BharatiVidyapeeth

(Deemed to be University)

Faculty of Engineering and Technology

Programme: B. Tech. (Chemical) (2021Course)

B. Tech. (Chemical) Semester V and VI Curriculum Syllabus

Bharati Vidyapeeth
(Deemed to be University)
Faculty of Engineering and Technology

Program: B. Tech. (Chemical) Semester – V CBCS 2021 Course

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
1		Mass Transfer Operations	4	2	-	60	40	25		25	150	4	1	-	5
2		Homogeneous Reaction Engineering	4	2	-	60	40	25	-	25	150	4	1	-	5
3		Biochemical Engineering	4	2	-	60	40	25	25	-	150	4	1	-	5
4		Renewable Energy*	4	-	-	60	40	-	-	-	100	4	-	-	4
5		Chemical Process Instrumentation	4	2	-	60	40	25	-	25	150	4	1	-	5
6		Vocational Course III: Fluid Moving Machineries	-	2	-	-	-	25	25	-	50	-	1	-	1
Total			**20**	**10**	**-**	**300**	**200**	**125**	**50**	**75**	**750**	**20**	**5**	**-**	**25**

*** Industry Taught Course III**

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
8	ADD-on	MOOC-II	-	-	-	-	-	-	-	-	-	-	-		2

Program: B.Tech. (Chemical) Semester – VI CBCS 2021 Course

Sr. No.	Course Code	Name of Course	Teaching Scheme (Hours/week)			Examination Scheme (Marks)						Credits			
			L	P/D	T	UE	IA	TW	OR	PR	Total	L	P	T	Total
1		Separation Techniques	4	2	-	60	40	25	-	25	150	4	1	-	5
2		Heterogeneous Reaction Engineering	4	2	-	60	40	25	-	25	150	4	1	-	5
3		Process Development and Engineering*	4	2	-	60	40	25	25	-	150	4	1	-	5
4		Chemical Process Modelling and Simulation	4	2	-	60	40	25	-	25	150	4	1	-	5
5		Quantitative Techniques, Communication and Values	4	-	-	60	40	-	-	-	100	4	-	-	4
7		Vocational Course IV: Piping Design	-	2	-	-	-	25	25	-	50	-	1	-	1
Total			**20**	**10**	**-**	**300**	**200**	**125**	**50**	**75**	**750**	**20**	**5**	**-**	**25**

*** Industry Taught Course IV**

Semester-V (Chemical)

MASS TRANSFER OPERATIONS					
Designation: Professional Core					
Pre-requisite Courses: Heat transfer operation and Fluid flow operation					
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	Term-work	: --
Total	: 06 Hours/Week	Term-work (TW)	: 25 Marks	Practical/Oral	: 01
		Practical/Oral	: 25 Marks	Total Credits	: 05
		Total	: 150 Marks		

Course Outcomes:	
After completion of the course students would be able to	
1	Evaluate diffusivity and rate of diffusion.
2	Evaluate mass transfer coefficients and understand interphase mass transfer.
3	Calculate the height of transfer unit, number of transfer unit, in absorption column.
4	Calculate rate of mass transfer in humidification.
5	Estimate rate and time of drying.
6	Analyze type of crystallization and estimate yield of crystallization.

Topics Covered

UNIT-I	**Diffusion** Molecular diffusion in fluids: Steady state diffusion in fluids at rest and in laminar flow, Steady state diffusion of A through non-diffusing B, equimolar counter diffusion, steady state diffusion in multicomponent mixture , molecular diffusion in fluids, diffusivity of liquids and gases, effect of temperature and pressure on diffusivity, diffusion in solids. Laws of diffusion and empirical equations – Maxwell's law, Stefan's law, Winkle man's method.	**(08 Hours)**
UNIT-II	**Mass transfer Coefficient and Interphase Mass Transfer:** a) Mass transfer coefficients: Mass transfer coefficient in laminar flow and in turbulent flow. Relation of individual and overall mass transfer coefficient. Theories of mass transfer. Mass, heat and momentum transfer analogies. b) Interphase mass transfer. Equilibrium in mass transfer, two resistance concept. diffusion between phases. Steady state co-current and counter current processes. continuous crosscurrent, counter-current, crosscurrent cascade operations and mass balances.	**(08 Hours)**
UNIT-III	**Absorption:** Introduction to absorption, types of tower packing's, contact between liquid and gas, pressure drop and limiting flow rates, material balances for each flow , limiting gas-liquid ratio, rate of absorption, calculation of HTU, NTU and HETP. Alternate forms of transfer coefficients and their relations. Tray Efficiencies, absorption in plate columns, absorption with chemical reaction. Equipment for absorption column.	**(08 Hours)**
UNIT-IV	**Humidification** Vapor-liquid equilibrium, enthalpy for pure substances, definitions of humidity	**(08 Hours)**

	terms, adiabatic saturation temperature, wet bulb and dry bulb temperatures, study of humidity charts, Lewis relation, method of adiabatic humidification and dehumidification. Equipment for humidification, cooling tower design.	
UNIT-V	**Drying** Basic principles of drying. equilibrium in drying. definitions of terms in drying, types of moisture binding, rate of drying curve, mechanism of batch drying and continuous drying, time requirement for drying, mechanism of moisture movement in solids. Equipment used for drying: Classification of dryers, solids handling in dryers, equipment for batch and continuous drying processes: working principle of tray driers, tower driers, rotary driers, spray driers. Concept of freeze drying	**(08 Hours)**
UNIT-VI	**Crystallization** Introduction to the process, principal rate of crystallization, Mier's super-saturation theory, growth and properties of crystals, crystallization rate, calculations of yield, mass and enthalpy balances. Equipment used in crystallization.	**(08 Hours)**

Project Based Learning	
1.	Prepare a model for any of the Mass transfer equipment.
2.	Power point presentation (seminar) on any topic of mass transfer and prepare a report.
3.	Evaluate efficiencies of different Gas-liquid contact equipment. .
4.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
5.	Compare working and principles for different mass transfer operations.
6.	Solve numerical based on crystallization and humidification.
7.	Write a technical report on your visit to a process industry.
8.	Solve old (last three years) GATE question papers with reference to Mass transfer-I subject.
9.	Group discussion on the recent advances in mass Transfer equipment.
10.	Technical interview based on the knowledge of Mass transfer.
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.	To calculate diffusion coefficient in Liquid-Liquid diffusion.
2.	To calculate diffusion coefficient in still air..
3.	To study characteristics of Wetted Wall Column.
4.	To calculate individual and overall interface mass transfer coefficient.
5.	To estimate efficiency of cooling Tower.
6.	To estimate rate of drying in tray drier/rotary drier
7.	To study the crystallization process by air, water cooling and seeding.
8.	Humidification and Dehumidification experiment.

9.	To study agitated batch crystallizer
10.	Study of Spray drier
Text Books/References	
1	Treybal R.E., Mass Transfer Operations, 3rd Ed., McGrawHill, 1981.
2	McCabe, W. L., J. Smith, and Harriot: "Unit operations of chemical engineering," Tata McGraw Hill.
3	King C. J. "Separation Techniques," McGraw Hill Publications
4	Richardson, J. F., and J. M. Coulson: "Chemical Engineering," Butterworth Heinemann, Volume 1.
5	E. L. Cussler, "Diffusion Mass Transfer in fluid systems " 3rd Ed. Cambridge Series in Chemical Engineering.
Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

HOMOGENEOUS REACTION ENGINEERING

Designation: Professional Core

Pre-requisite Courses: Basic knowledge of chemistry, Material and energy balance calculations.

Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	: 04Hours/Week	End Semester Examination	: 60 Marks	Theory	: 04
Practical	: 02Hours/Week	Internal Assessment	: 40 Marks	Tutorial	: -
Total	: 06 Hours/Week	Term-work (TW)	: 25 Marks	Practical	: 01
		Practical/Oral	: 25 Marks	Total Credits	: 05
		Total	: 150Marks		

Course Outcomes

1	Learn the rates of homogeneous chemical reactions and express the temperature dependent term of a rate equation with Arrhenius' Law and other theories.
2	Study experiments, analyze and interpret data, and apply the results to chemical systems and processes.
3	Design ideal batch reactors, ideal CSTR reactors and ideal plug flow reactors.
4	Analyze multiple reactor system, autocatalytic and recycle reactors.
5	Specify operating conditions to produce desired products from parallel and series chemical reactions.
6	Evaluate effect of temperature on reaction.

Topics Covered

UNIT-I	**Chemical Kinetics** Classification of reactions; rate laws and stoichiometry; relative rates of reaction; reaction order; rate limiting step; half life; concentration-dependent term of a rate equation; temperature-dependent term of a rate equation; Temperature dependency from Arrhenius law; Transition state theory; collision theory; rate equation using partial pressure and concentration; their interrelation; searching for a reaction mechanism.	**(08 Hours)**
UNIT-II	**Interpretation of Batch reactor data** Interpretation of batch experimental kinetics data using integral and differential analysis; constant volume batch reactor system; design equation for zero, first, second and third order irreversible and reversible reactions; graphical interpretation of these equations and their limitations; variable volume batch reactors; design equation for zero, first and second order irreversible and reversible reactions; graphical interpretation of their limitations.	**(08 Hours)**
UNIT-III	**Introduction to Reactor Design** Single ideal reactors under steady state conditions; design equations for batch; mixed flow & plug flow reactor; development of rate expression for mean holding time for a plug flow reactor; space time and space velocity; Introduction to Semi-batch reactor.	**(08 Hours)**
UNIT-IV	**Isothermal flow reactors** Size comparison of reactor performance; sequences of reactors; reactors with recycle; optimum size determination; 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	**(08 Hours)**

	staging; optimum recycle ratio for auto –catalytic (recycle) reactors.	
UNIT-V	**Design of reactors for Single and Multiple reactions** Parallel and consecutive reactions in batch; CSTR and PFR; qualitative discussion about product distribution; quantitative treatment of product distribution and reactor size; factors affecting such as choice; optimum yield, conversion, selectivity, reactivity on consecutive and parallel reactions in reactors.	**(08 Hours)**
UNIT-VI	**Non-Isothermal reactor for homogeneous reactor systems** Energy balances in reactors; adiabatic operations; non-adiabatic operations; stability of reactors; non-isothermal homogeneous reactor systems; rates of heat exchanges for different reactors; adiabatic operations for batch and continuous reactors; optimum temperature progression; rate, temperature and conversion profiles for exothermic and endothermic reactions.	**(08 Hours)**

Project Based Learning	
1.	Suggest best suitable reactor arrangement for zero, first and second order reaction.
2.	Derive the rate equations for various combinations of reactors.
3.	Prepare a model for any of the reactor.
4.	Elaborate in detail use of kinetics in equipment/reactor design.
5.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
6.	Group discussion on the recent advances in reaction engineering.
7.	Write a report on your visit to research and development laboratory of national/international repute.
8.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
9.	Visit chemical industry and prepare a detailed report on reactors used in industry.
10.	Students have to study any five NPTEL videos related to chemical reaction engineering and prepare/present power point presentation.
11.	Explain in detail use of kinetics in equipment/reactor design.
12.	Prepare a report on reactors which are newly introduced in the current year.
*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	Study of first order reaction kinetics.
2	Study of PFR & CSTR combination in second order reaction.
3	Rate constant of hydrolysis of methyl acetate by dilute HCl.
4	Hydrolysis of ester (e.g. ethyl acetate) by alkali (NaOH).
5	Study of CSTR .
6	Determination of Arrhenius parameters.
7	Rate constant for saponification of ethyl acetate with NaOH using CSTR
8	Rate constant for saponification of ethyl acetate with NaOH at ambient conditions using PFR
9	Rate constant for saponification of ethyl acetate with NaOH at ambient conditions using (i) Isothermal batch reactor (ii) Isothermal CSTR.
10	Study and operation of an adiabatic batch reactor.
11	Use MATLAB software to simulate Batch / CSTR / Plug flow reactor data
Te1xt Books/References	
1	O. Levenspiel, “Chemical Reaction Engineering”, 3rd Edition, John Wiley and sons, New Delhi, 2007.

2	H.S. Fogler , “Elements of Chemical Reaction Engineering”, 4th Edition, Prentice Hall of India, New Delhi, 2006.
3	K.J. Laidler, “Chemical Kinetics”, 3rd Edition, Pearson Education Inc
4	J.M.Smith, “Chemical Engineering kinetics”, 3rd Edition, McGraw Hill, 1981

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

BIOCHEMICAL ENGINEERING

Designation: Professional Core

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

Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	: 04Hours/Week	End Semester Examination	: 60 Marks	Theory	: 04
Practical	: 02Hours/Week	Internal Assessment	: 40 Marks	Tutorial	: -
Total	: 06 Hours/Week	Term-work (TW)	: 25 Marks	Practical	: 01
		Practical/Oral	: 25 Marks	Total Credits	: 05
		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.	**(08 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.	**(08 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.	**(08 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.	**(08 Hours)**
UNIT-V	**Microbial reactors** Different types of microbial reactors; Bioreactor operations for industrial-important biological products; Case studies.	**(08 Hours)**
UNIT-VI	**Introduction to downstream processing** Recovery and the purification of biosynthetic products	**(08 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 Fundamentals" 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

RENEWABLE ENERGY					
Designation: Professional Core					
Pre-requisite Courses: Basic knowledge of Chemistry, and Physics					
Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	: 04Hours/Week	End Semester Examination	: 60 Marks	Theory	: 04
Total	: 04 Hours/Week	Internal Assessment	: 40 Marks	Total Credits	: 04
		Total	: 100 Marks		

Course Outcomes	
Student will be able to	
1	Elaborate the importance of non-conventional energy technologies
2	Apply the solar photovoltaic (PV) technology to harness energy
3	Apply various biomass to bioenergy conversion processes to harness energy
4	Determine the wind turbine performance parameters such as efficiency, energy produced and capacity
5	Elaborate the importance of hydrogen as an alternative fuel
6	Obtain the sustainability of renewable energy technologies

Topics Covered		
UNIT-I	**Introduction Renewable Energy** Energy scenario; Role of energy sector in national economy; Energy and environment; Conventional energy resources; Non-conventional energy resources: need and present scenario; Overview and applications of non-conventional energy technologies: Solar, Wind, Hydrogen, Biomass, Hydro etc.	**(08 Hours)**
UNIT-II	**Solar Energy** Basics of solar energy: Physics of sun and its energy transport, Thermal radiation fundamentals, Sun-Earth geometric relationships, Measurement of solar radiation; Solar Thermal collectors: Overall system with details, Concept of aperture area, Sizing of air, Water heating systems, Solar concentrators, Thermal energy Storage systems; Solar photovoltaic (PV) technology: Solar cells, Cell technologies, Characteristics of PV cell, Main elements of PV System for electricity generation, Building integrated PV system and its components, Sizing of solar PV array for a given load, Battery system.	**(08 Hours)**
UNIT-III	**Biomass Energy and Biomass Conversion processes** Biomass Energy: Types, Compositions, Characteristics, Properties, Structural Components; Biomass utilisation through different conversion routes: Introduction to thermochemical and biochemical conversion processes, Kinetics of conversion processes, Types of reactors used, Physico-chemical characterization of products formed, Applications of products formed, Techno-economics of processes.	**(08 Hours)**
UNIT-IV	**Wind Energy** Introduction: Nature and power of the wind, Forces on the blades, Meteorology of wind, Wind speed variation with height, Wind speed statistics, Wind energy conversion principles; Wind measurements: rotational and other anemometers etc.; Wind energy conversion system: Types and	**(08 Hours)**

	classification, power, torque and speed characteristics, Aerodynamic design principles, Aerodynamic theories, Applications; Wind turbine design; Economics of wind energy utilization; Wind energy scenario; Environmental impacts of wind farms.	
UNIT-V	**Hydrogen Energy** Introduction of hydrogen energy; Properties of hydrogen as a fuel;Hydrogen production methods: fossil fuels, electrolysis, thermal decomposition, nuclear, photochemical, photocatalytic, hybrid etc.; Hydrogen storage: Metal hydrides, chemical hydrides, carbon nano-tubes etc. Hydrogen Economy: Hydrogen as an alternative fueland techno-economic aspects.	**(08 Hours)**
UNIT-VI	**Sustainability of Renewable Energy Technologies** Definition of sustainable renewable energy; Systems approach; Indicators of sustainability; Methodologies/tools to measure sustainability: Life cycle assessment (LCA) - introduction to concept; LCA methodology and its application.	**(08 Hours)**

Project Based Learning	
1.	Preparation of technical report based on various applications of solar energy
2.	Preparation of power point presentation on any topic related to solar energy utilization- with system sizing calculations considering location, efficiency etc.
3.	Visit to wind mill to understand the actual operation.
4.	Short literature review based on recent trends in the design of wind turbine
5.	Solving numerical based on solar collectors
6.	Group discussions on any of the following topics: a) Importance of renewable energy for society and industries b) Role of renewable energy on Indian and world economy
7.	Read recent research papers related to this subject area and prepare report
8.	Prepare question bank with appropriate answers based on the whole subject renewable energy
9.	Solving numerical based on wind energy calculations
10.	Students have to study any five NPTEL videos related to Renewable energy and prepare/present power point presentation

Text Books/References	
1.	Alternative Energy Systems & Applications by B.K.Hodge, Wiley, 2010
2.	Solar Energy (4th Edition) by S. P. Sukhatme and J. K. Nayak. McGraw Hill
3.	Sustainable Energy Systems and Applications, Springer, 2011
4.	Renewable Energy Technologies, by J.C.Sabonnadiere, Wiley, 2009
5.	Hydrogen and Fuel Cells: Emerging Technologies and Applications by Bent Sorenson, Academic Press.
6.	Gupta R. B. (2008); Hydrogen Fuel: Production, Transport and Storage, CRC Press

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

CHEMICAL PROCESS INSTRUMENTATION		
Designation: Professional Core		
Course Pre-requisites:		
Students should have		
Basic knowledge of Mathematics.		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures : 4 Hour/Week	End Semester Examination: 60 Marks	Theory : 04
Practical : 2 Hour /Week	Internal Assessment : 40 Marks	Practical : 01
Total : 6 Hour /Week	Term-work (TW) : 25 Marks	Total Credits : 05
	Practical/Oral : 25 Marks	
	Total : 150 Marks	

Course Outcomes:

After completion of the course students will be able to

1.	To explicate the need of process instrumentation and process control in chemical industries.
2.	To illustrate various pressure and strain measuring instruments.
3.	To elucidate spectrophotometry, colorimetry and conductometry
4.	To describe nephelometry ,turbidiemetry, refractometry and chromatography methods.
5.	To develop an ability to use theorems to compute the Laplace transform, inverse Laplace transforms. To calculate the transfer functions for first order and second order systems.
6.	To give details various control action for first order and second order system.

Topics covered

UNIT-I	**Introduction**: Basic Concepts and characteristics of measurement system; various elements of instrument; performance characteristics. **Temperature measurement**: Introduction, methods of temperature measurement by expansion thermometers, filled system thermometers; electrical temperature instruments; pyrometers; Calibration of Thermometers. **Level measurement**: Displacers; ultrasonic; microwaves; laser light.	**(08 Hours)**
UNIT-II	**Pressure and strain measuring instruments**: Introduction; classification; low, medium, and high pressure measuring instruments, pressure scales (units), manometers, elastic element pressure gauges with pressure equations (using bourdon tube, diaphragms, capsule, and bellows), transduction/ electrical sensors with pressure equations (based on variable capacitance, resistance, and inductance/reluctance-LVDT), force- balance transducers along with mathematical equations, solid-state devices, thin-film transducers, digital transducers, piezoelectric transducers, vibrating element sensors, pressure multiplexer, calibration of pressure sensors using dead- weight tester, Mechanical, optical, and electrical strain gauges.	**(08 Hours)**
UNIT-III	**Introduction to instrumental methods of analysis**: General Introduction; classification of instrumental methods; spectroscopy, properties of electromagnetic radiation, pH metry, Karl Fischer Titration. **Visible Spectrophotometry & Colorimetry**: Deviation from Beer's law; instrumentation applications; Molar compositions of complexes; examples. **Conductometry**: Introduction, laws; conductance; measurements; types of conductometric titrations; applications; advantages and disadvantages.	**(08 Hours)**
UNIT-IV	**Nephelometry and Turbidimetry**: Introduction; theory; comparison with spectrophotometry; applications. **Refractometry:** Introduction; Abbe refractometer; applications.	**(08 Hours)**

	Chromatography: Introduction; types; theoretical principles; theories of chromatography; development of chromatography; qualitative and quantitative analysis; applications. Gas Chromatography; Introduction, principles of gas chromatography, gas liquid chromatography, instrumentation, evaluation, retention volume, resolution. Branches of gas chromatography, applications and numerical. High Performance (Pressure) Liquid Chromatography; Introduction, principles, instrumentation, apparatus & materials, column efficiency and selectivity, applications. **GC-MS; LC-MS.**	
UNIT-V	**Process dynamics:** Introduction; tools of dynamics analysis; ideal forcing function; input output model; transfer function models; proportion of transfer function; poles & zeros of transfer function with qualitative response; dynamic behavior of pure integrator; pure gain; first order & second order systems (with or without dead time); physical example of these systems.	**(08 Hours)**
UNIT-VI	**Introduction to feedback control:** Final Control Elements - Valve characteristics; Instrumentation symbols. Introduction to Process Flow Diagram (PFD) and Piping & Instrumentation Diagram (P&ID). **Control theory basics:** The control loops; process control terms; components of control loops; basic control action i.e. on-off, P, I, D, PI, PD, PID for 1st order process control loops and 2ndorder response.	**(08 Hours)**

Project based learning:	
1.	Students have to visit chemical industry and prepare a detailed report on various instruments used for process variable measurement.
2.	Students have to visit chemical industry and prepare a detailed report on various instruments used for chemical analysis.
3.	Watch NPTEL video and make report on various instruments used for process variable measurement.
4.	Presentation on instruments used for process variable measurement.
5.	Group discussions on instruments used for process variable measurement.
6.	To find Transfer Function for 1st order and 2nd order Instrument or process.
7.	Draw the Control Loop for HEfor different process variable control.
8.	Draw the Control Loop for Batch Reactor for different process variable control.
9.	Draw the Control Loop for CSTR for different process variable control.
*Students in a group of 3 to 4 shall complete any one or two projects from the above list.	
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.	Calibration of Bimetallic thermometer.
2.	Gas Chromatography.
3.	High Performance Liquid Chromatography.
4.	UV Spectrophotometer.
5.	Dynamic behavior of non interacting system.
6.	Dynamic behavior of interacting system.
7.	Mercury Thermometer With well and Without Well.
8.	To Study the characteristics of On-Off Controller.

9.	Conductivity meter.
10.	PH meter analysis.
11.	Manometer Tuning.
12.	Calibration of RTD.
13.	To Study the Thermocouple.
Text Books/References:	
1	S.K.Singh, "Industrial Instrumentation & Control", Tata McGraw Hill publishing company ltd, New Delhi, 2000
2	D. Pastranabis, "Principals of industrial instrumentation", 2nd edition, Tata McGraw 4 Hill publishing company ltd, New Delhi, 2003
3	Eckman D.P. "Industrial Instrumentation", Willey Eastern Ltd, New Delhi, 1984.
4	A.C. Shrivastav "Techniques in Instrumentation", New Delhi, 1984.
5	W.Boltan, "Instrumentation and Process Measurement", Orient Longman Ltd, Hyderabad, 1st Edition, 1993.
6	Willard H.H, "Instrumental methods of analysis", 6th Edition, CBS Publication New Delhi 1986
7	Galen W. Ewing, "Instrumental Methods of Chemical Analysis", 5th Edition, McGraw Hill Book Company, Singapore, 1990
8	D. A. Skoog, "Principal of Instrumental Analysis", Southern Collage Publication, Japan 1984
9	G. R. Chatwal, S.K. Anand, "Instrumental method of chemical analysis", 5th Edition, Himalaya Publishing House, Mumbai 2002.
10	Ray Choudhuri and Ray Choudhuri "Process Instrumentation, Dynamics and control for Engineers", 1st Edition, Asian Books Pvt Ltd, New Delhi, 2003.
11	B.G. Liptak, "Instrument Engineers Handbook", 4thEdition , CRC Press, 2005.

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

VOCATIONAL COURSE III: FLUID MOVING MACHINERIES

Designation: Skill Development

Pre-requisite Courses: Fluid Mechanics

Teaching Scheme		Examination Scheme		Credits Allotted	
Practical	: 02 Hours/Week	Term-work (TW)	: 25 Marks	Oral	: 01
Total	: 02 Hours/Week	Oral	: 25 Marks	Total Credits	: 01
		Total	: 50 Marks		

Course Outcomes

After completion of the course students will be able to

1	Select the type of pump according to the requirement and calculate net positive suction head.
2	Obtain the operating parameters affecting the performance of a pump and calculate power requirement.
3	Analyse various types of blowers and obtain the factors affecting the performance of blowers.
4	Calculate the power requirement of blowers.
5	Select the various types of compressors and obtain the factors affecting the performance of compressors
6	Calculate the power requirement of compressors.

Topics Covered

UNIT-I	**Pumps:** Types, selection and specifications, characteristic curves, net positive suction head (NPSH) calculations.
UNIT-II	**Power requirement of pumps:** Operating parameters affecting the performance of a pump, Calculation of power requirement of various types of pumps, Operation and maintenance of pumps.
UNIT-III	**Blowers:** Selection and specifications, Factors affecting the performance of blowers.
UNIT-IV	**Power requirement of Blowers:** Operation and maintenance of blowers, Power calculations for given duty.
UNIT-V	**Compressors:** Design principle, Classification and types of compressors, Selection and specifications, Factors affecting the performance of compressors.
UNIT-VI	**Power requirement ofCompressors:** Operation and maintenance of compressors, Power calculations for given duty.

Term Work

Term work will consist of the practical based on the above topics. Any eightpracticals are to be performed in laboratory/industry by the students.

Text Books/References

1	W.L. McCabe, J.C. Smith, and P. Harriott, Unit Operations of Chemical Engineering, 5thedition, McGraw Hill Publications.
2	J.M. Coulson, J.F. Richardson, J.R. Backhurst, J.H. Harker, Chemical Engineering Volume 1, 6thedition, Pergamon Press.
3	S.K.Gupta, Momentum transfer operations, Tata McGraw Hill Publishers.
4	R.K. Bansal, A text book of fluid mechanics and hydraulic machines, Laxmi Publications (P) Ltd,

	NewDelhi.
5	M.M. Denn, Process fluid mechanics, Prentice Hall Publications.

Semester-VI (Chemical)

SEPARATION TECHNIQUES					
Designation: Professional Core					
Course Pre-requisites:					
Students should have basic knowledge of heat and mass 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	Term-work	: --
Total	: 06 Hours/Week	Term-work (TW)	: 25 Marks	Practical/Oral	: 01
		Practical/Oral	: 25 Marks	Total Credits	: 05
		Total	: 150 Marks		

Course Outcomes	
1	Apply the basics of distillation for the binary separation of ideal and nonideal mixture and determine the extent of separation obtained.
2	Describe the operation of continuous rectification and determine the number of stages required for distillation.
3	Determine the number of stages required for separation using liquid-liquid extraction and describe the extractors used industrially.
4	Obtain the requirement of solvent in leaching operation and obtain the extent of separation.
5	Plot the adsorption isotherms and estimate the amount of adsorption using single and multistage operations.
6	Explain 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. Distillation in packed towers: HETP concept, HTU and NTU calculations, Distillation column internals: Type of trays, Type of packing used.	**(08 Hours)**
UNIT-III	**Adsorption:** Types of adsorption, Nature of adsorbents, Equilibria in adsorption- Single	**(08 Hours)**

	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.	
UNIT-IV	**Liquid- Liquid Extraction:** Introduction, Choice of solvent, Ternary equilibrium, Binodal solubility curve, Single stage extraction, Multistage crosscurrent and countercurrent extraction, 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 Equipment: 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)**

Project Based Learning	
1.	Group discussion on the recent advances in Separation Techniques.
2.	Solve previous year GATE question papers with reference to 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.	Technical interview based on the knowledge of various separation techniques studied.
6.	Evaluation of number of stages using McCabe Thiele and PonchonSavarit method.
7.	Group discussion on equipments used for extraction or ion exchange technique and its application. .
8.	Visit to nearby industry to understand various separation techniques
9.	Watch NPTEL videos of distillation and prepare report
10.	Prepare technical report based on advance in novel separation techniques
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 Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

HETEROGENEOUS REACTION ENGINEERING

Designation: Professional Core

Pre-requisite Courses: Material and energy balance calculations, Fluid mechanics, Heat transfer, Mass transfer, Homogeneous reaction engineering

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
Tutorial	: -	Term work/Practical	: 50	Tutorial	: -
Total	: 06 Hours/Week	Total	: 150 Marks	Total Credits	: 05

Course Outcomes

1	Differentiate between heterogeneous reactions.
2	Estimate heterogeneous reaction rate controlling step and determine overall rate of reaction.
3	Estimate flow structure and phase hold-up of a given multiphase reactor.
4	Estimate flow non-ideality in a given multiphase reactor.
5	Estimate heat and mass transfer coefficient in a given 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 measure heat transfer coefficient; Effect of 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	**(08 Hours)**

	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.
Practicals	
1	Estimation of kinetics parameters for any two heterogeneous system
2	Estimation of thermodynamic parameters for any two heterogeneous system
3	Estimation of hydrodynamic parameters of any two heterogeneous system
4	Estimation of dispersion coefficient of any two heterogeneous system
5	Estimation of mass transfer coefficient of any two heterogeneous system
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

PROCESS DEVELOPMENT AND ENGINEERING

Designation: Professional Core

Pre-requisite Courses: Chemical engineering core courses

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
Tutorial	: -	Term work/Practical	: 50	Tutorial	: -
Total	: 06 Hours/Week	Total	: 150 Marks	Total Credits	: 05

Course Outcomes

1	Analyze synthesis routes of 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	Calculate cost per unit amount of product for 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.	**(08 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	**(08 Hours)**
UNIT-III	**Material science** Selection of material of construction for chemical process equipment; Operating condition; Techno-economic analysis	**(06 Hours)**
UNIT-IV	**Utilities** Utilization of energy; Selection of utility; Cost of utilities: water, air, steam, etc.; Heat exchange networks; Process intensification.	**(08 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.	**(08 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 process safety	**(08 Hours)**

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 analysis of any one multiphase reactor.
Term work	
1	Term work will be based on the assignments given. Assignments will be based the content covered in the course. Minimum six assignments can be given for a course
Text Books/References	
1	D. L. Erwine, "Industrial Chemical Process Design", 2nd Edition, 2013
2	P. Groggins, "Unit Processes in Organic Synthesis", 5th Edition, Tata McGraw Hill, 2001
3	Chandalia S. B., "Handbook of Chemical Process Development", 1st Edition, 2002
4	Silla H., "Chemical Process Engineering: Design and Economics", 1st Edition, CRC Press, 2003
Syllabus for Unit Tests	
Unit Test I	Units I, II, and III
Unit Test II	Units IV, V, and VI

CHEMICAL PROCESS MODELLING AND SIMULATION					
Designation: Professional Core					
Pre-requisite Courses: Students should have basic knowledge of					
1. Heat transfer, Mass transfer, Thermodynamics and Chemical reaction engineering					
2. Process Calculation					
3. Mathematics					
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	Term work / practical	: 50 Marks	Total Credits	: 05
		Total	: 150 Marks		

Course Outcomes	
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 equipments.
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 and degree of freedom analysis; Types of models: lumped model, distributed parameter model; Fundamental laws: continuity equation, energy equation, equations of motions, transport equations, equations of state, chemical kinetics.	**(08 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; Heat transfer with coil; Single and multiple effect evaporators.	**(08 Hours)**
UNIT-III	**Modelling of Separation equipments** Ideal binary distillation column; Multi component non-ideal distillation column; Batch distillation with holdup; Flash distillation; Packed column design; Extraction column, Absorption and stripping column	**(08 Hours)**
UNIT-IV	**Modelling of reactors** CSTR Modelling: 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, Fixed bed reactor.	**(08 Hours)**
UNIT-V	**Introduction to simulation** Introduction to simulation: Definition of simulation, need of simulation; Approaches of simulation: modular approach, equation-solving approach; decomposition of networks: tearing algorithms, algorithms based on the	**(08 Hours)**

	signal flow graph, algorithms based on reduced digraph; Simulation tools: design specification, sensitivity analysis and optimization.	
UNIT-VI	**Simulations using numerical methods** 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 and batch reactor.	**(08 Hours)**

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 have to 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.	Solving numerical based on heat transfer using modelling and simulation concept.
8.	Solving numerical based on distillation using modelling and simulation concept.
9.	Solve assignments allotted with group discussion and problem solving.
10.	Preparation of a brief report on chemical engineering systems.
	Term Work:
	Term work will consist of the practical's listed below, out of which any eight practicals 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 a reversible reaction in a batch reactor.
10	Simulation of any model equation.
11	Study of CSTR combination in first order reactions.
12	For simulation, faculty member may use any suitable simulation software like MATLAB, ASPEN, CHEMCAD, etc. In addition to these above stated practicals concerned faculty member may design his/her own practicals.
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,

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

QUANTITATIVE TECHNIQUES, COMMUNICATION AND VALUES		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS:**
Theory: 03Hours / Week Tutorial: 01Hour / Week	Semester End Examination: 60 Marks Internal Assessment: 40 Marks	Credits:4

Course Pre-requisites: The students should have knowledge of	
1	Basic math's and reasoning, and comprehensive ability
2	Basic knowledge of communication process, soft skills
3	Basic knowledge and idea about leaders and leadership qualities, ethics, etiquettes and values
Course Objective:	
	The **Quantitative Techniques, Communication and Values**aims to augment students to face the campus recruitment test and train them on applying short techniques/ tricks to solve questions of Maths, reasoning and English in very less amount of time. The communication and values section focuses on the aspects of communication and soft skills such as grooming personality for leading team, presentation, business communication which would enable graduates to project themselves as a professionals in the corporate sector and/or otherwise.
Course Outcomes: The student will be able to	
1	Solve the aptitude test in the recruitment and competitive exam by applying short techniques and solve the question in less amount of time
2	Apply the short mnemonics and techniques to solve the questions of logical reasoning in the placement and competitive exam in lesser time.
3	Develop the verbal ability to communicate effectively using suitable vocabulary and proper sentence pattern
4	Understand the concept of soft skills and its implication at workplace
5	Build up the ability to study employment business correspondences and its proper implications
6	Understand business ethics, etiquettes and values and apply them in the professional ventures.

Course Content:		
Unit-I	**QUANTITATIVE APTITUDE** :Number system, Percentage, profit and loss, Simple Interest and Compound Interest, Ratio, Proportion and Average, Mixture and Allegation, Time, Speed & Distance, Time & Work , Permutation & Combination, Probability, Pipes and Cisterns	**(8 Hrs)**
Unit-II	**NON-VERBAL REASONING :** 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 Chart.	**(8 Hrs)**
Unit-III	**VERBAL REASONING:** Sentence Patterns, Sentence correction and spotting errors, Vocabulary, antonyms and synonyms and analogy, Phrasal Verbs, idiomatic expressions, reading comprehension, closest, sentence rearrangement and theme detection	**(8 Hrs)**
Unit-IV	**SELF AWARENESS AND SOFT SKILLS DEVELOPMENT:** Concept of SWOT, Importance of SWOT, Individual & Organizational SWOT Analysis, Soft skills, meaning, need and importance, difference between soft skills and hard skills, life skills and personal skills, Leadership skills,-Importance ,Types, Attributes of good leader Motivational theories and leadership ,Emotional intelligence in personal and professional lives its importance need and application, Team Building and conflict resolution Skills ,Problem solving skills, Time Management and Stress Management Skills Pareto Principle(80/20) Rule in time management, Time management matrix,	**(8 Hrs)**

	creativity and result orientation, working under pressure, stress management	
Unit-V	**COMMUNICATION AND HONING EMPLOYMENT SKILLS:** Communication process, Non-verbal codes in communication, importance of LSRW in communication, Barriers to communication, Principles of effective Technical writing, Email writing and Netiquettes, **Letter writing** – formal letters, job application letter, cover letter, structure of technical report writing, Building Resume and CV, Tips to build an effective Resume Group discussion, Skills required for Group Discussion Interview skills, Ways of handling telephonic interviews, Importance of body language, grooming &etiquettes for getting right impression in PI&GD , Extempore, Introduction to PowerPoint presentation, ,Structure & flow of presentation,	**(8 Hrs)**
Unit-VI	**BUSINESS ETHICS ,ETIQUETTES AND VALUES:** The Importance of Ethics and Values in Business World, Respect for Individuality and diversity at workplace values of a good manager Key features of corporate etiquette, Corporate grooming & dressing, etiquettes in social & office Setting-Understand the importanceof professional behaviour at the work place, Corporate social responsibility (CSR) its importance and need.	**(8 Hrs)**
Internal Assessment:		
	Unit Test -1 UNIT – I, II, III	
	Unit Test -2 UNIT – IV, V, VI	

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 InduSijwali
5	Business Communication by Meenakshi Raman, Prakash Singh published by Oxford University press, second edition
6	Communication Skills by Sanjay Kumar, PushpLata, 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. KalyanaChakravarthi and Dr. T. LathaChakravarthi published by biztantra
Project Based Learning Topics:	
1	Prepare mock Tests on Unit –I and solve it in given time(use of PSD lab manual)
2	Prepare mock Tests on Unit –I and solve it in given time(use of PSD lab manual)
3	Prepare online model test based on Unit-II and solve it in specific time(use of PSD lab manual)
4	Prepare online model test based on Unit-II and solve it in specific time(use of PSD lab manual)
5	Form a model for spoken and written communication skills which avoid grammar mistakes and common errors
6	Develop various activity models for enriching and developing vocabulary
7	Preparing strategies by using SWOT and TWOS analysis

8	Analysing differences between Soft Skills, Hard skills, and Personal skills
9	Develop Bruce Tuchman's Team Building Models with classmates/Teammates
10	To study different personalities of Leaders from various sectors and find out their attributes and success stories
11	Preparing a model for Time Management Skills and Stress Management and conduct activities for effective implementation of it.
12	Form a model to develop LSRW and communication Skills
13	Conduct mock interview and practice GD activities to build competencies for actual selection process
14	Preparing a model for evaluating Values and Ethics of Good Managers
15	Preparing a model of dress codes and attire for different professional situations Corporate etiquettes and its implications
16	Develop some good activities to understand the importance and need of Corporate social responsibility (CSR)

Vocational Course IV: Piping Design					
Designation: Professional Core					
Pre-requisite Courses: Chemical engineering core courses					
Teaching Scheme		**Examination Scheme**		**Credits Allotted**	
Lectures	:	End Semester Examination	: -	Theory	: -
Practical	: 02 Hours/week	TW Assessment	: 25 Marks	Practical	: 01
Tutorial	: -	Oral/Practical	: 25 Marks	Tutorial	: -
Total	: 02 Hours/Week	Total	: 50 Marks	Total Credits	: 01

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 designing & 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 symbols piping 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 equipments, symbols usage according to industrial practices, Purpose of P&ID in process industrial/plants**.**	**(04 Hours)**
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 selection of 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	RutgerBotermans 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 Design Drafting and Design Methods for Process Applications", 2007, Gulf publishing Company, Houston, Texas
3	AlirezaBahadori, "Oil and Gas Pipelines and Piping Systems Design, Construction, Management, and Inspection", 2017, Gulf publishing Company, Elsevier Inc.
4	J. Phillip Ellenberger, "Piping and Pipeline Calculations Manual Construction, 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.