Bansilal Ramnath Agarwal Charitable Trust's

Vishwakarma Institute of Technology

(An Autonomous Institute affiliated to Savitribai Phule Pune University)

Structure & Syllabus of

B. Tech. (Chemical Engineering)

Pattern 'B21/C21/D21'

Effective from Academic Year 2021-22

Prepared by: - Board of Studies, Chemical Engineering

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

Signed by

Chairman -BOS	Dean-Academics	Chairman – Academic Board

VISHWAKARMA INSTITUTE OF TECHNOLOGY TRUST

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Vision statement of Institute

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

Mission statement of Institute

1. To endure that 100% students are employable in Industry, Higher studies, Become Entrepreneurs, Civil/Defense Services / Government Jobs and other areas like Sports and Theatre.
2. To strengthen Academic Practices in terms of Curriculum, Pedagogy, Assessment and Faculty Competence.
3. Promote Research Culture amongst Students and Faculty through Projectsand Consultancy.
4. To make students Socially Responsible Citizen.

Core Values

1. Faculty Centric Initiatives
2. Academic Practices
3. Research Culture
4. Use of Technology for Social and National Development

Vision statement of Department

To be recognized as a leading contributor in imparting technical education and research in Chemical engineering for development of the society.

Mission statement of Department

1. To deliver knowledge of Chemical Engineering by strengthening involvement of Research institutions and industries in academics
2. To build conducive environment for advanced learning through participation of faculty and students in collaborative research, consultancy projects, student exchange programs and internships
3. To develop competent Engineers with entrepreneurial skills to address socio-economic need.

Program Educational Objectives (PEO) Programme:

The Graduates would demonstrate

1. Core competency in Chemical Engineering to cater tothe industry and research needs.
2. Multi-disciplinary skills , team spirit and leadership qualities with professional ethics, to excel in professional career and/or higher studies.
3. Preparedness to learn and apply contemporary technologies for addressing impending challenges for the benefit of organization/society.
4. Knowledge of recommended standards and practices to design and implement automation solutions.

Program Outcomes Statements

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes Statements

Engineering Graduates will be able to:

1. Work in chemical engineering organizations demonstrating expertise in conventional chemical engineering design and operations.
2. Work in diverse, multidisciplinary fields such as biotechnology, nanotechnology, food, energy, environmental, product designs etc

B.Tech. Chemical Engineering Structure for Pattern B21 (applicable w.e.f. AY 21-22)

Second Year Module -III

Subject head	Course code	Course name	Contact hours per week		
			Theory	Lab	Tut
S1	**MD2201**	**DATA SCIENCE**	3	2	1
S2	**CS2221**	**INTERNET OF THINGS**	3	2	1
S3	**ME2205**	**3D PRINTING**	3	2	1
S4	**CS2218**	**OBJECT ORIENTED PROGRAMMING**	3	2	1
S5	**CH2281**	**ENGINEERING DESIGN AND INNOVATION – III**	-	-	-
S7	**CH2289**	**SOFTWARE DEVELOPMENT PROJECT**	1	-	-
		Total	14	16	3

Second Year Module – IV

Subject head	Course code	Course name	Contact hours per week		
			Theory	Lab	Tut
S1	**CH2201**	**FLUID FLOW OPERATIONS**	3	2	1
S2	**CH2221**	**PROCESS CALCULATIONS**	3	2	1
S3	**CH2202**	**PARTICULATE TECHNOLOGY**	3	2	1
S4	**CH2204**	**PHYSICAL AND ORGANIC CHEMISTRY**	3	2	0
S5	**CH2212**	**CHEMICAL PROCESS TECHNOLOGY**	2	-	-
S6	**CH2282**	**ENGINEERING DESIGN AND INNOVATION – IV**	-	-	-
		Total			

FF No. : 654

CH2201::FLUID FLOW OPERATIONS

Course Prerequisites: Introduction to vectors and tensors; Basic principles of fluid dynamics, heat transfer and mass transfer.

Course Objectives:

1. To understand different properties of fluids and flow behaviours
2. To learn to apply the hydrostatic law for pressure measurement
3. To learn to apply the principles of mass, momentum and energy conservation to solve fluid flow problems
4. To understand dimensional analysis methods to correlate different process flow parameters
5. To understand the development of hydrodynamic boundary layers and its impact on momentum transport.
6. To learn fluid transportations systems and power requirement in the transportations of fluids

Credits: 5 **Teaching Scheme Theory: 3** Hours/Week

Tut: 1 Hours/Week

Lab: 2 Hours/Week

Course Relevance:

SECTION-1
Fluids and properties of fluids, Newton's law of viscosity, rheological classification of fluids, types of flow, lines to describe the flow The basic equation of fluid statics, pressure-depth relationship, pressure forces on surfaces, pressure measurements, pressure measuring devices. Mass, momentum and energy balance equations, venturi meter, orifice meter, pitot tube for velocity measurement, variable area meter.
SECTION-1I

Fundamental dimension of quantities, dimensional homogeneity ,Reyleigh's method and Buckingham's π method, , concept of hydrodynamic boundary layer, growth over a flat plate, change in nature of boundary layer, and different thicknesses of boundary layer, drag on flat plate, coefficient of drag and its variation, hydrodynamic, thermal and concentration boundary layers.

Shell balance based solutions for laminar flow through circular tube (Hagen Poiseuelle equation), on inclined plane, Darcy-Weisbach equation, friction factor chart

Minor losses and major losses in pipes, concept of equivalent pipe, series and parallel pipe systems, different pipe fittings and valves, transportation of fluids, centrifugal pump.

List of Tutorials: (Any Three)

1. Examples on properties of fluids
2. Examples on rheology of fluids
3. Examples on hydrostatics
4. Examples on continuity equation
5. Examples on mechanical energy balance
6. Examples on dimensional analysis
7. Examples on laminar flow through pipe
8. Examples on frictional losses in pipes
9. Examples on Minor losses in pipe
10. Examples on power requirement in liquid transportation

List of Practicals: (Any Six)

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

List of Projects:

1. Design of orifice meter
2. Design of rotameter
3. Design of venturimeter
4. Analysis of water requirements of dairy industry
5. Design of Reynolds setup for flow characterization
6. Design of a Bernoulli law verification setup
7. Analysis of the viscous flow through a circular pipe
8. Simulation of the energy losses in pipeline systems
9. Design of an automatic irrigation system
10. Rheology of fluids

List of Course Seminar Topics:

1. Different flow behaviours in fluid processing
2. Role of fluid mechanics in vehicle design
3. Pressure measuring devices
4. Flow measuring devices
5. Fluid processing in petroleum industry
6. Rheology of solid liquid suspensions
7. Governing equations for fluid processing and mathematical analysis
8. Gravity separators
9. Processing of polymers
10. Energy losses in the flow systems

List of Course Group Discussion Topics:

1. Fluid statics and fluid dynamics
2. Laminar and Turbulent flow
3. Empirical models and first principle models
4. Hydro power plants and thermal power plants
5. Variable area meters and variable head meters
6. Major and minor energy losses
7. Rheology and rheometry
8. Pumps for various applications
9. Computational tools for fluid mechanics
10. Irrigation systems

List of Home Assignments:

Design:

1. Design of cavitation device by using orifice meter
2. Design of cavitation device by using Venturimeter
3. Design of rotameter for liquid flow measurement
4. Design of viscometer for the Newtonian fluids

Case Study:

1. Modern sensors for flow measurements
2. Modern pressure sensors for pressure measurements
3. Pumps used in petroleum industry
4. Pumps used in polymer processing

Blog:

1. Fluid mechanics in everyday life
2. Modern sensors for flow measurements
3. Wastewater treatment
4. Aerodynamics

Surveys:

1. Valves used in process industry
2. Water pollution in sugar industry
3. Pumps requirement for agriculture sector
4. Rain water harvesting

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	ESE	HA	LAB	CP	VIVA	SEM
15	15	10	30	10	10	10

MSE - Mid Semester Examination
ESE - End Semester Examination
HA - Home Assignment
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar
GD - Group Discussion

Text Books: ***(As per IEEE format)***

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

Reference Books: ***(As per IEEE format)***

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

Moocs Links and additional reading material:

1. www.nptelvideos.in
2. https://nptel.ac.in/courses/103/104/103104043/
3. https://nptel.ac.in/courses/103/103/103103133/

Course Outcomes:

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

CO PO Map

co/ po	po 1	po 2	po 3	po 4	po 5	po6	po 7	po8	po 9	po1 0	po1 1	po1 2	pso1 3	pso14
co1	2	2	2	2	1	1	1	0	1	0	1	0	3	1
co2	2	2	2	2	1	1	0	0	1	0	1	0	1	1
co3	2	3	3	2	2	1	0	0	1	0	1	0	3	1
co4	1	2	3	3	0	1	0	0	1	0	1	0	1	1
co5	3	3	3	3	2	1	0	0	1	0	1	0	2	1
co6	3	3	3	3	2	1	0	0	1	0	1	0	2	1

CO attainment levels

CO	Attainment level
1	1
2	2
3	4
4	3
5	5
6	5

Future Courses Mapping:

Heat Transfer, Mass Transfer, Reaction Engineering, Process Instrumentation and Control, Plant Engineering, Process Equipment Design,

Job Mapping:

All core chemical industries e.g. Oil and gas, paint, fertilizers, food, industrial chemicals manufacturing, etc

FF No. : 654

CH2221::PROCESS CALCULATIONS

Course Prerequisites: Chemistry, Mathematics, Basic of Thermodynamics

Course Objectives:

1.To understand material balance over a unit operation without chemical reaction.

2.To understand material balance over a unit operation with chemical reaction.

3.To understand energy balance over a unit.

4.To understand steady state, unsteady state, recycle, by-pass, purge adiabatic, isothermal, operations and material and energy balance for them

5. To understand Psychrometric calculations, non ideal calculations for gaseous and liquid mixtures, combustion calculations

Credits: 5 **Teaching Scheme Theory: 3** Hours/Week

Tut: 1 Hours/Week

Lab: 2 Hours/Week

Course Relevance:

The study of the subject will help to understand basic calculations required in the design of chemical plants and to do complete material and energy balance of chemical plants. This subject also gives an overview of all unit operations and helps to understand all unit operations and processes in chemical industries.

SECTION-1
Topics and Contents Dimensions and Units, Significance Unit conversions of mass, energy and pressure chemical calculations including mole, equivalent weight, solids, liquids, solutions and their properties, properties of gases. Non ideal calculations, for gas and liquid mixtures, Process flow sheet, Concept, Material balance calculations, Material balance of unit operations such as distillation, crystallization. Recycling, bypass and purge operations, material balance of unsteady state processes, Mass balance with chemical reactions, single, multiple reactions, excess and limiting reactants, conversion, yield and selectivity. Material balance with recycle, bypass and purge operation. Material balance of unsteady state processes with chemical reaction. Material balance of unsteady state processes with chemical reaction.
SECTION-1I

Topics and Contents

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

List of Tutorials: (Any Three)

1. Solve problems based on units and conversions
2. Solve problems based on material balance without chemical reaction.
3. Solve problem of recycle without chemical reaction
4. Solve problem of bypass and purge
5. Solve problems based on material balance with chemical reaction
6. Solve problem of bypass and purge with chemical reaction
7. Solve problems based on energy balance
8. Solve problems based on unit operations
9. Draw flow sheet for a chemical process
10. Study a complete process with PFD

List of Practicals: (Any Six)

1. Draw process flow diagram
2. Material balance on unit process at steady state
3. Material balance on unit process at unsteady state
4. Material balance on unit operation
5. Energy balance on unit operation
6. Energy balance on unit process
7. Recycle without chemical reaction on unit operation
8. Recycle with chemical reaction on unit operation
9. Finding standard heat of formation from data
10. Combine material and energy balance.

List of Projects:

1. Preparation of process flow sheet
2. Preparation of conversion charts.
3. Preparation of block diagram
4. Material balances of process; steady state.
5. Material balances of process with recycle; steady state.
6. Energy balances of process; steady state.
7. Combine material and energy balance.
8. Unsteady state material balance.
9. Psychometric calculations.
10. Calculation based on gas laws.
11. Fuel and combustion calculations

List of Course Seminar Topics:

1. Process flow diagram
2. Different unit systems
3. Humidification
4. Heat of reaction
5. Heat capacity at constant pressure
6. Different gas laws used in chemical operations
7. Recycle & bypass operations
8. Conversion and yield of a chemical process
9. Enthalpy changes for pure substance and their mixtures
10. Material & energy balance of evaporator

List of Course Group Discussion Topics:

1. Distillation Vs Evaporation.
2. Different types of unit systems.
3. Combustion of fuels.
4. Psychometric calculations.
5. Heat of formation vs heat of combustion.
6. Steady Vs unsteady state material balance
7. New separation techniques.
8. Humidification and dehumidification
9. Material Vs energy balance
10. Different gas laws.
11. Membrane separation processes
12. Evaporation Vs Crystallisation

List of Home Assignments:

Design:

1. Material & energy balance for extraction operation
2. Material & energy balance of reactor

3. Material & energy balance of drier
4. Material balance with chemical reaction
5. Material & energy balance of distillation column

Case Study:

1. Energy balances of process; steady state.
2. Material balances of process with recycle; steady state.
3. Combine material and energy balance.
4. Material balances of process with purge; steady state.
5. Material balances of process with bypass; steady state.

Blog:

1. Importance of material and energy balance.
2. Steady state energy balance
3. Steady state material balance without reaction.
4. Steady state material balance with reaction.
5. Unsteady state material balance.

Surveys:

1. Psychometric calculations.
2. Material balance of Combustion of fuels.
3. Material balance of different types of distillation.
4. Material balance of a multi effect evaporator.
5. Material balance of an unsteady state process.

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	ESE	HA	LAB	CP	VIVA	SEM	GD
10	10	10	10	10	20	15	15

MSE - Mid Semester Examination
ESE - End Semester Examination
HA - Home Assignment
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar
GD - Group Discussio

Text Books: ***(As per IEEE format)***

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

Reference Books: ***(As per IEEE format)***

1. Hougen O. A. and Watson K. M.; Chemical Process Principles (Part I), CBS Publishers New Delhi, 2nd Edition, 2001.
2. 'Chemical Process Design and Integration', Smith, R., 3rd Edition, Wiley, 2005.
3. 'Unit Processes in Organic Synthesis', Groggins, P.H., 3rd Edition, McGraw-Hill Book Co., 1958

Moocs Links and additional reading material:

www.nptelvideos.in

CO PO Map

CO /PO	PO :1	PO :2	PO :3	PO :4	PO :5	PO :6	PO :7	PO :8	PO :9	PO : 10	PO : 11	PO : 12	PSO: 13	PSO: 14
CO :1	2	1	3	1	1	1	1	0	0	1	1	1	2	1
CO :2	2	2	3	2	2	1	1	0	0	1	1	1	3	1
CO :3	2	2	3	2	2	1	1	0	0	1	1	1	3	1
CO :4	2	2	3	2	2	1	1	0	0	1	1	1	3	1
CO :5	2	2	3	2	2	1	1	0	0	1	1	1	3	1
CO :6	2	2	3	2	2	1	1	0	0	1	1	1	3	1

CO attainment levels

CO	Attainment level

CO .1	**3**
CO .2	**3**
CO .3	**4**
CO .4	**5**
CO .5	**5**
CO .6	**5**

Future Courses Mapping:

Mass transfer operations, Separation Techniques, Chemical reaction kinetics, Chemical reaction engineering, Process Equipment design

Job Mapping:

All core chemical industries e.g. Oil and gas, paint, fertilizers, food, industrial chemicals manufacturing, etc

FF No. : 654

CH2212:: CHEMICAL PROCESS TECHNOLOGY

Course Prerequisites: Chemistry, Mathematics, Basic of Thermodynamics

Course Objectives:

1. To understand the process fundamentals of chemical technology .
2. To understand unit operations and unit processes in the chemical industry.
3. To understand process flow sheets for production of specific chemical products.
4. To understand reaction temperature, pressure condition and heat network in process
5. To learn about analysis of different processes for the same product based on economics, effluent treatment, social aspects.

Credits: 5 **Teaching Scheme Theory: 3** Hours/Week

Tut: 1 Hours/Week

Lab: 2 Hours/Week

Course Relevance:

The study of the subject will help to understand basic process fundamentals, unit operations and unit processes in chemical plants and process flow sheets for production of specific chemical products. This subject also gives an overview of reaction temperature, pressure condition and heat network in process and helps to analyze different processes in chemical industries.

SECTION-1

Topics and Contents

Theory of Unit operations and industrial equipment and systems used in large scale plants; Unit processes, Development of flow diagram, schematic representation and application for unit operations and unit processes. Study the selection and process specific applications knowing available industrial equipment and plant accessories.Chlor-Alkali Industry:Chlor-alkali chart and importance of chlor-alkali industry, manufacturing processes process economics, and plants in India and a few examples of latest technology used in other nations; Manufacturing of soda ash, caustic soda, chlorine and engineering problems. Membrane cell, mercury cell diaphragm cell processes and electrolytic cell processes and flowsheets

Nitrogen industry Role of nitrogen in fertilizers, manufacturing of ammonia, nitric acid, urea, the above study must involves different routes adopted, limitations, advantages and disadvantages of the process; steam-reforming process technology. Coal gasification technologies (Fixed bed (Lurgi Process), Fluidised bed (Winkler Process)

SECTION-1I

Topics and Contents

Sulfur and Sugar Industry: Importance, manufacturing of sulfur by Frasch process, technology for the manufacturing of sulfuric acid. Sugar Industry: Manufacture of sugar and engineering problems associated, Dextrin and starch derivatives. detailed study and comparison between chamber and DCDA processes; process economics.
Phosphorus and Paper Pulp Industry: Importance, manufacturing of super phosphate, triple super phosphate, phosphoric acid, electro thermal processes and NPK fertilizers, production of pulp, engineering problems involved, paper manufacturing from pulp, and comparison of methods of manufacturing.

Petroleum industry:Overview of refinery process, Crude distillation, Cracking, Reforming, hydroprocessing, Refinery supporting processes. Combustion of solid, liquid, and gaseous fuels

List of Tutorials: (Any Three)

1. Draw BFD of the sulfur manufacturing plant.
2. Solve problems based on units and conversions
3. Draw BFD of the sugar manufacturing plant..
4. Draw BFD of the phosphorus manufacturing plant.
5. Draw BFD of the phosphoric acid manufacturing plant.
6. Draw BFD of the urea manufacturing plant.
7. Draw BFD of the chlorine manufacturing plant.
8. Draw BFD of the paper manufacturing plant.
9. Draw BFD of the Methanol manufacturing plant.
10. Draw flow sheet for a chemical process
11. Study a complete process with PFD

List of Practicals: (Any Six)

1. Draw process flow diagram
2. Study of nitric acid manufacturing process.
3. Study of sulfuric acid manufacturing process.
4. Draw Block flow diagram
5. Draw P & ID diagram
6. Study of cracking in the petroleum industry.
7. Study of ethanol manufacturing process.
8. Study of the Ammonium Nitrate manufacturing process.
9. Study of Phosphorus manufacturing process.
10. Study of Phosphoric acid manufacturing process

List of Projects:

1. Study of Soda Ash process.
2. Study of Urea manufacturing process.
3. Study of the ammonia manufacturing process.
4. Study of sulfur manufacturing process.
5. Detail study of sugar manufacturing plant.
6. Detail study of paper and pulp industry.
7. Study of Caustic soda manufacturing.
8. Study of Nitric acid manufacturing.
9. Study of sulfuric acid manufacturing.
10. Study of distillation in the petroleum industry.

List of Course Seminar Topics:

1. Process flow diagram
2. Study of Methanol manufacturing process.
3. Study of Soap manufacturing process.
4. Study of glycerin manufacturing process.
5. Study of Paint manufacturing process.
6. Study of the Starch manufacturing process.
7. Study of penicillin manufacturing process.
8. Study of chlorine manufacturing process.
9. Overview of refineries.
10. Advance separation processes.

List of Course Group Discussion Topics:

1. New trends in the petroleum industry.
2. New trends in the chlor alkali industry.
3. New trends in the nitrogen industry.
4. New trends in the sulfur industry.
5. Overveiw of refinery processes.
6. New trends in Caustic soda manufacturing.
7. New trends in Nitric acid manufacturing.
8. New trends in urea manufacturing.
9. New trends in the sulfuric acid manufacturing.
10. New trends in the Pulp and paper manufacturing.

List of Home Assignments:

Design:

1. Process flow diagram of Nitric acid plant.
2. Process flow diagram of soda ash plant.
3. Process flow diagram of ammonia plant.
4. Process flow diagram of sulfuric acid plant.
5. Process flow diagram of caustic soda plant.

Case Study:

1. Refinery processes.
2. Membrane separation processes
3. Coal gasification technologies
4. NPK fertilizers
5. Refinery supporting processes.

Blog:

1. Importance of petroleum industry.
2. Importance of the fertilizer industry.
3. Importance of the chlor alkali industry.
4. Importance of the Phosphorus and industry.
5. Importance of the Paper Pulp industry.

Surveys:

1. Review of petroleum industry products, equipment, cost.
2. Market survey of a chemical process.
3. Refinery supporting processes.
4. Food processing.
5. Ore purification processes.

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	ESE	HA	LAB	CP	VIVA	SEM	GD
10	10	10	10	10	20	15	15

MSE - Mid Semester Examination
ESE - End Semester Examination
HA - Home Assignment
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar
GD - Group Discussion

Text Books: ***(As per IEEE format)***

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

Reference Books: ***(As per IEEE format)***

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

Moocs Links and additional reading material:

www.nptelvideos.in

Course Outcomes:

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

CO PO Map

CO /PO	PO :1	PO :2	PO :3	PO :4	PO :5	PO :6	PO :7	PO :8	PO :9	PO : 10	PO : 11	PO : 12	PS O: 13	PS O: 14
CO :1	2	1	3	1	1	1	1	0	0	1	1	1	2	1
CO :2	2	2	3	2	2	1	1	0	0	1	1	1	3	1
CO :3	2	2	3	2	2	1	1	0	0	1	1	1	3	1
CO :4	2	2	3	2	2	1	1	0	0	1	1	1	3	1
CO :5	2	2	3	2	2	1	1	0	0	1	1	1	3	1
CO :6	2	2	3	2	2	1	1	0	0	1	1	1	3	1

CO attainment levels

CO	Attainment level
CO .1	**3**
CO .2	**3**
CO .3	**4**
CO .4	**5**
CO .5	**5**
CO .6	**4**

Future Courses Mapping:

Mass transfer operations, Separation Techniques, Process Equipment design

Job Mapping:

All core chemical industries e.g. Oil and gas, paint, fertilizers, food, industrial chemicals manufacturing, etc

FF No. : 654

CH2202::PARTICULATE TECHNOLOGY

Course Prerequisites: Basic science and knowledge of mathematics

Course Objectives:

1. Identify the important physical mechanisms occurring in processes involving particles
2. Discuss unit operations and its role in chemical industries and characterization of particulate solids
3. Understand size reduction, particle dynamics, separation of particles and handling
4. Understand mixing of solids, selection and working of different industrial mixers
5. Formulate and solve mathematical descriptions of settling, filtration and fluidization processes

Credits:5. **Teaching Scheme Theory: 3** Hours/Week

Tut: 1 Hours/Wee

Lab:**2** Hours/Week

Course Relevance:

It is a branch of science and engineering dealing with description and study of the processing, handling, characterization, conversion and various applications of particulate materials, both dry and wet in size ranging from centimetres to micron. It deals with mixing and agitation in chemical processes. It involves motion of particles through fluids and separation of solids from liquid and gas by different filtration equipment.

SECTION-1

Solid handling and transportation

Particle characterization: Relevance of fluid and particle mechanics, Measurement of particle size, Particle size distribution, Mean particle size, Relationship among shape factors and particle dimensions, Particles in mixtures

Particulate solids in bulk:General characteristics, Agglomeration, Resistance to shear and tensile forces, Angles of repose and of friction, Flow of solids in hoppers, Flow of solids through orifices

Screen analysis: Standard screen series, industrial screening equipment, calculation of effectiveness of screening

Storage of Solids: Bin and silos storage, Pressures in bins and silos, Flow out of bins

Conveyors: conveying equipment (Screw conveyors, Belt Conveyors, Chain and Flight conveyors, bucket elevators, pneumatic conveyors), Design calculation of Belt Conveyors

Mixing:Necessity of mixing and agitation in chemical industries,agitator selection, Calculation of power consumption in agitation, Mixers for cohesive solids, mixing equipment of free flowing solids, calculation of power requirement and mixing index of solid mixers

Size reduction and enlargement:Size reduction equipment,Crushing efficiency, Empirical relationships, Open circuit and closed circuit grinding, Nucleation and growth of particles

Separation of suspended solid particles from fluids:Froth flotation, magnetic separator, fiber and fabric filter, electrostatic precipitators, cyclone separator, hydro cyclone, Mineral jig, scrubbers, centrifuges, centrifugal clarifier

SECTION-1I

Topics and Contents

Motion of particles through fluids: Drag force, Drag coefficients, skin and form drag, Stoke's law, Newton's law, Criterion for settling regime, Free and hindered settling

Flow through packed beds:Void fraction, superficial velocity, channeling, Ergun equation and its derivation, Kozeny Carman equation, Burke-Plummer equation , Darcy's law and permeability, characteristics of fluidized systems, minimum fluidization velocity, types of fluidization, applications of fluidization technique, spouted beds and fixed bed

Filtration: Classification of filtration, Filter media and filter aids, filtration equipments, pressure drop through filter cake, filter medium resistance, specific cake resistance, continuous filtration, washing and dewatering of filter cakes , Centrifugal filtration

Membrane filtration: Classification, Nature of synthetic membranes, Cross flow microfiltration, Ultrafiltration, Reverse osmosis, Electro dialysis, Dialysis, Membrane Fouling

Gravity Settling Processes: Gravity classifier, sorting classifier, Clarifiers and thickeners, sedimentation, kynch theory of sedimentation, Design of thickeners

List of Tutorials: (Any Three)

1. Calculation of mixed particle sizes and size analysis.
2. Calculation of particle size distribution and mean average diameter.
3. Calculation of power requirement in crushing using crushing law.
4. Calculation of effectiveness of screening.
5. Calculation of criterion for settling and terminal velocity of particle.
6. Calculation of belt thickness, angle of idlers etc. for design of belt Conveyors.
7. Calculation of power requirement in agitation.
8. Calculation of minimum fluidization velocity.
9. Calculation of mixing index and standard deviation of solid mixing.
10. Calculation of area and depth of continuous thickener.

List of Practicals: (Any Six)

1. Cyclone Separator: To determine efficiency of cyclone separator. Properties of solids: To determine Avg. Particle size, Specific surface of mixture and No. of particles in the mixture
2. Screening: To determine the effectiveness of screen.
3. Sedimentation: To determine area of thickener by conducting batch sedimentation test
4. Centrifugal sedimentation of fine particles slurry.
5. Ball mill: To determine crushing law constant (by using Rittingers law, Bonds law and Kicks law).
6. Jaw Crusher: To determine crushing law constant (by using Rittingers law, Bonds law and Kicks law).
7. Vacuum Leaf Filter: To determine filter medium resistance and cake resistance by using vacuum leaf filter.
8. Fluidization: To determine minimum fluidization velocity and verify with Ergun Equation
9. Membrane separation
10. Drag Coefficient: To determine terminal settling velocity and compare with theoretical settling velocity

List of Projects:

1. Design of a filter
2. Design of gravity sedimentation process.
3. Design of fluidization process.
4. Design of conveyor (belt, chain,flight etc.)
5. Review on recent trends in filtration.
6. Plant design of STP.
7. Plant design of ETP plant.
8. Review on recent trends in gas-solid separation
9. Design of hydro-cyclone separator
10. Design of centrifugal and sedimentation process
11. Screen efficiency determination
12. Design of gas solid separator
13. Design of liquid- solid separator

List of Course Seminar Topics:

1. Properties of solids and it's effects on its performance
2. Screening equipments and factors affecting its effectiveness
3. Crushing equipments and their industrial applications
4. Grinding equipments and their industrial applications
5. Ultrafine grinding equipments and factors affecting their efficiency
6. Separation of solid from gases
7. Various conveyors used in transportation of bulk solids
8. Filtration operation and industrial filters
9. Sedimentation & batch sedimentation equipments

10. Fluidized bed and its applications

List of Course Group Discussion Topics:

1. Issues in Storage of solids and their remedies
2. Industrial screening equipments
3. Applications of screw conveyors and belt conveyors
4. Applications of chain conveyors and flight conveyors
5. Mixers used for cohesive solids and non cohesive solids
6. Open circuit versus closed circuit grinding
7. Selection and Optimization of Filter Aid , Filter Media and equipments
8. Membrane separation for gases
9. Membrane separation for liquids
10. Dialysis and electrodialysis

List of Home Assignments:

Design:

1. Thickener
2. Fluidized bed
3. Filtration unit
4. Belt conveyor
5. Membrane process

Case Study:

1. Importance of Particulate technology in Cement industry
2. Importance of Particulate technology in food industry
3. Importance of Particulate technology in pharmaceutical industry
4. Importance of Particulate technology in paint industry
5. Importance of Particulate technology in ceramic industry

Blog:

1. Membrane fouling and its remediation
2. Reverse osmosis and it’s advantages and drawbacks
3. Different filter media in filtration operation
4. Powder technology in glass industry
5. Powder technology in coal chemicals

Surveys:

1. Equipments used for centrifugal separations
2. Membrane separation in wastewater treatment
3. Equipments used for cross flow filtration
4. Membrane fouling and its remediation

5. Various Mixers used in industries

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	ESE	HA	LAB	CP	VIVA	SEM	GD
10	10	10	10	10	20	15	15

MSE - Mid Semester Examination
ESE - End Semester Examination
HA - Home Assignment
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar
GD - Group Discussion

Text Books: ***(As per IEEE format)***

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

Reference Books: ***(As per IEEE format)***

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

Moocs Links and additional reading material:

1. www.nptelvideos.in
2. https://swayam.gov.in/nd1_noc19_ch29/preview

Course Outcomes:

Student should be able to

1. Recognize basic principles of particle size measurement, bulk solid characteristics, screening and select suitable size reduction equipment.
2. Select suitable solid-solid, solid-fluid separation technique and storage tank.
3. Select and design suitable solid conveying system, agitators and solid-solid mixing process.
4. Design gas solid and liquid solid separation operation .
5. Describe concept of sedimentation and design sedimentation unit.
6. Describe concept of flow through packed bed and design fluidized bed

CO PO Map

CO /PO	PO :1	PO :2	PO :3	PO :4	PO :5	PO :6	PO :7	PO :8	PO :9	PO : 10	PO : 11	PO : 12	PSO: 13	PSO: 14
CO :1	1	2	2	2	2	2	2	2	2	2	0	2	1	2
CO :2	2	2	2	2	2	2	2	2	2	2	0	2	2	3
CO :3	2	2	2	2	2	2	2	2	2	2	0	2	2	3
CO :4	2	2	2	2	2	2	2	2	2	2	0	2	2	3
CO :5	2	2	2	2	2	2	2	2	2	2	0	2	2	2
CO :6	2	2	2	2	2	2	2	2	2	2	0	2	2	3

CO attainment levels

CO	Attainment level
CO:1	2
CO:2	3
CO:3	3
CO:4	5

CO:5	**4**
CO:6	**4**

Future Courses Mapping:

Nano technology, food and beverages technology, paint technology, separation technology

Job Mapping:

Particulate technology or powder technology plays vital role in the following industries: Coal chemicals, ceramics, Fertilizer, food and beverages, plastics, biomedical, explosives, paint, glass industry, nuclear industry, pharmaceuticals and aerospace

FF No. : 654

CH2204::PHYSICAL AND ORGANIC CHEMISTRY

Course Prerequisites: Fundamentals of Chemistry such as chemical bonding, physical and chemical changes, organic reactions, conventional and analytical tools and preliminary knowledge of concepts like AI.

Course Objectives:

1. To understand structure-activity relationship
2. To understand reaction mechanism
3. To study reaction kinetics
4. To study reaction thermodynamics
5. To study surface and electrochemical behavior of materials
6. To study theory and practice of modern analytical tools
7. To study application of AI and ML to Chemistry

Credits:.4.

Teaching Scheme Theory: 3 Hours/Week
Tut: 0 Hours/Week
Lab: 2 Hours/Week

Course Relevance:

The study of the subject will help understand chemistry and mechanism underlying physical and chemical changes in the reactions brought about in industry. Moreover, an understanding about synthesis, characterization and application of state-of-the-art tools like AI & Machine learning in Chemistry too will take place which is vital from an industrial point of view.

SECTION-1

Chemical Kinetics, Surface Chemistry, Electrochemistry

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

Electrochemistry**:**Equilibrium properties of electrolyte, Electrode potentials and applications, Electrochemical and Electro-analytical techniques, Bio electrochemistry.

SECTION-1I

Bonding, Reactions, Stereochemistry, safety, Biocatalysis& Instrumental analysis

Organic Chemistry:Electronic structure and Bonding, Acids and bases, Acidity and basicity of organic compounds, pKa and pK_b terms. Basics of Chemical Safety Engineering, Chemical Hygiene and Material Handling. Formation of Aliphatic Carbon-Carbon Bonds: Base Catalyzed Reactions, Formation of Aliphatic Carbon-Carbon Bonds: Acid Catalyzed Reactions, Electrophilic Aromatic Substitution, Nucleophilic Aromatic Substitution, Molecular Rearrangements, Organometallic Reagents. Stereochemistry: Basic concepts of Stereochemistry, conformational isomerism of ethane, propane, butane, cyclohexane. Optical isomerism. Resolution and diastereoselectivity. Heterocyclic compounds: Structure and synthesis. Synthesis of Some Naturally Occurring Compounds. Instrumental method of chemical analysis, Introduction to biocatalysis& biotransformation. Retrosynthetic biocatalysis, Applications of Computers in Chemistry - Introduction to Artificial Intelligence and Machine learning Algorithms, Quantitative structure-activity relationships and a glance at futuristic modeling techniques.

List of Practicals: (Any Six)

1. Study of adsorption of acetic acid on activated charcoal from solution.
2. To standardize $Na_2S_2O_3$ solution by preparing $K_2Cr_2O_7$ and to estimate percentage of Cu from brass.
3. To study the effect of concentration of the reactants on the rate of hydrolysis of an ester and study of kinetics of the reaction.
4. Determination of strength of HCl solution by titrating against NaOH using P^Hmetry.
5. Calculation of Heat of reaction using calorimeter.
6. Determination of the amount of glucose in the solution by hypoiodite method.
7. Determination of the amount of acetamide in the solution.
8. Oxidation of an organic compound using oxidizing agent- Theory explanation, and analysis of product.
9. Synthesis of p-nitroacetanilide from acetanilide– Theory explanation, and analysis of product.
10. Methyl orange- Theory explanation and analysis of product.

List of Projects:

1. Project on kinetics of chemical reaction determination.
2. Project on waste water treatment.
3. Project on organic compound preparation and analysis.
4. Project on extraction of organic compounds.
5. Project on alternate method determination of organic compound synthesis.
6. Project on biocatalyst application for different chemical processes.
7. Alcohol from Potatoes and Agriculture Waste
8. Caffeine from Waste Tea and Coffee
9. Food dyes and their chemistry
10. Environmental toxicology
11. Pesticides and their chemical influence
12. Climate chemistry
13. Synthesis and characterization of natural products
14. Developing novel synthetic methodologies for bioactive complex molecules
15. Combining organic chemistry, engineering, and biology to solve problems in medicinal chemistry

List of Course Seminar Topics:

1. Biocatalysts for industrial application
2. Adsorption isotherms - their merits and limitations
3. Study of Correlation between chemical kinetics and thermodynamics of selective reactions
4. Application of electroanalytical tools in characterizations of sample matrices
5. Study of effect of surface chemistry of materials on properties and applications
6. Organometallic reagents and their applications in selective reactions
7. Retrosynthetic biocatalysis and its applications
8. Synthesis and applications of naturally occurring compounds
9. Applications of computers in Chemistry
10. Modern analytical techniques vis-a-vis classical techniques

List of Course Group Discussion Topics:

1. Chemistry as a subject and as a central science
2. Scientific Measurements and their Importance in Chemistry
3. Measurement of physical quantities using appropriate instruments
4. Enthalpy changes in some physical and chemical processes
5. Similarities between transition metals and representative metals
6. Experimental determination of order of reaction
7. Dynamic nature of chemical equilibrium and applications of equilibrium constant
8. Separation and purification of organic compounds
9. Contribution of alkanes to the Greenhouse effect
10. Ecological threats - causes and effects
11. Industrial waste - cause, effect, treatment
12. Biocatalysts - advantages & limitations
13. Machine learning for process design, optimization, structural elucidation

List of Home Assignments:

Design:

1. Semi-batch/batch reactor for Cu metal nanoparticles synthesis
2. Method development for following kinetics of a reaction using spectroscopy
3. Designing a catalyst and its application
4. Analytical method/technique
5. Machine learning Algorithm for chemical mapping

Case Study:

1. A case study on Innovative catalysts for family of reactions
2. Kinetics and thermodynamics study of biocatalyzed reaction
3. Retrosynthesis in chemical industry
4. Application of AI elucidation of structure of molecules
5. Green synthesis, characterization and applications of nanocatalysts

Blog:

1. Chemical catalysis vis-a-vis Biocatalysis
2. Comparative advantages of modern analytical tools over classical tools
3. Naturally occurring compounds of industrial importance
4. Effect of surface chemistry on catalytic activity
5. Artificial Intelligence - most sought after tool for chemists

Surveys:

1. Functionlized catalysts for industrial applications
2. Kinetic study of biocatalyzed reactions
3. Spectroscopic examination of organic reactions
4. Electrochemical analytical tools for following chemical catalyzed reactions
5. Application of AI in chemical mapping

Suggest an assessment Scheme:

MSE	ESE	HA	LAB	CP	VIVA	SEM	GD
10	10	10	10	10	20	15	15

MSE - Mid Semester Examination

ESE - End Semester Examination

HA - Home Assignment

VIVA - Viva voice

SEM – Seminar

GD – Group Discussion

CP – Course Project

Text Books: ***(As per IEEE format)***

1. B. H. Puri and L.R Sharma.; Principles of Physical Chemistry, 7th Edition, S. Chand Company, New Delhi, 1994.
2. G. M Barrow.; Physical Chemistry, 6th Edition, Tata McGraw Hill, 1998.
3. B.K.Sharma; Instrumental method of analysis, 6th Edition, Goel Publishing House, 1995.
4. J.Clayden, N.Greeves, S.Warren, P, Wothers; Organic Chemistry, 3rd Edition, Oxford University Press.
5. ZdzislawHippe; Artificial Intelligence in Chemistry - Structure elucidation and simulation of organic reactions. 6the edn, Elesevier

Reference Books: ***(As per IEEE format)***

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

Moocs Links and additional reading material:

1. www.nptelvideos.in
2. https://www.coursera.org/learn/physical-chemistry
3. https://www.coursera.org/learn/spectroscopy
4. https://www.coursera.org/learn/basic-chemistry
5. https://www.coursera.org/learn/high-throughput
6. https://www.coursera.org/learn/thermodynamics-intro
7. https://www.mooc-list.com/course/machine-learning-coursera
8. https://www.classcentral.com/course/udacity-introduction-to-artificial-intelligence-301

Course Outcomes:

1. Find out the rate of chemical reaction and different kinetic parameters e.g. order or reaction, michaelismenten kinetics and rate constant etc.
2. Get adsorption isotherms and its study e.g. surface area determination Find out the structure and catalytic properties of metals etc.
3. Find out different thermodynamic parameters of chemicals. Calculation and application of virial equations to calculate volumetric parameters.
4. To select the reagents and physical and chemical conditions to carry out the desired reaction.
5. Get the stereo chemical structure and optical activity of organic compounds, synthesis mechanism of heterocyclic compounds and spectro-photochemical behavior of organic compounds.
6. Find out the effect of solvents on the reaction rate, the product formation and synthesis mechanism of some natural compounds.

CO PO Map

co/ po	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12	pso13	pso14
co1	1	2	1	0	1	1	1	2	1	2	1	0	0	0
co2	1	1	1	1	2	2	1	1	1	1	1	1	2	1

co3	**2**	**3**	**1**	**1**	**2**	**1**	**2**	**1**	**1**	**3**	**1**	**0**	**0**	**0**
co4	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**2**	**2**
co5	**2**	**1**	**1**	**2**	**0**	**1**	**2**	**1**	**2**	**1**	**1**	**0**	**0**	**0**
co6	**1**	**1**	**1**	**0**	**1**	**1**	**2**	**1**	**2**	**1**	**1**	**1**	**2**	**1**

CO attainment levels

CO	Attainment Level
1	**4**
2	**5**
3	**4**
4	**4**
5	**4**
6	**3**

Future Courses Mapping:

Advanced Physical Chemistry
Advanced Organic Chemistry
Application of AI to Chemical sciences

Job Mapping:

Chemists, Analysts, Process designer,

FF No. : 654

CH2282::ENGINEERING DESIGN AND INNOVATION IV

Course Prerequisites: Basic principles of physics, mathematics, chemistry, heat transfer

Course Objectives:

The Students will be able to

1. Do literature search appropriately with available tools
2. Defining of project title/idea
3. Allocation of tasks among the team members
4. Team spirit development
5. Write a report, research paper with required format
6. Present work effectively with concrete results

Credits: 04 **Teaching Scheme Theory: 0** Hours/Week

Tut: 0 Hours/Week

Lab: **8** Hours/Week

Course Relevance:

Engineering Design and development is specially design part of curriculum, that will facilitate application of theory concept in practice. This is project based learning experience. As in practical situation, where first project is defined and then respective required skilled are learned to accomplish the project. We are making student ready to face and approach actual problem.

SECTION-1&II
Topics and Contents This stage will include a complete report consisting of synopsis, the summary of the literature survey carried out, Details of experimental/theoretical work and results and discussion and conclusion. Students may undertake studies in application chemical engineering knowledge for manufacturing project, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of this work. The group of students is required to choose the topic in consultation with the Guide. A technical report of 15 pages is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation.

The external from Industry/research organization is invited to evaluate the projects done by students.

List of Project areas:

1. Agriculture
2. Personal Health
3. Social health
4. Hygiene
5. Energy
6. Environment
7. Potable Water
8. Solar based
9. Modeling and Simulation
10. Wastewater treatment
11. Air pollution
12. Solid waste management
13. Low cost product development

Suggest an assessment Scheme:

Assessment of Engineering Design and Innovation project includes three reviews spread across 4 months, where research innovative ideas, strategy of execution, actual execution, teamwork is assessed.

Every review is based on report writing, presentation of results and team work demonstration.

Two reviews are with internal faculty members
Third review is with an external industry expert.

Review 1: Literature search and deciding appropriate topic
Review 2: Progress of work on decided topic i.e setting experimental setup, developing methodology of solving the opted problem.
Review 3: Overall assessment of project work with team efforts.

Moocs Links and additional reading material:

1. www.nptelvideos.in
2. https://nptel.ac.in/courses/103/103/103103039/#watch
3. https://www.honeywellprocess.com/en-US/explore/solutions/integrated-technology/Pages/leap.aspx
4. https://www.gtu.ac.in/uploads/GIC%20Compendium%20IDP-UDP.pdf
5. https://www.udemy.com/course/leadership-psychology-cultivate-creativity-and-innovation/
6. https://www.coursera.org/learn/uva-darden-project-management
7. https://www.coursera.org/specializations/innovation-creativity-entrepreneurship

Course Outcomes:

The student will be able to –

1. Apply chemical engineering knowledge.
2. Work in a team.
3. Define a task (problem) and execute it.
4. Carry out literature search related to topic.
5. Write synopsis and complete literature search related to topic and complete report.
6. Present the outcome of work systematically in a team and write report

CO PO Map

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	3	1	1	1	0	1	1	1	1	1	1	1	1	1
CO2	0	0	0	0	0	0	0	2	3	1	3	1	0	0
CO3	3	1	1	1	1	1	1	1	1	1	1	1	1	1
CO4	1	3	1	1	1	1	1	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1	1	3	1	1	1	1
CO6	1	1	1	1	1	1	1	1	1	2	1	1	1	1

CO attainment levels

CO	Attainment level
1	2
2	3
3	3
4	5
5	5
6	4

Future Courses Mapping:

Next semester project, BTech course project

Job Mapping:

What are the Job opportunities that one can get after learning this course ?

1. Core Chemical Engineering industrial job
2. Chemical Engineering Design job
3. Chemical Engg. research jobs

B.Tech. Chemical Structure Pattern C21 (applicable w.e.f. AY 21-22)

Third Year Module – V

Subject head	Course code	Course name	Contact hours per week		
			Theory	Lab	Tut
S1	CH3211	HEAT TRANSFER	3	2	1
S2	CH3213	CHEMICAL ENGINEERING THERMODYNAMICS	3	2	1
S3	CH3215	CHEMICAL REACTION KINETICS	3	2	1
S4	CH3217	MASS TRANSFER OPERATIONS	3	2	-
S5	CS3231	ENGINEERING APPLICATIONS OF DATA SCIENCE	3	2	1
S6	CH3281	ENGINEERING DESIGN AND INNOVATION – V	-	8	-
		Total	15		3

Third Year Module – VI

Subject head	Course code	Course name	Contact hours per week		
			Theory	Lab	Tut
S1	CH3202	INSTRUMENTATION AND PROCESS CONTROL	3	2	1
S2	CH3205	PROCESS EQUIPMENT DESIGN	3	2	1
S3	CH3203	SEPARATION TECHNIQUES	3	2	1
S4	CH3201	CHEMICAL REACTION ENGINEERING	3	2	0
S5	CS3232	ENGINEERING APPLICATIONS OF DATA SCIENCE PROJECT	-	10	-
S5	CH3282	ENGINEERING DESIGN AND INNOVATION – VI	-	8	-
		Total	12		3

FF No. : 654

CH3211::HEAT TRANSFER

Course Prerequisites:

Course Objectives:

1. Distinguish between mechanisms of heat transfer and derive basic heat transfer equations from first principles.
2. Solve convection heat transfer problems.
3. Solve boiling and condensation problems.
4. Solve radiative heat transfer problems
5. Design simple heat exchangers
6. Solve basic evaporator calculations

Credits:5 **Teaching Scheme Theory:3** Hours/Week

Tut:1 Hours/Week

Lab: **2** Hours/Week

Course Relevance:

SECTION-1
Introduction to heat transfer, heat transfer mechanisms: conduction, convection and radiation heat transfer, conduction heat transfer law, Steady state heat conduction through composite slab, cylinder, sphere, critical thickness of insulation, unsteady state heat conduction: Lump heat parameter model, dimensional analysis : Rayleigh's and Buckingham's method, Newton's law of cooling, heat transfer correlations in natural and forced convection systems, Heat transfer from extended surfaces/fins, Boiling Heat Transfer, condensation Heat Transfer, Nusselt's theory, condensation on vertical/horizontal plate and cylinder, condensation on bank of horizontal tubes.
SECTION-1I

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

List of Practicals: (Any Six)

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

List of Course Projects:

1. Analysis of heat exchangers performance in double pipe heat exchanger
2. A project on design of heat exchanger or evaporator
3. Determination critical heat flux in pool boiling
4. Heat Transfer Analysis of Engine Cylinder Fins Having Triangular Shape
5. Design of Solar air cooler with heater
6. CFD analysis of double pipe heat exchanger
7. Study of evaporators
8. Design of Critical insulation for cylindrical geometry
9. Design of Critical insulation for spherical geometry
10. 2D Numerical analysis of 2 dimensional conduction problem.
11. Dimensional analysis of experimental data from conduction process
12. Dimensional analysis of experimental data from convection process
13. Dimensional analysis of experimental data from radiation process
14. Data fitting for conduction process
15. Data fitting for convection process

List of Course Seminar Topics:

1. Conduction basic understanding, significance in practical world with case study
2. Convection basic understanding, significance in practical world with case study
3. Radiation basic understanding, significance in practical world with case study
4. Critical insulation estimation in cylindrical geometry
5. Critical insulation estimation in spherical geometry
6. Pool boiling study with critical flux and other regions
7. Condensation process study with case study
8. Heat transfer with extended surfaces, need, significance and application
9. Boiling point elevation significance in evaporators
10. Evaporators for chemical industry with case study
11. Radiation for cosmos
12. Heat transfer studies in nuclear reactor
13. Theoretical study of heat exchanger with NTU method
14. Multiple effect evaporators
15. Types of heat exchanger and type of heat transfer modes involved.

List of Course Group Discussion Topics:

1. Best mode of heat transfer for liquid liquid system
2. Best mode of heat transfer for Solid solid system
3. Best mode of heat transfer for liquid solid system
4. Critical insulation critical parameter for insulation of Chemical equipments
5. Non-dimensional number need in convection
6. Usefulness of non dimensional number in critical insulation
7. Radiation crucial heat transfer process
8. Radiation in nuclear reactor: crucial process
9. Nuclear reactor accident, role of heat transfer
10. Need of passive cooling in nuclear reactor
11. Heat transfer analysis of Chernobyl nuclear reactor accident
12. Heat transfer analysis of Fukushima Nuclear Disaster nuclear reactor accident
13. Windscale Fire Nuclear Disaster
14. Three Mile Island Nuclear Accident
15. Kyshtym NuclearDisaster.

List of Home Assignments:

Design:

1. Design of water heater
2. Design of furnace
3. Design of insulation thickness
4. Design of multiple effect evaporator
5. Basic design of heat exchanger
6. Design of solar heater

Case Study:

1. Multiple effect evaporator in sugar industry
2. Multiple effect evaporator in
3. Radiation across the planets
4. Furnace heat transfer
5. Salt based power plant heat transfer

Blog:

1. Fukushima Nuclear Disaster nuclear reactor accident
2. Windscale Fire Nuclear Disaster
3. Three Mile Island Nuclear Accident
4. Kyshtym Nuclear Disaster.
5. Multiple effect evaporator

Surveys:

1. Heat transfer in solar power plant
2. Heat transfer in thermal power plants
3. Study on heat transfer in furnaces
4. Survey of convection heat transfer in heat exchanger
5. Survey on heat transfer in condensation process
6. Survey on heat transfer in boiling system

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	***ESE***	***HA***	***LAB***	***CP***	***VIVA***	***SEM***	***GD***
10	***10***	***10***	***10***	***10***	***20***	***15***	***15***

MSE - Mid Semester Examination
ESE - End Semester Examination
HA - Home Assignment
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar
GD - Group Discussion

Text Books: ***(As per IEEE format)***

1. D. Q. Kern, Process Heat Transfer,
2. MCabe and Smith, Unit Operation of Chemical Engineering, MCgraw Hill, 7th Edition
3. John Leinherd, Heat transfer, Plogiston press

Reference Books: ***(As per IEEE format)***

1. Richardson and Coulson, Chemical Engineering Design (Vol-6)
2. Eduardo Cao, Heat transfer in process engineering, MCgraw hill, 6th Edition

Moocs Links and additional reading material:

1. www.nptelvideos.in
2. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785
3. https://www.youtube.com/watch?v=ACjR7MIFaFw&list=PL5F4F46C1983C6785&index=3
4. https://www.youtube.com/watch?v=gIf-aIZz7-0&list=PL5F4F46C1983C6785&index=6
5. https://www.youtube.com/watch?v=bkWw7o45JmI&list=PL5F4F46C1983C6785&index=8
6. https://www.youtube.com/watch?v=qsombY4Q7ZY&list=PL5F4F46C1983C6785&index=9
7. https://www.youtube.com/watch?v=atQ-SWZFWF4&list=PL5F4F46C1983C6785&index=13
8. https://www.youtube.com/watch?v=63bKIq0Xwbw&list=PL5F4F46C1983C6785&index=17

Course Outcomes:

The student will be able to –

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

CO PO Map

CO/ PO	PO: 1	PO: 2	PO: 3	PO: 4	PO: 5	PO: 6	PO: 7	PO: 8	PO: 9	PO: 10	PO: 11	PO: 12	PSO :13	PSO :14
CO:	2	1	2	2	2	1	1	2	2	2	0	1	2	1

1														
CO: 2	**2**	**1**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**0**	**1**	**3**	**1**
CO: 3	**2**	**1**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**0**	**1**	**3**	**1**
CO: 4	**2**	**1**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**0**	**1**	**3**	**1**
CO: 5	**2**	**1**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**0**	**1**	**3**	**1**
CO: 6	**2**	**1**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**0**	**1**	**3**	**1**

CO attainment levels

CO	**Attainment level**
CO:1	**3**
CO:2	**3**
CO:3	**3**
CO:4	**4**
CO:5	**5**
CO:6	**5**

Future Courses Mapping:

Mass Transfer , Chemical Reaction Engineering , Transport Phenomena

Job Mapping:

1. Core Chemical Engineering industrial job
2. Chemical Engineering Design job
3. Chemical Engg. research jobs

FF No. : 654

CH3213::CHEMICAL ENGINEERING THERMODYNAMICS

Course Prerequisites:

Course Objectives:

1. To understand thermodynamic properties of pure fluids
2. To understand thermodynamic properties of solution and application
3. To understand thermodynamic phase equilibria
4. To understand thermodynamic chemical reaction equilibria

Credits:5 **Teaching Scheme Theory:3** Hours/Week

Tut:1 Hours/Week

Lab: 2 Hours/Week

Course Relevance:

SECTION-1
Thermodynamic Properties of Fluids: The fundamental property relations for homogeneous phases, Maxwell relationships, relations between thermodynamic properties, residual properties, residual properties by equations of state, two-phase systems, Thermodynamic diagrams Solution Thermodynamics and applications: Single phase mixtures and solutions; ideal solutions; partial molar properties; chemical Potential, effect of temperature and pressure on chemical potential, fugacity and fugacity Coefficient – pure species and species in solution, activity and activity coefficient, ideal solution Model, Non-ideal Solutions; excess Properties; generalized correlation for fugacity coefficient, activity coefficient models, Gibbs-Duhem equation; criteria for thermodynamic equilibrium; models for the excess Gibbs energy, property changes of mixing, heat effects of mixing Process
SECTION-1I

Phase Equilibria: The nature of equilibrium, criteria of phase equilibrium, Phase rule, Duhem's Theorem, Introduction to VLE, Raoult's law, VLE by modified Raoult's law, dew point and bubble point calculations, flash calculations, determine whether azeotrope exist, Equilibrium and stability, Introduction to liquid -liquid equilibrium (LLE), vapor – liquid – liquid equilibrium (VLLE), solid liquid equilibrium (SLE) and solid vapor equilibrium (SVE), equilibrium, adsorption of gases on solids

Chemical Reaction Equilibria: The reaction coordinates, criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant, effect of temperature on equilibrium constant, evaluation of the equilibrium constant, relation of equilibrium constant to composition, calculation of equilibrium conversion for single reaction, Phase rule and Duhem's theorem for reacting systems.

List of Practicals: (Any Six)

1. To derive and apply of Maxwell's Relation
2. To apply Clapeyron equation and Clausius Clapeyron equation
3. Determine thermodynamic properties like internal energy, enthalpy for pure fluids
4. To determine residual properties of gases
5. To determine fugacity and activity
6. To determine activity coefficient
7. To determine thermodynamic properties of solution
8. To determine excess property of solution
9. To determine property changes of mixing of solution
10. To carry out flash calculation for binary system
11. To generate VLE data
12. To generate LLE data
13. To determine equilibrium constant for chemical reactions
14. Case Study of chemical plant

List of Course Projects:

1. Analysis of system containing pure fluids/solution.
2. Verification of experimental data
3. Bubble point and dew point calculation for binary system
4. Property changes of mixing
5. Flash calculations
6. Prediction of azeotrope formation
7. Analysis of phase equilibria
8. Analysis of chemical reaction equilibria
9. Determination of equilibrium conversion
10. Study of non-ideal solutions
11. Solid liquid equilibrium (SLE)
12. Solid vapor equilibrium (SVE).

List of Course Seminar Topics:

1. Evaluating thermodynamics properties of real fluids – a step ahead of ideal systems.
2. Fugacity – an interesting character in thermodynamics.
3. Relevance of property changes of mixing.
4. Importance of chemical engineering thermodynamics in plant simulation
5. Usefulness of excess properties
6. Understanding interesting aspects of Entropy and its importance in thermodynamics.
7. Chemical potential from different point of view.
8. Fundamental property relations and its usage.
9. Energy properties and its estimation – A perspective.
10. Understanding thermodynamic diagrams.
11. Understanding thermodynamic cycles and Entropy.
12. Importance of Residual properties in understanding real fluids.
13. Applications of chemical engineering thermodynamics
14. Understanding the concept of Non – Ideality
15. Gibbs duhem equations and its utility.

List of Course Group Discussion Topics:

1. Equilibrium constant and Chemical Reaction equilibria
2. Which Models for activity coefficient?
3. Understanding Phase equilibria complexity of single to multicomponent systems
4. Property changes of mixing and Excess properties in understanding solutions
5. Vapour-Liquid Equilibria - an outlook
6. Thermodynamics of Chemical reactions
7. Phase Equilibria and its usage
8. Vapour liquid equilibria of non ideal solutions
9. Role of Phase diagrams to understand equilibria
10. Understanding role of equilibrium constant
11. Chemical reaction Equilibria - an outlook
12. Activity Coefficient in thermodynamics
13. Vapour-Liquid Equilibria - applications
14. Importance of Equilibrium constant and equilibrium yield
15. Study of parameters affecting chemical equilibrium

List of Home Assignments:

Design:

1. Thermodynamic data for distillation column design
2. Thermodynamic data for reactor design
3. Thermodynamic data for overall plant design
4. Thermodynamic data for flash calculations

Case Study:

1. Simulation of chemical reaction equilibria
2. Activity coefficient models in thermodynamic packages
3. Techniques used for estimating the temperature of earth's interior
4. Effects of physical properties estimation on process design

Blog:

1. Importance of prediction on thermodynamic properties
2. Connect of chemical engineering thermodynamics to society
3. Chemical reaction equilibria in chemical industry
4. Phase equilibria - a perspective

Surveys:

1. Chemical reactions confined within carbon nanotubes
2. Thermodynamic properties of aromatic hydrocarbon mixtures
3. Chemical reactions in sugar manufacturing
4. Thermodynamic properties of aliphatic hydrocarbon mixtures

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	ESE	HA	LAB	CP	VIVA	SEM	GD
10	10	10	10	10	20	15	15

MSE - Mid Semester Examination
ESE - End Semester Examination
HA - Home Assignment
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar
GD - Group Discussion

Text Books: ***(As per IEEE format)***

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

Prentice-Hall of India Pvt. Ltd.

Reference Books: ***(As per IEEE format)***

1. B. G. Kyle; Chemical and Process Thermodynamics; Third Edition, Prentice Hall, New Jersey, 1999.
2. S. I. Sandler; Chemical and Engineering Thermodynamics; Third edition, John Wiley, New York, 1999.
3. O. A. Hougen, K. M. Watson, R. A. Ragatz; Chemical Process Principles Part II, Thermodynamics; John Wiley 1970
4. R. Reid, J. Praunitz, T. Sherwood; The Properties of Gases and Liquids; Third edition, McGraw-Hill, New York, 1977

Moocs Links and additional reading material:

www.nptelvideos.in

Course Outcomes:

The student will be able to –

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

CO PO Map

CO/ PO	PO: 1	PO: 2	PO: 3	PO: 4	PO: 5	PO: 6	PO: 7	PO: 8	PO: 9	PO: 10	PO: 11	PO: 12	PSO :13	PSO :14
CO: 1	2	2	2	2	2	1	1	2	2	2	0	1	2	1
CO: 2	2	2	2	2	2	1	1	2	2	2	0	1	3	1
CO:	2	2	2	2	2	1	1	2	2	2	0	1	3	1

3														
CO: 4	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**0**	**1**	**3**	**1**
CO: 5	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**0**	**1**	**3**	**1**
CO: 6	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**0**	**1**	**3**	**1**

CO attainment levels

CO	Attainment level
CO:1	**4**
CO:2	**4**
CO:3	**5**
CO:4	**5**
CO:5	**5**
CO:6	**5**

Future Courses Mapping:

Separation Techniques, Process Equipment Design

Job Mapping:

3. Core Chemical Engineering industrial job
4. Chemical Engineering Design job
5. Chemical Engg. research jobs

FF No. : 654

CH3215::MASS TRANSFER OPERATION

Course Prerequisites:

Course Objectives:

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

Credits:5 **Teaching Scheme Theory:3** Hours/Week

Tut:1 Hours/Week

Lab: 2 Hours/Week

Course Relevance:

SECTION-1
Introduction to Mass Transfer and Molecular Diffusion: Introduction to Mass Transfer Operations. Molecular Diffusion in gases and liquids, diffusivities of gases and liquids, types of diffusion, Fick's and Maxwell law of diffusion, Measurement of liquid-phase diffusion coefficient, Concept of diffusivity, diffusivity of liquids, Eddy diffusion, film theory, penetration theory, surface renewal theory, Steady state diffusion. mass transfer coefficients, Mass, heat and momentum transfer analogies. ; Interphase mass transfer, local two phase mass transfer, overall mass-transfer coefficient, average overall coefficient, steady state co-current and countercurrent processes, Continuous co- current and counter current processes, cascades, batch processes, Stages and mass transfer rates. Gas- liquid operations and Equipment for Mass Transfer, Overall mass transfer coefficient, Gas dispersal equipments – bubble columns, Liquid dispersal equipments – Venturi scrubbers, wetted wall columns. Gas dispersed Sparged vessels – flow of gas velocity problems based on aeration tank as a time for sparging Gas hold up. Liquid hold up – determination of interfacial area based on hold up and MTC. Tray tower versus packed tower
SECTION-1I

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

List of Practicals: (Any Six)

1. Study diffusion of liquid into a gas in a vertical pipe and calculate mass transfer coefficient.
2. Study steady state diffusion of acetone in air and calculate diffusivity.
3. To study characteristics of tray dryer and calculate rate of drying.
4. To study steady state molecular diffusion of acetic acid through water and determine diffusivity.
5. To determine efficiency of rotary dryer.
6. To study characteristics of cooling tower for efficiency and relative cooling.
7. To calculate mass transfer coefficient for absorption of CO2 into NaOH solution.
8. To calculate mass transfer coefficient for absorption of CO2 into water.
9. To determine mass transfer coefficient for air-water system during humidification and de- humidification process.
10. To study crystallization to find yield.
11. Study diffusion of solid into a liquid and calculate mass transfer coefficient
12. Any two experiments from above syllabus using virtual lab.

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List of Course Projects:

1. Design of tray dryer
2. Design of rotary dryer
3. Design of plate column stripper
4. Design of packed column stripper
5. Design of tray tower absorber
6. Design of packed tower absorber
7. Design of cooling tower
8. Design of batch crystallizer
9. Design of forced circulation crystallizer
10. Data analysis of diffusion of solid into liquid
11. Data analysis of diffusion of liquid into gas
12. Data analysis of diffusion of liquid into liquid

List of Course Seminar Topics:

1. Diffusion process of daily phenomena
2. Diffusion process study for industrial processes.
3. Diffusion process study for biological processes.
4. Diffusion process study for pharmaceutical processes.
5. Study of interphase mass transfer in regular observable process.
6. Study of interphase mass transfer in industrial processes.
7. Study of absorber with respect to mass transfer.
8. Study of dryer for mass transfer.
9. Study of crystalliser for mass transfer.
10. Study of stripper for mass transfer.
11. Study of absorber for highly soluble gases.
12. Selection criteria for absorber
13. Study of different dryers
14. Study of different crystallisers
15. Role of mass transfer coefficient in mass transfer

List of Course Group Discussion Topics:

1. Mass Transfer essential part over heat transfer in given process
2. Molecular verses convective diffusion.
3. Interphase mass transfer key study for 2 or more phases and component system
4. Mass Transfer coefficient important to decide efficacy of process
5. Absorber crucial part for environment verses economy of process
6. Is mass transfer consideration crucial for nuclear system
7. Is mass transfer crucial for pharmaceutical industry
8. Selection appropriate dryer for low moisture content process
9. Selection of appropriate dryer for high moisture content product
10. Selection of crystalliser for low solid content magma
11. Selection of crystalliser for high solid content in magma
12. Operating window for distillation column
13. Operating window for absorber
14. Mass transfer in microchannels
15. Mass transfer in nanofluids

List of Home Assignments:

Design:

1. Design of absorber
2. Design of interphase mass transfer equipment
3. Design of Crystalliser
4. Design of dryer
5. Designing mass transfer system for one diffusing and other non-diffusing component
6. Designing mass transfer system for counter diffusing components
7. Deciding mass transfer coefficient for efficient system

Case Study:

1. Case study of interphase mass transfer system
2. Case study on dryer
3. Case study on absorber
4. Case study on crystalliser
5. Case study on diffusion process

Blog:

1. Molecular diffusion and convective diffusion efficacy
2. Interphase mass transfer key parameter to gauge efficacy of process
3. Absorber effective medium for reducing pollution
4. Drying crucial for preservation of substance
5. Crystalliser important for pure product

Surveys:

1. Mass transfer in Pharmaceutical industry
2. Role of interphase mass transfer in Petroleum industry
3. Humidity monitor crucial in drying process.
4. Efficient dryer for multipurpose.
5. Versatile crystalliser

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	ESE	HA	LAB	CP	VIVA	SEM	GD
10	10	10	10	10	20	15	15

MSE - Mid Semester Examination
ESE - End Semester Examination
HA - Home Assignment
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar
GD - Group Discussion

Text Books: ***(As per IEEE format)***

1. Robert Trybal, Mass Transfer operation, Edition 5, Mcgraw hill publication
2. McCabe, W. L.; Smith, J. C.; Harriett, .;Unit Operations of Chemical Engineering, 4th Edition, McGraw-Hill.

Reference Books: ***(As per IEEE format)***

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

Moocs Links and additional reading material:

www.nptelvideos.in

Course Outcomes:

The student will be able to –

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

CO PO Map

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CO: 3	2	1	2	2	2	1	1	2	2	2	0	1	3	1
CO: 4	2	1	2	2	2	1	1	2	2	2	0	1	3	1
CO: 5	2	1	2	2	2	1	1	2	2	2	0	1	3	1
CO: 6	2	1	2	2	2	1	1	2	2	2	0	1	3	1

CO attainment levels

CO	Attainment level

CO:1	**4**
CO:2	**4**
CO:3	**4**
CO:4	**5**
CO:5	**5**
CO:6	**5**

Future Courses Mapping:

Separation Techniques, Chemical Reaction Engineering, Transport Phenomena

Job Mapping:

1. Core Chemical Engineering industrial job
2. Chemical Engineering Design job
3. Chemical Engg. research jobs

FF No. : 654

CH3217::CHEMICAL REACTION KINETICS

Course Prerequisites: Knowledge of basics of chemistry and mathematics

Course Objectives:

1. To study chemical reaction kinetics of homogeneous reactions
2. To study different types of chemical reactors used in industries
3. To learn design of reactors used for homogeneous reactions
4. To study multiple reactor system and their selection
5. To optimise the parameters like temperature and pressure for reactions

Credits:5 **Teaching Scheme Theory:3** Hours/Week

Tut:1 Hours/Week

Lab: 2 Hours/Week

Course Relevance:

SECTION-1
Homogeneous reaction kinetics and design of Ideal reactors Elementary and non elementary reactions, Stoichiometry, Fractional conversion, Rate of reaction based on all components of the reaction and their interrelation, Law of mass action, Rate Constant-Based on thermodynamic activity, partial pressure, mole fraction and concentration of the reaction components and their interrelation, Temperature dependency of rate Constant - Arrhenius law, Transition state theory and collision theory. Batch reactor concept- Constant volume Batch reactor system; Design equation for zero, first, Second irreversible and reversible reactions, graphical interpretation of these equations and their limitations, Variable volume Batch reactors. Design equation for first and second order irreversible and reversible reactions, graphical interpretation of their limitations, Multiple reactions- Stoichiometry and rate equations for series and parallel reactions, Ideal reactors- Concept of ideality, Types of flow reactors and their differences, Design equations for ideal reactor, Enzyme and microbial fermentors, Industrial scale reactors
SECTION-1I

Multiple reactor systems and Temperature and Pressure Effects

Multiple reactor systems- Size comparison of reactors, Optimum size determination, Staging of reactors, Flow reactors in series and parallel, Performance of infinite number of back mix reactors in series, Back mix and plug flow reactors of different sizes in series and their optimum way of staging; Recycle reactors- Optimum recycle ratio for auto-catalytic (recycle) reactors ,Yield and selectivity, Parallel reactions, best operating conditions for mixed and plug flow reactors, irreversible Series reactions, Effect of temperature and pressure- Equilibrium Conversion, Optimum temperature progression, Isothermal, Adiabatic and non isothermal operations, Temperature and conversion profiles for exothermic and endothermic reactions

List of Tutorials:

Problems based on

1. Rate law determination using reaction mechanism
2. Kinetic parameters determination using integral method for irreversible and reversible reactions
3. Kinetic parameters determination using differential method for complex reactions
4. Design of batch and flow reactors for constant volume system
5. Design of batch and flow reactors for variable volume system
6. Determination of best size for a given conversion considering maximization of rectangles
7. Design of recycle reactors
8. Quantitative treatment about product distribution and reactor size for parallel reactions
9. Quantitative treatment about product distribution and reactor size for series reactions
10. Optimal temperature progression for adiabatic operation

List of Practicals: (Any Six)

1. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in batch reactor – I (Where M=1)
2. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in straight tube, coli Bent Tube reactor and PFR
3. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in mixed flow reactor.
4. Verification of Arrhenius law
5. Semi batch Reactor Addition of NaOH in Ethyl acetate, Utilization of **POLYMATH** for finding behavior of products with respective of time.
6. Study the effect of various combinations of reactors on conversion
7. Non linear regression in **POLYMATH** to get kinetic parameters
8. To generate the temperature-conversion profile for an adiabatic reaction in a CSTR
9. To generate the temperature-conversion profile for an adiabatic reaction in a PFR
10. To determine optimum residence time for multiple parallel reactions
11. Design of a CSTR using DWSIM software
12. Design of a PFR using DWSIM software

List of Course Projects:

1. Utilization of POLYMATHS for finding behaviour of products with respective of time in reactors
2. Effect of reactor types on product distribution for multiple reactions.
3. To generate temperature conversion profiles for exothermic and endothermic reactions
4. Design and simulation using ASPEN of isothermal plug / mixed flow reactor/
5. Design and simulation using ASPEN of non- isothermal mixed flow reactor
6. Design of recycle reactor using ASPEN software
7. Generate temperature conversion profile for adiabatic plug /CSTR flow reactor
8. Study of product distribution for series reactions in plug flow reactor
9. Study of product distribution for parallel reactions in plug flow reactor
10. Finding tau optimum using POLYMATH for multiple reactions
11. Study of product distribution for series reactions in mixed flow reactor
12. Determination of the reaction kinetics for multiple reactions
13. Design of Batch reactor using DWSIM software
14. Design of a CSTR using DWSIM or CAPE OPN software
15. Design of a PFR using DWSIM software

List of Course Seminar Topics:

1. Reaction mechanism to generate rate laws for homogeneous reactions
2. Different methods interpret batch reactor data to generate rate laws
3. Multiple reactor system
4. Flow reactors used in chemical industries
5. Polymerisation processes
6. Nuclear Reactor
7. Bio reactor
8. Micro reactors, design and applications
9. Plastic waste management
10. Process intensification
11. Recycling of plastic
12. Nano particles and it’s application
13. Waste water treatment methods
14. Potable water from waste water
15. Temperature control in exothermic and endothermic reactions

List of Course Group Discussion Topics:

1. Role of Batch processes and continueous processes in chemical industries
2. Aspects of chemical reaction engineering
3. Flow reactors used in chemical industries and their characteristics
4. Temperature dependency on rate constant from Arrhenius collision and transition theory
5. Adiabatic and nonadiabatic reactors and their application
6. Different combinations of reactors to get optimum volume
7. Constant volume and variable volume reactors
8. Applications of CRE in polymer industries
9. Applications of CRE in petrochemical industries
10. Applications of CRE in Biochemical industries
11. Optimum temperature progression and it's use in reactor design
12. Micro reactors and their applications
13. Different flow patterns and their applications in industrial reactors
14. Types of reactions and suitable reactors
15. Autocatalytic reactions and reactors used for it
16. Importance of Conversion, fractional yield and selectivity in design reactors

List of Home Assignments:

Design:

1. Design of isothermal Plug flow reactor and simulation using ASPEN Software
2. Design of non isothermal Continuous stirred tank reactor simulation using ASPEN Software
3. Design of isothermal stirred tank reactors in series simulation using ASPEN Software
4. Design and comparison of CSTR and PFR

Case Study:

1. Determination of detailed kinetics of a catalytic reaction
2. CO2 Chemisorption process
3. Carbon capture methods
4. Parallel Reactions in plug flow reactors

Blog:

1. Hydrogen from biomass
2. Novel reactors in chemical industries
3. Application of oxidation methods in wastewater treatment

4. Difficulties in scale up of nano materials.

Surveys:

1. Kinetic study of homogeneous reactions
2. Various Polymer industries in india and types of polymers
3. Fertilizer industries in india and it's future scope
4. Pulp and paper industries in India and it's future scope

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	ESE	HA	LAB	CP	VIVA	SEM	GD
15	15	10	10	10	20	10	10

MSE - Mid Semester Examination
ESE - End Semester Examination
HA - Home Assignment
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar
GD - Group Discussion

Text Books: ***(As per IEEE format)***

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

Reference Books: ***(As per IEEE format)***

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

Moocs Links and additional reading material:

NPTEL :: Chemical Engineering - NOC:Chemical Reaction Engineering-I

Course Outcomes:

The student will be able to –

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

CO PO Map

CO/ PO	PO: 1	PO: 2	PO: 3	PO: 4	PO: 5	PO: 6	PO: 7	PO: 8	PO: 9	PO: 10	PO: 11	PO: 12	PSO :13	PSO :14
CO: 1	3	2	1	2	3	2	2	2	2	1	1	1	2	1
CO: 2	3	2	1	2	3	2	2	2	2	2	2	2	2	2
CO: 3	3	2	2	2	3	2	2	2	2	2	2	2	2	2
CO: 4	3	2	2	2	3	2	2	2	2	2	2	2	3	3
CO: 5	3	3	3	2	3	2	2	2	2	2	2	2	3	3
CO: 6	3	2	2	2	3	2	2	2	2	2	2	2	3	3

CO attainment levels

CO	Attainment level

CO:1	**2**
CO:2	**2**
CO:3	**4**
CO:4	**5**
CO:5	**5**
CO:6	**5**

Future Courses Mapping:

Chemical Reaction Engineering, Bioengineering etc**.**

Job Mapping:

Chemical, Petroleum, Petrochemical Industries, Biochemical Industries etc.

FF No. : 654

CS3231::ENGINEERING APPLICATIONS OF DATA SCIENCE

Course Prerequisites:

1. Linear Algebra Basics
2. Central Tendency & Measures of Dispersion – Mean, Mode, Median
3. Probability
4. Some exposure to programming environment – C programming; Python

Course Objectives:

1. Understand data science fundamentals and Perform dimensionality reduction operations
2. Apply descriptive statistics tools
3. Deduce meaningful statistical inferences
4. Use unsupervised and supervised classification algorithms
5. Utilize the data science principles to solve chemical engineering problems

Credits:5 **Teaching Scheme Theory:3** Hours/Week

Tut:1 Hours/Week

Lab: 2 Hours/Week

Course Relevance:

SECTION-1

Overview of Data Science fundamentals- Introduction to Data Science, Data Vs Information Vs Insight, Primary and Secondary data, Data Analytics life cycle, Role of Data Analyst, Data Engineer, Data Scientist. And **Applications of Data science in the context of Chemical, Biochemical engineering, material designs, process operations, fault diagnosis.** Cheminformatics: Cheminformatics Vs Bioinformatics, Databases in Cheminformatics, Cheminformatics applications.

Big data: Characteristics of Big Data, Big data Types, Big data Analytics process, Overview Hadoop, Big Data Analytics Chemical Engineering, Univariate and Multivariate Analysis. **IIOT:** Overview of IIOT Architecture, IIOT in the context of Chemical Engineering.

Outliers: Introduction, Types of outliers, Outliers detections in normal, skewed and other distributions, Outlier treatment techniques-Trimming, Capping, **Data Discretization**-Equal width binning, Equal frequency Binning, Hierarchical **Clustering** - Agglomerative and Divisive clustering.

Machine Learning: Supervised, Unsupervised and Reinforcement learning and algorithms. **Hypothesis testing**, Support Vector Machines.

SECTION-1I

Introduction to Artificial Intelligence, various definitions of AI, AI Applications and Techniques, Types of AI, AI- Intelligent Agents, Types of Agents, Turing Test and Reasoning - forward and backward chaining, Expert System in AI.AI Search Algorithms-Uninformed and informed search algorithms.

Artificial Intelligence and its current and futuristic applications to chemical engineering

Deep learning

Historical context and motivation for deep learning, AI Vs Machine Learning Vs Deep Learning. Artificial Neural network fundamentals- Activation function: Linear function, Sigmoid function, Heviside step function, Tanh activation function. optimizing logistic classifier using gradient descent, stochastic gradient descent.

Neural networks: Feed forward neural networks, deep networks, regularizing a deep network, model exploration, and hyper parameter tuning

Deep Belief Networks, shallow neural networks, Recurrent neural networks, Practical aspects of Deep learning, batch normalization and programming frameworks, foundations of convolutional neural networks, deep convolutional models

List of Practicals: (Any Six)

1. Data visualization
2. Unconstrained Optimization
3. Hypothesis Testing
4. Linear regression
5. Logistic Regression
6. Nearest Neighbor classification
7. Naive Bayes classification
8. Clustering
9. Classifier performance using Confusion matrix and other attributes
   Cross Validation methods

List of Course Projects:

1. Sentiment analysis
2. Data analysis
3. Data prediction
4. HVAC needs forecasting
5. Customer relationship management
6. Clinical decision support systems
7. Development of machine learning solutions using available data sets (multiple projects)
8. Fraud detection

List of Course Seminar Topics:

1. Data analytics in Chemical Engineering
2. Ensemble modeling techniques
3. Text pre-processing
4. Feature scaling for machine learning
5. Multivariate normal distribution applications
6. Distance metrics and their applications
7. Visualization techniques such as Chernoff's faces
8. Tree based algorithms
9. Ridge regression

List of Course Group Discussion Topics:

1. Machine learning for Chemical Engineering
2. Data Science for chemical engineering
3. Regression types and their applications
4. Data Science and it's importance in today's world
5. Use of Artificial Neural Networks in Chemical Industries
6. Data Visualization Techniques
7. Big data in Chemical Engineering
8. Operational Historians
9. Types Of data analysis
10. Different types of clustering
11. Hypothesis testing in Data Science
12. Classification Techniques in Machine learning

List of Home Assignments:

Case Study:

1. Machine learning Application based case study
2. Bigdata Concept application based case study
3. Deep Learning Application based Case Study
4. Artificial Intelligence Application based Case study
5. Neural Network Application based case study.
6. Application of IIOT in the field of Chemical Engineering

Surveys:

Principles of surveying will be implemented by groups to demonstrate use of data science principles in home assignments

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	ESE	HA	LAB	CP	VIVA	SEM	GD
10	10	10	10	10	20	15	15

MSE - Mid Semester Examination
ESE - End Semester Examination
HA - Home Assignment
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar
GD - Group Discussion

Text Books: ***(As per IEEE format)***

1. James, G. et al, Introduction to Statistical Learning, https://www.statlearning.com/
2. Venkatasubramanian, V., "The Promise of Artificial Intelligence in Chemical Engineering: Is It Here, Finally?", AIChE J, Vol 65(2), 2019, https://aiche.onlinelibrary.wiley.com/doi/pdf/10.1002/aic.16489
3. Goodfellow, I. et al, "'Deep Learning", MIT Press, https://www.deeplearningbook.org/
4. Ian Goodfellow, Deep Learning, MIT Press, 2016.
5. Jeff Heaton, Deep Learning and Neural Networks, Heaton Research Inc, 2015

Reference Books: ***(As per IEEE format)***

1. Li Deng (Author), Dong Yu, Deep Learning: Methods and Applications (Foundations and Trends in Signal Processing), Now Publishers Inc, 2009.
2. Elaine Rich and Kelvin Knight, Artificial Intelligence, 3rd edition, Tata McGraw Hill , 2017.
3. DAN.W. Patterson, Introduction to A.I. and Expert Systems – PHI, 2007.

Moocs Links and additional reading material:

1. www.nptelvideos.in
2. https://www.coursera.org/
3. https://nptel.ac.in/courses/106/106/106106179/
4. https://nptel.ac.in/courses/106/106/106106212/

Course Outcomes:

The student will be able to –

1: Apply knowledge of data science and machine learning algorithms to solve and design real-world applications in the field of Chemical Engineering

2: Demonstrate knowledge of statistical data analysis techniques in the field of Chemical Engineering and biotechnology.

3: Application of machine learning approach and understand fundamental issues and challenges of Big Data analytics and IIOT in the field of Chemical engineering.

4: Design single and multi-layer feed-forward deep networks, tune various hyper-parameters for analyzing performance of deep networks.

5: Identify Artificial Neural Network techniques in building intelligent machines

6: Differentiate between various approaches to Artificial Intelligence

CO PO Map

CO/ PO	PO: 1	PO: 2	PO: 3	PO: 4	PO: 5	PO: 6	PO: 7	PO: 8	PO: 9	PO: 10	PO: 11	PO: 12	PSO :13	PSO :14
CO: 1	3	2	1	2	3	2	2	2	2	1	1	1	1	1
CO: 2	3	2	1	2	3	2	2	2	2	2	2	2	1	1
CO: 3	3	2	2	2	3	2	2	2	2	2	2	2	1	1
CO: 4	3	2	2	2	3	2	2	2	2	2	2	2	1	1
CO: 5	3	3	3	2	3	2	2	2	2	2	2	2	1	1
CO: 6	3	2	2	2	3	2	2	2	2	2	2	2	1	1

CO attainment levels

CO	Attainment level
CO:1	**2**
CO:2	**2**
CO:3	**4**
CO:4	**5**
CO:5	**5**
CO:6	**5**

Future Courses Mapping:

Advanced Data Science, Big Data etc**.**

Job Mapping:

Chemical, Petroleum, Petrochemical Industries, Biochemical Industries etc.

FF No. : 654

CH3281::ENGINEERING DESIGN AND INNOVATION V

Course Prerequisites: Basic principles of physics, mathematics, chemistry, heat transfer

Course Objectives:

The Students will be able to

1. Do literature search appropriately with available tools
2. Defining of project title/idea
3. Allocation of tasks among the team members
4. Team spirit development
5. Write a report, research paper with required format
6. Present work effectively with concrete results

Credits: 04 **Teaching Scheme Theory: 00** Hours/Week

Tut: 00 Hours/Week

Lab:**08** Hours/Week

Course Relevance:

Engineering Design and development is specially design part of curriculum, that will facilitate application of theory concept in practice. This is project based learning experience. As in practical situation, where first project is defined and then respective required skilled are learned to accomplish the project. We are making student ready to face and approach actual problem.

SECTION-1&II
Topics and Contents This stage will include a complete report consisting of synopsis, the summary of the literature survey carried out, Details of experimental/theoretical work and results and discussion and conclusion. Students may undertake studies in application chemical engineering knowledge for manufacturing project, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature

survey is expected to be carried out as a part of this work. The group of students is required to choose the topic in consultation with the Guide.

A technical report of 15 pages is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation.
The external from Industry/research organization is invited to evaluate the projects done by students.

List of Project areas:

1. Agriculture
2. Personal Health
3. Social health
4. Hygiene
5. Energy
6. Environment
7. Potable Water
8. Solar based
9. Modeling and Simulation
10. Waste water treatment
11. Air pollution
12. Solid waste management
13. Low cost product development

Suggest an assessment Scheme:

Assessment of Engineering Design and Innovation project includes three reviews spread across 4 months, where research innovative ideas, strategy of execution, actual execution, teamwork is assessed.

Every review is based on report writing, presentation of results and team work demonstration.

Two reviews are with internal faculty members
Third review is with an external industry expert.

Review 1: Literature search and deciding appropriate topic
Review 2: Progress of work on decided topic i.e setting experimental setup, developing methodology of solving the opted problem.
Review 3: Overall assessment of project work with team efforts.

Moocs Links and additional reading material:

1. www.nptelvideos.in
2. https://nptel.ac.in/courses/103/103/103103039/#watch
3. https://www.honeywellprocess.com/en-US/explore/solutions/integrated-technology/Pages/leap.aspx

4. https://www.gtu.ac.in/uploads/GIC%20Compendium%20IDP-UDP.pdf
5. https://www.udemy.com/course/leadership-psychology-cultivate-creativity-and-innovation/
6. https://www.coursera.org/learn/uva-darden-project-management
7. https://www.coursera.org/specializations/innovation-creativity-entrepreneurship

Course Outcomes: The student will be able to –

1. Apply chemical engineering knowledge
2. Learn how to work in a team.
3. Define a task (problem) and execute it.
4. Carry out literature search related to topic.
5. Write synopsis and complete literature search related to topic and complete report.
6. Present the outcome of work systematically in a team.

CO PO Map

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	3	1	1	1	0	1	1	1	1	1	1	1	1	1
CO2	0	0	0	0	0	0	0	2	3	1	3	1	0	0
CO3	3	1	1	1	1	1	1	1	1	1	1	1	1	1
CO4	1	3	1	1	1	1	1	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1	1	3	1	1	1	1
CO6	1	1	1	1	1	1	1	1	1	2	1	1	1	1

CO attainment levels

CO	Attainment level
1	2
2	3
3	3
4	5
5	5
6	4

Future Courses Mapping:

Next semester project, BTech course project

Job Mapping:

What are the Job opportunities that one can get after learning this course

1. Core Chemical Engineering industrial job
2. Chemical Engineering Design job
3. Chemical Engg. research jobs

FF No. : 654

CH3202::INSTRUMENTATION AND PROCESS CONTROL

Course Prerequisites: None

Course Objectives:

1. To understand the methodology of dynamic modeling
2. To understand the notion of feedback control
3. To understand the operation of a PID controller
4. To be able to carry out controller design using various time-domain and frequency domain techniques
5. To understand advanced process control schemes used in industry.

Credits: 5 **Teaching Scheme Theory: 3** Hours/Week

Tut: 1 Hours/Week

Lab: 2. Hours/Week

Course Relevance:

This subject deals with control of industrial systems and so is of vital importance. With this subject the students will get an understanding of dynamic behavior of processes. The key notion of control of a process at the desired operating point is addressed in this course. With a number of theoretical and practical controller design tools covered in the course, the students will get a thorough exposure to this important area of industrial process control.

SECTION-1

Instrumentation, Process Dynamics, Feedback Control

Instrumentation: Measurement fundamentals. Temperature, flow, pressure, level and composition measuring instruments. Static and dynamic characteristics. Control valves: sizing and valve characteristics

Process Dynamics: Introduction to process control. Review of Laplace transforms. Development of mathematical and dynamic models of chemical engineering systems. First order, second order systems. Systems with time delays. Interacting & non-interacting processes.

Feedback control: Block diagram. PID controller. Typical time-domain responses of feedback control systems. Servo and regulatory problems.

Stability Analysis: Stability analysis of closed-loop control systems. Routh stability criterion. Root locus. Bode stability analysis. Design of feedback control systems using time-domain and frequency-domain techniques. Controller tuning methods such as Ziegler-Nichols.

Advanced Process Control: Feedforward control, cascade control, ratio control, selective control etc. Introduction to digital control.

SECTION-1I

Control System Design, Advanced Process Control

Stability Analysis: Stability analysis of closed-loop control systems. Routh stability criterion. Root locus. Bode stability analysis. Design of feedback control systems using time-domain and frequency-domain techniques. Controller tuning methods such as Ziegler-Nichols.

Advanced Process Control: Feedforward control, cascade control, etc. Introduction to digital control.

Overview of data science techniques relevant to industrial process control

List of Tutorials: (Any Three)

Problems on

1. Solution of ordinary differential equations using laplace transforms
2. First order systems
3. Second order systems
4. Systems with dead time
5. Block diagram reduction
6. Dynamic response of PID controlled systems
7. Routh test
8. Root locus
9. Bode analysis
10. Data science techniques in industrial process control

List of Practicals: (Any Six)

1. Measurements for temperature, pressure, flow, level etc
2. Interacting and non-interacting systems
3. Process identification: First order plus dead time system
4. P controlled system
5. PI controlled system
6. PID controlled system
7. Root locus based controller design using a software tool such as Scilab
8. Bode analysis based controller design using a software tool such as Scilab
9. Dynamic simulation of simple systems such as liquid level on a chemical engineering simulation software
10. Dynamic simulation of a distillation column

List of Projects:

1. Controller tuning
2. P&ID diagrams for flow sheets
3. Design a control system using time-domain techniques such as root-locus
4. Design a control system using frequency-domain techniques such as Bode design
5. Dynamic behaviour of pure capacity process
6. Feedback control system design using Scilab/Octave/Matlab/Python etc
7. Dynamic simulation of a distillation column
8. Dynamic simulation of a chemical plant flowsheet
9. Data science techniques in chemical process control
10. Feedforward control / Cascade control / Selective control / Multiloop and multivariable control

List of Course Seminar Topics:

1. Air & water quality measurement
2. Electrical methods for temperature measurement
3. Process Instrumentation & control in sugar industry
4. Process Instrumentation & control of polyetheylene (fluidized bed) plant
5. Process Instrumentation & control of ethylene oxide plant
6. Process Instrumentation & control of styrene plant
7. Model predictive control
8. Heat exchanger control
9. Process Instrumentation & Control of crude atmospheric distillation unit
10. Process Instrumentation & Control of Fluid Catalytic Cracker plant

List of Course Group Discussion Topics:

1. Variable head flow meters
2. Variable pressure flow meters
3. PID Controller tuning
4. Root locus and controller design
5. Bode plot and controller design
6. Level control
7. Flow control
8. Process control in paper industry
9. Distillation column control
10. Boiler control

List of Home Assignments:

Design:

1. PID controller tuning using Root locus
2. PID Controller tuning using Bode plot
3. PID controller tuning using Ziegler-Nichols open loop method
4. PID Controller tuning using Cohen-Coon method
5. Digital PID controller implementation with anti-reset windup & derivative overrun compensation

Case Study:

1. Control of highly nonlinear processes
2. Use of nanotechnology in process instrumentation
3. Big data analytics in chemical industry
4. BASF Verbund
5. Machine learning in chemical industry

Blog:

1. Internet of Things in Chemical Industry
2. Batch process control
3. Advanced process control in chemical industry
4. Process control in plant-on-chip systems
5. Deep learning in chemical industry

Surveys:

1. Real time optimization (RTO) systems
2. Sustainability through process control
3. On-line analyzers in chemical industry
4. Batch process control
5. Statistical process control

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy

MSE	ESE	HA	LAB	CP	VIVA	SEM
15	15	10	30	10	10	10

MSE - Mid Semester Examination

ESE - End Semester Examination

HA - Home Assignment

LAB - Laboratory

CP - Course Project

VIVA - Viva voice

SEM - Seminar

GD - Group Discussion

Text Books: ***(As per IEEE format)***

1. D. R. Coughanowr, "Process Systems Analysis and Control", 2nd ed. McGraw-Hill, 1991.
2. B. C. Nakra and K. K. Chaudhry, "Instrumentation, Measurement and Analysis", 2nd ed. Tata McGraw-Hill, 2004.

Reference Books: ***(As per IEEE format)***

1. D. E. Seborg, T. F. Edgar and D. A. Mellichamp, "Process Dynamics and Control", 2nd ed. John Wiley & Sons, 2004.

Moocs Links and additional reading material:

1. P. Saha, "Process Control and Instrumentation", IIT Guwahati, NPTEL. [Online]. Available: https://nptel.ac.in/courses/103/103/103103037/
2. S. S. Jogwar, "Chemical Process Control", IIT Bombay, NPTEL. [Online]. Available:https://nptel.ac.in/courses/103/105/103105064/
3. B. S. Johnson, "Process Dynamics, Operations and Cotrol", MIT OPENCOURSEWARE, MIT. [Online] Available:

https://ocw.mit.edu/courses/chemical-engineering/10-450-process-dynamics-operations-and-control-spring-2006/

Course Outcomes:

The student will be able to –

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

CO PO Map

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CO1	2	1	1	1	1	1	1	1	1	1		1	1	1
CO2	2	1	2	1	2	1	1	1	1	1		1	1	1
CO3	2	1	3	3	2	1	1	1	1	1		1	1	1
CO4	2	1	3	1	2	1	1	1	1	1		1	1	1
CO5	2	1	2	1	2	1	1	1	1	1		1	1	1
CO6	2	1	2	1	1	1	1	1	1	1		1	1	1

CO attainment levels

CO	Attainment Level
1	3
2	5
3	5
4	5
5	5
6	3

Future Courses Mapping:

Advance Process Control

Job Mapping:

1. In EPC industry
2. Software based Chemical industry
3. In scale up of plant in consultancy industry

FF No. : 654

CH3205::PROCESS EQUIPMENT DESIGN

Course Prerequisites: Basics of heat transfer and materials

Course Objectives:

1. To Understand design the heat exchanger
2. To Comprehend design of hydraulic plate design
3. To Understand the material standards for design
4. To Comprehend axillary equipment
5. To Understand mixing vessel details

Credits: 04 **Teaching Scheme Theory: 03 Hours/Week**

Tut: 01 Hours/Week

Lab: 02 Hours/Week

Course Relevance:

Process equipment design is of vital importance for industrial design. It covers important design of heat exchange that is crucial for heat recovery or heat transfer in industry. Agitator vessel design is another crucial part for chemical industry. Plate and pack column comprehension is very much part of every chemical industry. Auxiliary equipment study completes remaining part of any process industry.

SECTION-I

Topics and Contents

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

SECTION-II

Topics and Contents

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

List of Tutorials: (Any Three)

1. Heat exchanger design for SATHE
2. Heat exchanger design for double pipe HE.
3. Heat exchanger design for Plate type HE.
4. Design hydraulic plate design
5. Design of vaporiser
6. Design of reboiler
7. Design of condenser
8. Auxiliary equipment
9. Pack column
10. Supports for equipment

List of Practicals: (Any Six)

1. Design of Shell and Tube heat exchanger.
2. Design of double pipe heat exchanger
3. Design of vaporiser
4. Design of condenser
5. Design of distillation column
6. Design of types of supports for vessels
7. Design of various types of heads for vessels
8. Design of agitators for chemical reactors
9. Literature survey on types of safety valves, safety devices for chemical equipments
10. Autocad drawing of tubes sheet for the Shell and tube heat exchanger.
11. Economic analysis for Shell and tube heat exchanger.
12. Economic analysis for Shell and tube heat exchanger

List of Projects:

1. Optimisation of Shell and Tube heat exchanger considering particular heating or cooling objective
2. Optimisation of Plate type heat exchanger considering particular heating or cooling objective
3. Optimisation of Double pipe heat exchanger considering particular heating or cooling objective
4. Optimisation of Helical tube type heat exchanger considering particular heating or cooling objective
5. Optimisation of evaporator to obtain thick liquor with particular concentration considering various industrial needs
6. Optimisation of tray/packed column for separation by using distillation, absorption, etc operations with an industrial example.
7. Condenser design for multicomponent vapor mixtures.
8. Design of multi-effect evaporator.
9. Design of extractive distillation system
10. Design of extractive distillation system
11. Design of liquid-liquid separator.
12. Design of liquid-liquid separator.

List of Course Seminar Topics:

1. Shell and Tube heat exchangers : Basic need, design, application, limitation
2. Double pipe heat exchanger for process industry
3. Plate type heat exchanger for efficient operation
4. Graphite exchanger for highly corrosive application
5. BS standards, TEMA standards, IS standard for Design
6. Evaporators in Chemical Industry
7. Reboilers for process industry
8. Condensers important aspect of chemical plant
9. Pack column for process industry
10. Plate column for purification of product
11. Flanges and gasket for equipment
12. Supports for Chemical Equipment
13. Agitated vessels for efficient reactor
14. Agitators for Chemical Reactor
15. Dryers for Chemical products
16. Liquid-liquid and gas-liquid separators

List of Course Group Discussion Topics:

1. Advances in heat exchanger design
2. Best heat exchanger for corrosive fluids handled
3. Best heat exchanger for petroleum product cooling or heating
4. National, international material codes for design
5. Distillation plate vs packed column
6. Best Evaporators for industry i.e Chemical, forced, natural circulation
7. Overall heat transfer, velocity, pressure drop, dirt factor balance
8. Necessity of heat exchange in process industry
9. Necessity of heat exchange in daily life
10. Re-Boilers in Chemical Industry
11. Condensers in Process industry
12. Dryers in process industry
13. Agitators for process industry
14. Best suitable cooling tower for process industry
15. Role of materials in Heat exchanger design

List of Home Assignments:

Design:

1. Design heat exchanger to cool crude oil available at 50000 kg/hr flowrate from 110 0C to 50 0C.
2. Design plate type distillation column to recover 99% ethanol from 50% ethanol water feed available at 20000 kg/hr flow rate
3. Design efficient agitator for absorption of CO2 in K2CO3 solution
4. Design multiple efficient evaporator for concentration of sugar syrup from 15% to 45% with flowrate of 35000 kg/hr of feed
5. Design of distillation column for separation of ethanol water system for handling 10000 kg/hr of 50% Ethanol in feed, giving 99% purity at top.

Case Study:

1. Heat exchanger used for heat recovery in Chemical process industry
2. Plate type heat exchanger
3. Tray column
4. Packed column
5. Auxillaryequipments

Blog:

1. Smart heat exchangers for 21st centry
2. Distillation boon for chemical industry
3. Codes, standards: Best safety aspect of industry
4. Separators bottleneck of chemical industry
5. Valves selection for industry

Surveys:

1. Recent advances in heat exchanger
2. Advancement in plate type column
3. Pack column efficient way for enrichment of compound
4. Most efficient Agitator for process industry
5. Best accessory stream for process industry

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	ESE	HA	LAB	CP	VIVA	PPT/ GD
15	15	10	20	10	20	10

MSE - Mid Semester Examination

ESE - End Semester Examination

HA - Home Assignment

LAB - Laboratory

CP - Course Project

VIVA - Viva voice

SEM - Seminar

GD - Group Discussion

Text Books: ***(As per IEEE format)***

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

Reference Books: ***(As per IEEE format)***

1. Walas, S. M; Chemical process equipment: selection and design; Butterworth-Heinemann, 1990.
2. Ludwig, E.E.; Applied Process Design for Chemical and Petrochemical Plants, Vol. 1 and 2; 3rd Ed.; Gulf Publishing Co., 1997.
3. Eugene F. Megyesy; Pressure Vessel Handbook; 10th Edition; Pressure Vessel Publishing, INC.
4. R. K. Sinnott; Coulson and Richardson's Chemical Engineering Volume 6 - Chemical Engineering Design; 4th Edition; Pergamon Press.

Moocs Links and additional reading material:

www.nptelvideos.in

Course Outcomes:

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

CO PO Map

CO /PO	PO: 1	PO: 2	PO: 3	PO: 4	PO: 5	PO: 6	PO: 7	PO: 8	PO: 9	PO: 10	PO: 11	PO: 12	PSO :13	PSO :14
CO :1	1	1	3	1	1	1	1	1	1	1	1	1	1	1
CO :2	1	1	3	1	1	1	1	1	1	1	1	1	1	1
CO :3	1	1	3	1	1	1	1	1	1	1	1	1	1	1
CO : 4	1	1	3	1	1	1	1	1	1	1	1	1	1	1
CO : 5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CO : 6	1	1	1	1	1	1	1	1	1	1	1	1	1	1

CO attainment levels

CO	Attainment levels
CO:1	3
CO:2	3
CO:3	4
CO: 4	4
CO: 5	5
CO: 6	3

Future Courses Mapping:

Advanced design, Design with assistance of sotware

Job Mapping:

4. In design, In Engineering Project company industry
5. Software based Chemical industry
6. In scale up of plant in consultancy industry

FF No. : 654

CH3203::SEPARATION TECHNIQUES

Course Prerequisites: Heat Transfer, Chemical Engineering Thermodynamics, Fluid Flow Operations, Mass transfer 1

Course Objectives:

1. To understand and apply principles of mass transfer operations
2. To generate the input data for design of separation columns
3. To design the separation columns for distillations, extraction, leaching and adsorption
4. To analyse the factors affecting separation
5. To understand working of industrial separation equipments

Credits: 5 **Teaching Scheme Theory: 3** Hours/Week

Tut: 1 Hour/Week

Lab: **2** Hours/Week

Course Relevance:

Separation Techniques play a vital role in many industrial processes. Separation is crucial for the quality of desired product. A group of operations are carried out for separating the components of mixtures and is based on the transfer of material from one phase to another.

SECTION-1

Topics and Contents

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

SECTION-1I

Topics and Contents

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

List of Tutorials: (Any Three)

1. To calculate number of stages of a distillation column using Lewis Sorel method
2. To calculate number of stages of a distillation column using Mc Cabe Thiele method
3. To Generate enthalpy-concentration diagram
4. To calculate number of stages of a distillation column using PonchonSavarit method
5. To prepare input data (eg, ternary diagram) for liquid liquid extraction design
6. To calculate number of stages for solvent extraction column
7. To calculate number of stages for solid-liquid extraction column
8. To generate and study adsorption isotherms
9. To calculate number of stages for adsorption column
10. To study kinetics of Ion-exchange equilibria

List of Practicals: (Any Six)

1. To generate VLE data for binary ideal/non-ideal systems
2. To study ASTM Distillation
3. To determine Column Tray Efficiency for distillation
4. To generate equilibrium data for liquid-liquid extraction
5. To study solid-liquid mass transfer with/without chemical reaction
6. To verify Freundlich/ Langmuir isotherm equation for batch adsorption
7. To study differential distillation and verify Rayleigh equation
8. To study / carry out steam distillation of substance and determine steam requirement
9. To conduct binary distillation in a packed column at total reflux and to estimate HETP and HTU for column
10. To obtain data for equilibrium distribution of solute in two insoluble solvents for example acetic acid in water and toluene phases and determine percentage extraction
11. To study the (cross current) liquid- liquid extraction for extracting acetic acid from benzene using water as solvent
12. To carry out leaching operation using groundnuts and n-Hexane and find out quantity of oil and to determine the efficiency of single stage leaching operation
13. To obtain the breakthrough curve for continuous process in adsorption column
14. To study the operation of a batch rectification column under constant or total reflux condition

List of Projects:

1. Design of distillation column
2. Ternary diagram for a system of three liquid one pair partially soluble for example acetic acid, benzene and water system
3. Study liquid- liquid extraction in a packed column and determine HTU and HETP for the tower
4. Analysis of ion-exchange equilibria
5. Analysis of multi-component distillation system
6. Process design of leaching equipment
7. Process design of adsorption equipment
8. Analysis of vapour liquid equilibria
9. Design and simulation of reactive distillation
10. Analysis and Design of hybrid separation processes
11. Design and analysis of Supercritical Extraction Units
12. Process Design of Solvent Extractors
13. Design and Simulation of Extractive Distillation

List of Course Seminar Topics:

1. Production of ethanol to blend in gasoline
2. Oil and gas value chain
3. Solar distillation
4. Industrial application of leaching operation
5. Multicomponent distillation
6. Ion exchange resins and its industrial application
7. Role of vacuum distillation unit in refinery
8. Solvent Extraction: A potential separation technique
9. Importance of isotherms and breakthrough curve in adsorption
10. Pressure swing adsorption and applications
11. Atmospheric distillation unit in refinery
12. Finer selection of solvents for solvent extraction
13. Separation techniques in Fertilizer industry
14. Separation applications by Ion exchange process
15. Separation Techniques in pharmaceutical industry

List of Course Group Discussion Topics:

1. Distillation - A Boon or Curse to Separation?
2. Distillation or solvent extraction - path to separation of close boiling mixtures
3. Where to compromise – Cost of Separation or Purity?
4. Azeotropic distillation or Extractive distillation
5. Importance of Separation Technologies in Refinery
6. Challenges and opportunities in multicomponent distillation
7. Government policy on emission/discharge from Chemical industries
8. Zero discharge in chemical industry - role of mass transfer
9. Scope of improvement in leaching operation
10. Adsorption – an intermediate solution to separation
11. Critical use of leaching operation in metallurgy
12. Role of adsorption and other competing processes in ETP plants

13. Role of separation techniques in Swachh Bharat Aviyan
14. Membrane separation as an alternative to conventional separations
15. Limitation of solvent extraction process in small scale industries

List of Home Assignments:

Design:

1. Tray type Distillation Column
2. Packed type Distillation Column
3. Solvent Extraction Column
4. Leaching Column
5. Adsorption Column

Case Study:

1. Industrial separation equipments for gaseous mixture
2. Separation processes in chemical plant
3. Development of novel separation techniques
4. Competing separation techniques
5. Industrial separation equipments for liquid mixtures

Blog:

1. Recent developments in distillation processes
2. Adsorption Isotherms and their interpretations
3. Use of Green Technology in Separation Processes
4. Improvements in conventional leaching techniques
5. Hybrid separation Techniques used in Industry

Surveys

1. Comparison between azeotropic distillation and solvent extraction for separation of azeotropes
2. Application of leaching in food processing industries
3. Solvent choice in liquid-liquid extraction
4. Use of leaching process in small scale industries
5. Alternative to adsorption process used in industry

Suggest an assessment Scheme:

Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	ESE	HA	LAB	CP	VIVA	GD/PPT
15	15	10	30	10	10	10

MSE - Mid Semester Examination
ESE - End Semester Examination
HA - Home Assignment
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar
GD - Group Discussion

Text Books: ***(As per IEEE format)***

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

Reference Books: ***(As per IEEE format)***

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

Moocs Links and additional reading material:

1. www.nptelvideos.in
2. https://swayam.gov.in/nd1_noc19_ch31/preview

Course Outcomes:

The student will be able to –

1. Generate VLE data for ideal and non-ideal system
2. Carry out process design of distillation column and analyze implications of factors affecting distillation column and also the implications of non-ideal phase behavior

3. Select suitable solvent for liquid-liquid extraction and design liquid-liquid extraction column and select equipment required for given separation
4. Calculate the number of stages required for a leaching operation
5. Carry out process design of adsorption column
6. Draw analogy between adsorption and ion exchange and analyze ion exchange equilibria

CO PO Map

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CO: 4	2	2	2	2	2	1	1	2	2	2	0	1	3	1
CO: 5	2	2	2	2	2	1	1	2	2	2	0	1	3	1
CO: 6	2	2	2	2	2	1	1	2	2	2	0	1	3	1

CO attainment levels

CO	Attainment level
CO:1	**4**
CO:2	**5**
CO:3	**5**
CO:4	**5**
CO:5	**5**
CO:6	**5**

Future Courses Mapping:

Mass Transfer with Chemical reactions, Petroleum Refining, Advanced Separation Techniques, Advanced Transport Phenomena

Job Mapping:

Industries like refineries, pharmaceuticals, paint, fertilizers, chemicals, automobiles etc

FF No. : 654

CH3210::CHEMICAL REACTION ENGINEERING

Course Prerequisites: Basics of chemistry

Course Objectives:

1. Understand evaluation of different routes for chemical synthesis
2. Comprehend solar energy aspects
3. Understand biofuel product routes
4. Comprehend Carbon capture technology
5. Understand municipal solid waste technology

Credits: 4 **Teaching Scheme Theory: 3** Hours/Week

Tut: 0 Hours/Week

Lab: **2** Hours/Week

Course Relevance: Every technology can be/should be developed in greener way. Evolution of different routes for chemical synthesis for design of safer chemical and solvent. Solar energy, biochemical energy, solid waste treatment, carbon capture, waste treatment are important for future technology development.

SECTION-1

Topics and Contents

Nature of chemicals, world scenario of chemicals, Evolution of different routes of chemical synthesis and analysis of greener route, Prevention, balance of Atom Economy and process with green route, Designing safer chemicals, Safer solvent and auxiliaries, Energy efficiency for green synthesis, Use of green and renewable feedstock for green synthesis, Reduction of derivatives, greener routes for Catalysis, Design for degradation, Real time analysis of pollution prevention. Greenhouse emissions, Carbon capture, Kyoto Protocol and Clean development Mechanism, Clean Coal Technology, IGCC, Coal blending and gasification

SECTION-1I

Topics and Contents

Solar energy a greener energy source, wind as green energy source, Waste as a Renewable Energy Source, Waste-to-Energy Conversion: Thermochemical

Conversion, Biochemical Conversion, Physico-chemical Conversion, Factors affecting Energy Recovery from waste, Agricultural Residues, Animal Waste, Industrial Wastes, Forestry Residues, Municipal Solid Waste (MSW), Biomass briquette.

List of Practical: (Any Six)

1. Solar as green energy source, a review
2. Wind as green energy source, a review
3. Green Building for greener future, a review
4. Green routes for chemical synthesis, a review
5. Biomass briquettes and pellets, a review
6. Real time analysis of pollution prevention.
7. Performance evaluation of Evacuated Solar collector.
8. Waste to energy conversion for MSW
9. Carbon capture
10. Analysis of Clean coal Technology

List of Projects:

1. Design of solar based power generation system
2. Design of solar power plant
3. Detailed analysis of pollution prevention system
4. Analysis of Waste recycle system for MSW
5. Design of Bio-fuel system from green raw material
6. Design of industry waste to green solution
7. Detailed review on green catalyst
8. Design of clean coal technology system
9. Study of municipal solid waste treatment method
10. Study of Chemical reactor analysis for green productivity

List of Course Seminar Topics:

1. Solar energy and power generation
2. Concentrate solar energy production schemes
3. Solar photovoltaic cell
4. Air pollution advanced control system
5. Biofuel for green future
6. Green catalyst for green production
7. Coal technology for green future
8. Chemical reactor use for green technology
9. Industry waste water treatment for green technology
10. Solid waste management for green technology

List of Course Group Discussion Topics:

1. Solar energy future
2. Concentrated solar system
3. Photovoltaic solar cell for green future
4. Best way of air pollution control
5. Best biofuel route for energy efficiency
6. Best green catalyst route for chemical reaction green route
7. Best way to use coal technology
8. Best waste water treatment route for green technology
9. Solid waste treatment method
10. Biochemical conversion for green technology

List of Home Assignments:

Design:

1. Solar power system with binary fluid design for 100 kW capacity
2. Municipal solid waste treatment system design to process 100 kg/day of waste
3. Biofuel system design for 100 kW capacity
4. Binary solar power cycle for 10-100 kW capacity
5. Photovoltaic solar cell for 10 kW capacity

Case Study:

1. Industry waste water treatment for specific industry
2. Coal gasification system using fluidized bed

3. Green catalyst with green route for chemical synthesis
4. Solid waste management for useful product
5. Solar energy any one way of energy harvestment

Blog:

1. Best way for solar energy harvesting
2. Best biofuel route for green technology
3. Coal gasification efficient way to energy
4. Green catalyst for chemical synthesis
5. municipal solid waste management

Surveys:

1. Thermochemical conversion
2. Biochemical Conversion
3. Carbon capture
4. Solid waste management
5. Biofuels

Suggest an assessment Scheme:

MSE	*ESE*	*HA*	*LAB*	*CP*	*VIVA*	*GD/ PPT*
15	*15*	*10*	*20*	*10*	*20*	*10*

MSE - Mid Semester Examination
ESE - End Semester Examination
HA - Home Assignment
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM – Seminar
GD - Group Discussion

Text Books :(As per IEEE format)

1. MaltiGoel, Carbon Capture and storage: R&D Technology for Sustainable Energy future, 2nd edition, Tata McGraw - Hill Publishing Co. Ltd, 2016.
2. Singh Ritu**,** Kumar, Sanjeev, Green Technologies and Environmental Sustainability, 1st edition, SAGE Publication, 2018.

Reference books : (As per IEEE format)

1. Martin Kaltschmitt, Hermann Hofbauer,Biomass Conversion and Biorefinery, Edition 3, Apple publication, 2016.
2. Huu Hao Ngo,Wenshan Guo,Rao Y. Surampalli; andTian C. Zhang, Green Technologies for Sustainable Water Management, ASCE Press, 2015.

Moocs Links and additional reading material:

1. www.nptelvideos.in
2. https://www.edx.org/course/technology-innovation-sustainable-epflx-innov4devx

Course Outcomes:

1. Comprehend solar energy and its associated factor for green energy
2. Comprehend wind energy for green future
3. Understand green route of development for chemical
4. Comprehend carbon captures and environmental impact
5. Understand waste recovery for green future
6. Understand clean coal technology for green energy

CO PO Map

CO/PO	PO :1	PO :2	PO :3	PO :4	PO :5	PO :6	PO :7	PO : 8	PO :9	PO :10	PO :11	PO :12	PSO :13	PSO :14
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CO: 4	2	2	2	2	2	1	1	2	2	2	0	1	3	1
CO: 5	2	2	2	2	2	1	1	2	2	2	0	1	3	1
CO: 6	2	2	2	2	2	1	1	2	2	2	0	1	3	1

CO attainment levels

CO	**Attainment level**
CO:1	4
CO:2	5
CO:3	4
CO:4	5
CO:5	4
CO:6	5

Future Courses Mapping:

Sustainable system

Job Mapping:

1. Energy industry
2. Environmental chemical industry
3. Biofuel based industry

FF No. : 654

CH3282::ENGINEERING DESIGN AND INNOVATION VI

Course Prerequisites: Basic principles of physics, mathematics, chemistry, heat transfer

Course Objectives:

The Students will be able to

1. Do literature search appropriately with available tools
2. Defining of project title/idea
3. Allocation of tasks among the team members
4. Team spirit development
5. Write a report, research paper with required format
6. Present work effectively with concrete results

Credits: 04 **Teaching Scheme Theory: 00** Hours/Week

Tut : 00 Hours/Week

Lab : **8** Hours/Week

Course Relevance:

Engineering Design and development is specially design part of curriculum, that will facilitate application of theory concept in practice. This is project based learning experience. As in practical situation, where first project is defined and then respective required skilled are learned to accomplish the project. We are making student ready to face and approach actual problem.

SECTION-1&II
Topics and Contents This stage will include a complete report consisting of synopsis, the summary of the literature survey carried out, Details of experimental/theoretical work and results and discussion and conclusion. Students may undertake studies in application chemical engineering knowledge for manufacturing project, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, *solutions, modeling and simulation* related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of this work. The group of students is required to choose the topic in consultation with the Guide.

A technical report of 15 pages is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation.

The external from Industry/research organization is invited to evaluate the projects done by students.

List of Project areas:

1. Agriculture
2. Personal Health
3. Social health
4. Hygiene
5. Energy
6. Environment
7. Potable Water
8. Solar based
9. Modeling and Simulation
10. Waste water treatment
11. Air pollution
12. Solid waster management
13. Low cost product development

Suggest an assessment Scheme:

Assessment of Engineering Design and Innovation project includes three reviews spread across 4 months, where research innovative ideas, strategy of execution, actual execution, teamwork is assessed.

Every review is based on report writing, presentation of results and team work demonstration.

Two reviews are with internal faculty members
Third review is with an external industry expert.

Review 1: Literature search and deciding appropriate topic
Review 2: Progress of work on decided topic i.e setting experimental setup, developing methodology of solving the opted problem.
Review 3: Overall assessment of project work with team efforts.

Moocs Links and additional reading material:

1. www.nptelvideos.in
2. https://nptel.ac.in/courses/103/103/103103039/#watch
3. https://www.honeywellprocess.com/en-US/explore/solutions/integrated-technology/Pages/leap.aspx

4. https://www.gtu.ac.in/uploads/GIC%20Compendium%20IDP-UDP.pdf
5. https://www.udemy.com/course/leadership-psychology-cultivate-creativity-and-innovation/
6. https://www.coursera.org/learn/uva-darden-project-management
7. https://www.coursera.org/specializations/innovation-creativity-entrepreneurship

Course Outcomes: The student will be able to –

1. Apply chemical engineering knowledge.
2. Learn how to work in a team.
3. Define a task (problem) and execute it.
4. Carry out literature search related to topic.
5. Write synopsis and complete literature search related to topic and complete report.
6. Present the outcome of work systematically in a team.

CO PO Map

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	3	1	1	1	0	1	1	1	1	1	1	1	1	1
CO2	0	0	0	0	0	0	0	2	3	1	3	1	0	0
CO3	3	1	1	1	1	1	1	1	1	1	1	1	1	1
CO4	1	3	1	1	1	1	1	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1	1	3	1	1	1	1
CO6	1	1	1	1	1	1	1	1	1	2	1	1	1	1

CO attainment levels

CO	Attainment level
1	2
2	3
3	3
4	5
5	5
6	4

Future Courses Mapping:

Next semester project, BTech course project

Job Mapping:

What are the Job opportunities that one can get after learning this course

1. Core Chemical Engineering industrial job
2. Chemical Engineering Design job
3. Chemical Engg. research jobs

B.Tech. Chemical Structure Pattern D21 (applicable w.e.f. AY 21-22)

Final Year Module –VII

Subject head	Course code	Course name	Contact hours per week			Credits
			Theory	Lab	Tut	
S1	CH4201	PROJECT MANAGEMENT	2	-		2
S1	MD4201	ENGINEERING AND MANAGERIAL ECONOMICS	2	-		
S2	CH4253	BIOPROCESS ENGINEERING	2			2
S3	CH4255	NANOSCIENCE AND NANOTECHNOLOGY	2	-	-	2
S4	CH4289	MAJOR PROJECT	-	20	-	10
OR						
S1	CH4293	INDUSTRY INTERNSHIP	-	-	-	16
	CH4291	RESEARCH INTERNSHIP				
	CH4294	INTERNATIONAL INTERNSHIP				
	CH4295	CAPSTONE PROJECT				
Total						16

Final Year Module -VIII

Subject head	Course code	Course name	Contact hours per week			Credits
			Theory	Lab	Tut	
S1	CH4208	PETROLEUM ENGINEERING	2	-		2
S2	CH4204	INDUSTRIAL POLLUTION CONTROL	2			2
S3	CH4210	FOOD TECHNOLOGY	2			2
S4	CH4288	MAJOR PROJECT 2	-	20	-	10
OR						
S1	CH4293	INDUSTRY INTERNSHIP	-	-	-	16
	CH4291	RESEARCH INTERNSHIP				
	CH4294	INTERNATIONAL INTERNSHIP				
	CH4295	CAPSTONE PROJECT				
Total						16

FF No. : 654

CH4201::PROJECT MANAGEMENT

Course Prerequisites:None

Course Objectives:

To understand project management by understanding the monitoring of project and recommending corrective actions

Credits:2 **Teaching Scheme Theory:2** Hours/Week

Tut: ……... Hours/Week

Lab: **……...** Hours/Week

SECTION-1
Topics and Contents Introduction: Definition & Characteristics of Project, Performance Parameters: Time, Cost & Quality. Difference with respect to Standard Routine Production. Classification of Projects: Sector based, Investment based, Technology based, Causation based, Need based (BMERD) - Balancing, Modernization, Replacement, Expansion & Diversification Project Life Cycle Phases – Concept/Initiation Phase: Parameters Involved in Project Identification. Sources of New Project Ideas. Governmental Framework for Identification of Opportunities, Incentives from state & central govt.; Import-substitution projects Project Conceptualization & Feasibility Analysis Project Definition Phase: Project Formulation & Feasibility. Types of Feasibility Studies – Pre-feasibility, Support/Functional, Feasibility Study. Preparation of Project Feasibility Report & Specification; Aspects of Project Feasibility Managerial/Organization: Promoters Background, Criteria of Evaluation, Marketing/Commercial: Demand & Supply, Competition, Market Survey, Porter's 5 Forces, Operational/Technical: Process, Technology, Location, Capacity, Labour, Raw Material & Utility Availability. Financial: Cost of Project, Means of Finance, Financial Projections – Profit & Loss Account, Balance Sheet, Funds Flow Statement, Cash Flow Statement, Schedule of Fixed Assets, Schedule of Term Loans. Socio-Economic: Socio-Cost Benefit Analysis. Effective Rate of Protection, Domestic Resource Cost
SECTION-1I

Topics and Contents

Project Planning, Implementation & Control Planning & Organization Phase: Project Planning, Scheduling & Monitoring, Statement of Works, Project Specifications, Work Breakdown Structure, Network Analysis & Duration Estimating Network Diagrams – PERT/CPM, Estimate Activity Times, Milestone Scheduling. Project Organization & Management. Project Organization Structure, Role of Project Manager.

Text Books: ***(As per IEEE format)***

1. Narendra Singh; Project Management & Control; Himalaya Publishing House, Mumbai
2. S. Choudary, Project Management, Tata McGraw Hill

Reference Books: ***(As per IEEE format)***

1. Maylor, Project Management, Pearson Education,
2. Gopal & Ramamurthy; Project Management Handbook; Macmilan.
3. Project Management Body of Knowledge

Moocs Links and additional reading material:

www.nptelvideos.in

Course Outcomes:

Students will be able to:

1. Learn the basic concepts of project and project management
2. Ascertain the feasibility of small and medium projects with respect to managerial, marketing, operational, financial and socio-economic perspectives
3. Plan and schedule small and medium projects to achieve the triple constraint of time, cost
4. Understand the concepts of project risk
5. Monitor the progress of projects to determine variances and recommend corrective actions

CO PO Map

CO/PO	PO: 1	PO: 2	PO: 3	PO: 4	PO: 5	PO: 6	PO: 7	PO : 8	PO: 9	PO:10	PO: 11	PO:12	PSO: 13	PSO: 14
CO:1	2	1	1	1	1	1	1	1	1	1	0	1	1	3
CO:2	2	1	2	1	2	1	1	1	1	1	0	1	1	3
CO:3	2	1	3	3	2	1	1	1	1	1	0	1	1	3
CO: 4	2	1	3	1	2	1	1	1	1	1	0	1	1	3
CO: 5	2	1	2	1	2	1	1	1	1	1	0	1	1	3
CO: 6	2	1	2	1	1	1	1	1	1	1	0	1	1	3

CO attainment levels

CO	Attainment level
CO : 1	**3**
CO : 2	**4**
CO : 3	**5**
CO : 4	**5**
CO: 5	**5**
CO: 6	**5**

Future Courses Mapping:

Advanced Project Management

Job Mapping:

Management field

FF No. : 654

MD4201:: FINANCIAL MANAGEMENT & COSTING

Course Prerequisites:

Basic concepts of cost, profit, loss, debit and credit.

Course Objectives:

Students will be able to:

1. Understand, analyze and interpret financial statements
2. Understand concept of financial accounting for analysis of financial statements of a business.
3. Develop an ability of decision making about investments.

Credits:2 **Teaching Scheme Theory:2** Hours/Week

Course Relevance: Basic knowledge of Finance for working in a industry

SECTION-1
1. Financial Statement Analysis- Nature and Scope of Finance Function; Financial goal profit vs. wealth, Maximization; Scope and Functions of Financial Management, Financial Planning and Forecasting. Budgets & Budgetary Control: Types of Budget, Preparation of Budgets: Operational & Financial Budgets, Financing and Dividend decisions. Types of accounts, bookkeeping, Profit and Loss Account and Balance Sheet, Cash Flow Statement **2. Capital Budgeting and ratio Analysis** -Ratio Analysis Classification, Ratio Analysis and its limitations. Types of Ratios, Activity Turnover, Profitability, Liquidity, etc., B: Common Size Statement, Index Statement, Capital Budgeting - Nature of Investment decisions; Investment evaluation criteria - Non-DCF & DCF Techniques, PBP, Discounted PBP, PI, ARR, Annual Worth **3. Working Capital Management** - Meaning, significance and types of working capital; calculating operating cycle period and estimation of working capital requirements; sources of working capital, NPV and IRR comparison; Capital rationing. Various committee reports on bank finance; Dimensions of working capital management
SECTION-1I

4. Introduction to concept of Cost and Overheads - Cost, Cost Centre, Cost Unit, Elements of Cost: Material Cost. Different methods of pricing of issue of materials Labour Cost: Direct & Indirect cost, Different methods, Direct Expenses: Constituents and Significance, Prime Cost, Classification: Production, Office & Administration, Selling & Distribution. Treatment of Overheads: Collection, Primary and Secondary Distribution and Absorption of Overheads Machine, Labour hour rate, Under/Over Absorption of Overheads, Preparation of Cost Sheet

5. Costing Methods - Job Costing, Unit Costing, Contract Costing, Process Costing, Activity Based Costing Simple numerical on various methods of costing to enable ascertains cost of product. Standard costing: Concept, Standard Cost, Standard costing. Calculation of Variance Numerical on calculation of variances, Variance – Variance Analysis

6. Marginal Costing and Break Even Analysis - Fixed & Variable (Marginal) Cost, Marginal Cost. Applications of Marginal Costing in Decision-making: Product Mix, Profit Planning, Make or Buy Decisions. Limiting Factor, Cost Volume Profit Analysis, Concept of Break-Even, P/V Ratio and Margin of Safety

List of Home Assignments:

Design:

1. Design a cost estimate for running a Shoe Company.
2. Design a cost estimate for running a Fabrication Shop.
3. Design a cost estimate for running an Online Book Company.
4. Design a cost estimate for running a Grocery Company.
5. Design a cost estimate for running a Data Science Company.

Case Studies:

1. Ratio Analysis based on real life data from project on Profit and loss and Balance sheet in any one sector Company (KPO/BPO, Manufacturing, Pharma.
2. Compare Analysis of published results of organisations to enable investment decision
3. Apply Product Costing to estimate cost of any process used in any one sector Company (KPO/BPO, Manufacturing, Pharma,....
4. Apply Service Costing to estimate cost of any process used in any one sector Company (KPO/BPO, Manufacturing, Pharma,....
5. Apply Process Costing to estimate cost of any process used in any one sector Company (KPO/BPO, Manufacturing, Pharma,....

Blog

1. Taxation
2. Product Costing
3. Service Costing
4. Process Costing
5. Investment Decisions

Surveys

1. Interest Rates
2. Domestic Investment Decisions
3. Industrial Investment Decisions
4. Government Schemes
5. Suggestions about taxation.

Suggest an assessment Scheme:
Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.
Mid semester - 30
End semester - 30
Home assignment - 10 marks
CVV - 30 marks

Text Books: ***(As per IEEE format)***

1. Prasanna Chandra, Financial Management – Theory and Practice, Edition 8, 2011, Tata McGraw Hill Education,
2. B. K. Bhar, Cost Accounting– Methods and Problems, Academic Publishers,1980
3. M.Y. Khan and P K Jain, Financial Management: Text, Problems and Cases, Tata McGraw Hill Education
4. Amitabha Mukherjee and Mohammed Hani, Modern Accountancy, Edition 2, 2002, Tata McGraw Hill Education

Reference Books: ***(As per IEEE format)***

1. Paresh P. Shah, Financial Management, Reprint No. 2 2011, Biztantra, New Delhi,
2. S. N. Maheshwari, Introduction to Accountancy, Edition 11, 2013, Vikas Publishing House
3. M. Y. Khan, P. K. Jain, Management Accounting –Text, Problems, Cases, Tata McGraw Hill Publishers, 2013

Moocs Links and additional reading material:

www.nptelvideos.in

Course Outcomes:
Students will be able to:
1.Understand and analyze financial statements and budgeting, interpret accounting ratios
2.Understand the concepts of Capital Budgeting and Working Capital management
3. Understand the mechanics of financial accounting for preparation of financial statements to ascertain the performance and financial position of a business
4.Classify, apply different types of costs and overheads to ascertain costs of a product/ process
5.Apply costing methods as per the suitability for various production processes and services.
6.Develop decision making of optimum product mix, profit planning, make or buy decisions

CO PO Map

CO/PO	PO:1	PO:2	PO:3	PO:4	PO:5	PO:6	PO:7	PO:8	PO:9	PO:10	PO:11	PO:12	PSO:13	PSO:14	PSO:15
CO:1	1	2	2	1	1	2	1	2	2	2	2	2	1	1	2
CO:2	1	2	2	2	1	2	1	2	2	2	2	2	1	1	2
CO:3	1	2	2	1	2	2	2	2	2	2	2	1	1	1	1
CO:4	1	2	2	1	2	2	2	2	2	2	2	1	1	1	1
CO:5	1	1	2	2	2	2	2	1	2	2	2	2	1	2	1
CO:6	1	1	2	1	2	2	1	1	2	2	2	2	1	2	1

CO attainment levels

CO1-3; CO2-3; CO3-4; CO4-4; CO5-4; CO6-4

Future Courses Mapping:

Advanced Financial Management courses

Job Mapping:
Better growth opportunities for higher Management positions.

FF No. : 654

CH4253:: BIOPROCESS ENGINEERING

Course Prerequisites:

Course Objectives:

The student will be able to

1. To understand cell structure and biochemicals.
2. To understand enzymes and enzyme kinetics.
3. To understand different types of bioreactors and scale up bioreactors.
4. To understand commercially used different bioprocesses.

Credits: 2 **Teaching Scheme Theory: 2.** Hours/Week

Tut: 0 Hours/Week

Lab: **0** Hours/Week

Course Relevance:.

The study of the subject will help to understand basic concepts of biochemicals, enzymes and enzyme kinetics required in the design of bioprocesses and different types of bioreactors used in bioprocesses. This subject also gives an overview of scale up of bioreactors and commercially used different bioprocesses.

SECTION-1
Topics and Contents Introduction to structure of cells, important cell types, growth of microbial cells. Bio-chemicals: Primary, secondary, tertiary structure of biomacromolecules such as lipids, sugars and polysaccharides, nucleotides, RNA, DNA, amino acids, proteins, hybrid biochemicals etc. Enzyme substrate complex and enzyme action with examples from industrial enzymes, simple enzymes, kinetics with one and two substrates. Michaelis-Menten kinetics. Models of enzymes kinetics with brief introduction
SECTION-1I

Topics and Contents

Major components in bioreactor, Types of bioreactors, modern bioreactors types, scale up and its difficulties, considerations on aeration, agitation, and heat transfer, Discuss manufacturing process for major products produced by biochemical reactions such as alcohol, acetic acid and vinegar, acetone, lactic acid, citric acid, wine.

List of Home Assignments:

Design:

1. Bioreactor design.
2. Michaelis-Menten kinetics
3. Enzyme kinetics with one substrate
4. Enzyme kinetics with two substrate
5. Monod growth kinetics

Case Study:

1. Scale up of bioreactor.
2. Lactic acid manufacturing.
3. Acetic acid manufacturing.
4. Ethanol manufacturing.
5. Single cell proteins.

Blog:

1. Different types of bioreactors.
2. Enzyme substrate complex.
3. Different types of enzymes.
4. Different types of proteins.
5. DNA

Surveys:

1. Applications of bioprocesses in the food sector.
2. Applications of bioprocesses in the healthcare sector.
3. Applications of bioprocesses in the industrial chemicals sector.
4. Applications of bioprocesses in the dairy sector.
5. Applications of bioprocesses in the agricultural sector.

Suggest an assessment Scheme:
Suggest an Assessment scheme that is best suited for the course. Ensure 360 degree assessment and check if it covers all aspects of Blooms Taxonomy.

MSE	*ESE*	*HA*	*VIVA*
30	*30*	*10*	*30*

MSE - Mid Semester Examination

ESE - End Semester Examination

HA - Home Assignment

VIVA - Viva voice

Text Books: ***(As per IEEE format)***

1. Bailey, James E Ollis, Davis F, "Biochemical Engineering", McGraw Hill.
2. Shuler M. L. and F. Kaegi, 'Bioprocess Engineering – Basic Concepts', Prentice Hall Publication ,2nd Edition

Reference Books: ***(As per IEEE format)***

1. Aiba A-Humphery A.E., Mills N.F , "Biochemical Engineering",., Academic Press.
2. Atkinson B, "Biochemical Reactors", Pion Ltd. London.
3. Ghosh T.K., et. Al., "Advances in Biochemical Engineering", Vol.1/3, Springer Verlag 1971-74
4. Wingard L.B., "Enzyme Engineering", Fr. Interscience N.Y. 1972.
5. Peavy H. S., Rowe D. R., Tchobanoglous G., "Environmental Engineering", McGraw-Hill, 1985.
6. P. F. Stanbury, A. Whitekar, S. J. Hall, 'Principles of Fermentation Technology',

Butterworth-Heinemann An Imprint of Elsevier, 2nd Edition.

Moocs Links and additional reading material:

www.nptelvideos.in

Course Outcomes:

The student will be able to:

1. Describe different types of biochemicals.
2. Derive the kinetics & describe mechanism of bio-cataysis.
3. Describe various components & types of bioreactors.
4. Describe various bioprocesses in chemical industry

CO PO Map

CO/PO	PO: 1	PO: 2	PO: 3	PO: 4	PO: 5	PO: 6	PO: 7	PO : 8	PO: 9	PO:10	PO: 11	PO:12	PSO: 13	PSO: 14
CO:1	2	1	1	1	1	1	1	1	1	1	0	1	1	3
CO:2	2	1	2	1	2	1	1	1	1	1	0	1	1	3
CO:3	2	1	3	3	2	1	1	1	1	1	0	1	1	3
CO: 4	2	1	3	1	2	1	1	1	1	1	0	1	1	3

CO attainment levels

CO	Attainment level
CO : 1	**3**
CO : 2	**4**
CO : 3	**5**
CO : 4	**5**

Future Courses Mapping:

Biotechnology
Job Mapping: Pharmaceutical industries, Water and wastewater treatment plants, Food industries, Medicine sector, Industrial chemical manufacturing, etc

FF No. : 654

CH4255::NANOSCIENCE AND NANOTECHNOLOGY

Course Prerequisites:

None

Course Objectives:

1. To get an overview of the state of the art, historical development and future trends in nanoscience and nanotechnology
2. To understand the various characterization techniques which lie at the heart of the development of the field
3. To understand various methods of synthesis and industrial production of nanosystems

Credits: 2 **Teaching Scheme Theory: 2** Hours/Week

Course Relevance:

The course aims to provide an overview of the highly multidisciplinary field of nanoscience and nanotechnology which has a vast range of applications.

SECTION-1
Section I: Overview, Physics of Nanomaterials, Characterization *Introduction: Histroical development of nanotechnology. Overview of nanotechnology. Global trends. Overview of typical products in market utilizing nanotechnology.* *Physics of Nanomaterials: Coverage of physics of materials appropriate for applications to nanotechnology* *Characterisation of Nanomaterials: Microscopy techniques, spectroscopy techniques, XRD etc*
SECTION-1I

Section II: Synthesis, Applications, Socio-Economic & Environmental Aspects

Synthesis / Fabrication of nanomaterials: Top-down and bottom-up approaches for synthesis of nanomaterials. Industrial scale production of nanomaterials.

Applications of Nanotechnology: Current and potential applications of nanotechnology. Biological nanomaterials. Nanoelectronics.

Nanomachines& nanodevices etc.

Research directions.

Economic, environmental and societal aspects of nanotechnology.

List of Course Seminar Topics:

1. Risk potential and analysis of nanomaterials
2. Nanotechnology for waste water treatment
3. Opportunities in nanotechnology
4. Nanofluids for lubrication
5. Application of functionalized nanoparticles for remediation of organic pollutants
6. Study of characterization tools for surface topography
7. wearable electronics
8. Nanotechnology in diagnosis and treatment
9. lab on a chip
10. Design and development of nanocatalysts for host of applications
11. Electron microscopy and its history
12. Advancements in quantum sensors for Bio applications
13. Quantum computers in surface metrology
14. Quantum polymers, their properties and applications
15. Plasma technology and its applications in reference to nanosynthesis
16. Advanced analytical tools for nanomaterials characterization

List of Home Assignments:

Design:

1. Nanomaterials for heat exchange applications
2. Polymer based nanocomposites
3. Nanoadsorbents for contaminants remediation
4. Measuring the flow of nanoparticles using flow meters
5. Design of a carbon nanotube manufacturing plant

Case Study:

1. Materials innovation for 3D printing
2. Additive manufacturing and its benefits to aerospace industry
3. Carbon nanotube sensors for gas detection
4. Optical fiber sensor to monitor energy storage
5. Machine learning in nanotechnology

Blog

1. Is it too soon to call 3D printing a clean technology?
2. How could Graphene be used in future optical communications?

3. Can Nanodiamonds be used for next generation energy storage?
4. How can nanophotovoltaics help in the maximum efficiency of energy generation?
5. Applications of deep learning in nanotechnology

Surveys

1. comparison between particle analysis techniques
2. Application of nanoparticles in the remediation of heavy metals
3. Nanomaterials in protective coatings
4. Nanotechnology in agriculture
5. Career opportunities for chemical engineers in nanotechnology

Suggest an assessment Scheme:

MSE	*ESE*	*HA*	*VIVA*
30	*30*	*10*	*30*

MSE - Mid Semester Examination

ESE - End Semester Examination

HA - Home Assignment

VIVA - Viva voice

SEM - Seminar

Text Books:

1. R. W. Kelsall et al, "Nanoscale Science and Technology", John Wiley and Sons, 2005.
2. C. P. Poole Jr, F. J. Owens, "Introduction to Nanotechnology", Wiley India, 2006.
3. D. J. Griffiths, "Introduction to Quantum Mechanics", D.J. 2nd ed. Pearson, 2005.

Reference Books:

1. B. Bhushan ed., "Springer Handbook of Nanotechnology", Springer, 2004.

Moocs Links and additional reading material:

1. P. Haridoss, "Nanotechnology: Science and Applications', NPTEL, [Online]. Available: https://nptel.ac.in/courses/113/106/113106093/

2. A. Subramaniam and K. Balani, "Nanostructures and Nanomaterials: Characterization and Properties", NPTEL, [Online]. Available: https://nptel.ac.in/courses/118/104/118104008/

Course Outcomes:

The student will be able to –

1. describe history of nanotechnology
2. understand basics of physics and chemistry involved in nanotechnology
3. explain the major characterization techniques used in nanotechnology
4. classify and describe various nanosynthesis methods
5. analyze any given nanotechnology product / process in terms of characterization techniques, synthesis methods and applications
6. analyze current and future trends

CO PO Map

CO/ PO	PO: 1	PO: 2	PO: 3	PO: 4	PO: 5	PO: 6	PO: 7	PO: 8	PO: 9	PO: 10	PO: 11	PO: 12	PSO : 13	PSO : 14
CO1	2	1	1	1	1	1	1	1	1	1	0	1	1	1
CO2	2	1	2	1	2	1	1	1	1	1	0	1	1	1
CO3	2	1	3	3	2	1	1	1	1	1	0	1	1	1
CO4	2	1	3	1	2	1	1	1	1	1	0	1	1	1
CO5	2	1	2	1	2	1	1	1	1	1	0	1	1	1
CO6	2	1	2	1	1	1	1	1	1	1	0	1	1	1

CO attainment levels

CO	Attainment Level
1	3
2	5
3	4
4	4
5	4
6	3

Future Courses Mapping:
None

Job Mapping:

1. *Research organisations carrying out nanosystems research*
2. *Industrial research divisions*
3. *Postgraduate education*
4. *Entrepreneurship in nanomaterials manufacturing*

FF No. : 654

CH4289::MAJOR PROJECT

Course Prerequisites: Basic principles of physics, mathematics, chemistry, heat transfer

Course Objectives:

The Students will be able to

1. Do literature search appropriately with available tools
2. Defining of project title/idea
3. Allocation of tasks among the team members
4. Team spirit development
5. Write a report, research paper with required format
6. Present work effectively with concrete results

Credits: 10 **Teaching Scheme Theory: …..** Hours/Week

Tut: ……... Hours/Week

Lab:**20** Hours/Week

Course Relevance:

SECTION-1&II
Topics and Contents This stage will include a complete report consisting of synopsis, the summary of the literature survey carried out, Details of experimental/theoretical work and results and discussion and conclusion. Students may undertake studies in application chemical engineering knowledge for manufacturing project, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of this work. The group of students is required to choose the topic in consultation with the Guide. A technical report of 15 pages is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation. The external from Industry/research organization is invited to evaluate the projects done by students.

List of Project areas:

1. Agriculture
2. Personal Health
3. Social health
4. Hygiene
5. Energy
6. Environment
7. Potable Water
8. Solar based
9. Modeling and Simulation
10. Waste water treatment
11. Air pollution
12. Solid waster management
13. Low cost product development

Suggest an assessment Scheme:

Assessment of project includes three reviews spread across 4 months, where research innovative ideas, strategy of execution, actual execution, teamwork is assessed.

Every review is based on report writing, presentation of results and team work demonstration.

Two reviews are with internal faculty members
Third review is with an external industry expert.

Review 1: Literature search and deciding appropriate topic
Review 2: Progress of work on decided topic i.e setting experimental setup, developing methodology of solving the opted problem.
Review 3: Overall assessment of project work with team efforts.

Moocs Links and additional reading material:

1. www.nptelvideos.in
2. https://nptel.ac.in/courses/103/103/103103039/#watch
3. https://www.honeywellprocess.com/en-US/explore/solutions/integrated-technology/Pages/leap.aspx
4. https://www.gtu.ac.in/uploads/GIC%20Compendium%20IDP-UDP.pdf
5. https://www.udemy.com/course/leadership-psychology-cultivate-creativity-and-innovation/
6. https://www.coursera.org/learn/uva-darden-project-management
7. https://www.coursera.org/specializations/innovation-creativity-entrepreneurship

Course Outcomes:

The student will be able to –

1. Apply chemical engineering knowledge.
2. Learn how to work in a team.

3. Define a task (problem) and execute it.
4. Carry out research and development work.
5. Design equipments or process for chemical engineering plants.
6. Document findings or design in selected topic

CO PO Map

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	3	1	1	1	0	1	1	1	1	1	1	1	1	1
CO2	0	0	0	0	0	0	0	3	3	1	3	1	0	0
CO3	3	1	1	1	1	1	1	1	1	1	1	1	1	1
CO4	1	3	1	1	1	1	1	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1	1	3	1	1	1	1
CO6	1	1	1	1	1	1	1	1	1	2	1	1	1	1

CO attainment levels

CO	Attainment level
1	2
2	3
3	3
4	5
5	5
6	4

Future Courses Mapping:

Semester long internship

Job Mapping:

What are the Job opportunities that one can get after learning this course

1. Core Chemical Engineering industrial job
2. Chemical Engineering Design job

3. Chemical Engg. research jobs

FF No. : 654

CH4293::INDUSTRY INTERNSHIP

Course Prerequisites:

Heat Transfer, Mass Transfer, Fluid Flow Operations, Process Calculations, Mass Transfer Operation, Separation Techniques, Chemical Reaction Engineering, Instrumentation and Process Control, Transport Phenomena

Guidelines:

1. HOD to constitute a committee of four senior faculty members for Internship allocation.
2. Students need to maintain minimum attendance of 75% at the place of work and produce Digital record duly signed by competent authority.
3. Total Internship period is minimum 16 weeks or 4 months.
4. Internship undertaken is to be Industrial Internship.
5. Students need to submit monthly reports to Company and Institute.
6. Final presentation (CVV) would be conducted at the end of semester.
7. Distribution of credits and other guidelines are subject to change.

Course Outcomes:

The student will be able to –

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

FF No. : 654

CH4291::RESEARCH INTERNSHIP

Course Prerequisites:

Heat Transfer, Mass Transfer, Fluid Flow Operations, Process Calculations, Mass Transfer Operation, Separation Techniques, Chemical Reaction Engineering, Instrumentation and Process Control, Transport Phenomena

Guidelines:

1. HOD to constitute a committee of four senior faculty members for Internship allocation.
2. Students need to maintain minimum attendance of 75% at the place of work and produce digital record duly signed by competent authority.
3. Total Internship period is minimum 16 weeks or 4 months.
4. Internship undertaken is to be Research Internship.
5. Students need to submit monthly reports on Research Project.
6. Final presentation (CVV) would be conducted at the end of semester.
7. Distribution of credits and other guidelines are subject to change.

Course Outcomes:

The student will be able to –

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

FF No. : 654

CH4294::INTERNATIONAL INTERNSHIP

Course Prerequisites:

Heat Transfer, Mass Transfer, Fluid Flow Operations, Process Calculations, Mass Transfer Operation, Separation Techniques, Chemical Reaction Engineering, Instrumentation and Process Control, Transport Phenomena

Guidelines:

1. HOD to constitute a committee of four senior faculty members for Internship allocation.
2. Students need to maintain minimum attendance of 75% at the place of work and produce digital record duly signed by competent authority.
3. Total Internship period is approximately 16 weeks or 4 months.
4. Internship undertaken to be taken outside India as Industrial Internship or Research Internship.
5. Students need to submit monthly reports on Industry Project/Research Project.
6. Final presentation (CVV) would be conducted at the end of semester.
7. Distribution of credits and other guidelines are subject to change.

Course Outcomes:

The student will be able to –

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

FF No. : 654

CH4292::PROJECT INTERNSHIP

Course Prerequisites:

Heat Transfer, Mass Transfer, Fluid Flow Operations, Process Calculations, Mass Transfer Operation, Separation Techniques, Chemical Reaction Engineering, Instrumentation and Process Control, Transport Phenomena

Guidelines:

1. HOD to constitute a committee of four senior faculty members for Internship allocation.
2. Students need to maintain minimum attendance of 75% at the place of work and
3. Produce digital record duly signed by competent authority.
4. Total Internship period is minimum 16 weeks or 4 months.
5. Internship undertaken is to be Project Internship.
6. Students need to submit monthly project report.
7. Final presentation (CVV) would be conducted at the end of semester.
8. Distribution of credits and other guidelines are subject to change.

Course Outcomes:

The student will be able to –

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