasi-equilibrium approximations. **(2)**
2. Determine rate expressions by analyzing reactor data including integral and differential analysis on constant and variable volume systems **(3)**
3. Design ideal reactors i.e. plug flow and CSTR for first and second order reversible and irreversible, constant and variable volume systems. **(3)**
4. Select and size isothermal reactors for series and/or parallel systems of reactions and product distribution for multiple reactions **(4)**
5. Quantitatively predict the performance of common chemical reactors in various combinations **(4)**
6. Generate temperature and conversion profiles for exothermic and endothermic reactions **(5)**

CH3079 :: ENGINEERING DESIGN AND DEVELOPMENT 1

Credits: 4 **Teaching Scheme: 02 (TH) + 04 (LAB) Hours / Week**

A project will be carried out in the following domain to approach societal needs and technology related to chemical engineering to be applied to execute the project and various tools will be used to analyze the results.

Domain

a. Healthcare
b. Agriculture
c. Defense Applications
d. Education
e. Environment
f. Water and Sanitation
g. Clean Energy
h. Sustainable and Smart City
i. Responsible Consumption
j. Climate
k. Poverty and Hunger
l. Others

A detailed literature survey is carried out and plan for experimental/theoretical work is made. Students may also undertake industry visit to understand application of chemical engineering knowledge for projects related to manufacturing, synthesis, design and development, product testing etc.

Design and fabrication of experimental set up and/or development of model with use of relevant computer programs can be carried out. Analysis of experimental results and/or verification of theoretical model is to be reported.

The group of students is required to choose the domain and topic of project in consultation with the Guide.

A technical report is required to be submitted at the end of the term and a presentation will be given by students based on the same. Modern audio-visual techniques may be used at the time of presentation.

Course Outcomes:

The student will be able to –

1. Apply chemical engineering knowledge. **(2)**
2. Work in a team. **(1)**
3. Approach and execute a practical problem given in a project **(3)**
4. Carry out research and development work. **(3)**
5. Design equipments or process for chemical engineering plants **(4)**
6. Apply written, oral, and graphical communication in technical and non-technical environment. **(3)**

CH3089:: SEMINAR

Credits: **1**	**Teaching Scheme: -** Laboratory 2 Hrs/Week

Seminar should be based on any latest engineering topic allotted to students. The topic may be defined by the guide in discussion with the student.

Students may undertake studies in research survey, literature review and analysis, synthesis, design and development, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of the work. The group of students is required to choose the topic in consultation with the Guide.

A technical report is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation.

Course Outcomes
1. The student will be able to write a technical report. **(4)**
2. The student will be able to present any chosen topic. **(4)**
3. The student will be able to do literature survey of a given topic. **(3)**
4. The student will be able to use modern audio visual techniques at the time of presentation. **(2)**
5. The student will be able to convey the content of any chosen topic. **(3)**

Title: Course Structure **FF No. 653**
Branch: Chemical Engineering **Year: Third Year B. Tech.** **Academic Year: 2018-19**
Semesters: VI **Module: VI** **Pattern: C-18**

Sr. No	Subject Code	Subject Name	Teaching Scheme (Hrs/Week)		Examination scheme						Credits
			Theory	Lab	CA		MSE	ESA		Total	
					HA	LAB		ESE	VIVA		
1	CH3060	Separation Techniques	3	2	10	30	10	30	20	100	4
2	CH3062	Process Equipment Design	3	2	10	30	10	30	20	100	4
3	CH3064	Instrumentation and Process Control	3	2	10	30	10	30	20	100	4
4	CH3066	Chemical Technology	3	2	10	30	10	30	20	100	4
5	CH3078	Engineering Design and Development 2 (EDD2)	2	4							4
6	CH3088	Summer Training									1
7	CH3084	PD1									
8	CH3074	GP2									
Total											21

Abbreviations Used			
CA	**Continuous Assessment**	**ESE**	**End Semester Examination**
HA	**Home Assignment**	**ESA**	**End Semester Assessment**
MSE	**Mid Semester Examination**		

CH3060:: SEPARATION TECHNIQUES

Credits: 4 **Teaching Scheme: 03(TH) + 02(LAB) Hours / Week**

Section 1: **(20Hours)**

Distillation and Liquid-Liquid Extraction. Distillation: Vapour – liquid equilibria for ideal and non-ideal systems, relative volatility, methods of distillation - differential, flash, low pressure, batch rectification. Continuous rectification for binary system, multistage (tray) towers, Lewis Sorrel method, McCabe Thiele method, concept of reflux, Fenske's equation, Fenske-Underwood equation, use of open steam. Partial and total Condensers, reboilers. Ponchon Savarit method for multistage operations, tray efficiencies, packed column design, complex distillation columns, concept of multi component distillation, extractive and azeotropic distillation, Fenske- Underwood-Gilliland shortcut method for multi-component distillation.
Liquid-Liquid Extraction: Ternary liquid-liquid equilibrium, triangular coordinates, single-stage extraction, Multi-stage crosscurrent extraction, continuous countercurrent multistage extraction. Types of extractors.

Section 2: **(20Hours)**
Leaching, Adsorption and Ion Exchange. Solid-Liquid Extraction: Single stage leaching, continuous counter current leaching, ideal stage equilibrium, operating time, constant and variable underflow, number of ideal stages, stage efficiencies, Leaching equipments.
Adsorption: Physical and chemical adsorption, adsorbents, adsorption equilibrium and isotherms, Single-stage, multi-stage cross-current and multi-stage counter current operations, equilibrium and operating lines, Liquid-solid agitated vessel adsorber, packed continuous contactor, breakthrough curves, Rate equations for adsorbents, nonisothermal operation, pressure-swing adsorption, Ion Exchange- Principles of Ion Exchange Equilibria and rate of ion exchange

List of Practicals:
Minimum 6 experiments from the following list to be performed:

1. To generate VLE data for binary ideal/non-ideal systems
2. To study differential distillation and verify Rayleigh equation
3. To carry out steam distillation of substance and determine steam requirement
4. To conduct binary distillation in a packed column at total reflux and to estimate HETP and HTU for column
5. To obtain data for equilibrium distribution of solute in two insoluble solvents for example acetic acid in water and toluene phases and determine percentage extraction
6. To study the (cross current) liquid- liquid extraction for extracting acetic acid from benzene using water as solvent
7. To carry out leaching operation using groundnuts and n-Hexane and find out quantity of oil and to determine the efficiency of single stage leaching operation
8. To verify Freundlich/ Langmuir isotherm equation for batch adsorption
9. To obtain the breakthrough curve for continuous process in adsorption column
10. Case study on separation processes in chemical plant.

List of Project areas:
Minimum 1 Project from list to be completed:

1. Design of distillation column
2. To prepare the ternary diagram for a system of three liquid one pair partially soluble for example acetic acid, benzene and water system
3. Study liquid- liquid extraction in a packed column and determine HTU and HETP for the tower
4. Analysis of ion-exchange equilibria
5. Design of multi-component distillation system using ASPEN software
6. Process design of leaching/adsorption equipment

Text Books:

3. Treybal R. E.; Mass Transfer Operations, Third edition, McGraw Hill, 1980
4. Coulson J. M., Richardson J. F.; Chemical Engineering – Vol. I & II, Sixth edition, Butterworth Heinemann, 1999
5. King C.J.; Separation Processes; Tata McGraw - Hill Publishing Co. Ltd., 1982.
6. Dutta B. K.; Principles of Mass Transfer and Separation Processes; Prentice-Hall of India Private Ltd., 2007

Reference Books:

1. McCabe W. L., Smith J. C., Harriett P.; Unit Operations of Chemical Engineering; Fourth edition, McGraw-Hill, 1985.
2. Wankat. P.C.; Separations in Chemical Engineering: Equilibrium Staged Separations; Prentice Hall, NJ, US, 1988
3. Perry R. H., Green D. W.; Perry's Chemical Engineer's Handbook; Sixth Edition, McGraw-Hill, 1984

Course Outcomes:

The student will be able to –

1. generate VLE data for ideal and non-ideal system **(3)**
2. carry out process design of distillation column **(4)**
3. analyze implications of factors affecting distillation column operation and design like the effect of reflux ratio, feed conditions etc. and also the implications of non-ideal phase behavior (e.g., azeotropes) and apply to multicomponent distillation **(5)**
4. select suitable solvent for liquid-liquid extraction based on properties like selectivity, distribution coefficient etc. and design liquid-liquid extraction column and select equipment required for given separation **(5)**
5. calculate the number of stages required for a leaching operation **(5)**
6. draw analogy between adsorption and ion exchange, carry out process design of adsorption column. **(5)**

CH3062:: PROCESS EQUIPMENT DESIGN

Credits: 04 **Teaching Scheme: 03(TH) + 02(LAB) Hours / Week**

Section 1: **(20Hours)**

Heat Exchangers: Introduction, process heat transfer, types of heat exchangers, codes and standards for heat exchangers, materials of construction, API scale, LMTD, countercurrent & concurrent exchangers, temperature approach & cross, counter-flow: double pipe exchangers, baffles and tie rods, design of shell and tube heat exchangers as per IS: 4503 and TEMA standards i.e. shell, tube sheets, channel, channel cover, flanged joints. Design of Double pipe, plate type heat exchangers. Joints, bearings, drives, mechanical seals, fabrication methods. Evaporators & pressure vessels**:** Classification of vaporizing equipment, evaporators (including different types such as kettle, thermosiphon, vertical, horizontal etc. Chemical evaporators, natural circulation & forced circulation evaporators, the calculation of chemical evaporators. Types of pressure vessels, codes and standards for pressure vessels (ASME Sec VIII Div-1, 2), material of construction, selection of material, selection of corrosion allowance and weld joint efficiency, purging of vessels. selection and design of various heads such as flat, torispherical, elliptical, hemispherical and conical. Opening/ nozzles and manholes, nozzle sizing, calculations etc. Flanged joints: Gasket: types, selection, and design, bolt design and selection, flange dimensions flange rating calculation**.** Condenser Design and support design: Condenser design for condensation of single vapors, Design of total and partial condenser with pressure balance. Vertical condenser, horizontal condenser. Allowable pressure drop in condensers, condenser-subcooler, condensation of steam- surface condenser. jacket for vessels. Introduction and classification of supports, design of bracket or lug supports, saddle support.

Section 2: **(20Hours)**

Mass transfer equipments with storage vessel and mixer consideration: Tray column design and storage vessels: Design of plate column- distillation columns, design variables in distillation, design methods for binary systems, plate efficiency, approximate column sizing, plate contactors, plate hydraulic design. Various types of storage vessels and applications, losses in storage vessels, storage of fluids- storage of volatile & non-volatile liquids- fixed roof and variable volume tanks, Various types of roofs used for storage vessels. Storage of gases- spherical vessels. Packed Column Design and mixers: Choices of packing, types of packing, packed bed height (distillation and absorption), HETP, HTU, NTU, Cornell's method, Onda's method, column diameter, column internals, column auxiliaries. Mixers- Various types of mechanical mixers- propeller, turbines & paddles their selection, flow patterns in agitated tanks, baffling, design practices, standard geometry tank, power dissipation and discharge flow correlation, mechanical agitator design. Reaction vessels. Filters, Dryers and auxillary process vessels **:** Study of various types of filters like vacuum filters, pressure filters, centrifuges and rotary drum filters, design of rotary drum filters including design of drum, shaft, bearing and drive system. Types of dryers, batch type dryers, continuous dryers. Study of auxiliary process vessels such as reflux drum, knockout drum, liquid-liquid and gas-liquid separators, entrainment separators, oil water separator, Decanter, gravity separator, safety devices.

List of lab practical:
Minimum 6 experiments from the following list to be performed:

1. design of Shell and Tube heat exchanger.
2. design of double pipe heat exchanger
3. design of plate type heat exchanger
4. design of vaporiser
5. design of condenser
6. design of distillation column
7. Design of types of supports for vessels
8. Design of various types of heads for vessels
9. Design of agitators for chemical reactors
10. Literature survey on types of safety valves, safety devices for chemical equipments
11. Literature survey on Advances in filters used in Chemical industry
12. Literature survey on Advances in different types of seals e.g. mechanical seal etc. in Chemical industry
13. Autocad drawing of tubes sheet for the Shell and tube heat exchanger.
14. Economic analysis for Shell and tube heat exchanger.
15. Mechanical design details for Shell and tube heat exchanger.

List of Project areas:
Minimum 1 Project from list to be completed:

1. Optimisation of Shell and Tube heat exchanger considering particular heating or cooling objective
2. Optimisation of Plate type heat exchanger considering particular heating or cooling objective
3. Optimisation of Double pipe heat exchanger considering particular heating or cooling objective
4. Optimisation of Helical tube type heat exchanger considering particular heating or cooling objective
5. Optimisation of evaporator to obtain thick liquor with particular concentration considering various industrial needs
6. Optimisation of tray/packed column for separation by using distillation, absorption, etc operations with an industrial example.

Text Books:

1. D. Q. Kern;Process Heat Transfer; Tata McGraw Hill Publications, 2009
2. R. K. Sinnott; Coulson & Richardson's Chemical Engineering, Volume-6; Elsevier Butterworth Heinemann, MA, 2005.
3. V.V. Mahajani, S. B. Umarji; Joshi's Process Equipment Design; 5th Edition; Trinity Press
4. Lloyd E. Brownell, Edwin H. Young; Process Equipment Design; 1st Edition; Wiley-Interscience

Reference Books:

1. Walas, S. M; Chemical process equipment: selection and design; Butterworth-Heinemann, 1990.

2. Ludwig, E.E.; Applied Process Design for Chemical and Petrochemical Plants, Vol. 1 and 2; 3rd Ed.; Gulf Publishing Co., 1997.
3. Eugene F. Megyesy; Pressure Vessel Handbook; 10^{th} Edition; Pressure Vessel Publishing, INC.
4. R. K. Sinnott; Coulson and Richardson's Chemical Engineering Volume 6 - Chemical Engineering Design; 4^{th} Edition; Pergamon Press

Course Outcomes:

The student will be able to –

1. Carry out the detailed thermal design of double pipe and shell and tube heat exchanger for given requirement. **(5)**
2. Design a multiple effect evaporation system for specific requirement of concentration. **(4)**
3. Do hydraulic plate design and tray column design for desired separation needs. **(5)**
4. Select type and size of packing and packed column design with internals for required separation. **(3)**
5. Select and design support for vessels. **(4)**
6. Choose and design auxiliary process equipment required for various simple separation & storage requirements. **(4)**

CH3064:: INSTRUMENTATION AND PROCESS CONTROL

Credits: 04 **Teaching Scheme: 03(TH) + 02(LAB) Hours / Week**

Section 1: **(20Hours)**

Instrumentation: Measurement fundamentals. Temperature, flow, pressure, level and composition measuring instruments. Static and dynamic characteristics. Control valves: sizing and valve characteristics
Process Dynamics: Introduction to process control. Review of Laplace transforms. Development of mathematical and dynamic modeling of chemical engineering systems.
First order, second order systems. Systems with time delays. Interacting & noninteracting processes
Single loop feedback control: Feedback control. Block diagram. Feedback controllers: PID control etc. Typical time-domain responses of feedback control systems. Servo and regulatory problems.

Section 2: **(20Hours)**

Stability Analysis: Stability analysis of closed-loop control systems. Routh stability criterion. Root locus technique. Bode stability analysis.
Design of Feeback Control Systems:Design of feedback control systems using time-domain and frequency-domain techniques. Controller tuning methods such as Ziegler-Nichols.
Advanced Process Control: Feedforward control, cascade control, ratio control, selective control etc. Introduction to digital control. Multiloop and multivariable control. Plantwide control.

List of Practicals:

Measurements for temperature, pressure, flow, level etc
Process dynamics
PID Controlled system: P, I, D modes and controller tuning
Feedback control system design using Matlab
Dynamic simulation on a chemical engineering simulator such as Aspen
Dynamics of Chemical Engineering Systems such as distillation column, reactor etc.
Dynamics of distillation column
Dynamics of reactor
Stability analysis
Dynamic behaviour of liquid level in two consecutive tanks.

List of Project areas:

1. Controller tuning
2. P&ID diagrams for flow sheets
3. design a control system using time-domain techniques such as root-locus
4. design a control system using frequency-domain techniques such as Bode design
5. Dynamic behaviour of pure capacity process
6. Feedback control system design using Matlab

Text Books:

1. Coughanowr D.R., “Process Systems Analysis and Control”, 2nd ed, McGraw-Hill.
2. Nakra, B.C., Chaudhry, “Instrumentation, Measurement and Analysis”, K.K., 2nd ed, Tata McGraw-Hill.

Reference Books:

1. Ekmann, D. P.; Industrial Instrumentation, Fifteenth Wiley Eastern Reprint, 1st Edition, Wiley Eastern Ltd.
2. Luyben, W.L. ‘Process Modeling, Simulation and Control for Chemical Engineers’, 2^{nd} ed., McGraw-Hill.
3. Seborg, D. E.; Edgar, T. F.; MellichampD.A. 'Process Dynamics and Control', 2nd ed, John Wiley & Sons.
4. Considine, D. M., “Process/Industrial Instruments and Controls Handbook”,4th Edition, McGraw-Hill.
5. George Stephanopolous, “Chemical Process Control”, Eastern Economy edition, Prentice-Hall, 2005.
6. Liptak, B.G, “Instrument Engineer's Handbook, Volume I: Process Measurement and Analysis”, 4th ed, CRC Press.
7. Liptak, B.G. 'Instrument Engineer's Handbook, Volume II: Process Control and Optimization', 4th ed, CRC Press, 2005.
8. Harriot, P., “Process Control” Tata McGraw Hill Publishing Co., 1991.
9. Doebelin, E.O., Manik, D.N., “Doebelin's Measurement Systems”, 6th ed, McGraw-Hill.

Course Outcomes:

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

1. carry out selection and performance analysis of measuring instruments **(2)**
2. write dynamic models of chemical engineering systems **(3)**
3. carry out process identification and tune a PID controlled system **(5)**
4. design a control system using time-domain techniques such as root-locus **(5)**
5. design a control system using frequency-domain techniques such as Bode design **(5)**
6. carry out preliminary analysis of Advanced Process Control systems **(4)**

CH3066:: CHEMICAL TECHNOLOGY

Credits: 04 **Teaching Scheme: 03(TH) + 02(LAB) Hours / Week**

Section 1: **(20Hours)**

Basic Concepts: Theory of Unit operations and industrial equipment and systems used in large scale plants; Unit processes, Development of flow diagram, schematic representation and application for unit operations and unit processes. Study the selection and process specific applications knowing available industrial equipment and plant accessories. Chlor-Alkali Industry : Chlor-alkali chart and importance of chlor-alkali industry, manufacturing processes process economics, and plants in India and a few examples of latest technology used in other nations; Manufacturing of soda ash, caustic soda, chlorine and engineering problems. Membrane cell, mercury cell diaphragm cell processes and electrolytic cell processes and flowsheets . Nitrogen industry : Role of nitrogen in fertilizers, manufacturing of ammonia, nitric acid, urea, the above study must involves different routes adopted, limitations, advantages and disadvantages of the process; steam-reforming process technology. Coal gasification technologies (Fixed bed (Lurgi Process), Fluidised bed (Winkler Process)

Section 2: **(20Hours)**

Sulfur and Sugar Industry: Importance, manufacturing of sulfur by Frasch process, technology for the manufacturing of sulfuric acid. Sugar Industry: Manufacture of sugar and engineering problems associated, Dextrin and starch derivatives. Detailed study and comparison between chamber and DCDA processes; process economics. Phosphorus and Paper Pulp Industry:Importance, manufacturing of super phosphate, triple super phosphate, phosphoric acid, electro thermal processes and NPK fertilizers, production of pulp, engineering problems involved, paper manufacturing from pulp, and comparison of methods of manufacturing. Petroleum and polymer industry **:** Overview of refinery process, Crude multicomponent distillation, Cracking, Reforming, polymerization industries (polyethylene, polypropylene, PVC and polyester synthetic fibers).

List of Laboratory experiments

1. Drawing process flow diagram for reactor and distillation column with different combination of gas, liquid, solid reactants, endothermic, exothermic reactions, high low pressure system.
2. Literature review on synthesis of Chemical Products.
3. Market review for given chemical product.
4. Report writing on the chemical plant in Latex including literature, market survey, raw material handling, packing etc.
5. Industrial visit to Chemical Plant.
6. Preparing material safety data sheet for Chemical Product
7. Preparing OSHA sheets
8. Waste treatment methods in Chemical Industry
9. Heating arrangements/cooling arrangements in Chemical Industry

10. Systems for obtaining vacuums in Chemical industry

List of project:

1. Draw process flow diagram, process utility diagram, P & ID diagram, complete floorwise digram, (individual process to individual student) for the processes of Chemical Technology.
2. Basic material and Energy Balance of Chemical Plant
3. Find breakeven point for the New Chemical Plant.
4. Pinch Analysis for Chemical Plant
6. Complete hazop study of Chemical Plant

Textbooks:

1. 'Dryden Outline of Chemical. Technology', Rao, M. Gopala, 3rd Edition, East West Publishers, 1997.
2. 'Shreve's Chemical Process Industries', Austin, George T., 5th Edition, McGraw-Hill, 1984.

Reference Books:

1. 'Chemical Process Design and Integration', Smith, R., 3rd Edition, Wiley, 2005.
2. 'Unit Processes in Organic Synthesis', Groggins, P.H., 3rd Edition, McGraw-Hill Book Co., 1958.

Course Outcomes:

The student will be able to –

1. Apply process fundamentals of chemical technology in process industries. **(2)**
2. Apply knowledge of chemical technology in unit operations and unit processes happening in chemical industry. **(3)**
3. Develop process flow sheets for production of specific chemical product. (4)
4. Comprehend reaction temperature, pressure condition and heat network in process flowsheet. **(3)**
5. Analyze different process for same product based on economics, effluent treatment, social aspects. **(3)**
6. Explain Petroleum refinery operation and supplementary processes. **(3)**

CH3078:: ENGINEERING DESIGN AND DEVELOPMENT 2

Credits: 4 **Teaching Scheme: 02 (TH) + 04 (LAB) Hours / Week**

A project will be carried out in the following domain to approach societal needs and technology related to chemical engineering to be applied to execute the project and various tools will be used to analyze the results.

Domain

a. Healthcare
b. Agriculture
c. Defense Applications
d. Education
e. Environment
f. Water and Sanitation
g. Clean Energy
h. Sustainable and Smart City
i. Responsible Consumption
j. Climate
k. Poverty and Hunger
l. Others

A detailed literature survey is carried out and plan for experimental/theoretical work is made. Students may also undertake industry visit to understand application of chemical engineering knowledge for projects related to manufacturing, synthesis, design and development, product testing etc.

Design and fabrication of experimental set up and/or development of model with use of relevant computer programs can be carried out. Analysis of experimental results and/or verification of theoretical model is to be reported.

The group of students is required to choose the domain and topic of project in consultation with the Guide.

A technical report is required to be submitted at the end of the term and a presentation will be given by students based on the same. Modern audio-visual techniques may be used at the time of presentation.

Course Outcomes:

The student will be able to –

1. Apply chemical engineering knowledge. **(2)**
2. Work in a team. **(1)**
3. Approach and execute a practical problem given in a project **(3)**
4. Carry out research and development work. **(3)**
5. Design equipments or process for chemical engineering plants **(4)**
6. Apply written, oral, and graphical communication in technical and non-technical environment. **(3)**

CH3088:: SUMMER TRAINING

Credits: 01	

Guidelines:

1. Students need to maintain minimum attendance of 75% at the place of work and produce digital record duly signed by competent authority.
2. Total training period is minimum one month.
3. Training undertaken can be industrial or research.
4. Students need to submit reports on company/research project and plant Study / research report.
5. Final presentation would be conducted at the end of semester.

Course Outcomes:
The student will be able to –

1. Apply Chemical Engineering knowledge **(4)**
2. Design equipments or process for chemical engineering plants. **(5)**
3. Carry out research and development work. **(5)**
4. Work effectively as member or leader in team. **(3)**
5. Organize, comprehend and write technical report. **(4)**
6. Follow ethics and professional standards of organization/industry. **(3)**
7. Troubleshoot problems. **(5)**

Pattern 'D18'

Final Year BTech Chemical Engineering

Academic Year 2018-19

Content

FF: 653

Title : Course Structure **Branch: Chemical Engineering**

Year: Final Year B. Tech. **Academic Year: 2018-19** **Semester: VII** **Module: VII**
Pattern: D18

Sr. No.	Subject Code	Subject Name	Teaching Scheme (Hrs/Week)		Examination scheme						Credits
			Theory	Lab	CA		MSE	ESA		Total	
					HA	LAB		ESE	VIVA		
	CH4063	Plant Engineering and Project Economics	3	2							
	CH4069	Project Management	3	2						100	4
OE1	CH4059	Environmental Pollution	3	2	10	30	10	30	20		
	CH4058	Transport Phenomena	3	2							
OE2	CH4066	Food Technology	3	2	10	30	10	30	20	100	4
	CH4057	Chemical Reaction Engineering	3	2							
OE3	CH4068	Analytical Chemistry	3	2	10	30	10	30	20	100	4
Major Project	CH4093	Major Project I		8							4
	CH4094	Major Project II									
PD1	CH4073										
Total											16

<u>OR</u>

Module VIII Final Year B. Tech Chemical Engineering **FF: 653**

Sr. No.	Subject Code	Subject Name	Teaching Scheme(Hrs/ Week)		Examination scheme					Total	Credits
			Theory	Lab	CA		MSE	ESA			
					HA	LAB		ESE	VIVA		
1	CH4096	Industry Internship								100	16
2	CH4095	Research Internship									
3	CH4070	Global Internship									

Abbreviations Used			
CA	**Continuous Assessment**	**MSE**	**Mid Semester Examination**
HA	**Home Assignment**	**ESE**	**End Semester Examination**
ESA	**End Semester Assessment**		

CH4063: PLANT ENGINEERING AND PROJECT ECONOMICS

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20 Hr)**

Chemical Engineering Plant Design; General Overall Design Considerations, Practical Design Considerations, Basic engineering in process, thermodynamic and kinetic feasibility, process feasibility, capacity identification, and selection process specification equipment specification material selection, Engineering Flow Diagrams: BFD, PFD, and P & ID, Pilot Plant. Health and Safety Considerations; General Design Considerations: Health and Safety Hazards, Loss Prevention: Hazard Assessment Techniques: HAZOP, HAZAN, Fault Tree Analysis, etc. , Environmental Protection, Plant Location, Plant Layout, Plant Operation and Control, etc, Process Design Development: Development of design database, Process Creation, Process Design, Patent considerations Importance of laboratory development to pilot plant, scale up methods.

Chemical Plant Cost Estimation; Cash flow for industrial operations: Cumulative cash position, Factors Affecting Investment and Production Costs, Capital Investments: Fixed-Capital Investment, Working Capital, and Estimation of Capital Investment: Types of Capital Cost Estimates, Cost Factors in Capital Investment, Estimation of Total Product Cost: Manufacturing Costs, General Expenses. Estimation of various components of project cost as per recommended practice by India Financial Institutes, Plant & machinery estimate, Cost of Production. Cost Indexes

Section 2: **(20 Hr)**

Project Financing and Profitability Analysis: Project Financing Greenfield projects, Add-on projects, ongoing business Interest & Investment Costs: Types of interest: simple interest, ordinary and exact simple interest, nominal and effective interest rates, compound interest, continuous interest. Loan repayment, Periodic payments, annualized cost, capitalized cost, Present worth and discount, annuities, costs due to interest on investment; Borrowed capital versus owned capital, source of capital, income-tax effects, design-engineering practice for interest and investment costs. Taxes and Insurance: Types of taxes: property taxes, excise taxes, income taxes. Insurance, types of insurance. Profitability, Project Evaluation: Break even analysis, incremental analysis, ratio analysis, discounted profit flow technique. Feasibility report, Annual report, alternative investments, and replacements. Depreciation: purpose of depreciation as a cost, types of depreciation, depletion, service value, salvage value, present value, depreciation in chemical project, methods for determining depreciation, appreciation of depreciation concept, depreciation rates, the depreciation schedule.

List of Practicals:
Minimum 6 experiments from the following list to be performed:

1. To do material balance of chemical plant.
2. To do energy balance of chemical plant.
3. To do plant layout of chemical plant.
4. To do HAZOP analysis of chemical plant.
5. To do fault tree analysis of chemical plant.
6. To determination costs of various equipments.
7. To estimate economic of chemical plant.
8. To estimate capitalized cost of chemical plant.
9. To determine profitability of chemical plant.
10. To determine depreciation of equipments.

List of Project areas:
Minimum 1 Projects from list to be completed:

1. General Overall Design Considerations, Plant layout
2. HAZOP, Fault tree analysis
3. Capital cost estimation, cost index
4. Types of interest, present worth, annuity
5. Estimation of depreciation of equipments
6. Estimation of profitability

Text Books:

1. Peters, M.S., Timmerhaus, K.D. "Plant design and economics for chemical engineers", 4th Edition, McGraw Hill, 1990.

Reference Books:

1. Mahajani V.V., Mokashi S. M. "Chemical Project Economics", Macmillan India Publication , 1st Edition, 2005 .
2. Bausbacher E. and Hunt R. "Process Plant Layout and Piping Design", 1st Edition, Prentice Hall Publication, 1993.

Course Outcomes:
The student will be able to –
1. Develop various steps of chemical plant design. **(3)**
2. Do and describe health & safety analysis. **(4)**
3. Estimate & predict cost estimation of chemical plant. **(4)**
4. Estimate & describe different types of interest. **(4)**
5. Estimate & describe taxes, insurance, profit analysis. **(4)**
6. Describe and calculate depreciation. **(5)**

CH4069: PROJECT MANAGEMENT

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20 Hr)**

Introduction to types of management, management suitable for projects, Introduction to Project management, Project management Process and role of Project Manager, Characteristics of projects, Definition and objectives of Project Management, Stages of Project Management, Types of projects, financial evaluation of projects using various methods such as payback period method, average rate of return method, net present value method, profitability index method, internal rate of return method, etc. Project cost estimation methods and application, Introduction to project planning, Dynamic Project Planning and Scheduling, Building the work breakdown schedule, Estimation of task and project duration, Project Scheduling with Resource Constraints, Project scheduling and Planning Tools: Work Breakdown structure, CPM/PERT Network, Gantt charts. Project monitoring and evaluation plan, Project evaluation approaches, Project Cost Control and Time Cost Tradeoff

Section 2: **(20 Hr)**

Project monitoring and evaluation plan, Project evaluation approaches, Project Cost Control and Time Cost Tradeoff, Types of contract, sub-contracts, tenders, types of payments to contractors, Introduction and objectives of project audit, phases of project audit, types of project audit, agencies of project audit (Indian scenario)

List of Practicals:
Minimum 6 experiments from the following list to be performed:

1. A study on cost management.
2. A study on integration management.
3. A study on procurement management.
4. A study on resource management.
5. A study on requirement of project management.
6. A study on schedule management.
7. A study on risk management.
8. A study on marketing and sales.
9. A study on team motivation techniques
10. A study on ethics and organizational culture.

List of Project areas:
Minimum 1 Projects from list to be completed:

1. A project on organization structure.
2. A project on cost control and management.

3. A project on balance sheet of company
4. A project on financing of company
5. A project on resent projects done by company
6. A project on cost variance of certain period over the time

Text Books:

1. Nagarajan K.; Project Management; 1st Edition., New Age International.
2. Mahajani V. V. , Nokashi S. M.; Chemical Project Economics; 1st Edition; Macmillan India Ltd.

Reference Books:

1. Choudhury S.; Project Scheduling and Monitoring in Practice, 1st Edition; SAP.
2. Joy P. K.; Total Project Management: The Indian Context; 1st Edition; Macmillan India Ltd.

Course Outcomes:
The student will be able to –

1. Obtain an understanding of management, project management and its principles in a contemporary project environment. **(3)**
2. Understand functions of project manager, project life cycle and project portfolio management. **(3)**
3. Select project from options, estimate cost, time and do the planning and scheduling activity. **(4)**
4. Monitor and evaluate the project progress and cost time relationship and estimates. **(4)**
5. Understand contracts and tenders and billing system and use in the project. **(4)**
6. Understand types, necessity and importance of audit and learn from audit. **(4)**

CH4062: ENVIRONMENTAL POLLUTION

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20 Hr)**

Introduction
An overview of environmental engineering, pollution of air, water and soil, impact of population growth on environment, impact of development on the environment, chemical pollution, solid wastes, prevention and control of environmental pollution.
Air Pollution- Sources, Effects and Measurement
Sources scales of concentration and classification of air pollutants. Effects of air pollutants on human health, plants, animals, materials, measurement of air pollutants, particulate pollution: cleaning methods, collection efficiency, particulate collection systems.
Water Pollution
Domestic and industrial wastewater, types, sources and effects of water pollutants. Waste water characteristics–DO, BOD, COD, TOC, total suspended solids, colour and odour, bacteriological quality, oxygen deficit, determination of BOD constants.

Section 2: **(20 Hr)**

Waste Water Treatment
Primary and secondary treatment, design and basic operating principles of activated sludge process, sludge treatment and disposal, trickling filter. Advanced methods of waste water treatment, UASB, photo catalytic reactors, wet-air oxidation. Tertiary treatment methods
Solid Waste Management
Sources and classification of solid wastes, disposal methods, incineration, composting, recovery and recycling.
Regulations and Standards
Laws and standards for water pollution, air pollution, land pollution.
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List of Practicals:
Minimum 6 experiments from the following list to be performed:

1. Determination of acidity of various water samples.
2. Determination of the alkalinity of various water samples.
3. Determination of the chloride content in the given water samples.
4. Determination of the optimum coagulant dose for the removal of maximum turbidity
5. Determination of the hardness of the given water sample
6. Determination of the iron content of water samples
7. Determination of Dissolved oxygen of water
8. Determination of Biochemical oxygen demand (B.O.D.) of given Water / wastewater samples (BOD5)

9. Determination of Chemical oxygen demand (COD) of given sample.
10. Determination of sulphate content of the given water sample

List of Project areas:
Minimum 1 Projects from list to be completed:

1. Water pollution
2. Gaseous Pollution
3. Particulate pollution
4. Solid waste management

Text Books:

1. Kiely Gerard; Environmental Engineering; Special edition 2007, Tata McGraw-Hill International
2. Metcalf and Eddy; Wastewater Engineering,; 3rd edition., Tata McGraw Hill Publishers
3. Rao C.S; Environmental Pollution Control Engineering; 2nd edition, New Age International (P) Ltd
4. Sasikumar K.; Solid Waste Management; 1st edition2009, Prentice Hall India Learning Private Limited

Reference Books:

1. Flagan R.C. and Seinfield J.H; Fundamentals of Air Pollution Engineering; 1988., Prentice Hall
2. Crowford Martin; Air Pollution Control Theory; 1st edition. McGraw Hill Publishers

Course Outcomes:
The student will be able to –

1. Identify hazardous pollutants in the plant or area. **(3)**
2. Design reduction method and pollution treatment technique. **(4)**
3. Develop the analysis techniques for different pollutants. **(5)**
4. Determine the pollution level with respect to the pollution standards. **(3)**
5. Analyze the impact of various factors on the environment. **(4)**
6. Determine the suitability of water for different usage. **(3)**

CH4058: TRANSPORT PHENOMENA

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section1: **(20 Hr)**

Newton's law of viscosity, temperature and pressure dependence of viscosity for gases and liquids. Basics of momentum transport, combined momentum flux. Equation of continuity, equation of motion. Shell momentum balances and boundary conditions. Shell momentum balances for flow of falling film, flow through circular tube, flow through annulus, flow of two adjacent immiscible fluids etc. Fourier law of energy transport. Dependence of thermal conductivity on temperature, pressure. Shell energy balances for heat conduction: Heat flux and temperature distribution for heat sources such as electrical, nuclear, viscous. Heat flux through composite walls.

Section 2: **(20 Hr)**

Fick's law of diffusion. Temperature and pressure dependence of diffusivity.
Shell mass balances for diffusion through stagnant film, diffusion with homogeneous and heterogeneous chemical reaction, diffusion and chemical reaction inside a porous catalyst etc.
Turbulent transport phenomena, Boundary layer theory.
Macroscopic momentum, energy and mass balances. Use of macroscopic balances to solve steady state and unsteady state problems

List of Practicals:
Minimum 6 experiments from the following list to be performed:

Solve problems / carry out simulations based on
1. Shell momentum balances: Cartesian coordinate system
2. Shell momentum balances: Cylindrical coordinate system
3. Shell momentum balances: Spherical coordinate system
4. Shell energy balances: Cartesian coordinate system
5. Shell energy balances: Cylindrical coordinate system
6. Shell energy balances: Spherical coordinate system
7. Shell mass balances: Cartesian coordinate system
8. Shell mass balances: Cylindrical coordinate system
9. Shell mass balances: Spherical coordinate system
10. Dimensional analysis

List of Project areas:
Minimum 1 Projects from list to be completed:

Projects based on design calculations / simulations of
1. Macroscopic momentum balances
2. Macroscopic energy balances
3. Macroscopic mass balances
4. Combined mass, energy, momentum macroscopic balances
5. Dimensional analysis ans scale up
6. Product design involving transport phenomena

Text Books:

1. Bird R. B, Stewart W.E., Lightfoot E.W., 'Transport Phenomena', John Wiley, 2nd Ed., 2000.
2. Brodkey R. S., Hershey H. C., 'Transport Phenomena', McGraw-Hill International Edition, 1988.

Reference Books:

1. Wilty J.R., Wilson R.W., Wicks C.W., 'Fundamentals of Momentum, Heat and Mass Trasport', 2nd Ed., John Wiley, New York, 1973.

Course Outcomes:

Students will be able to-

1. Solve shell momentum balance problems for simple systems. **(4)**
2. Solve shell energy balance problems for simple systems. **(4)**
3. Solve shell mass balance problems for simple system. **(4)**
4. Setup and solve macroscopic momentum balances for a given system. **(5)**
5. Setup general equations of continuity and motion. **(5)**
6. Carry out dimensional analysis and scale up exercise for complex systems. **(4)**

CH4066: FOOD TECHNOLOGY

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20 Hr)**

Properties of liquid, solids and gases used in food processing, water activity, effect of processing on sensory, nutritional properties. Food safety, good manufacturing practices and quality assurance, Food processing scenario of India, Need of food processing in India, Raw material preparations, size reduction, mixing and forming, separation and concentration of food components, fermentation and enzyme technology, irradiation, processing using electric field, high hydrostatic pressure, light or ultrasound. Survey of fermented food, advantages and disadvantages of fermented food, Heat Processing using steam or water, pasteurization, heat sterilization, evaporation and distillation, extraction, dehydration, dielectric, ohmic and infrared heating , Baking, roasting and frying.

Section 2: **(20 Hr)**

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Chilling controlled or modified atmosphere storage and packaging, freezing, freeze drying and concentration. Ice cream manufacture flow-sheet and process, Coating or enrobing, packaging, filling and sealing of containers, material handling, storage and distribution, Advertising of food products, Coating or enrobing, packaging, filling and sealing of containers, material handling, storage and distribution, Advertising of food products.

List of Practicals:
Minimum 6 experiments from the following list to be performed:

1. Study of food testing.
2. Study of effect on nutritional values of fruits and vegetables.
3. Study of Indian industries in food processing.
4. Study of food processing and sensory characteristics.
5. Study of water activity.
6. Study of food decay.
7. Study of food preservation.
8. Study of additives in food.
9. Study of food storage methods.
10. Study of physic-chemical property of food product.

List of Project areas:
Minimum 1 Projects from list to be completed:

1. A project on food preservation techniques.
2. A project on food analysis.
3. A project on packaging of food product.
4. A project on marketing of food product.
5. A project on byproduct of food waste.
6. A project on evolution in food processing.

Text Books:

1. Fellows P.; Food Processing Technology; 2nd Edition ; CRC Press New York.

Reference Books:

1. Considine D.M.; Food and Food Production Encyclopedia; 2nd Edition; VNR New York.
2. Singh N. P.; Fruit and Vegetable Preservation; 1st Edition, Oxford Book Company India.
3. Simpson S. P., Straus M. C. ; Post Harvesting Technology of Horticultural Crops; Oxford Book Company India.

Course Outcomes:

The student will be able to –

1. Understand need of food preservation and processing and food properties. **(3)**
2. Understand and select ambient temperature operations for food preservation and processing. **(4)**
3. Understand and select high temperature operations for food preservation and processing. **(4)**
4. Understand and select low temperature operations for food preservation and processing. **(4)**
5. Know the post processing operations, principles and equipment involved and its importance. **(4)**

CH4057: CHEMICAL REACTION ENGINEERING

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20 Hr)**

Non-Ideal flow and Heterogeneous processes, catalysis and adsorption
Residence time distribution in vessels: E, F and C curve, and their relationship for closed vessels, conversion in reactors having non-ideal flow; models for non-ideal flow: Dispersion model, Tank in Series, model, Multi parameter model. Mixing of fluids, Self-mixing of single fluid. Dead Zone and Bypass model Two parameter models. Early and late mixing of fluid, mixing of two miscible fluids. Global rate of reaction, Types of Heterogeneous reactions Catalysis, The nature of catalytic reactions, Adsorption: Surface Chemistry and adsorption, adsorption isotherm, Rates of adsorption. Solid catalysts: Determination of Surface area, Void volume and solid density, Pore volume distribution, Theories of heterogeneous catalysis, Classification of catalysts, Catalyst preparation, Promoters and inhibitors, Catalyst deactivation (Poisoning). Mechanism of deactivation, Rate equation for deactivation, Regeneration of catalyst.

Section 2: **(20 Hr)**

Fluid-particle noncatalytic, catalytic and fluid-fluid non-catalytic reactions
Selection of a model for gas-solid non catalytic reaction, Un-reacted core model, Shrinking core model, Rate controlling resistances, Determination of the rate controlling steps, Application of models to design problems. Various contacting patterns and their performance equations. Introduction to heterogeneous fluid - fluid reactions, Rate equation for instantaneous, Fast and slow reaction, Equipment used in fluid- fluid contacting with reaction, Application of fluid -fluid reaction rate equation to equipment design, Towers for fast reaction, Towers for slow reactions. Introduction of fluid particle catalytic reactions, Rate equation, Film resistance controlling, surface flow controlling , Pure diffusion controlling, Heat effects during reaction, Various types of catalytic reactors : Fixed bed reactor- construction, operation and design, Isothermal operation, Adiabatic operation, Fluidized bed reactor, Slurry reactor, Trickle bed reactor. Experimental methods for finding rates, Product distribution in multiple reactions.

List of labs:
Minimum 6 experiments from the following list to be performed:

1. To calculate the mass-transfer coefficient (KSL) for physical and chemical dissolution and to calculate the enhancement factor for ‘solid-liquid’ systems
2. To calculate the mass-transfer coefficient for physical and chemical dissolution and to calculate the enhancement factor for ‘liquid-liquid’ systems
3. To study residence time distribution (RTD) in a CSTR and to find out peclet No.
4. To determine RTD of a packed bed reactor and to find out Peclet No.

5. To study residence time distribution (RTD) in a plug flow reactor
6. Finding τ optimum using polymaths for parallel Reactions
7. Finding conversion and rate of heterogeneous reactions.
8. Study reaction in heterogeneous and homogeneous manner
9. Study of a packed bed reactor it's performance
10. Study of a fluidized bed reactor and it's performance

Project areas:
Minimum 1 Projects from list to be completed:

1. Synthesizing a rate law, mechanism and rate limiting step for heterogeneous reactions.
2. Design of fluid- fluid reactors
3. Design of fluid- particle reactors
4. Catalyst preparation, adsorption isotherms
5. One parameter model
6. Evaluate different moments of Non ideality

Text Books:

1. Levenspiel, O., 'Chemical Reaction Engineering', 3rd. edition, John Wiley& Sons, 2001.
2. Fogler, H. S., 'Elementsof Chemical Reaction Engineering', 3rd Ed., PHI, 2002.

Reference Books:

1. Walas, S. M., 'Reaction Kinetics for Chemical Engineers', McGraw Hill, 1959.
2. Smith, J.M., 'Chemical Engineering Kinetics', 3rd ed., McGraw Hill, 1987.

Course Outcomes:

The student will be able to –

1. Distinguish between various RTD curves and predict the conversion from a non-ideal reactor using tracer information. **(5)**
2. Calculate the global rate of heterogeneous catalytic reactions. **(4)**
3. Determine the characteristics of solid catalyst like porosity, pore volume, etc. **(3)**
4. Select model for fluid-particle reactions and calculate the rate of reactions. **(4)**
5. Select model for fluid-fluid reactions and calculate the rate of reactions. **(4)**
6. Design the various types of rectors depending on the different types of heterogeneous Catalytic and non-catalytic reactions. **(5)**

CH4068: ANALYTICAL CHEMISTRY

Credits: 4 **Teaching Scheme: 03 (TH) + 02 (LAB) Hours / Week**

Section 1: **(20 Hr)**

Introduction to Analytical Chemistry, Conductometric titrations – General concept and basis of conductometric titrations, apparatus and measurement of conductivity, Applications of direct conductometric measurements.Standard and formal potentials, types of electrodes. Direct potentiometry and potentiometric titrations, Amperometry & Polarography - Theory, apparatus, qualitative and quantitative applications of polarography to organic and inorganic systems. Amperometric titrations – Theory, apparatus, types of titration curves, Electrogravimetry & Coulometry - Theory. coulometers coulometric titrations, Electrogravimetry – Theory of electrogravimetry

Section 2: **(20 Hr)**

Separation techniques - General aspects of separation techniques – Role of separation technique in analysis, Classification choice of separation method distribution processes Extraction – Distribution law and derivation, solvents and their choice, Solvent micro-extraction, GPC and UPLC, determination of molecular weights - weight average and number average, analytical and industrial applications. New development in chromatography – Plasma chromatography, super critical fluid chromatography, Ultra Performance Liquid Chromatography – Theory and Practice, Lab-on-a-chip – introduction, merits, limitations, applications vis-à-vis conventional techniques, Chemical microscopy –Electron microscopy – SEM, TEM, AFM - Principle, sample preparation,Reading & interpreting micrograph, Metallurgical microscopic examination, specimen preparation and examination, interpretation of micrographs, other analytical techniques for metallurgical examination

List of Practicals:
Minimum 6 experiments from the following list to be performed:

1. **1.** Preparation of samples for various analytical techniques
2. Study of outcomes of various analytical techniques
3. determination of cell constant, and testing various samples for its conductance
4. Conductometric titration of mixture of acids v/s alkali
5. Chromatographic separation of mixtures using classical techniques (TLC/Column)
6. Chromatographic separation of mixtures using non-classical techniques (HPLC)
7. Chromatographic separation of mixtures using non-classical techniques (GC)
8. Spectrophotometric determination of compounds from given samples
9. Simultaneous determination of two components

10. Extraction of analytes from given samples using sonication
11. Study of ultrasound assisted synthesis
12. Study of kinetics of organic & inorganic compound degradation using ultrasound
13. Conducting potentiometric titrations
14. Designing analytical tools
15. Interpretation of statistical data generated in various analytical techniques.

List of Project areas:
Minimum 1 Projects from list to be completed:

1. Conductometry
2. Spectrophotometry
3. Analytical method development
4. Material synthesis & characterization
5. Study of outcomes of analytical instruments
6. Classical methods of analysis

Text Books:

1. Willard, Merit Dean and Settle; Instrumental Methods of Analysis; IV, CBS Publishers and Distributors, 1986.
2. Kealey, Blackie; Experiments in Modern Analytical Chemistry; Chapman & Hall, 1986.

Reference Books:

1. J.G. Dick; Analytical Chemistry; McGraw Hill Publishers, 1974.
2. D.A. Skoog; Principles of Instrumental Analysis; Saunders College Pub. Co, III Edn, 1985.

Course Outcomes:
The student will be able to –

1. Identify the technique to be employed for the characterization of a given sample. **(3)**
2. Develop suitable extraction technique for sample preparation. **(4)**
3. Calculate unknown concentration of the target analyte selectively in a given sample. **(4)**
4. Test the samples for the qualitative and quantitative analysis of the analytes. **(4)**
5. Develop methods for the separation and quantification of samples using chromatography. **(4)**
6. Develop analytical ability to solve problems in the analytical world. **(4)**

CH4093: MAJOR PROJECT 1

Credits: 4 **Teaching Scheme: 0 (TH) + 08 (LAB) Hours / Week**

Contents:
This is the final stage in the project work. This stage will include comprehensive report on the work carried out at this stage and relevant portions from stage I and stage II, including experimental studies, analysis and/or verification of theoretical model, conclusions etc.
Students may undertake studies in application chemical engineering knowledge for manufacturing project, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of this work. The group of students is required to choose the topic in consultation with the Guide.
A technical report is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation.

Text Books:

1. B.A. Bhanvase, "Project Writing Manual" Chemical Engineering Department, VIT, Pune

Reference Books: Nil

Course Outcomes:

The student will be able to –

1. Apply Chemical Engineering knowledge. **(4)**
2. Learn How to Work in Team. **(3)**
3. Carry out research and development work. **(5)**
4. Design equipments or process for chemical engineering plants. **(5)**
5. Apply oral and graphical communication in both technical and non-technical environments. **(3)**
6. Apply written communication in both technical and non-technical environments. **(4)**

CH4094: MAJOR PROJECT 2

Credits: 4 **Teaching Scheme: 0 (TH) + 08 (LAB) Hours / Week**

Contents:

This stage will include comprehensive report on literature survey, design and fabrication of experimental set up and/or development of model, relevant computer programs.

Students may undertake studies in application chemical engineering knowledge for manufacturing project, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. The group of students is required to choose the topic in consultation with the Guide.

A technical report is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation.

Text Books:

1. B.A. Bhanvase, “Project Writing Manual” Chemical Engineering Department, VIT, Pune

Reference Books: Nil

Course Outcomes:

The student will be able to –

1. Apply Chemical Engineering knowledge. **(4)**
2. Learn How to Work in Team. **(3)**
3. Define a task (problem) and execute it. **(3)**
4. Carry out research and development work. **(5)**
5. Design equipments or process for chemical engineering plants. **(5)**
6. Document findings or design in selected topic. **(4)**

CH4096: INDUSTRY INTERNSHIP

Credits: 16

Guidelines:

1. Students opting for Internship module should not have any LIVE backlog.
2. HOD to constitute a committee of four senior faculty members for Internship allocation.
3. Students need to maintain minimum attendance of 75% at the place of work and produce digital record duly signed by competent authority.
4. Total Internship period is minimum16 weeks or 4 months.
5. Internship undertaken is to be Industrial Internship.
6. Students need to submit monthly reports to Company and Institute.
7. Final presentation (CVV) would be conducted at the end of semester.
8. Distribution of credits and other guidelines are subject to change.

Course Outcomes:

The student will be able to –

1. Apply Chemical Engineering knowledge. **(4)**
2. Design equipments or process for chemical engineering plants or apply knowledge in core and multidisciplinary field though research and development. **(5)**
3. Work effectively as member or leader in team. **(3)**
4. Organize, comprehend and write technical report. **(4)**
5. Follow ethics and professional standards of organization/industry. **(3)**

CH4095: RESEARCH INTERNSHIP

Credits: 16

Guidelines:

1. Students opting for Internship module should not have any LIVE backlog.
2. HOD to constitute a committee of four senior faculty members for Internship allocation.
3. Students need to maintain minimum attendance of 75% at the place of work and produce digital record duly signed by competent authority.
4. Total Internship period is minimum 16 weeks or 4 months.
5. Internship undertaken is to be Research Internship.
6. Students need to submit monthly reports on Research Project.
7. Final presentation (CVV) would be conducted at the end of semester.
8. Distribution of credits and other guidelines are subject to change.

Course Outcomes:

The student will be able to –

1. Apply Chemical Engineering knowledge. **(4)**
2. Design equipments or process for chemical engineering plants or apply knowledge in core and multidisciplinary field though research and development. **(5)**
3. Work effectively as member or leader in team. **(3)**
4. Organize, comprehend and write technical report. **(4)**
5. Follow ethics and professional standards of organization/industry. **(3)**

CH4070: GLOBAL INTERNSHIP

Credits: 16

Guidelines:

1. Students opting for Internship module should not have any LIVE backlog.
2. HOD to constitute a committee of four senior faculty members for Internship allocation.
3. Students need to maintain minimum attendance of 75% at the place of work and produce digital record duly signed by competent authority.
4. Total Internship period is approximately 16 weeks or 4 months.
5. Internship undertaken to be taken outside India as Industrial Internship or Research Internship.
6. Students need to submit monthly reports on Industry Project/Research Project.
7. Final presentation (CVV) would be conducted at the end of semester.
8. Distribution of credits and other guidelines are subject to change.

Course Outcomes:

The student will be able to –

1. Apply Chemical Engineering knowledge. **(4)**
2. Design equipments or process for chemical engineering plants or apply knowledge in core and multidisciplinary field though research and development. **(5)**
3. Work effectively as member or leader in team. **(3)**
4. Organize, comprehend and write technical report. **(4)**
5. Follow ethics and professional standards of organization/industry. **(3)**