Bharati Vidyapeeth

(Deemed to be University)

Pune, India

College of Engineering, Pune

B. Tech. Chemical Curriculum

(2023 Course)

Bharati Vidyapeeth (Deemed to be University)

College of Engineering, Pune

Faculty of Engineering and Technology

Department of Chemical Engineering

B. Tech. (Chemical) (2023 Course) (Semester V-VI)

Curriculum Structure and Syllabi

BHARATI VIDYAPEETH (DEEMED TO BE UNIVERSITY)

COLLEGE OF ENGINEERING, PUNE

B. Tech. (Chemical): Semester –V (2023 COURSE)

Sr. No.	Category	Course Code	Course	Teaching Scheme			Examination Scheme (Marks)						Credits			
				L	P	T	ESE	IA	TW	PR	OR	Total	L	P	T	Total
1			Numerical Methods for Chemical Engineering	2	-	1	60	40	-	-	-	100	2	-	1	3
2			Design of Multiphase Reactor	4	-	-	60	40	-	-	-	100	4	-	-	4
3			Separation Techniques	4	2	-	60	40	25	25	-	150	4	1	-	5
4			Chemical Process Control and Automation	3	2	-	60	40	25	25	-	150	3	1	-	4
5			Industrial Pollution and Abatement	3	-	-	60	40	-	-	-	100	3	-	-	3
6			Skill Based Course –V: Piping Design	-	2	-	-	-	25	-	25	50	-	1	-	1
7			Environmental studies	4	-	-	60	40	-	-	-	100	4			4
Total				**20**	**6**	**1**	**360**	**240**	**75**	**50**	**25**	**750**	**20**	**3**	**1**	**24**

BHARATI VIDYAPEETH (DEEMED TO BE UNIVERSITY)

COLLEGE OF ENGINEERING, PUNE

B. Tech. (Chemical): Semester –VI (2023 COURSE)

Sr. No	Category	Course Code	Course	Teaching Scheme			Examination Scheme (Marks)						Credits			
				L	P	T	ESE	IA	TW	PR	OR	Total	L	P	T	Total
1			Plant Utility and Process Safety	2	-	1	60	40	-	-	-	100	2	-	1	3
2			Process Development and Engineering	3	-	-	60	40	-	-	-	100	3	-	-	3
3			Biochemical Engineering	3	2	-	60	40	25	-	25	150	3	1	-	4
4			Chemical Process Equipment Design and Drawing	3	2	-	60	40	25	-	25	150	3	1	-	4
5			Chemical Process Modelling and Simulation	3	2	-	60	40	25	25	-	150	3	1	-	4
6			Professional Skills	-	2	-	-	-	25	-	25	50		1	-	1
7			Skill Based Course – VI: Chemical Process Simulation	-	2	-	-	-	25	-	25	50	-	1	-	1
Total				**14**	**10**	**1**	**300**	**200**	**125**	**25**	**100**	**750**	**14**	**5**	**1**	**20**
8			VAC-II	-	2	-	-	40	-	-	-	-	-	2	-	2
9			MOOC -II	-	-	-	-	-	-	-	-	-	-	-	-	2

NUMERICAL METHODS FOR CHEMICAL ENGINEERING

Designation: Professional Core

Course Pre-requisites: Basic knowledge of mathematics including derivative, integration etc.

Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lecture	: 02 Hours/Week	End Semester Examination	: 60 Marks	Lecture	: 02
Tutorial	: 01 Hours/Week	Internal Assessment	: 40 Marks	Tutorial	: 01
Total	: 03 Hours/Week	Total	: 100 Marks	Total	: 03

Course Outcomes

After completion of the course students will be able to

1.	Estimate the true percent relative error for given problem.
2.	Compute the roots of the equation using bracketing methods and open methods.
3.	Solve Chemical Engineering problems using regression analysis.
4.	Solve Chemical Engineering problems using numerical differentiation methods.
5.	Evaluate the integral value using Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpson's $3/8^{th}$ rule, and Romberg integration.
6.	Apply finite difference methods to solve boundary value problems.

Topics Covered

Unit I	**Approximations and Error Analysis** Approximations, Significant figures, Accuracy and precision; Error definitions, Round off error, Truncation error, True percent relative error, Pre-specified percent tolerance, Total numerical error, Error propagation, Error analysis of numerical differentiation, Root mean square error, Mean square error, Analysis of variance.	**(06 Hours)**
Unit II	**Engineering Applications: Roots of equations** Bracketing methods: Bisection method, False position method; Open methods: Secant method, Newton-Rapson method, Modified Newton-Rapson method; Roots of Polynomials: Mueller's method, Bairstow's method, Picard's method; Solve Chemical Engineering problems using above methods.	**(06 Hours)**
Unit III	**Regression analysis** Regression analysis: Linear regression, Least square regression, Logistic regression, Polynomial regression, Nonlinear Regression, Curve fitting, Regression Vs Classification. Solve Chemical Engineering problems using above methods.	**(06 Hours)**
Unit IV	**Interpolation** Interpolation: Direct Method, Lagrange interpolating polynomials, Newton's Divided-Difference interpolating polynomials, Sterling's interpolation, Inverse interpolation, Approximation of functions.	**(06 Hours)**

	Solve Chemical Engineering problems using above methods.	
Unit V	**Engineering Applications: Differential Equations** Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods: Euler's method, Modified Euler's method, 2nd order Runge-Kutta Method, 4th order Runge-Kutta method; Picard's method of successive approximations; Taylor series method; Milne's predictor-corrector method; Richardson Extrapolation; Ordinary Differential Equation: Boundary Value Problems.	**(06 Hours)**
Unit VI	**Numerical Integration** Solve Chemical Engineering problems using Newton- Cotes integration, Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule, Romberg integration; Cauchy integral formula; Multiple application of Simpson's 1/3rd, 3/8th rule, Trapezoidal rule. Solve Chemical Engineering problems using above methods.	**(06 Hours)**

Project Based Learning Individual student/Students in a group of 3 to 4 shall complete any one project from the below list	
1	Estimate the error and do the error analysis for any chemical Engineering based problem.
2	Find the roots of equations for the problems based on Fluid Mechanics, Heat Transfer.
3	Solve the equations from Heat Transfer, Fluid Mechanics, and Particulate Technology using numerical differentiation methods.
4	Estimate the integral value for the problems based on Heat Transfer, Fluid Mechanics, Chemical Engineering Thermodynamics, and Particulate Technology etc.
5	Solve Chemical Engineering problems using regression analysis.
6	Solve Chemical Engineering problems using interpolation.
7	Solve old (last five years) question papers with reference to particular topic.
8	Solve old (last five years) GATE paper questions of Numerical Methods for Chemical Engineering subject.
9	With suitable case study explain in detail how this subject is prerequisite for Process Modeling of chemical processes.
10	With the help of this subject knowledge, write a guideline report on how you would apply your concepts for industrial practice.

Text Books/ References	
1	S. C. Chapra and R.P. Canale, Numerical Methods for Engineers, 6th Ed., Tata-McGraw Hill Publications, 2015.
2	T. F. Edgar and D. M. Himmblblau, Optimization of Chemical Processes, 2nd Ed., Tata-McGraw Hill Publications, 2001.
3	M. K. Jain, S. R .K. Iyengar and R. K. Jain, Numerical methods for Scientific and Engineering Computational, 5th Ed., New Age International (P) Publishers, 2005.
4	S. S. Sastri , Introductory methods of Numerical analysis, 4th Ed., Prentice-Hall India, 2009.
5	S. Pushpavanam, Mathematical Methods for Chemical Engineering, 1st Ed., Prentice-Hall of

	India, 2012.
	E. Balagurusamy, Numerical Methods, McGraw Hill Education (India) Private Limited, 2008.
Syllabus for Unit Test	
Unit Test I	Unit – I, II, III
Unit Test II	Unit – IV, V, VI

DESIGN OF MULTIPHASE REACTORS

Designation: Professional Core

Pre-requisite Courses: Material and Energy Balance Calculations, Thermodynamics, Fluid Mechanics, Heat Transfer, Mass transfer, Chemical Reaction Engineering

Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 04 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Total : 04 Hours/Week	Internal Assessment : 40 Marks	Total Credits : 04
	Total : 100 Marks	

Course Outcomes

1	Classify multiphase reactors based on type of energy input
2	Estimate equilibrium composition of multiphase reactors for a given process condition
3	Estimate reaction rate controlling step and determine overall rate of reaction for multiphase systems.
4	Determine hydrodynamic characteristics of multiphase reactor.
5	Estimate heat and mass transfer coefficient for multiphase reactor.
6	Design and scale up a given multiphase system.

Topics Covered

UNIT-I	**Introduction** Classification of heterogeneous reaction; Qualitative description; Examples of industrial importance	**(06 Hours)**
UNIT-II	**Thermodynamics of Heterogeneous Reactions** Criteria of chemical reaction equilibrium; Standard Gibbs free energy change and equilibrium constant; Estimation of equilibrium constant; Effect of temperature and pressure on equilibrium constant; Equilibrium conversions for single and multi-reaction systems.	**(08 Hours)**
UNIT-III	**Kinetics of Heterogeneous Reactions** Mechanisms of heterogeneous reactions; Determination of rate controlling step; Estimation of overall rate of reaction; Factors affecting the rate of reaction; Heterogeneous catalysis: selection of catalyst, external and internal diffusion effects, catalyst deactivation.	**(08 Hours)**
UNIT-IV	**Hydrodynamics and Mixing** Hydrodynamic characteristics of different multiphase reactors: Mechanically Agitated Contactors (MAC), Bubble Columns, Slurry Reactors, Fluidized Beds, Loop Reactors and Modified Versions. Experimental methods to measure phase mixing; Effect of geometrical, system, and operating parameters on phase mixing in multiphase reactors; Quantification of phase mixing; Development of a mathematical model	**(08 Hours)**
UNIT-V	**Heat and mass transfer** Experimental methods to measureheat transfer coefficient; Effect of	**(08 Hours)**

	geometrical, system, and operating parameters on heat transfer coefficient in multiphase reactors; Quantification of heat transfer coefficient; Application of correlations available to different multiphase reactors. Experimental techniques used for estimation of mass transfer coefficient and selection of suitable technique for a multiphase reactor; Effect of geometrical, system, and operating parameters on mass transfer coefficient in multiphase reactors; Quantification of mass transfer coefficient; Application of correlations available to different multiphase reactors.	
UNIT-VI	**Design and scale up of multiphase reactors** Generalized methodology of design and scale up of multiphase reactors; Examples of industrial importance.	**(08 Hours)**

Project Based Learning	
1	Elaborate any one heterogeneous system of industrial importance
2	Visit to any one chemical process industry and present a report on any one multiphase reaction system.
3	Study recent advances in measurement of phase hold-up methodologies.
4	Study recent advances in phase flow measurement techniques in multiphase systems.
5	Study any one recent review article on hydrodynamic aspects of any one multiphase system in group and make a report.
6	Prepare power point presentation on recent advances hydrodynamic/mixing characteristics of any one multiphase system.
7	Prepare power point presentation on heat/mass transfer measurement methodologies for any one multiphase system.
8	Enlist the steps to standardize any one multiphase reactor.
9	Group discussion on design and scale up aspects of multiphase reactors.
10	Present techno-economic analysis of any one multiphase reactor.

Text Books/References	
1	V. G. Pangarkar, "Design of multiphase reactors", 1st Edition, Wiley, 2015
2	L. K. Doraiswamy and M. M. Sharma, "Heterogeneous Reactions", 2nd Edition, Volume I and II.
3	G. B. Tatterson, "Fluid Mixing and Gas Dispersion in Stirred Reactors", 10th Edition, Academic Press, London, 1994
4	W. D. Deckwer, "Bubble Column Reactors", Cambridge University Press, New York, 2000.
5	Diazo Kunji and O. Levenspiel, "Fluidization Engineering", 2nd Edition, Butterworth Heinemann, 1991
6	J. F. Devidson and Harrison, " Fluidization", 10th Edition, Academic Press, London, 1994.
7	J. M. Smith, H. C. Van Ness and M. M. Abbott, "Introduction to Chemical Engineering Thermodynamics", 5th Edition, McGraw Hill International, Singapore, 1996.

Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

SEPARATION TECHNIQUES					
Designation: Professional Core					
Course Pre-requisites:					
Students should have basic knowledge of					
1	Fundamentalsof mass transfer				
2	Fundamentals of heat transfer				
TEACHING SCHEME:		**EXAMINATION SCHEME:**		**CREDITS ALLOTTED:**	
Lectures	: 04 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 04
Practical	: 02 Hours/Week	Internal Assessment	: 40 Marks	Practical	: 01
Total	: 06 Hours/Week	TW	: 25 Marks	Total Credits	: 04
		Practical/Oral	: 25 Marks		
		Total	: 150 Marks		
Course Outcomes:					
After completion of the course students would be able to					
1.	Apply the basics of distillation for the binary separation of mixtures and determine the extent of separation obtained.				
2.	Determine the number of stages required for the separation of binary mixtures using distillation.				
3.	Estimate the percentage of adsorption and dosage of adsorbent forsingle and multistage operations.				
4.	Determine the percentage of extraction and number of stages required for separation using liquid-liquid extraction.				
5.	Obtain the percentage of leaching and amount of solvent required in leaching operation.				
6.	Describe the operation and applications of novel separation techniques				
Topics covered					
UNIT-I	**Introduction:** Review of various separation techniques, Selection of the technique of separation, pros and cons of various methods. **Basics of Distillation:** Equilibrium of vapor and liquid, relative volatility, Raoult's law, Ideal and Non-ideal behavior study, Azeotropes, positive and negative deviation from ideality, Methods of distillation - simple, flash distillation, Rayleigh's equation, Graphical and analytical method for determination of the compositions, Introduction to reactive distillation, Azeotropic distillation, Molecular or low pressure distillation, Extractive distillation.			**(08 Hours)**	
UNIT-II	**Rectification:** Continuous rectification for binary systems, Tray towers, McCabe Thiele's method of calculation of number of trays, Method of PonchonSavarit, Enthalpy concentration diagrams, Tray efficiencies, Concept of reflux, cold reflux, partial and total cold reflux, Effect of feed temperature and q-line equation derivation, Total reflux, Optimum reflux, Fenske Underwood equation, Condenser and reboilers used in distillation, Use of open steam for distillation, Rectification of Azeotropic mixtures.			**(08 Hours)**	

	Distillation in packed towers: HETP concept, HTU and NTU calculations, Distillation column internals: Type of trays, Type of packing used.	
UNIT-III	**Adsorption:** Types of adsorption, Nature of adsorbents, Equilibria in adsorption- Single gases and vapors, adsorption hysteresis, Effect of temperature, Heat of adsorption, adsorption of liquids, Langmuir isotherms, Freundlich isotherms, Introduction to pressure swing and temperature swing adsorption, Equipment: Continuous contact, Steady state moving bed absorbers. **Ion exchange process**: Basic principles and chemical reactions, Techniques and applications, Equilibria and rate of ion exchange, Equipment studies.	**(08 Hours)**
UNIT-IV	**Liquid- Liquid Extraction:** Introduction, Choice of solvent, Ternary equilibrium, Binodal solubility curve, Single stage extraction, Multistage crosscurrent andcountercurrentextraction, extraction calculations using triangular and rectangular coordinates, Solvent free basis calculations, Nxy diagrams, Material balances, Continuous countercurrent extraction with reflux, stage efficiency. Continuous countercurrent extraction in packed columns: HTU and NTU calculations. Types of extractors: Stage type and differential extractors.	**(08 Hours)**
UNIT-V	**Leaching (Solid Liquid Extraction):** Introduction:Classification of leaching processes, Factors affecting the leaching process, Solid –liquid equilibria. Methods of calculation: Single stage leaching, multistage cross-current leaching, Continuous countercurrent leaching. Leaching Equipments: Unsteady state and steady state equipment.	**(08 Hours)**
UNIT-VI	**Novel separation techniques:** Membrane separation techniques- Ultrafiltration, Nano-filtration, Reverse osmosis process,Electro dialysis, Rate based processes such as diffusion coefficient based inert gas generating from air by carbon molecular sieves.	**(08 Hours)**

Assignments	
1.	Group discussion on the recent advances in mass transfer operations.
2.	Solve previous university question papers with reference to particular topic of this subject.
3.	Seminar presentation on a particular topic specified in the syllabus and submission of report based on it.
4.	Estimation of composition of vapor and liquid in flash distillation
5.	Compute the composition of residue and distillate in simple distillation.
6.	Evaluation of number of stages using McCabe Thiele andPonchonSavarit method.
7.	HTU and NTU calculation for distillation in packed columns.
8.	Group discussion on equipments used for extraction.
9.	Estimate the number of stages required for single and multistage extraction operation.
10.	Estimate the number of stages required for single and multistage leaching operation.
11.	Group discussion on ion exchange technique and its application.

12.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
13.	Presentation on novel separation techniques.
14.	Solve old GATE question papers with reference to this subject.
15.	Group discussion on the recent advances in separation techniques.
16.	Write a report on your visit to research and development laboratory of national/international repute.
17.	Technical interview based on the knowledge of separation techniques.

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Term Work:

Term work will consist of the experiments listed below, out of which any eight experiments are to be performed in laboratory by the students.

1.	Simple distillation
2.	Distillation with total reflux
3.	Steam distillation
4	Equilibrium diagrams for liquid -liquid extraction
5.	Cross current multistage extraction
6.	York Schiebel column for extraction
7.	Bubble cap distillation column
8.	Sieve tray distillation column
9.	Vapour liquid equilibria
10.	Solid liquid extraction of oil
11.	Langmuir and Freundlich adsorption isotherm

Text Books/References:

1.	Treybal R. E., “Mass Transfer Operation”,McGraw Hill publication.
2.	Coulson J. M. Richardson, “Chemical engineering", Vol, I and II, Pergamon Press.
3.	King C. J., “Separation Techniques”, McGraw Hill publication.
4.	Smith B. D., “Design of Equilibrium stage process”, McGraw Hill publication.

Syllabus for Unit Test:

Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

CHEMICAL PROCESS CONTROL AND AUTOMATION					
Designation: Professional Core					
Course Pre-requisites:					
Students should have					
1.	Basic knowledge of Mathematics.				
2.	Chemical Process Instrumentation				
TEACHING SCHEME:		**EXAMINATION SCHEME:**		**CREDITS ALLOTTED:**	
Lectures	: 03 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 03
Practical	: 02 Hours/Week	Internal Assessment	: 40 Marks	Practical	: 01
Total	: 05 Hours/Week	TW	: 25 Marks	Total Credits	: 04
		Practical/Oral	: 25 Marks		
		Total	: 150 Marks		
Course Outcomes:					
After completion of the course students will be able to					
1.	Apply basic control action and develop mathematical models for a given physical system				
2.	Illustrate behavior of chemical processes and elucidate transient response of system.				
3.	Articulate stability of the system and analyze frequency response of process.				
4.	Apply tuning methods to tune the control system and analyze advanced control system.				
5.	Apply knowledge for identifying interaction between loops of MIMO system				
6.	Analyze digital control system.				
Topics covered					
UNIT-I	**Open Loop Response of Simple Systems:** Concentration and temperature responses of a stirred tank **Dynamic Behavior of Chemical Processes:** Linearization of liquid level systems; **S**econd order systems: Response of interacting and non interacting systems. Transfer functions and the input-output models. Dynamics and analysis of first, second and higher order systems.				**(06 Hours)**
UNIT-II	**Transient Response of Control Systems:** Servo and regulated operation, General equations for the transient response, proportional control of a signal capacity process; Integral control, Proportional-integral control and derivative action. **Stability:** Concept of stability, Stability criterion, Routh test for stability.				**(06 Hours)**
UNIT-III	**Root Locus Analysis:** Concept of root locus, Locus diagram. **Frequency Response Analysis:** First order systems, Bode diagram, and Complex numbers to get frequency				**(06 Hours)**

	response.	
UNIT-IV	Controller Tuning: Tuning rules: Ziegler Nichols method, Cohen coon method etc.Nyquist plot. Controller selection and tuning, Control valve characteristics and sizing, **Advanced Control Schemes:** cascade control, Feed forward and ratio control, inferential control and adaptive control.	**(06 Hours)**
UNIT-V	**MIMO control system** Transfer function, input output pairing, interactions, transient response and stability, RGA and loop pairing and decoupling	**(06 Hours)**
UNIT-VI	**Digital control system;** Digital approximation of classical controls. Computer process control and block diagram, computer control loops Introduction to DDC, DCS, PLC and SCADA Systems.	**(06 Hours)**

List of Experiments:

Term work will consist of the experiments listed below, of which at least eight should be performed in laboratory by the students.

1.	To study the closed loop flow controller
2.	To study the closed loop level controller
3.	To study the ratio controller
4.	To study the cascade controller
5.	Root locus analysis on software (Ex. MATLAB)
6.	To study the closed loop pressure control for P control action and calculate offset.
7.	To study the closed loop pressure control for PI action PID action.
8.	To study optimizing performance for pressure control trainer by using tuning technique with help of PID action.
9.	To study closed loop system for servo problem having PI action consideration.
10.	Bode plot on software (Ex. MATLAB)
11.	Nyquist plot on software (Ex. MATLAB)
12.	PID control loop simulation for a first order process (Ex. SIMULINK)

Project based learnings:

1.	Students have to visit chemical industry and prepare a detailed report on various controllers used in industry.
2.	Watch NPTEL video and make report on various topics in process dynamics and control
3.	Group discussions on controllers used for chemical processes.
4.	To find Transfer Function for 1st order and 2nd order process.
5.	Draw the Control Loop and Block Diagram for different chemical processes.
6.	Solve numerical questions in last three year question papers.
7.	Give details on Advance Controllers.
8.	Give details on Digital Controllers.
9.	Elucidate IMC Controller in Detail.

10.	Explicate MPC Controller in Detail.
11.	Clarify process Identification of any Chemical Process in detail
12.	Enlighten Optimal control of any one Chemical Process.
Text Books/References:	
1	G. Stephanopoulos, *Chemical Process Control: An introduction to theory and practice,* Prentice Hall, New Jersey, 1984.
2	P. Harriott, *Process Control, Reprint of text,*ed. Tata McGraw Hill, 1983.
3	D. R. Coughanowr, *Process system analysis and control,* 2nded, McGraw Hill, 1991.
4	Seborg, D.E., Edgar, T.F. and Mellichamp, "Process dynamics and control," Wiley, New York, D.A. 2003.
Syllabus for Unit Test:	
Unit Test -I	UNIT – I , II, III
Unit Test -II	UNIT – IV, V, VI

INDUSTRIAL POLLUTION AND ABATEMENT

Designation: Professional Core

Course Pre-requisites: Basic fundamentals included in environmental sciences, Fundamentals of unit operation.

Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lecture	: 03 Hours/Week	End Semester Examination	: 60 Marks	Lecture	: 03
Total	: 03 Hours/Week	Internal Assessment	: 40 Marks	Total	: 03
		Total	: 100 Marks		

Course Outcomes

After completion of the course students will be able to

1.	Identify and demonstrate the characterization of wastewater with statutory limits for disposal.
2.	To analyze the important parameters of the wastewater such as BOD, COD, DO, etc.
3.	Demonstrate the various physical unit operations used in the treatment.
4.	Define the various treatment methods available for wastewater and solid waste.
5.	Demonstrate the effect of various air pollutants on man and environment.
6.	Exhibit the operations of various air pollution control equipments.

Topics Covered

Unit I	**Introduction** Overview of pollution aspects in Chemical Process Industries (CPI), Types of pollution, pollution control aspects. Environmental legislation, Pollution control acts, Sources of pollution, Characteristics of industrial waste water, Indian standards for disposal of industrial effluents.	**(06 Hours)**
Unit II	**Air Pollution** Sources, Effects and Measurement Sources Classification of air pollutants. Effects of air pollutants on human health, plants, animals, materials, measurement of air pollutants, particulate pollution: cleaning methods, collection efficiency, and particulate collection systems.	**(06 Hours)**
Unit III	**Water Pollution** Domestic and industrial wastewater: types, sources and effects of water pollutants; Waste water sampling and analysis:Measurement of physical characteristics, Measurement of D.O., B.O.D., C.O.D., Th.OD, Toxicity, Colour, estimation of inorganic substances.	**(06 Hours)**
Unit IV	**Waste Water Treatment** Physical Unit Operations :Screening Grit removal, flow equalization, Mixing & Flocculation, Sedimentation, Floatation, Types of Aeration, removal of VOCS; 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.	**(06 Hours)**

	Tertiary treatment methods	
Unit V	**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.	**(06 Hours)**
Unit VI	**Industrial case studies** Concept of zero discharge system; Application of advanced treatment methods for water reclamation and reuse; study of minimum two case studies for treatment of industrial waste: pesticide industry, textile industry, pharmaceutical industry etc.	**(06 Hours)**

Project Based Learning	
1	Prepare a report on STTP used in city
2	Prepare a list of different pollutants and their permissible limits
3	Analyze wastewater content from different sources
4	Prepare a report on solid waste management from your city
5	Find out how much air pollution is created by your vehicle
6	Design a simple filter for the water treatment

Text Books/ References	
1.	L. Theodore, A. J. Bhomlore: Air Pollution Control Equipments, Springer-Verlag Berlin and Heidelbarg GmbH 2011
2.	J.M. Coulson, J. F. Richerdson: Chemical Engineering Design, Vol.6, *Elsevier Butterworth-Heinemann*,2005
3.	M.N.Rao, H.V.N. Rao: Air Pollution, McGraw-Hill, 2004
4.	S.P. Mahajan: Pollution Controls in process industries, Tata McGraw-Hill.
5.	C.S.Rao: Environmental Pollution control Engineering, New Age International (P) Ltd, 2006
6.	N. Nevers: Air Pollution control Engineering, Mc Graw-Hill Education

Syllabus for Unit Test	
Unit Test I	Unit – I, II, III
Unit Test II	Unit – IV, V, VI

SKILL BASED COURSE –V: PIPING DESIGN					
Designation: Professional Core					
Pre-requisite Courses: Chemical engineering core courses					
Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Practical	: 02 Hours/week	Term Work	: 25 Marks	Practical	: 01
Total	: 02 Hours/Week	Oral/Practical	: 25 Marks	Total Credits	: 01
		Total	: 50 Marks		

Course Outcomes	
1	Define the material for piping in given process
2	Select the type of fitting and define valves for given process
3	Design piping for heat treatment systems
4	Establish the PFD and arrange the piping accordingly
5	Define the P&ID and select the controls for given process
6	Select the proper code for design of piping requirement for given process

Topics Covered		
UNIT-I	**Introduction to piping design & engineering** Need for piping and its design requirements, Piping materials and selection, Pipe dimensioning, Schedule numbers, Common piping abbreviations, Common abbreviations etc.	**(04 Hours)**
UNIT-II	**Basic Piping components required** Type of Fittings - elbows, weld tee, stub in, couplings, reducers, weld cap, screwed and socket welded fittings, Pipe nipples, flanged fittings and use of fittings Type Flange -Types, P-T ratings and facings, Gaskets, bolts and nuts. Major Valves - Types, Materials operations, applicability, codes and specifications.	**(04 Hours)**
UNIT-III	**Piping Equipment** Horizontal vessels/accumulators, fractionation columns, pumps, heat exchangers, re-boiler, air cooled heat exchanger, heaters/boilers, storage tanks, fractional distillation process	**(04 Hours)**
UNIT-IV	**Piping Engineering flow diagram and its concept** Uses of flow diagrams, process flow diagrams, mechanical flow diagrams, utility flow diagrams, piping symbols, line symbols, valve symbolspiping isometrics, general arrangement drawings- sections/elevations/ detail drawings	**(04 Hours)**
UNIT-V	**P&IDs** Purpose of P&ID'S, study of P&ID'S, stages of development of P&ID'S, process and instrumentation diagrams, process equipment's,symbols usage	**(04 Hours)**

	according to industrial practices, Purpose of P&ID in process industrial/plants**.**	
UNIT-VI	**Basic knowledge of applicable standards** ASME/ANSI Codes & Specification, Specification classes, Piping abbreviations, General abbreviations	**(04 Hours)**

Term work: Following are few practicals to be performed as a part of termwork. These are just for guidelines concerned faculty or course coordinator can design own term work	
1.	Case study on piping material selection based upon process condition and fluids involved
2.	Prepare a study report on schedule number, its application in piping design and piping abbreviations.
3.	Define selection of fitting based upon process requirements and conditions
4.	Define selectionof valves based upon process requirements
5.	Design piping requirements for heat exchange equipments
6.	Design the piping requirement for reboiler and other equipments involving phase change
7.	Define about the concept of flow diagram and its importance in piping design factors involved in designing flow diagram
8.	Prepare the general arrangement drawing for given plant case study
9.	Prepare report on formation of P&ID for given plant case study
10.	Prepare the P&ID for given plant case study and define its components and importance
11.	Prepare the report on ASME codes their classes and usability along with standard mentioned
12.	Prepare the report on ANSI codes their classes and usability along with standard mentioned
13.	Piping and its structural design would be defined considering suitable case study
14.	Industrial visit to study actual life piping design and

Text Books/References

1	Rutger Botermans and Peter Smith,"Process Piping Design Handbook– Vol II: Advanced Piping Design", 2008, Gulf publishing Company, Houston, Texas
2	Peter Smith,"Process Piping Design Handbook– Vol I: The Fundamentals of Piping DesignDrafting and Design Methodsfor Process Applications", 2007, Gulf publishing Company, Houston, Texas
3	Alireza Bahadori, "Oil and Gas Pipelinesand Piping SystemsDesign, Construction, Management, and Inspection", 2017, Gulf publishing Company, Elsevier Inc.
4	J. Phillip Ellenberger, "Piping and PipelineCalculationsManualConstruction, Design Fabrication and Examination", 2nd Edition, 2014, Butterworth-Heinemann, Elsevier Inc.
5	Geoff Barker, "The Engineers Guide for Plant Layout and Piping Design for the Oil Gas Industries", 2018, Gulf publishing Company, Elsevier Inc.

ENVIRONMENTAL STUDIES					
Designation: Professional Core					
Pre-requisite Courses: Basic Science, Chemistry					
Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	: 04 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 04
Total	: 04 Hours/Week	Internal Assessment	: 40 Marks	Total Credits	: 04
		Total	: 100 Marks		
Course Outcomes					
1	a. Appreciate the historical context of human interactions with the environment. b. Gain insights into the international efforts to safeguard the Earth's environment and resources.				
2	a. Understand the concept of natural resources; identify types of natural resources, their distribution and use with special reference to India. b. Discuss the factors affecting the availability of natural resources, their conservation and management. c. Explain sustainable development, its goals, targets, challenges and global strategies for sustainable development.				
3	a. develop a critical understanding of the environmental issues of concern b. understand the concepts of spatial and temporal scales and their importance c. understand the sectoral effects on the local, regional, and global environmental issues				
4	a. Understand the concepts of ecosystems, biodiversity and conservation. b. Describe the main types of ecosystems and their distribution in India and the world. c. Discuss the factors impacting biodiversity loss and ecosystem degradation in India and the world. d. Explain major conservation strategies taken in India.				
5	a. Develop an understanding of pollution and its types. b. Learn about sources of different kinds of pollution. c. Sensitize themselves to adverse health impacts of pollution.				
6	a. gain a comprehensive knowledge of climate change, its science and response measures b. have an overview of national and global efforts to address climate change adaptation and mitigation.				
7	a. Develop a critical understanding of the complexity of environmental management. b. Understand broad aspects of environmental management systems. c. Understand different methods of assessing environmental quality and associated risks.				
8	a. Learn about how the nations of the world work together for the environment. b. Learn about the major international treaties and our country's stand on and responses to the major international agreements. c. Learn about major international institutions and programmes and the role played by them in the protection and preservation of the environment.				
9	Identify, observe environmental issues and provide solutions to them through case studies.				
Topics Covered					

UNIT-I	**Humans and the Environment** The man-environment interaction: Humans as hunter-gatherers; Mastery of fire; Origin of agriculture; Emergence of city-states; Great ancient civilizations and the environment, Indic Knowelege and Culture of sustainability; Middle Ages and Renaissance; Industrial revolution and its impact on the environment; Population growth and natural resource exploitation; Global environmental change. Environmental Ethics and emergence of environmentalism: Anthropocentric and eco-centric perspectives (Major thinkers); The Club of Rome- Limits to Growth; UN Conference on Human Environment 1972; World Commission on Environment and Development and the concept of sustainable development; Rio Summit and subsequent international efforts.	**(04 Hours)**
UNIT-II	**Natural Resources and Sustainable Development** Overview of natural resources: Definition of resource; Classification of natural resources- biotic and abiotic, renewable and non-renewable. Biotic resources: Major type of biotic resources- forests, grasslands, wetlands, wildlife and aquatic (fresh water and marine); Microbes as a resource; Status and challenges. Water resources: Types of water resources- fresh water and marine resources; Availability and use of water resources; Environmental impact of over-exploitation, issues and challenges; Water scarcity and stress; Conflicts over water. Soil and mineral resources: Important minerals; Mineral exploitation; Environmental problems due to extraction of minerals and use; Soil as a resource and its degradation. Energy resources: Sources of energy and their classification, renewable and non-renewable sources of energy; Conventional energy sources- coal, oil, natural gas, nuclear energy; Non-conventional energy sources- solar, wind, tidal, hydro, wave, ocean thermal, geothermal, biomass, hydrogen and fuel cells; Implications of energy use on the environment. Introduction to sustainable development: Sustainable Development Goals (SDGs)- targets and indicators, challenges and strategies for SDGs	**(06 Hours)**
UNIT-III	**Environmental Issues: Local, Regional and Global** Environmental issues and scales: Concepts of micro-, meso-, synoptic and planetary scales; Temporal and spatial extents of local, regional, and global phenomena. Pollution: Impact of sectoral processes on Environment; Types of Pollution- air, noise, water, soil, thermal, radioactive ;municipal solid waste, hazardous waste; trans-boundary air pollution; acid rain; smog. Land use and Land cover change: land degradation, deforestation, desertification, urbanization. Biodiversity loss: past and current trends, impact. Global change: Ozone layer depletion; Climate change.Disasters – Natural	**(06 Hours)**

	and Man-made (Anthropogenic)	
UNIT-IV	**Conservation of Biodiversity and Ecosystems** Biodiversity and its distribution: Biodiversity as a natural resource; Levels and types of biodiversity; Biodiversity in India and the world; Biodiversity hotspots; Species and ecosystem threat categories. Ecosystems and ecosystem services: Major ecosystem types in India and their basic characteristics forests, wetlands, grasslands, agriculture, coastal and marine; Ecosystem services- classification and their significance. Threats to biodiversity and ecosystems: Land use and land cover change; Commercial exploitation of species; Invasive species; Fire, disasters and climate change. Major conservation policies: in-situ and ex-situ conservation approaches; Major protected areas; National and International Instruments for biodiversity conservation; the role of traditional knowledge, community-based conservation; Gender and conservation.	**(06 Hours)**
UNIT-V	**Environmental Pollution and Health** Understanding pollution: Production processes and generation of wastes; Assimilative capacity of the environment; Definition of pollution; Point sources and non-point sources of pollution. Air pollution: Sources of air pollution; Primary and secondary pollutants; Criteria pollutants- carbon monoxide, lead, nitrogen oxides, ground-level ozone, particulate matter and sulphur dioxide; Other important air pollutants- Volatile Organic compounds (VOCs), Peroxyacetyl Nitrate (PAN), Polycyclic aromatic hydrocarbons (PAHs) and Persistent organic pollutants (POPs); Indoor air pollution; Adverse health impacts of air pollutants; National Ambient Air Quality Standards. Water pollution: Sources of water pollution; River, lake and marine pollution, groundwater pollution; water quality Water quality parameters and standards; adverse health impacts of water pollution on human and aquatic life. Soil pollution and solid waste: Soil pollutants and their sources; Solid and hazardous waste; Impact on human health. Noise pollution: Definition of noise; Unit of measurement of noise pollution; Sources of noise pollution; Noise standards; adverse impacts of noise on human health. Thermal and Radioactive pollution: Sources and impact on human health and ecosystems.	**(06 Hours)**
UNIT-VI	**Climate Change: Impacts, Adaptation and Mitigation** Understanding climate change: Natural variations in climate; Structure of atmosphere; Anthropogenic climate change from greenhouse gas emissions– past, present and future; Projections of global climate change with special reference to temperature, rainfall, climate variability and extreme events; Importance of 1.5 °C and 2.0 °C limits to global warming;	**(06 Hours)**

	Climate change projections for the Indian sub-continent. Impacts, vulnerability and adaptation to climate change: Observed impacts of climate change on ocean and land systems; Sea level rise, changes in marine and coastal ecosystems; Impacts on forests and natural ecosystems; Impacts on animal species, agriculture, health, urban infrastructure; the concept of vulnerability and its assessment; Adaptation vs. resilience; Climate-resilient development; Indigenous knowledge for adaptation to climate change. Mitigation of climate change: Synergies between adaptation and mitigation measures; Green House Gas (GHG) reduction vs. sink enhancement; Concept of carbon intensity, energy intensity and carbon neutrality; National and international policy instruments for mitigation, decarbonizing pathways and net zero targets for the future; Energy efficiency measures; Renewable energy sources; Carbon capture and storage, National climate action plan and *Intended Nationally Determined Contributions* (INDCs); Climate justice.	
UNIT-VII	**Environmental Management** Introduction to environmental laws and regulation: Constitutional provisions- Article 48A, Article 51A (g) and other derived environmental rights; Introduction to environmental legislations on the forest, wildlife and pollution control. Environmental management system: ISO 14001 Concept of Circular Economy, Life cycle analysis;Cost-benefit analysis Environmental audit and impact assessment; Environmental risk assessment Pollution control and management; Waste Management-Concept of 3R (Reduce, Recycle and Reuse) and sustainability; Ecolabeling /Ecomark scheme	**(06 Hours)**
UNIT-VIIII	**Environmental Treaties and Legislation** An overview of instruments of international cooperation; bilateral and multilateral agreements; conventions and protocols; adoption, signature, ratification and entry into force; binding and nonbinding measures; Conference of the Parties (COP) Major International Environmental Agreements: Convention on Biological Diversity (CBD); Cartagena Protocol on Biosafety; Nagoya Protocol on Access and Benefit-sharing; Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES); Ramsar Convention on Wetlands of International Importance; United Nations Convention to Combat Desertification (UNCCD); Vienna Convention for the Protection of the Ozone Layer; Montreal Protocol on Substances that Deplete the Ozone Layer and the Kigali Amendment; Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal; Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade; Stockholm Convention on Persistent Organic Pollutants; Minamata	**(06 Hours)**

	Convention on Mercury; United Nations Framework Convention on Climate Change (UNFCCC); Kyoto Protocol; Paris Agreement; India's status as a party to major conventions Major Indian Environmental Legislations: The Wild Life (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; The Forest (Conservation) Act, 1980; The Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; The Biological Diversity Act, 2002; The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006; Noise Pollution (Regulation and Control) Rules, 2000; Industry-specific environmental standards; Waste management rules; Ramsar sites; Biosphere reserves; Protected Areas; Ecologically Sensitive Areas; Coastal Regulation Zone; Status phase-out of production and consumption of Ozone Depleting Substances by India; National Green Tribunal; Some landmark Supreme Court judgements. Major International organisations and initiatives: United Nations Environment Programme (UNEP), International Union for Conservation of Nature (IUCN),World Commission on Environment and Development (WCED), United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Panel on Climate Change (IPCC), and Man and the Biosphere (MAB) programme.	
UNIT-IX	**Case Studies and Field Work** The students are expected to be engaged in some of the following or similar identified activities: • Discussion on one national and one international case study related to the environment and sustainable development. • Field visits to identify local/regional environmental issues, make observations including data collection and prepare a brief report. • Participation in plantation drive and nature camps. • Documentation of campus biodiversity. • Campus environmental management activities such as solid waste disposal, water Management and sanitation, and sewage treatment.	**(30 Hours)**

Text Books/References

1	Fisher, Michael H. (2018) An Environmental History of India- From Earliest Times to the Twenty-First Century, Cambridge University Press.
2	Chiras, D. D and Reganold, J. P. (2010). Natural Resource Conservation: Management for a Sustainable Future.10th edition, Upper Saddle River, N. J. Benjamin/Cummins/Pearson.
3	Harper, Charles L. (2017) Environment and Society, Human Perspectives on Environmental Issues 6th Edition. Routledge.
4	Bawa, K.S., Oomen, M.A. and Primack, R. (2011) Conservation Biology: A Primer for South Asia. Universities Press.
5	Jackson, A. R., & Jackson, J. M. (2000). Environmental Science: The Natural Environment and Human Impact. Pearson Education
6	Central Pollution Control Board Web page for various pollution standards.

	https://cpcb.nic.in/standards/
7	Pittock, Barrie (2009) Climate Change: The Science, Impacts and Solutions. 2nd Edition. Routledge.
8	Jørgensen, Sven Marques, Erik João Carlos and Nielsen, Søren Nors (2016) Integrated Environmental Management, A transdisciplinary Approach. CRC Press.
9	UNEP (2007) Multilateral Environmental Agreement Negotiator's Handbook, University of Joensuu, ISBN 978-952-458-992-5
10	Ministry of Environment, Forest and Climate Change (2019) A Handbook on International Environment Conventions & Programmes. https://moef.gov.in/wp-content/uploads/2020/02/convention-V-16-CURVE-web.pdf

Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

PLANT UTILITY AND PROCESS SAFETY					
Designation: Professional Core					
Pre-requisite Courses: Mechanical operations, Fluid dynamics, Heat transfer, Mass Transfer, Reaction Engineering					
Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	: 02 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 02
Tutorial	: 01 Hour /Week	Internal Assessment	: 40 Marks	Tutorial	: 01
Total	: 04 Hours/Week	Total	: 100Marks	Total credits	: 03

Course Outcomes:	
After completion of the course students would be able to:	
1	Identify the common utilities required for Chemical Plant.
2	Express various types of boilers and their selection.
3	Analyze the importance of insulation and air pressure in process.
4	Identify and analyze the hazards.
5	Integrate the theoretical and practice knowledge to understand hazards activities.
6	Implement the safety designs and procedures.

Topics covered		
UNIT-I	**Identification of Common Plant Utilities** Role and importance of pant utilities in chemical plants, Water, compressed air, steam, vacuum, refrigeration, venting, flaring and pollution abating. Water and its quality, storage and distribution for cooling and fire fighting, Water resource management.	**(04 Hours)**
UNIT-II	**Steam Generation and Utilization** Steam generation and its application in chemical process plants, distribution and utilization; Types of boilers and their operation; steam economy, Steam condensers and condensate utilization, Steam generation by utilizing process waste heat using thermic fluids	**(04 Hours)**
UNIT-III	**Fluid moving: Compressors, Blowers and Vacuum Pumps** Compressors, blowers and vacuum pumps and their performance characteristics; Methods of developing vacuum and their limitations, material handling under vacuum, Creation of low pressure/vacuum by pumps and ejectors. **Refrigeration and HVAC** Fundamentals of refrigeration, refrigerant management and safety, Selection of refrigerants; Processes of HVAC.	**(04 Hours)**
UNIT-IV	**Elements of Safety** Elements of safety, safety and site selection; Plant layout and unit plot planning; Definition of risk and hazard, Identification and assessment of the hazards, distinction between hazards and risk, Industrial hygiene, toxicological studies, Hazard operability (HAZOP) hazard analysis (HAZAN); Safety	**(04 Hours)**

	Integrity Level (SIL) Studies; Technology selection and transfer, choosing the right process.	
UNIT-V	**Safety in Chemical Processes** Introduction, Chemical Process classification, Process design and safety parameter integration. **Chemicals and their Hazards** Material Safety data sheet, Material safety parameters analysis, butyl amine, acrylamide, acrylonitrile, allyl alcohol, benzene, bromine, isopropyl alcohol, acetaldehyde, ethylene oxide, anhydrous ammonia, acetone, toluene, p-xylene, acetic acid, oleum, carbon monoxide.	**(04 Hours)**
UNIT-VI	**Operational safety, safety Procedures and Designs** Process Safety Hierarchy, Process Safety Strategies, Operational safety, Managing Safety, Safety Reviews and Accident Investigations, Designs for Process Safety, Inherently Safer Designs, Controls: Double Block and Bleed, Safeguards or Redundancy, Block Valves, Explosion Suppression, Designs for Runaway Reactions.	**(04 Hours)**

Text Books/References:

1	Sathiyamoorthy M.: Chemical Plant Utilities, Lambert Academic Publishing India, 2016
2	Coker A. K.:Ludwig's Applied Process Design for Chemical and Petrochemical Plants, Vol. 1, 4th Ed., Elsevier,USA, 2007
3	McKettaJ. J.: Encyclopedia of Chemical Processing and Design, Vol. 44, CRC Academic Press, USA, 1993
4	McDowall R.: Fundamentals of HVAC Systems, 1st Ed., Butterworth-Heinemann Elsevier, 2006
5	CrowlD. A., LouvarJ. F.: Chemical Process Safety Fundamentals with Applications, 3rd Ed. Prentice Hall USA, 2011
6	KletzT.A.:Hazop and Hazan: Identifying and Assessing Process Industry Hazards", Fouth Edition, CRC Press, 1999
	.

Project based learning: Below is the list of possible topics, which is for guidance faculty can design and provide relevant topics in addition to these

1	Prepare a report on safety issues of any one particular industry.
2	Prepare Utility Line Diagram (ULD) for typical process.
3	Write a report on HAZOP study of one particular hazard.
4	Prepare a report on the color codes for utility pipelines in chemical plants.
5	Enhancement in collaborative learning is done through, group assignments on the topic of chemicals and their possible hazards, MSDS study and Hazard reduction and safety mechanism that will be given to encourage students to work with classmates to discuss and complete a report
6	Write a report on " Importance of Industrial Hygiene in Chemical Industry"
7	Group discussions on any of the following topics: a) Importance of various utilities in chemical industries. b) Process safety in petroleum industry c) HAZOP Vs HAZAN
8	Design a manual for application of utilities for various plants.

9	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
10	Write a technical report on HAZAN study of any one particular threat.
11	Elaborate the role of safety engineer in Chemical industry.
12	Organizing a industrial visit to nearby industry to understand the plant utilities and safety measures.
13	Write a report on your visit to research and development laboratory of national/international repute.

Syllabus for Unit Test:	
Unit Test : I	Units : I, II, and III
Unit Test : II	UNIT : IV, V, and VI

PROCESS DEVELOPMENT AND ENGINEERING					
Designation: Professional Core					
Course Pre-requisites: Conceptual knowledge of all core Chemical Engineering subjects.					
Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lecture	: 03 Hours/Week	End Semester Examination	: 60 Marks	Lecture	: 03
Total	: 03 Hours/Week	Internal Assessment	: 40 Marks	Total	: 03
		Total	: 100 Marks		
Course Outcomes					
After completion of the course students will be able to					
1.	Analyze synthesis routes for a given compound and select techno-economically feasible route.				
2.	Design and scale up chemical process equipment.				
3.	Select material of construction for chemical process equipment.				
4.	Estimate cost per unit amount of product for different utilities.				
5.	Propose equipment support system for a given plant.				
6.	Differentiate between conventional and green approaches on economic basis.				
Topics Covered					
Unit I	**Preliminary process development** Multiple process synthesis; Selection of process; Basic economic evaluation; Development of a preliminary process system: Modular approach; Sequencing of operations and integration in processes.				**(06 Hours)**
Unit II	**Design and scale-up** Identification of rate controlling steps of processes; Batch, semi- batch and/or continuous mode of operation/process; Concept of dedicated and multiproduct plant facilities, pilot plant, mini plants; Design and scale up aspects.				**(06 Hours)**
Unit III	**Material science** Selection of material of construction for chemical process equipment; Operating condition; Techno-economic feasibility analysis.				**(06 Hours)**
Unit IV	**Utilities** Utilization of energy; Selection of utility; Cost of utilities: water, air, steam, etc.; Heat exchange networks; Process intensification.				**(06 Hours)**
Unit V	**Process Engineering** Preparation of Conceptual process and instrumentation diagrams; Preparation of process specifications for typical equipment; Equipment support system: Load calculations and commissioning of equipments; Labeling of process equipment and piping system.				**(06 Hours)**
Unit VI	**Green approach and process safety** Energy conservation: solar and wind energy; Green synthesis routes; Minimization of waste; Waste treatment by green route; Process hazards and				**(06 Hours)**

	process safety.	
Project Based Learning		
1	Analyze possible synthesis rout for a given compound on economic platform.	
2	Visit to any one chemical process industry and present a report on equipment support system.	
3	Study recent advances in material science and engineering.	
4	Study recent advances in waste water treatment and waste minimization.	
5	Study any one recent review article on process development of any one synthetic route in group and make a report.	
6	Prepare power point presentation on green approaches and process safety.	
7	Prepare power point presentation on hazardous waste management.	
8	Prepare a report on recent development in solar and wind energy sectors.	
9	Group discussion on design and scale up aspects of chemical process equipment.	
10	Present techno-economic feasibility analysis of any one multiphase reactor.	
Text Books/ References		
1	D. L. Erwine, "Industrial Chemical Process Design", 2nd Edition, 2013	
2	P. Groggins, "Unit Processes in Organic Synthesis", 5thEdition, Tata McGraw Hill, 2001	
3	Chandalia S. B., "Handbook of Chemical Process Development", 1stEdition, 2002	
4	Silla H., "Chemical Process Engineering: Design and Economics", 1stEdition, CRC Press, 2003	
Syllabus for Unit Test		
Unit Test I	Unit – I, II, III	
Unit Test II	Unit – IV, V, VI	

BIOCHEMICAL ENGINEERING

Designation: Professional Core

Pre-requisite Courses: Basic knowledge of Biology, Chemical Reaction Engineering

Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	: 03Hours/Week	End Semester Examination	: 60 Marks	Theory	: 03
Practical	: 02Hours/Week	Internal Assessment	: 40 Marks	Practical	: 01
Total	: 05 Hours/Week	Term-work (TW)	: 25 Marks	Total Credits	: 04
		Practical/Oral	: 25 Marks		
		Total	: 150Marks		

Course Outcomes

1	Learn bioenergetics principles.
2	Analyze the kinetics of enzyme catalyzed reactions.
3	Analyze the kinetics of substrate utilization.
4	Learn fermentation process in all aspects.
5	Identify the bioremediation processes and learn the mechanism.
6	Design the reactors for biochemical reactions.

Topics Covered

UNIT-I	**Introduction to Biochemical Engineering** Definition and scope of biochemical engineering; Unit operations in biochemical processes; Introduction to bioenergetics; Batch and continuous culture, Mixed microbial culture, Fed batch culture.	**(06 Hours)**
UNIT-II	**Kinetics of enzyme catalyzed reactions in free and immobilized states** Michaelis-Menten equation and its various modifications; Effects of External mass transfer in immobilized enzyme systems; analysis of intraparticle diffusion and reaction.	**(06 Hours)**
UNIT-III	**Kinetics of substrate utilization, product formation and biomass production** Monod growth model and its various modifications; structured and unstructured kinetic rate models; Thermal death kinetics of cells & spores.	**(06 Hours)**
UNIT-IV	**Fermentation** Modes of bioreactor operation; batch, continuous and fed batch, Mixing and aeration, operation, measurement of parameters and control of bioreactors; Preparation and sterilization of medium for fermentation; study of product formation kinetics in a fermentation process.	**(06 Hours)**
UNIT-V	**Microbial reactors** Different types of microbial reactors; Bioreactor operations for industrial-important biological products; Case studies.	**(06 Hours)**

UNIT-VI	Introduction to downstream processing Recovery and the purification of biosynthetic products	(06 Hours)

Project Based Learning	
1.	Write a report on the recent advances in Biochemical processes with reference to the current year.
2.	Analyze kinetics of different microorganisms.
3.	Search out some industries related to Biochemical processes.
4.	Write a technical report on your visit to a research laboratory.
5.	List out all the techniques for fermentation.
6.	Perform any one fermentation technique.
7.	Find out different types of microbial reactors.
8.	Prepare a report on downstream processing.
9.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
10.	Group discussion on process design for bio products.
*Students in a group of 3 to 4 shall complete any one project from the above list.	
Term Work	
Term work will consist of the experiments listed below, which are to be performed in laboratory by the students.	
1	Media Preparation
2	To study Sterilization techniques
3	Gram strain technique
4	Effect of substrate concentration on enzyme kinetics
5	Effect of temperature on enzyme kinetics
6	Effect of time on enzyme kinetics
7	Effect of pH on enzyme kinetics
8	Study of isolation of chloroplast
9	Study of Urease Test
10	Detection of Adulteration in Milk
11	To study isolation techniques.

Te1xt Books/References	
1	R. Dutta: Fundamental of Biochemical Engineering, Springer , Ann Book India, 2008
2	J.E.Bailey, D.E.Ollis: Biochemical Engineering Fundamental, 2nd Edition, McGraw Hill Education, 2017
3	M.Doble, A.K.Kruthiventi, V.G.Gaikar: Bio transformations and Bioprocesses, Marcel Dekker Inc, New York, USA 2004

Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

CHEMICAL PROCESS EQUIPMENT DESIGN AND DRAWING

Designation: Professional Core

Course Pre-requisites: Conceptual knowledge of all core Chemical Engineering subjects such as Heat Transfer, Mass Transfer, Reaction Engineering, etc.

Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lecture	: 03 Hours/Week	End Semester Examination	: 60 Marks	Lecture	: 03
Practical	: 02 Hours/Week	Internal Assessment	: 40 Marks	Practical	: 01
Total	: 05 Hours/Week	TW	: 25 Marks	Total	: 04
		Practical/Oral	: 25 Marks		
		Total	: 150 Marks		

Course Outcomes

After completion of the course students will be able to

1.	Estimate maximum working pressure and design pressure for given system.
2.	Estimate the pressure vessel design procedure for optimal size.
3.	Estimate the plate efficiency with design procedure of plate distillation column.
4.	Estimate the packed distillation column design calculations using the height of transfer unit concept.
5.	Estimate the fluidized bed dryer design procedure.
6.	Estimate the design procedure for equipments such as cyclone separator, decanter, electrostatic precipitator, etc.

Topics Covered

Unit I	**Introduction to Process Equipment Design** General design procedure, Equipment classification, Introduction to various mechanical properties of materials, Material of construction, Lining for chemical plants and equipments, resistance of metals to corrosion under varying conditions of temperature and pressure etc. Theories of failures, Application and use of various codes and standards in design. Representation of different utilities and symbols, Study of design parameters such as:Maximum working pressure, Design pressure, Design temperature, Design stress and factor of safety, Design of wall thickness and minimum actual thickness, Corrosion allowance, Design loading, Possions ratio.	**(06 Hours)**
Unit II	**Design of pressure vessels and storage tank** Design of pressure vessels: Vessels subjected to internal pressure and combined loading, Cylindrical and spherical shell, Resultant stresses induced in pressure vessel, Stresses in high pressure vessels, Optimum vessel size, Design of various heads and closures such as:Flat head, Torispherical head, Elliptical head, Hemispherical head, and Conical head, etc. Design of storage tank:Types of storage tank, Types of roof for storage tank,	**(06 Hours)**

	Types of losses in floating roof tank, Estimation of nozzle diameter for drain in storage tank.	
Unit III	**Tray Column Design** 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.	**(06 Hours)**
Unit IV	**Packed Column Design** 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.	**(06 Hours)**
Unit V	**Filters and Dryers** Various types of filters such as: Vacuum filters, Pressure filters, Centrifuges, and Rotary drum filters, etc. Design principles for filters. Types of dryers, Batch type dryers, Continuous dryers, Design principles for fluidized bed dryer	**(06 Hours)**
Unit VI	**Design of some novel separation equipments** Design procedure for some separation equipments like Gas-liquid separator, Liquid-liquid separator, Cyclone separator, Gravity thickener, Decanter, Electrostatic precipitator, Adsorption column, Ion exchange equipment.	**(06 Hours)**

Term Work	
Term work will consist of the Practicals/drawings listed below, out of which any six are to be done by students.	
1	Design and drawing of enclosures and supports
2	Design and drawing of pressure vessels.
3	Design and drawing of storage tanks.
4	Design and drawing of distillation column.
5	Design and drawing of absorption column.
6	Study of various types of packings.
7	Design calculations of packed column.
8	Design calculations of fluidized bed dryer.
9	Design and drawing of rotary filter.
10	Study the conditions of stress analysis of columns.
Project Based Learning	
1	Prepare a report on technologically advancedequipments which are recently introduced.
2	Prepare a report on different codes and symbols used in design of a particular plant.
3	Prepare a model for any of the equipment
4	Group discussions on the following topics: a) Advances in equipment design. b) Distillation column selection and sizing. c) Packed column vs Plate column.
5	Visit to any chemical process industry and present a report on different equipments utilized for processing.
6	Solve old (previousfive years) GATE paper questions of Chemical Process Equipment Design

	and Drawing subject.
7	Group presentation (seminar) on equipment selection and design.
8	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in designing economic plant layout for any process industry.
Text Books/ References	
1	Joshi, M.V, and Mahajani, V.V., "Process Equipment Design," 3rd Ed. Macmillan India Limited, New Delhi, 1996
2	Bownell, L.E., and Young, E.M., "Process Equipment Design", Wiley Eastern, 1968.
3	Sinnott. R.K, Coulson and Richardson's, "Chemical Engineering", Volume 6, 3rd Ed., Butterworth Heinemann, New Delhi, 1999.
4	Bhattacharya, B. C., "Chemical Equipment Design," CBS publishers.
5	Dawande, S. D., " Process Equipment Design" DENETT publishers
Syllabus for Unit Test	
Unit Test I	Unit – I, II, III
Unit Test II	Unit – IV, V, VI

CHEMICAL PROCESS MODELLING AND SIMULATION

Designation: Professional Core

Pre-requisite Courses: Fundamentals of Thermodynamics, Heat and Mass Transfer, Process Control, Reaction Engineering and Mathematics.

Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lecture	: 03 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 03
Practical	: 02 Hours/Week	Internal Assessment	: 40 Marks	TW/Oral	: 01
Total	: 05 Hours/Week	TW	: 25 Marks	Total Credits	: 04
		Practical/Oral	: 25 Marks		
		Total	: 150 Marks		

Course Outcomes

After completion of the course students will be able to

1.	Express mass balance, energy balance and momentum balance equation for various chemical process systems.
2.	Express models for heat transfer equipment such as double pipe heat exchangers, shell and tube heat exchanger, etc.
3.	Develop models for separation equipment.
4.	Develop models for reaction equipment such as batch reactor, CSTR, etc.
5.	Recognize simulation approaches.
6.	Simulate model equations using numerical methods.

Topics Covered

Unit I	**Introduction to Modelling:** Introduction, definition of modelling, different types of models, applications of mathematical modelling, principles of formulation, lumped model, distributed parameter model, degree of freedom analysis. Fundamental laws: continuity equation, energy equation, equations of motions, transport equations, equations of state, chemical kinetics.	**(06 Hours)**
Unit II	**Modelling of Heat transfer equipment:** Double pipe heat exchanger, shell and tube heat exchanger, two heated tanks, single component vaporizer, steady-state heat conduction through a hollow cylindrical pipe, evaporator.	**(06 Hours)**
Unit III	**Modelling of Separation equipment:** Simple distillation, Ideal binary distillation column, multi component non-ideal distillation column, batch distillation with holdup, flash distillation, extraction column, Absorption column	**(06 Hours)**

Unit IV	**Modelling of reactors:** Two phase CSTR with heat removal, series of isothermal constant holdup CSTRs, CSTRs with variable holdups, Gas phase-pressurized CSTR, Non–Isothermal CSTR, Batch reactor, gas liquid bubble reactor, semi-batch reactor.	**(06 Hours)**
Unit V	**Introduction to simulation:** Introduction to simulation, definition of simulation, approaches of simulation: modular approaches, equation-solving approach, decomposition of networks: tearing algorithms, algorithms based on the signal flow graph, algorithms based on reduced digraph.	**(06 Hours)**
Unit VI	**Simulations using numerical methods:** Use of numerical methods to solve mathematical model equations and estimate parameters of Gravity flow tank, Three CSTRs in series, Non-isothermal CSTR, Binary distillation column, Multi-component distillation column, Batch reactor.	**(06 Hours)**

Term Work	
Term work will consist of the programs / practical's listed above, out of which any eight programs/practical's are to be performed in laboratory by the students.	
1	Study of gravity flow tank.
2	Study of Batch reactor
3	Simulation of CSTR
4	Simulation of bubble point temperature
5	Simulation of distillation column.
6	Simulation of heat exchanger
7	Simulation of first order reaction system in batch reactor.
8	Simulation of first order reaction system in CSTR
9	Study of reversible reaction in a batch reactor.
10	Simulation of any model equation.
11	Study of CSTR combination in first order reactions.
12	For simulation, simulation software like MATLAB, ASPEN, CHEMCAD, etc can be used . In addition to these above stated practicals' concerned faculty member may design his/her own practical's

Project Based Learning	
1	Draw a flow diagram to build a simulation of any specific product.
2	Write a mathematical model for unit operation and processes involved in any specific chemical industry.
3	Prepare a report on modelling and simulation of different chemicals reactors.
4	Students must study any five NPTEL videos related to Chemical Process Modelling and simulation and prepare/present power point presentation.
5	Collect experimental data from literature and estimate unknown parameters for chemical reactors/heat exchanger/distillation unit.

6	Literature search for any industrial data for modelling and simulation.
7	Model a equipment in pfd using modelling and simulation concept.
8	Solving numerical based on distillation using modelling and simulation concept.
9	Solve group assignments allotted with discussion in groups and problem solving.
10	Preparation of a brief report on in chemical engineering systems.
Text Books/ References	
1	W. L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.
2	S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
3	R.E.G. Franks, Modeling and Simulation in Chemical Engineering, WielyIntrscience, NY, 1972.
4	B.V. Babu, Process Plant Simulation, Oxford University Press, NY 2004.
5	D. Himmelblau, K.B. Bischoff, Process Analysis and Simulation, John Wiley & Sons, 1968
Syllabus for Unit Test	
Unit Test I	Unit – I, II, III
Unit Test II	Unit – IV, V, VI

PROFESSIONAL SKILLS			
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Practical : 2 Hour /Week	TW	: 25 Marks	Practical : 01
	Practical/Oral	: 25 Marks	Total : 01
	Total	: 50 Marks	

Course Pre-requisites: The students should have knowledge of	
1	Basic mathematical concepts, reasoning skills, and comprehension abilities.
2	Fundamentals of communication processes and soft skills.
3	Basic understanding of leadership qualities, ethics, etiquettes, and values.
Course Objective:	
	This course is structured to provide students with a well-rounded foundation in quantitative aptitude, logical and verbal reasoning, professional communication, employment skills, leadership development, and business ethics. By integrating these components, students will be better equipped to excel in recruitment processes and succeed in their professional careers.
Course Outcomes: The student will be able to	
1	Apply shortcut techniques to solve quantitative aptitude questions efficiently in recruitment and competitive exams.
2	Utilize logical reasoning methods and mnemonics to enhance problem-solving skills in placement tests.
3	Improve verbal communication skills, including vocabulary, sentence patterns, and reading comprehension, for effective professional interactions.
4	Develop proficiency in job application writing, resume building, and interview skills to enhance employability..
5	Understand and apply soft skills, leadership qualities, and professional ethics in the workplace.
6	Demonstrate appropriate corporate etiquette, business ethics, and values in professional settings.

Course Content:

Unit-I	**QUANTITATIVE APTITUDE** : • Number System, Percentage, Profit and Loss, Simple & Compound Interest • Ratio, Proportion, and Average • Mixture and Allegation • Time, Speed & Distance, Time & Work • Permutation & Combination, Probability • Pipes and Cisterns	**(4 Hrs)**

Unit-II	**LOGICALREASONING :** • Coding-Decoding, Number Series, Blood Relation, Directions • Cubes & Dices, Data Interpretation, Data Sufficiency • Set Theory & Syllogisms, Matching, Selection & Arrangement • Clocks & Calendars, Visual Reasoning • Input-Output & Flow Charts	**(4 Hrs)**
Unit-III	**VERBAL REASONING:** • Sentence Patterns, Sentence Correction, Spotting Errors • Vocabulary, Antonyms & Synonyms, Analogy • Phrasal Verbs, Idiomatic Expressions • Reading Comprehension, Cloze Test • Sentence Rearrangement and Theme Detection	**(4 Hrs)**
Unit-IV	**HONING EMPLOYBILITY AND PRESENTATION SKILLS:** • Job Application Letters: Layout, Structure, Covering Letter • Resume & CV Building: Structure, Effective Writing Tips • Group Discussion: Skills, Strategies, and Evaluation • Interview Skills: Telephonic & Face-to-Face Interviews • Body Language, Grooming & Etiquette for GD & PI • Extempore Speaking Techniques • Presentation Skills: Structure, Layout, Flow, and PPT Creation	**(4 Hrs)**
Unit-V	**SOFT SKILLS AND LEADERSHIP DEVELOPMENT:** • Soft Skills: Definition, Importance, and Differences from Hard Skills • Life Skills & Personal Development • Team Building & Conflict Resolution • Problem-Solving, Time & Stress Management • Pareto Principle (80/20 Rule), Time Management Matrix • Leadership Skills: Importance, Types, Attributes of a Good Leader • Motivational Theories and Emotional Intelligence in Professional Life	**(4 Hrs)**
Unit-VI	**BUSINESS ETHICS ,ETIQUETTES AND VALUES:** • Ethics & Values in the Business World • Respect for Individuality and Workplace Diversity • Key Features of Corporate Etiquette • Corporate Grooming & Dressing • Social & Office Etiquette • Importance of Professional Behavior in the Workplace • Corporate Social Responsibility (CSR): Need and Importance	**(4 Hrs)**
Term Work Assignments		
1	**Unit-I: QUANTITATIVE APTITUDE** 1. Solve 20 practice problems on Number System, Percentage, and Profit & Loss. 2. Create a comparative analysis of Simple Interest vs. Compound Interest with real-world examples.	
2	**Unit-II: LOGICAL REASONING**	

	1. Solve a set of logical reasoning problems covering Coding-Decoding, Blood Relations, and Directions. 2. Prepare a case study on how logical reasoning skills are used in competitive exams and corporate assessments.
3	**Unit-III: VERBAL REASONING** 1. Identify and correct errors in 10 sentences focusing on sentence structure and grammatical mistakes. 2. Develop a vocabulary list with antonyms, synonyms, and phrasal verbs commonly used in professional settings.
4	**Unit-IV: HONING EMPLOYABILITY AND PRESENTATION SKILLS** 1. Draft a job application letter along with a structured resume tailored for a technical position. 2. Participate in a mock group discussion and receive peer and instructor feedback. 3. Conduct a mock interview (telephonic & face-to-face) and submit an evaluation report
5	**Unit-V: SOFT SKILLS AND LEADERSHIP DEVELOPMENT (Term Work Assignments)** 1. Conduct a self-assessment on personal soft skills and identify areas for improvement. 2. Develop a time management plan using the Pareto Principle (80/20 Rule) and Time Management Matrix. 3. Prepare a report on different leadership styles and their impact in the corporate world.
6	**Unit-VI: BUSINESS ETHICS, ETIQUETTES, AND VALUES** 1. Write a report on corporate ethics and how companies implement ethical policies. 2. Conduct a role-play activity demonstrating appropriate corporate etiquette in business interactions. 3. Prepare a presentation on the significance of Corporate Social Responsibility (CSR).
Reference Books:	
1	Quantitative Aptitude by R. S. Agarwal published by S. Chand
2	The Book of Numbers by Shakuntala Devi
3	A Modern Approach To Logical Reasoning by R. S. Agarwal published by S. Chand
4	A New Approach to Reasoning Verbal & Non-Verbal by Indu Sijwali
5	Business Communication by Meenakshi Raman, Prakash Singh published by Oxford University press, second edition
6	Communication Skills by Sanjay Kumar, Pushp Lata, published by Oxford University press, second edition
7	Technical Communication by Meenakshi Raman, Sangeeta Sharma published by Oxford University press
8	Developing Communication Skills by Krishna Mohan, Meera Banerji published by Macmillan India Pvt Ltd
9	Soft Skills by Meenkashi Raman, published by Cengage publishers

10	Soft Skills by Dr. K Alex published by Oxford University press
11	Soft skills for Managers by Dr. T. Kalyana Chakravarthi and Dr. T. Latha Chakravarthi published by biztantra

SKILL BASED COURSE –VI: CHEMICAL PROCESS SIMULATION

Designation: Professional Core

Pre-requisite Courses: Fundamentals of Computer, Mechanical operations, Heat Transfer, Fluid Flow, Mass Transfer, Thermodynamics and Chemical reaction engineering.

Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Practical	: 02 Hours/Week	TW	: 25 Marks	TW/Oral	: 01
Total	: 02 Hours/Week	Practical/Oral	: 25 Marks	Total Credits	: 01
		Total	: 50 Marks		

Course Outcomes

After completion of the course students will be able to

1.	Apply fundamental knowledge to build a PFD and select thermodynamic models.
2.	Estimate phase diagram for a given mixture.
3.	Simulate distillation, absorption column and estimate parameters.
4.	Design and simulate batch and continuous reactors and estimate design parameters.
5.	Develop a simulation model for separation and reactor assembly.
6.	Apply all fundamental knowledge to build a simulation environment for a given problem.

Topics Covered

Unit I	**Fundamentals of simulation** Programming languages applied for simulations; Thermodynamic Packages; Basic concepts of building PFD.
Unit II	**VLE data estimation** Estimation of VLE data for different binary mixtures at isothermal and isobaric conditions 1. Flash calculations and phase diagrams 2. Program/ simulation applying different activity Coefficient models 3. Estimation of binary interaction parameters
Unit III	**Simulation of Separation Units** 4. Process, design of absorption/ Distillation column 5. Estimating HTU, NTU, HETP absorption column 6. Estimating design parameters of distillation column
Unit IV	**Simulation of Reactors** 7. Simulation of batch, semi-batch and continuous stirred reactors. 8.Estimating conversion/purity/selectivity in batch reactor 9. Case study selecting any example
Unit V	**Simulation of Reactor and Separator unit** 10. Theoretical calculation for reactor separator unit, variable selection for design. 11. Optimization of the reactor + Separator unit.
Unit VI	**Application to Chemical Engineering**

	12. Simulate chemical engineering case studies involving unit operations and processes using open software 13. Optimizing the variables.
Term Work	
Term work will consist of the programs/practical's listed above, out of which any eight programs/practical's are to be performed in laboratory by the students.	
Text Books/ References	
1	Finlayson, Introduction to chemical engineering computing. John Wiley & Sons, 2012
2	W. L. Luyben, Process Modeling Simulation and Control for Chemical Engineers,McGraw Hill, 1990.
3	J. Haydary, Chemical Process Design and Simulation, Wiley, 2019.
4	A.K. Jana, Chemical process modelling and computer simulation. PHI Learning Pvt. Ltd. 2011.
5.	D. Himmelblau, K.B. Bischoff, Process Analysis and Simulation, John Wiley & Sons, 1968

VAC-II: AGRICULTURE BASED VALUES ADDED PRODUCTS		
Designation: Value added course		
Pre-requisite Courses: Biology, Chemistry		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 2 Hours/Week	Internal Assessment : 40 Marks	Theory : 02
	Total : 40 Marks	Total credits : 02

Course Outcomes:	
After completion of the course students would be able to:	
1	Study microorganisms useful in agricultural field.
2	Learn process engineering in agricultural field.
3	Analyze mechanism of biopesticides.
4	Learn transformation of Agro-Waste into Value-Added products.
5	Learn Biofuel processing
6	Study of value added products in various industries

Topics covered		
UNIT-I	Agricultural Process Engineering Importance of engineering properties of Agricultural Produce and Classification. Physical properties- shape, size, roundness, sphericity, volume, density, porosity, specific gravity, surface area of grains, fruits and vegetables	**(02 Hours)**
UNIT-II	Problems associated with conventional value-added products, Emerging Value-Added Products from Waste, Economical Consideration of Value-added Products, Economical Methods to Add Value to Raw Commodities, Feasibility in Producing Value added Products, Vertical integration	**(02 Hours)**
UNIT-III	Biopesticides Sustainable agriculture-problems and its impact on agriculture with Biopesticides, indicators of sustainability, Productionof Biopesticides as innovative approach ,Weed management	**(02 Hours)**
UNIT-IV	Transformation of Agro-Waste into Value-Added Bioproducts and Bioactive Compounds: Micro/Nano Formulations and Applications in various fields	**(02 Hours)**
UNIT-V	Biofuel from agricultural waste, Types of biofuel, production of Biofuel,Valorization of agricultural wastes for biofuel applications	**(02 Hours)**
UNIT-VI	Value added products in 1.Wheat and rice 2. Fruits and vegetables—Mango, Citrus and Potato 3. Milk and dairy products 4. River and marine products, etc	**(02 Hours)**

Project Based Learning (Internal Assessment)	
1.	Preparation of a brief report on Microbes in human welfare in agricultural field
2.	Learn to test characteristics of soil
3.	Analyze various agro based products from different industry
4.	Group discussion on “sustainable farming for value added products”
5.	Prepare power point presentation on “Industries manufacturing biopesticides”
6.	Analyze processes used in India for the manufacturing of biofuels .

Text Books/References:	
1	**V**ishnu R., Deepak K.,TarafdarJ., Tatiana M., "Organic and Biogenic Nano-Agri-Inputs in Sustainable Crop Production: A Path to Food Safety and Security" Nova Science Publishers
2	**V**ishnu R., Tatiana M., "Biochar: Advances in Research and Applications", Nova Science Publishers
3	Marcos O.,JoséB.,**"** Biomass: The Novel Green Gold – Current Trends and Future Uses of Biomass Resources" Nova Science Publishers
4	Hitesh M.,Bhabendu M., Soumya M.,"The Future of Smart Agriculture" Nova Science Publishers

VAC-II: FOOD TECHNOLOGY		
Designation: Value added course		
Pre-requisite Courses: Biology, Chemistry, Transport Processes		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 2 Hours/Week	Internal Assessment : 40 Marks	Theory : 02
	Total : 40 Marks	Total credits : 02

Course Outcomes:	
After completion of the course students would be able to:	
1	Explain the principles of food processing.
2	Identify and select the method of processing for conductive and convective foods.
3	Explain balancing and freezing of foods.
4	Select membrane processes for food processing as per desired application.
5	Explain osmotic dehydration of food.
6	Explain extrusion cooking and packaging of foods.

Topics covered		
UNIT-I	Principle of food processing: Rheology of solid, semi-solid and liquid foods. Heat transfer and thermal death times, Schmidt plot procedure.	**(02 Hours)**
UNIT-II	Canning of food: Thermal processing, determining time of heat sterilization process. Conductive and convective foods.	**(02 Hours)**
UNIT-III	Balancing and freezing of foods: Balancing processes, freezing, Ultra-high temperature thermal processing, food sterilization, probability of non-sterile unit, Convective drying of food, rate of drying, time of drying.	**(02 Hours)**
UNIT-IV	Membrane processing of liquid foods: Principles, membrane configuration, types, evaporation concentration of liquid food, evaporator load calculation.	**(02 Hours)**
UNIT-V	Osmotic dehydration of food: Mechanism of osmotic dehydration, kinetics. Microwave heating of food, Frying of food, heat and mass transfer in frying.	**(02 Hours)**
UNIT-VI	Extrusion cooking of foods: extrusion process, role of moisture content. Packaging of foods, packaging materials, shelf life, water transmission rate, prediction of packaging time. Process control in food manufacturing.	**(02 Hours)**

Project Based Learning (Internal Assessment)	
1.	Preparation of a brief report on Food processing industry
2.	Learn different unit operations in food industry
3.	Analyze functions of membrane in food industry
4.	Group discussion on “sustainable food processing”
5.	Prepare power point presentation on “Use of preservatives in food industry”
6.	Analyze materials used in India for the packaging of food products

Text Books/References:	
1	Frazier, W.C., and Westhoff, D.C., (1995). Food Microbiology. 4th ed. New Delhi: Tata McGraw-Hill publishing Company Limited.

2	Basic Food Microbiology; Bannett, Chapman and Hall
3	Potter, Norman N., Hotchkiss, Joseph H., Food Science, fifth edition.
4	Frazier, Food Microbiology, Tata McGraw Hill, (2007).

VAC-II: NANOSCIENCE		
Designation: Value added course		
Pre-requisite Courses: Physics, Chemistry, Transport Processes		
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Lectures : 2 Hours/Week	Internal Assessment : 40 Marks	Theory : 02
	Total : 40 Marks	Total credits : 02

Course Outcomes:	
After completion of the course students would be able to:	
1	Define the concept of nanomaterials and Nanotechnology
2	Distinguish between the synthesis techniques for nanomaterials and apply the appropriate synthesis technique.
3	Recognize the properties of nanomaterials and effect on them due to nanoscale.
4	Recognize the forms of nanomaterials based on dimensions.
5	Elaborate the effect of Nano structuring on properties nanostructured materials.
6	Express various types of nanomaterials and characterization techniques

Topics covered		
UNIT-I	Introduction, Scientific Revolutions; Types of nanomachines and nanotechnology; periodic table; Atomic structure molecules and phase Energy, Molecular and Atomic size, Surfaces and dimensional space; Top down and bottom up.	**(02 Hours)**
UNIT-II	Nano material synthesis methods, Introduction to Nano scale materials - Synthesis and processing, method of nano structured materials preparation – mechanical grinding, wet chemical synthesis – sol-gel processing, gas phase synthesis, gas condensation processing, chemical vapor condensation – nano composite synthesis – processing.	**(02 Hours)**
UNIT-III	Nanomaterials properties Opportunity at the nano scale - Length and time scale in structures -energy landscapes-Inter dynamic aspects of inter molecular forces	**(02 Hours)**
UNIT-IV	Quantum dots - Nano wires-Nano tubes; 2D and 3D films; Nano and mesopores, micelles, nano machines-biological membranes	**(02 Hours)**
UNIT-V	Physical properties of nanostructured materials, Influence of Nano structuring on Mechanical - Optical, electronic, magnetic and chemical properties – gramsize effects on strength of metals optical properties of quantum dots and quantum wires carbon nano tubes -magnetic behavior	**(02 Hours)**
UNIT-VI	Nanostructures-surface chemistry of tailored monolayer -self assembling; Characterization Techniques: X-ray Diffraction, Scanning Electron Microscopy (SEM), Transmission Electron microscopy (TEM), Optical Spectroscopy, Atomic Force Micrograph (AFM), Particle Size Analyzer.	**(02 Hours)**
Project Based Learning (Internal Assessment)		

1.	Preparation of a brief report on Innovative nano materials in various industries
2.	Learn to characterize nano materials
3.	Analyze various nanomaterials
4.	Group discussion on applications of nanomaterials in chemical industry”
5.	Prepare power point presentation on “synthesis of nanomaterials ”
6.	Analyze types of nanomaterials and its uses.
Text Books/References:	
1	A. Sengupta , Sarkar, Chandan Kumar, “Introduction to Nano- Basics of Nanoscience and Nanotechnology” Springer, 2015
2	A.Sean, Hays, “ Nanotechnolgy, the brain and the future” Springer, 2013
3	S. Kulkarni, “Nanotechnology, Principles and Practices” Springer, 2014
4	M. Ineke, E. Claude, “ Nnaotechnology and Human Health” 2014