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 'B23/C23/D23'

Effective from Academic Year 2023-24

B.Tech. Chemical Structure Pattern B22 (applicable w.e.f. AY 23-24)

Second Year Module -III

Subject head	Course code	Course name	Contact hours per week			Credits
			Theory	Lab	Tut	
S1	MD2201	DATA SCIENCE	2	2	1	4
S2	CS2221	INTERNET OF THINGS	2	2	1	4
S3	ME2205	3D PRINTING	2	2	1	4
S4	CS2218	OBJECT ORIENTED PROGRAMMING			-	4
S5	CH2227	CHEMICAL ENGINEERING MATHS				
S6	CH2293	ENGINEERING DESIGN AND INNOVATION – III	-	8	-	6
S7	CH2291	DESIGN THINKING-3	-	-	1	1
S8		AUDIT COURSE LLP				
		Total	14	16	3	23

Second Year Module - IV

Subject head	Course code	Course name	Contact hours per week			Credits
			Theory	Lab	Tut	
S1	CH2221	FLUID FLOW OPERATIONS	2	2	1	4
S2	CH2223	PROCESS CALCULATIONS	2	2	1	4
S3	CH2222	PARTICULATE TECHNOLOGY	2	2	1	4
S4	CH2224	PHYSICAL AND ORGANIC CHEMISTRY	2	2	1	4
S5						
S6	CH2294	ENGINEERING DESIGN AND INNOVATION – IV	-	12	-	6
S7	CH2292	DESIGN THINKING-3	-	-	1	1
S8		AUDIT COURSE LLP				
		Total				23

FF No. : 654

CH2227::CHEMICAL ENGINEERING MATHEMATICS

Course Prerequisites:

Basic understanding of Mathematics, linear algebra and differential equations.

Course Objectives:

1. To understand calculations for linear equations with matrices.
2. To understand numerical methods to solve ordinary differential equations and integration.
3. To understand numerical methods to solve partial differential equations.
4. To understand formulation of numerical programming and optimization.

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 various numerical methods used to find the root of equation, solution of differential equations and to find integration of a function required for chemical engineering. This subject also gives an overview of formulation of numerical programming and optimization of chemical operations.

SECTION-1
System of Linear Equation: Introduction to modeling, Matrix algebra, Systems of linear equation using Eigen values and Eigen vector, multiple ODE, steady state analysis, Numerical Analysis I: Root finding methods for algebraic equations:- False position method, Newton-Raphson method), Bisection method, Trapezoidal rule, Simpson's 1/3 rule, integration with unequal segments, Simpson's 3/8 rule
SECTION-1I

Numerical Analysis II: Properties of finite methods (stability, convergence etc.) Finite difference method, elliptical and parabolic equations, Laplace equation, solution techniques, boundary conditions ,explicit and implicit method. Optimization: Basic concept of optimization and formulation, Nature of optimization problem (constraints and unconstraint), Liner programming by simplex method.

Assessment Scheme:

ESE
100

ESE - End Semester Examination

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

1. Chapra, S.C.; Canale, R.P., "Numerical Methods for Engineers", 4th Edition, Tata-McGraw Hill Publications, 2002.

2. Edger, T. F.; Himmelblau, D. M., "Optimization of chemical processes", McGraw-Hill, 2nd Edition, 2001.

3. R.B. Bird, W.E. Stewart and E.W. Lightfoot, "Transport Phenomena", John Wiley,

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

1. Rice, R.G.; Do, D.D., "Applied Mathematics and Modeling for Chemical Engineers", John Wiley and Sons, 1995.

2. Jenson, V.G.; Jeffreys, G. V., "Mathematical Methods in Chemical Engineering", 2nd Edition, Academic Press, 1997.

3. Mickley, H. S.; Shewrwood, T. S.; Reed, C. E., "Applied Mathematics in Chemical Engineering", McGraw-Hill, 1957.

4.Riggs, James B., "An Introduction to Numerical Methods for Chemical Engineers", 2nd Edition, Texas Tech University Press, 1994.

5. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and sons, inc.

Moocs Links and additional reading material: www.nptelvideos.in

Course Outcomes:

The student will be able to –

1. Solve different Chemical engineering problems by using matrices.

2. Solve different Chemical engineering problems using numerical methods.

3. Solve different elliptical and parabolic equations.

4. Solve industrial problems by using linear optimization techniques.

CO PO Map

co/po	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12	pso13	pso14
co1	3	3	2	2	1	1	1	0	0	0	1	1	1	1

co2	**3**	**3**	**2**	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**1**
co3	**3**	**3**	**2**	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**1**
co4	**3**	**3**	**2**	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**1**

CO attainment levels

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

Future Courses Mapping:
Process Calculations, Mass transfer operations, Separation Techniques, Chemical reaction kinetics, Chemical reaction engineering,

Job Mapping:

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

FF No. : 654

CH2293::ENGINEERING DESIGN AND INNOVATION III

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: 06 **Teaching Scheme Theory: …..** Hours/Week

Tut: ……... Hours/Week

Lab: **12** 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: www.nptelvideos.in

1. https://nptel.ac.in/courses/103/103/103103039/#watch
2. https://www.honeywellprocess.com/en-US/explore/solutions/integrated-technology/Pages/leap.aspx
3. https://www.gtu.ac.in/uploads/GIC%20Compendium%20IDP-UDP.pdf
4. https://www.udemy.com/course/leadership-psychology-cultivate-creativity-and-innovation/
5. https://www.coursera.org/learn/uva-darden-project-management
6. 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* *Core Chemical Engineering industrial job* *Chemical Engineering Design job* *Chemical Engg. research jobs*

CH2291::DESIGN THINKING 3

Course Prerequisites: Basic principles of Science

Course Objectives:

To provide ecosystem for paper publication and patent filing

Credits: 04 **Teaching Scheme** **Tut: 1** Hours/Week

Course Relevance: To assist for publication of research paper or patent

SECTION-1&II
Topics and Contents *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 paper/patent is required to be published 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:
Based on the quality of paper publication they are assessed.

Moocs Links and additional reading material: www.nptelvideos.in

Course Outcomes: The student will be able to –

1. Understand the importance of doing Research
2. Interpret and distinguish different fundamental terms related to research
3. Apply the methodology of doing research and mode of its publication
4. Write a Research Paper based on project work
5. Understand Intellectual property rights
6. Use the concepts of Ethics in Research
7. Understand the Entrepreneurship and Business Planning

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	1	1	1	1	1	0	0	0	0	0	0	1	1	1
CO2	1	1	1	1	1	0	0	0	0	0	0	1	1	1
CO3	2	2	3	3	2	2	1	2	2	3	0	1	1	1
CO4	3	3	3	3	3	2	1	2	2	3	1	1	1	1
CO5	1	1	1	1	1	0	0	0	0	0	0	1	0	0
CO6	2	2	2	2	2	2	1	3	2	3	0	1	0	0
CO7	1	1	1	1	1	0	0	0	0	0	0	1	0	0

CO attainment levels

CO	Attainment level

1	**2**
2	**2**
3	**3**
4	**5**
5	**2**
6	**3**
7	**2**

Future Courses Mapping:

Next semester project, BTech course project

Job Mapping:
What are the Job opportunities that one can get after learning this course
Core Chemical Engineering industrial job
Chemical Engineering Design job
Chemical Engg. research jobs

FF No. : 654

CH2221::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 behaviors
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 the development of hydrodynamic boundary layers and its impact on momentum transport.
5. To learn to apply the equations of laminar flow for pressure drop and power requirements.
6. To learn fluid transportations systems and power requirement in the transportations of fluids

Credits: 4 **Teaching Scheme Theory: 2** 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.*
SECTION-1I
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 *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 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 pipes
11. Verification of Stokes's law

List of Course 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 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.

ESE	*HA*	*CP*	*VIVA*	*SEM*
20	*20*	*20*	*20*	*20*

ESE - End Semester Examination
HA - Home Assignment
CP - Course Project
VIVA - Viva voice
SEM - Seminar

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: www.nptelvideos.in
https://nptel.ac.in/courses/103/104/103104043/
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. Determine the effect of boundary layer formation on the fluid flow.
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	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12	pso13	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

CH2223:: 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 operation without chemical reaction.
4. To understand energy balance over a unit operation with chemical reaction..
5. To understand steady state, recycle, by-pass, purge streams and material and energy balance for them

Credits: 4

Teaching Scheme Theory: 2 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
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, Mass balance with chemical reactions,single, multiple reactions, excess and limiting reactants, conversion, yield and selectivity. Material balance with recycle, bypass and purge operation.
SECTION-1I
Sensible heat changes in gases, liquids and solids, latent heat of phase change, Enthalpy changes in pure substances and their mixtures, Heat of solutions, 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, Simultaneous material and energy balance, Psychrometric calculations.

List of Practicals: (Any Six)

1. Draw process flow diagram
2. Material balance on unit process at steady state
3. Material balance with simultaneous equation
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. Prepare conversion of units chart.
10. Combine material and energy balance.

List of Projects:

1. Material balance of Sulfuric acid manufacturing plant.
2. Material balance of Soda Ash manufacturing plant.
3. Material balance of Caustic Soda manufacturing plant.
4. Material balance of Urea manufacturing plant.
5. Material balance of Ammonia manufacturing plant.
6. Material balance of sulfur manufacturing plant.
7. Material balance of Sugar manufacturing plant.
8. Material balance of Nitric acid manufacturing plant.
9. Material balance of Cement manufacturing plant.
10. Material balance of Phosphoric Acid manufacturing plant.
11. Material balance of Methanol manufacturing plant.
12. Material balance of Cracking in petroleum plant.

List of Course Seminar Topics:

1. Combustion and its material balance
2. Extraction and Its material balance
3. Humidification
4. Heat of reaction
5. Distillation and Its material balance
6. Adsorption and Its material balance
7. Recycle & bypass operations
8. Drying and Its material balance
9. Reactor and Its material balance
10. Material & energy balance of evaporator
11. Crystallization and Its material balance
12. Absorption and Its material balance

List of Home Assignments:

Design:

1. Material balance of unsteady state operation.
2. Material balance of humidification.
3. Material balance of reactor in sulfuric acid manufacturing
4. Material balance of reactor in nitric acid manufacturing
5. Material balance of reactor in phosphoric acid manufacturing

Case Study:

1. Unsteady state material balance.
2. Combustion and its material balance.
3. Psychrometric calculations.
4. Unit processes with a recycle stream.
5. Unit processes with a purge stream.

Blog

1. Importance of petroleum industry.
2. Importance of Combustion.
3. Importance of Psychrometric calculations.
4. Importance of Recycle.
5. Importance of Bypass stream.

Surveys

1. Humidification.
2. Dehumidification.
3. Fuel combustion.
4. Various Psychrometric operations.
5. Absorption.

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.

ESE	*CP*	*VIVA*	*SEM*
30	*30*	*20*	*20*

ESE - End Semester Examination
HA - Home Assignment
CP - Course Project
VIVA - Viva voice
SEM – Seminar

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

Moocs Links and additional reading material: www.nptelvideos.in

Course Outcomes:

Course Outcomes:

Student should be able to

1. Determine the quantities of chemicals in different mode i.e. moles and equivalent mass and able to convert various physical quantities in different unit systems
2. Formulate, analyze and solve steady state material balances for unit operations and unit processes.
3. Perform material balances for recycling, by-passing and purging operations
4. Perform energy balances for unit operations
5. Perform energy balances for unit processes
6. Perform Psychrometric calculations.

CO PO Map

co/ po	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12	pso13	pso14

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, 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

CH2222::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:4 **Teaching Scheme Theory: 2** Hours/Week

Tut: 1 Hours/Week

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 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 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.

ESE	*HA*	*CP*	*VIVA*	*GD*
20	*20*	*20*	*20*	*20*

ESE - End Semester Examination
HA - Home Assignment
CP - Course Project
VIVA - Viva voice
GD - Group Discussion

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

1. McCabe W. L. and Smith J. C.; Unit Operations of Chemical Engineering; 5th Edition;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:

www.nptelvideos.in

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

CH2224::PHYSICAL AND ORGANIC CHEMISTRY

Course Prerequisites: Fundamentals of Chemistry such as chemical bonding, physical and chemical changes, organic reactions, conventional and analytical tools

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: 2 Hours/Week
Tut: 1 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 ΔH°, Second law of thermodynamics, entropy, entropy changes of an ideal gas, Third law of thermodynamics.

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

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.

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,

List of Tutorials

1. BET Adsorption Isotherm
2. Standard Electrode Potential and Applications of Electrode Potential
3. Study of Biocatalysis and its Applications.
4. Gas Chromatography.
5. Artificial Intelligence and Machine learning.
6. Numericals on heat of reactions.

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 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 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:

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.

ESE	*Lab*	*CP*	*VIVA*	*GD*
30	*10*	*20*	*20*	*20*

ESE - End Semester Examination
HA - Home Assignment
CP - Course Project
VIVA - Viva voice
GD - Group Discussion

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. Zdzislaw Hippe; 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: www.nptelvideos.in
https://www.coursera.org/learn/physical-chemistry
https://www.coursera.org/learn/spectroscopy
https://www.coursera.org/learn/basic-chemistry
https://www.coursera.org/learn/high-throughput
https://www.coursera.org/learn/thermodynamics-intro
https://www.mooc-list.com/course/machine-learning-coursera
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, michaelis menten 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

CH2228::CHEMICAL TECHNOLOGY

Course Prerequisites:

Chemistry, 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

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 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
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. *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.*

SECTION-1I

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 ; 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,

Assessment Scheme:

ESE
100

ESE - End Semester Examination

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: Student should be able to
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

CO PO Map

co/po	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12	pso13	pso14
co1	1	1	3	1	1	1	1	0	0	1	1	1	3	1
co2	1	1	3	1	1	1	1	0	0	1	1	1	3	1
co3	1	1	3	1	1	1	1	0	0	1	1	1	3	1
co4	1	1	3	1	1	1	1	0	0	1	1	1	3	1

CO attainment levels

CO	Attainment level
1	3
2	4
3	4
4	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

CH2294::ENGINEERING DESIGN AND INNOVATION IV

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

Course Objectives:

The Students will be able to

7. Do literature search appropriately with available tools
8. Defining of project title/idea
9. Allocation of tasks among the team members
10. Team spirit development
11. Write a report, research paper with required format
12. Present work effectively with concrete results

Credits: 06 **Teaching Scheme Theory: …..** Hours/Week

Tut: ……... Hours/Week

Lab: **12** 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: **14.** Agriculture **15.** Personal Health **16.** Social health **17.** Hygiene **18.** Energy **19.** Environment **20.** Potable Water **21.** Solar based **22.** Modeling and Simulation **23.** Wastewater treatment **24.** Air pollution **25.** Solid waste management **26.** 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: www.nptelvideos.in

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

Course Outcomes: The student will be able to –

7. Apply chemical engineering knowledge.
8. Work in a team.
9. Define a task (problem) and execute it.
10. Carry out literature search related to topic.
11. Write synopsis and complete literature search related to topic and complete report.
12. 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
Core Chemical Engineering industrial job
Chemical Engineering Design job
Chemical Engg. research jobs

CH2292::DESIGN THINKING 4

Course Prerequisites: Basic principles of Science

Course Objectives:

To provide ecosystem for paper publication and patent filing

Credits: 04 **Teaching Scheme** **Tut: 1** Hours/Week

Course Relevance: To assist for publication of research paper or patent

SECTION-1&II

Topics and Contents

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 paper/patent is required to be published 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:

14. Agriculture
15. Personal Health
16. Social health
17. Hygiene
18. Energy
19. Environment
20. Potable Water
21. Solar based
22. Modeling and Simulation
23. Waste water treatment
24. Air pollution
25. Solid waste management
26. Low-cost product development

Suggest an assessment Scheme:
Based on the quality of paper publication they are assessed.

Moocs Links and additional reading material: www.nptelvideos.in

Course Outcomes: The student will be able to –

8. Understand the importance of doing Research
9. Interpret and distinguish different fundamental terms related to research
10. Apply the methodology of doing research and mode of its publication
11. Write a Research Paper based on project work

12. Understand Intellectual property rights
13. Use the concepts of Ethics in Research
14. Understand the Entrepreneurship and Business Planning

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	1	1	1	1	1	0	0	0	0	0	0	1	1	1
CO2	1	1	1	1	1	0	0	0	0	0	0	1	1	1
CO3	2	2	3	3	2	2	1	2	2	3	0	1	1	1
CO4	3	3	3	3	3	2	1	2	2	3	1	1	1	1
CO5	1	1	1	1	1	0	0	0	0	0	0	1	0	0
CO6	2	2	2	2	2	2	1	3	2	3	0	1	0	0
CO7	1	1	1	1	1	0	0	0	0	0	0	1	0	0

CO attainment levels

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

7	**2**

Future Courses Mapping:

Next semester project, BTech course project

Job Mapping:
What are the Job opportunities that one can get after learning this course
Core Chemical Engineering industrial job
Chemical Engineering Design job
Chemical Engg. research jobs

B.Tech. Chemical Structure Pattern C22 (applicable w.e.f. AY 23-24)

Third Year Module - V

Subject head	Course code	Course name	Contact hours per week			Credits
			Theory	Lab	Tut	
S1	CH3231	HEAT TRANSFER	2	2	1	4
S2	CH3233	CHEMICAL ENGINEERING THERMODYNAMICS	2	2	1	4
S3	CH3235	CHEMICAL REACTION KINETICS	2	2	1	4
S4	CH3237	MASS TRANSFER OPERATIONS	2	2	-	4
S5	CH3290	ENGINEERING DESIGN AND INNOVATION – III	-	12	-	6
S6	CH3289	DESIGN THINKING - V	-	-	1	1
		Total	14	16	3	23

Third Year Module - VI

Subject head	Course code	Course name	Contact hours per week			Credits
			Theory	Lab	Tut	
S1	CH3232	INSTRUMENTATION AND PROCESS CONTROL	2	2	1	4
S2	CH3234	PROCESS EQUIPMENT DESIGN	2	2	1	4
S3	CH3236	SEPARATION TECHNIQUES	2	2	1	4
S4	CH3238	CHEMICAL REACTION ENGINEERING	2	2	-	4
S5	CH3294	ENGINEERING DESIGN AND INNOVATION – IV	-	12	-	6
S6	CH3293	DESIGN THINKING – 6	-	-	1	1
		Total	13	16	3	23

FF No. : 654

CH3231::HEAT TRANSFER

Course Prerequisites: None

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:4 **Teaching Scheme Theory:2** 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 on its 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 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. 15. Kyshtym Nuclear Disaster.

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.

ESE	*Lab*	*CP*	*VIVA*	*GD*
30	*10*	*20*	*20*	*20*

ESE - End Semester Examination
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
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
   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: www.nptelvideos.in
https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785
https://www.youtube.com/watch?v=ACjR7MIFaFw&list=PL5F4F46C1983C6785&index=3
https://www.youtube.com/watch?v=gIf-aIZz7-0&list=PL5F4F46C1983C6785&index=6
https://www.youtube.com/watch?v=bkWw7o45JmI&list=PL5F4F46C1983C6785&index=8
https://www.youtube.com/watch?v=qsombY4Q7ZY&list=PL5F4F46C1983C6785&index=9
https://www.youtube.com/watch?v=atQ-SWZFWF4&list=PL5F4F46C1983C6785&index=13
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. Develop the correlations using dimensional analysis.
4. Apply basic laws of radiation for solving heat transfer problems.
5. Design simple heat exchangers.
6. Select and design a suitable evaporator for a given application.

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	3	1
CO: 2	2	2	2	2	2	1	1	2	2	2	0	1	3	1
CO: 3	2	2	2	2	2	1	1	2	2	2	0	1	3	1
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	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:
Core Chemical Engineering industrial job
Chemical Engineering Design job
Chemical Engg. research jobs

FF No. : 654

CH3233::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:4 **Teaching Scheme Theory:2** 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 thermodynamic properties of real fluids - a step ahead of ideal system
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 their Utility
16. Importance of prediction on thermodynamic properties
17. Connect of chemical engineering thermodynamics to society
18. Chemical reaction equilibria in chemical industry
19. Phase equilibria - a perspective
20. Utility of simulation of chemical reaction equilibria
21. Activity coefficient models in thermodynamic packages
22. Techniques used for estimating the temperature of earth's interior
23. Effects of physical properties estimation on process design
24. Thermodynamic data for distillation column design
25. Thermodynamic data for reactor design
26. Thermodynamic data for overall plant design
27. Thermodynamic data for flash calculations
28. Chemical reactions confined within carbon nanotubes
29. Thermodynamic properties of aromatic hydrocarbon mixtures
30. 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.

ESE	*Lab*	*CP*	*VIVA*	*SEM*
30	*10*	*20*	*20*	*20*

ESE - End Semester Examination
Lab - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar

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, data and models
4. Apply criteria of phase equilibria for vapour liquid system and generate VLE data
5. Analyze phase equilibria involving vapor and/or liquid and/or solid
6. Analyze chemical reaction equilibria and use standard heats and free energies of formation 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
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CO: 2	2	2	2	2	2	1	1	2	2	2	0	1	3	1
CO: 3	2	2	2	2	2	1	1	2	2	2	0	1	3	1
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:
Mass Transfer, Chemical Reaction Engineering, Transport Phenomena

Job Mapping:
Core Chemical Engineering industrial job
Chemical Engineering Design job, Chemical Engg. research jobs

FF No. : 654

CH3237::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. Performs mass transfer calculations for absorber, 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:4 **Teaching Scheme Theory:2** 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.

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 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. 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.

ESE	*Lab*	*CP*	*VIVA*	*GD*
30	*10*	*20*	*20*	*20*

ESE - End Semester Examination
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
GD - Group Discussion

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

1. Robert Trybal, Mass Transfer operation, Edition 5, Mcgraw hill publication
2. B. K. Datta, Principle of mass transfer, Edition, PHI Learning publication, 2015

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

1. Perry R. H., Green D. W.; Perry's Chemical Engineer's Handbook; Sixth Edition, McGraw-Hill, 1984
2. 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 flux and estimate mass transfer coefficient and diffusivity for gas-liquid and liquid-liquid system
2. Select and design appropriate gas-liquid contacting devices
3. Select and design gas absorption and stripping column
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 crystallization system and fundamental of design

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

Future Courses Mapping:

Separation Techniques, Chemical Reaction Engineering, Transport Phenomena

Job Mapping:
Core Chemical Engineering industrial job

FF No. : 654

CH3235::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 optimize the parameters like temperature and pressure for reactions

Credits:4 **Teaching Scheme Theory:2** 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,, 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
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 ,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 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 the value of rate constant 'k' for the saponification of ethyl acetate with NaOH in a 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 behavior of products with respective to 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/CAPE OPEN 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 (B)/ parallel (A) 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
16. Design of isothermal stirred tank reactors in series simulation using ASPEN Software
17. Temperature conversion profiles for adiabatic reactions in PFR
18. Design of a fermentor
19. Determination of detailed kinetics of a catalytic reaction
20. Determination of kinetics of polymerization reaction

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 its application
13. Waste water treatment methods
14. Potable water from waste water
15. CO2 Chemisorption process
16. Carbon capture methods
17. Hydrogen from biomass
18. Pulp and paper industries in India and it's future scope
19. Difficulties in scale up of nano materials.

20. Temperature control in exothermic and endothermic reactions

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.

ESE	*Lab*	*CP*	*VIVA*	*Seminar*
30	*10*	*20*	*20*	*20*

ESE - End Semester Examination
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar

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.

ESE	*Lab*	*CP*	*VIVA*	*SEM*
30	*10*	*20*	*20*	*20*

ESE - End Semester Examination
LAB - Laboratory
CP - Course Project
VIVA - Viva voice
SEM - Seminar

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:	3	3	3	2	3	2	2	2	2	2	2	2	3	3

5														
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

CH3290::ENGINEERING DESIGN AND INNOVATION III

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: …..** Hours/Week

Tut: ……... 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. 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: www.nptelvideos.in

13. https://nptel.ac.in/courses/103/103/103103039/#watch
14. https://www.honeywellprocess.com/en-US/explore/solutions/integrated-technology/Pages/leap.aspx
15. https://www.gtu.ac.in/uploads/GIC%20Compendium%20IDP-UDP.pdf
16. https://www.udemy.com/course/leadership-psychology-cultivate-creativity-and-innovation/
17. https://www.coursera.org/learn/uva-darden-project-management
18. 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* *Core Chemical Engineering industrial job* *Chemical Engineering Design job* *Chemical Engg. research jobs*

No. : 654

CH3289::DESIGN THINKING 5

Course Prerequisites: Basic principles of science

Course Objectives:

To provide ecosystem for paper publication and patent filing

Credits: 01 **Teaching Scheme** **Tut: 1** Hours/Week

Course Relevance: To assist for publication of research paper or patent

SECTION-1&II

Topics and Contents

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 paper/patent is required to be published 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:
It is based on type of publication

Moocs Links and additional reading material: www.nptelvideos.in

Course Outcomes: The student will be able to –

1. Understand the importance of doing Research
2. Interpret and distinguish different fundamental terms related to
3. Research
4. Apply the methodology of doing research and mode of its
5. publication
3. Write a Research Paper based on project work
4. Understand Intellectual property rights
5. Use the concepts of Ethics in Research
6. Understand the Entrepreneurship and Business Planning

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	1	1	1	1	1	0	0	0	0	0	0	1	1	1
CO2	1	1	1	1	1	0	0	0	0	0	0	1	1	1
CO3	2	2	3	3	2	2	1	2	2	3	0	1	1	1
CO4	3	3	3	3	3	2	1	2	2	3	1	1	1	1

CO5	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
CO6	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**3**	**2**	**3**	**0**	**1**	**0**	**0**
CO7	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**

CO attainment levels

CO	Attainment level
1	**2**
2	**2**
3	**3**
4	**5**
5	**2**
6	**3**
7	**2**

Future Courses Mapping:

Next semester project, BTech course project

Job Mapping:
What are the Job opportunities that one can get after learning this course
Core Chemical Engineering industrial job
Chemical Engineering Design job
Chemical Engg. research jobs

FF No. : 654

CH3232::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: 4 **Teaching Scheme Theory: 2** 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.*
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 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
11. PID Controller tuning using Cohen-Coon method
12. Digital PID controller implementation with anti-reset windup & derivative overrun compensation
13. Digital PID controller implementation with anti-reset windup & derivative overrun compensation
14. PID controller tuning using Ziegler-Nichols open loop method
15. Use of nanotechnology in process instrumentation

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
11. Control of highly nonlinear processes
12. Real time optimization (RTO) systems
13. Sustainability through process control
14. On-line analyzers in chemical industry
15. Batch process control
16. Statistical process control
17. Big data analytics in chemical industry
18. BASF Verbund
19. Machine learning in chemical industry
20. PID Controller tuning using Cohen-Coon method
21. Process control in plant-on-chip systems
22. BASF Verbund
23.

Suggest an assessment Scheme:

ESE	*HA*	*CP*	*VIVA*	*GD*
20	*20*	*20*	*20*	*20*

ESE - End Semester Examination

HA - Home Assignment

CP - Course Project

VIVA - Viva voice

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:

1. Chemical Process control by George Stephonopolous
2. 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/

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

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:

4. P. Saha, "Process Control and Instrumentation", IIT Guwahati, NPTEL. [Online]. Available: https://nptel.ac.in/courses/103/103/103103037/
5. S. S. Jogwar, "Chemical Process Control", IIT Bombay, NPTEL. [Online]. Available:https://nptel.ac.in/courses/103/105/103105064/
6. 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

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

CO attainment levels

CO	Attainment Level
1	3
2	5

3	**5**
4	**5**
5	**5**
6	**3**

Future Courses Mapping:

None

Job Mapping:

1. *Industries providing control system solutions*
2. *Industries providing chemical process simulation services, OTS etc*
3. *Postgraduate education*

CH3234::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: 02 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.

Introduction to Course outcome and assessment: 2 hr

a. Explanation of Course outcomes

b. Explanation of Course outcome to assessment mapping.

SECTION-1

Topics and Contents 14 hr

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. 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-1I

Topics and Contents 14 hr

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, 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.

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 Course Projects:

Every project will consist of Process flow diagram, Process Utility diagram, Piping and Instrumentation diagram, Material balance, heat balance, heat exchanger, reactor, distillation column design for given flowsheet for Chemical manufacturing.

1. Manufacturing of Sulfuric acid
2. Manufacturing of Hydrochloric acid
3. Manufacturing of Nitric acid
4. Manufacturing of salicylic acid
5. Manufacture of toluene
6. Manufacturing of caprolactum
7. Manufacturing of phenol
8. Manufacturing of cyclohexane
9. Manufacturing of cumene
10. Synthesis gas by steam methane reforming
11. Manufacturing of ammonia
12. Manufacturing of Soda Ash
13. Manufacturing of Caustic soda
14. Manufacturing of Acetone
15. Manufacturing of Ethanol
16. Manufacturing of Butanol
17. Manufacturing of Methanol
18. Manufacturing of Pentane
19. Manufacturing of hexane
20. Manufacturing of Heptane
21. Manufacturing of Benzoic Acid
22. Manufacturing of MTBE
23. Manufacturing of Butylene
24. Design of multi-effect evaporator.
25. Design of extractive distillation system
26. Design of extractive distillation system
27. Design of liquid-liquid separator.
28. Design of liquid-liquid separator.

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. Auxillary equipments

Blog

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

Assessment Scheme:

ESE	*HA*	*CP*	*VIVA*	*GD*
20	*20*	*20*	*20*	*20*

ESE - End Semester Examination
HA - Home Assignment
CP - Course Project
VIVA - Viva voice
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. 6 Choose and design auxiliary process equipment required for various simple separation & storage requirements

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:

In design, In Engineering Project company industry

Software based Chemical industry

In scale up of plant in consultancy industry

CH3236::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: 4

Teaching Scheme Theory: 2 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, McCabe Thiele method, concept of reflux, Fenske's equation, Fenske-Underwood equation, use of open steam. Partial and total Condensers, reboilers. Ponchon Savarit method for multistage operations, tray efficiencies, 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 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 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. 5. Alternative to adsorption process used in industry

Suggest an assessment Scheme:

ESE	*HA*	*CP*	*VIVA*	*SEM*
20	*20*	*20*	*20*	*20*

ESE - End Semester Examination

HA - Home Assignment

CP - Course Project

VIVA - Viva voice

SEM – Seminar

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. 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. 3. Perry R. H., Green D. W.; Perry's Chemical Engineer's Handbook; Sixth Edition, McGraw-Hill, 1984

Moocs Links and additional reading material: www.nptelvideos.in
https://swayam.gov.in/nd1_noc19_ch31/preview

Course Outcomes:
The student will be able to –

1. Carry out process design of distillation column using/generating VLE data
2. Determine parameters like distribution of key components using various shortcut methods for multicomponent distillation and/or analyze implications of factors affecting distillation column
3. Select suitable solvent for liquid-liquid extraction and design liquid-liquid extraction column
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

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: 3	2	2	2	2	2	1	1	2	2	2	0	1	3	1
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

CH3238::CHEMICAL REACTION ENGINEERING

Course Prerequisites: Chemical reaction kinetics, numerical methods

Course Objectives:

1. Apply knowledge of RTD to diagnose non ideal reactors and selection of appropriate models to predict conversion from different reactors
2. Apply principles and kinetic tools in analyzing the rates of chemical reactions for
3. heterogeneous reactions
4. Demonstrate catalytic phenomena with extensions to surface chemistry,
5. Selection of a model for gas-solid non catalytic reactions and apply it to design
6. reactors
4. Determine fluid -fluid reaction rate equations and apply to equipment design
5. Design various types of catalytic reactors

Credits:4 **Teaching Scheme Theory: 2.** Hours/Week

Tut:1... Hours/Week

Lab: **2..** Hours/Week

Course Relevance: Chemical reaction engineering is an advanced course of undergraduate chemical engineering curriculum, which is concerned with the exploitation of chemical reactions on a commercial scale. Chemical Process economics depends upon the selection and design of a chemical reactor.

SECTION-1

Non-Ideal flow Heterogeneous processes, catalysis and adsorption

Residence time distribution in vessels: E, F and C curve, and their relationship for closed vessels, conversion in reactors having non-ideal flow; models for non-ideal flow: Dispersion model, Tank in Series, model, mixing of fluids, two parameter model, mixing of two miscible fluids. Global rate of reaction, Types of Heterogeneous reactions Catalysis, The nature of catalytic reactions, Adsorption: Surface Chemistry and adsorption, adsorption isotherm, Rates of adsorption. Solid catalysts: Determination of Surface area, Void volume and solid density, Pore volume distribution, Theories of heterogeneous catalysis, Classification of catalysts, Catalyst preparation, Promoters and inhibitors, Catalyst deactivation (Poisoning)

SECTION-1I

Fluid-particle noncatalytic, catalytic and fluid-fluid non-catalytic reactions

Selection of a model for gas-solid non catalytic reaction, Un-reacted core model, Shrinking core model, Rate controlling resistances, Determination of the rate controlling steps, Application of models to design problems. Various contacting patterns and their performance equations, Introduction to heterogeneous fluid - fluid reactions, Rate equation for eight kinetic regimes i.e. instantaneous, Fast and slow reaction, Equipment used in fluid- fluid contacting with reaction, Application of fluid -fluid reaction rate equation to equipment design, Towers for fast reaction, Towers for slow reactions. Introduction of fluid particle catalytic reactions, Rate equation, Pore diffusion controlling, Heat effects during reaction, Various types of catalytic reactors construction, operation and design, Isothermal operation in Fixed bed reactor, Fluidized bed reactor, Experimental methods for finding rates.

List of Practical: (Any Six)

1. To study residence time distribution (RTD) in a CSTR and to find out peclet Number
2. To study residence time distribution (RTD) in a plug flow reactor
3. To determine RTD of a packed bed reactor and to find out Peclet No.
4. To determine RTD of CSTRs in series
5. To determine number of tanks in series equivalent to a real PFR
6. To determine heterogeneous reaction kinetics by LHHW approach
7. ASPEN simulation of Packed bed reactor
8. Study of a fluidized bed reactor and its performance
9. Case study of a trickle bed reactor
10. Adsorption isotherms

List of Projects:

1. Synthesizing a rate law, mechanism and rate limiting step for heterogeneous reactions.
2. Design of fluid- fluid reactors and Simulation using ASPEN
3. Design of fluid- particle reactors and Simulation using ASPEN
4. Catalyst preparation and adsorption isotherms
5. Conversion prediction by Dispersion Model
6. Study of Scale up processes for nano particle synthesis
7. Design of a fermentor
8. Multiple reactions in CSTR with heat effects
9. Design and simulation of a fixed bed reactor
10. Design and simulation of a fluidised bed reactor
11. Conversion prediction by T-I-S model
12. Conversion prediction by segregation model
13. Conversion prediction by maximum mixedness model
14. Diagnosis of reactors using RTD curves
15. Design of slurry reactor

List of Course Seminar Topics:

1. Modern nuclear reactors
2. Poisoning, Deactivation, regeneration and deactivation rate determination
3. Membrane bioreactors and it's application in wastewater treatment
4. Role of Chemical reaction engineering in pollution prevention
5. Recent catalyst Characterization techniques
6. Reactive Distillation
7. Reactive Absorption
8. Reactive Extraction
9. Nano materials and it's application in chemical reaction engineering
10. Micro reactors and its application
11. Scope of Chemical reaction engineering in sustainable development
12. Adsorption process and it's application
13. Advances in chemical reactors
14. Scope of Chemical reaction engineering in biotechnology
15. Membrane bio reactors
16. Catalytic reactors used in petroleum industries
17. Synthesis of nanoparticles by various methods
18. Fisher Tropsch reaction in slurry reactor
19. Challenges in manufacturing of polymers
20. Coal hydrogenation in slurry reactor
21. Any advanced technique used in process intensification in a chemical process
22. Modern reactors in chemical industries
23. Heat exchange facilities for highly exothermic reactions in fixed bed reactor
24. Recent trends in chemical reaction engineering
25. Softwares used in chemical reaction engineering
26. Membrane reactors and it's applications in chemical industries
27. Polymers and it's applications
28. Nano bio materials and it's application

Suggest an assessment Scheme:

ESE	*Lab*	*CP*	*VIVA*	*SEM*
30	*10*	*20*	*20*	*20*

ESE - End Semester Examination

HA - Home Assignment

CP - Course Project

VIVA - Viva voice

SEM – Seminar

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

1. Levenspiel, O., 'Chemical Reaction Engineering', 3rd. edition, John Wiley& Sons, 2001.
2. Fogler, H. S., 'Elements of Chemical Reaction Engineering', 3rd Ed., PHI, 2002.
3. 3.Smith, J.M., 'Chemical Engineering Kinetics', 3rd ed., McGraw Hill, 1987.

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

1. Walas, S. M., 'Reaction Kinetics for Chemical Engineers', McGraw Hill, 1959.
2. 2.Fromment G.F. and Bischoff K.B., Chemical Reactor Analysis and Design, John Wiley 1994.
3. 3.Sharma, M.M. and Doraiswamy, L.K. Heterogeneous reactions: Analysis, Examples and
4. Reactor Design. Vols. I & II, John Wiley and Sons, NY, 1984.

Moocs Links and additional reading material: www.nptelvideos.in

https://www.edx.org/course/technology-innovation-sustainable-epflx-innov4devx

Course Outcomes:

Course Outcomes:

The student will be able to –

1. Distinguish between various RTD curves and predict the conversion from a non-ideal reactor using tracer information
2. Calculate the global rate of heterogeneous catalytic reactions
3. Determine the characteristics of solid catalyst like surface area, porosity, pore volume, etc
4. Select model for fluid-particle reactions and design the fluid particle reactors
5. Select model for fluid-fluid reactions and design columns and tanks
6. Design fixed bed and fluidized bed reactor

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	1	1	2	2	2	0	1	2	1
CO: 2	1	2	2	2	2	1	1	2	2	2	0	1	3	1
CO: 3	2	2	2	2	2	1	1	2	2	2	0	1	3	1
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:

Advanced reaction engineering, Petroleum refining and petrochemicals technology, Bioengineering, Environment engineering

Job Mapping:

Student can work in chemical, petrochemical, pharmaceutical, fertilizer, biochemical industries

FF No. : 654

CH3294::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: …..** Hours/Week

Tut: ……... 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 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: www.nptelvideos.in

19. https://nptel.ac.in/courses/103/103/103103039/#watch

20. https://www.honeywellprocess.com/en-US/explore/solutions/integrated-technology/Pages/leap.aspx
21. https://www.gtu.ac.in/uploads/GIC%20Compendium%20IDP-UDP.pdf
22. https://www.udemy.com/course/leadership-psychology-cultivate-creativity-and-innovation/
23. https://www.coursera.org/learn/uva-darden-project-management
24. 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
Core Chemical Engineering industrial job
Chemical Engineering Design job
Chemical Engg. research jobs

FF No. : 654

CH3293::DESIGN THINKING 6

Course Prerequisites: Basic principles of Science

Course Objectives:

To provide ecosystem for paper publication and patent filing

Credits: 04 **Teaching Scheme** **Tut: 1** Hours/Week

Course Relevance: To assist for publication of research paper or patent

SECTION-1&II
Topics and Contents *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 paper/patent is required to be published 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:

Moocs Links and additional reading material: www.nptelvideos.in

Course Outcomes: The student will be able to –

1. Understand the importance of doing Research
2. Interpret and distinguish different fundamental terms related to research
3. Apply the methodology of doing research and mode of its publication
4. Write a Research Paper based on project work
5. Understand Intellectual property rights
6. Use the concepts of Ethics in Research
7. Understand the Entrepreneurship and Business Planning

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	1	1	1	1	1	0	0	0	0	0	0	1	1	1
CO2	1	1	1	1	1	0	0	0	0	0	0	1	1	1
CO3	2	2	3	3	2	2	1	2	2	3	0	1	1	1
CO4	3	3	3	3	3	2	1	2	2	3	1	1	1	1
CO5	1	1	1	1	1	0	0	0	0	0	0	1	0	0
CO6	2	2	2	2	2	2	1	3	2	3	0	1	0	0
CO7	1	1	1	1	1	0	0	0	0	0	0	1	0	0

CO attainment levels

CO	Attainment level
1	2
2	2
3	3
4	5
5	2
6	3
7	2

Future Courses Mapping:

Next semester project, BTech course project

Job Mapping: *What are the Job opportunities that one can get after learning this course* *Core Chemical Engineering industrial job* *Chemical Engineering Design job* *Chemical Engg. research jobs*

B.Tech. Chemical Structure Pattern D22 (applicable w.e.f. AY 23-24)

Final Year Module -VII

Subject head	Course code	Course name	Contact hours per week			Credits
			Theory	Lab	Tut	
S1	MD4206	MARKETING MANAGEMENT	2	-		2
S2	CH4203	PLANT ENGINEERING AND PROJECT ECONOMICS	2			2
S3	CH4205	TRANSPORT PROCESSES	2	-	-	2
S4	CH4289	MAJOR PROJECT	-	20	-	10
		OR				
S1	CH4293	INDUSTRY INTERNSHIP	-	-	-	16
	CH4291	RESEARCH INTERNSHIP				
	CH4294	INTERNATIONAL INTERNSHIP				
	CH4292	PROJECT INTERNSHIP				
		Total				16

Final Year Module -VIII

Subject head	Course code	Course name	Contact hours per week			Credits
			Theory	Lab	Tut	
S1	CH4259	INDUSTRIAL POLLUTION CONTROL	2	-		2
S2	CH4353	BIOPROCESS ENGINEERING	2			2
S3	CH4255	NANOSCIENCE AND NANOTECHNOLOGY	2			2
S4	CH4280	MAJOR PROJECT 2	-	20	-	10
OR						
S1	CH4293	INDUSTRY INTERNSHIP	-	-	-	16
	CH4291	RESEARCH INTERNSHIP				
	CH4294	INTERNATIONAL INTERNSHIP				
	CH4295	CAPSTONE PROJECT				
Total						16

MD4206::MARKETING MANAGEMENT

Course Prerequisites: None

Course Objectives:

1. To provide basic understanding of marketing management concepts and their relevance to business development
2. To make students aware of the questionnaire for market research
3. To provide understanding of consumer & industrial buying decision process & motives.
4. 4.To provide understanding of the concept of product management and branding in context of consumer and industrial products
5. To develop knowledge for optimizing marketing mix to get competitive advantage

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

Course Relevance: This course will provide basic knowledge of Marketing for working in a business environment.

SECTION-1
1. Concepts of Marketing *Definition of Marketing, Core marketing concepts, Marketing Management philosophies, Micro and Macro Environment, Characteristics affecting Consumer behavior, Types of buying decisions, buying decision process, Classification of consumer products, Market Segmentation* ***2. Marketing Information Systems And Research*** *Components of marketing information system–benefits & uses marketing research system, marketing research procedure, Demand Estimation research, Test marketing, Segmentation Research - Cluster analysis, Discriminant analysis. Sales forecasting: objective and subjective methods* ***3. Marketing of Industrial Goods***

Nature and importance of the Industrial market, classification of industrial products, participants in the industrial buying process, major factors influencing industrial buying behavior, characteristics of industrial market demand. Determinants of industrial market demand Buying power of Industrial users, buying motives of Industrials users, the industrial buying process, buying patterns of industrial users.

SECTION-1I

Topics and Contents

1. Product Management

The concept of a product, features of a product, classification of products, product policies – product planning and development, product line, product mix – factors influencing change in product mix, product mix strategies, meaning of "New – product; major stages in new – product development product life cycle.

2. Branding

Reasons for branding, functions of branding features of types of brands, kinds of brand name.

3. Pricing Policies

Importance of Price, pricing objectives, factors affecting pricing decisions, procedure for price determination, kinds of pricing, pricing strategies and decisions

4. Advertising and Sales Promotion (Digital marketing)

Objectives of advertisement function of advertising, classification of advertisement copy, advertisement media – kinds of media, advantages of advertising. Objectives of sales promotion, advantages sales promotion,

5. Packaging

Meaning, growth of packaging, function of packaging, kinds of packaging.

List of Home Assignments:

Design:

1. Consumer Analysis for a firm
2. Market segmentation plan
3. Business market stakeholder analysis
4. Product line analysis
5. Pricing strategy for the product/service

Case Study:

1. How Social Media Insights Marketing
2. Impact of E-Commerce on marketing
3. Case study on societal Marketing
4. Product Development analysis
5. Personal Selling

Blog

1. Marketing through social media
2. Changing buying motives for the consumer
3. Ethics in marketing
4. Marketing & Distribution
5. Industrial engineering tools for marketing

Surveys

1. Consumer Analysis
2. Market analysis for particular Product or Service
3. Factors influencing industrial buying
4. Impact of promotion
5. 5. Impact on advertisement on the consumer preferences.

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.

Assessment scheme

Sr. No	*Type of Assessment*	*Conduction*	*Marks*
1	*MCQ Exam – Section I*	*Mid Semester*	*30 Marks converted to 30 equivalent Marks*
2	*Home Assignment*	*End of Semester*	*100 Marks converted to 10 equivalent Marks*
3	*MCQ Exam – Section II*	*End of Semester*	*30 Marks converted to 30 equivalent Marks*
4	*Comprehensive Viva Voce*	*End of Semester*	*100 Marks converted to 30 equivalent Marks*

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. Wiliam J Stanton, Fundamentals of Marketing Mcgraw Hill
2. R.S.N. Pillai and Mrs. Bagavathi , Marketing S. Chand

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 attainment levels

Future Courses Mapping:

Mention other courses that can be taken after completion of this course

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

CH4203:: PLANT ENGINEERING AND PROJECT ECONOMICS

Course Prerequisites:

Process Calculations, Chemical Technology, Process equipment design

Course Objectives:

The student will be able to

1. Understand capital cost estimation, product cost estimation
2. Understand different interest rates, cash flows, taxes and insurance
3. Understand depreciation and profitability analysis
4. Understand general consideration: health and safety hazards

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 general design considerations, health and safety considerations, different types of cost estimations of chemical plants. Move over this subject also deals with depreciation and different types of methods for depreciation calculations.

SECTION-1
Topics and Contents *Chemical Plant Cost Estimation; Cash flow for industrial operations:* *Cumulative cash position, Factors Affecting Investment and Production Costs,* *Capital Investments: Fixed-Capital Investment, Working Capital, and* *Estimation of Capital Investment: Types of Capital Cost Estimates, Cost* *Factors in Capital Investment, Estimation of Total Product Cost:* *Manufacturing Costs, General Expenses. Estimation of various components of*

project cost as per recommended practice by India Financial Institutes, Plant

& machinery estimate, Cost of Production. Cost Indexes

SECTION-1I

Topics and Contents

Depreciation: purpose of depreciation as a cost, types of depreciation,

depletion, service value, salvage value, present value, depreciation in chemical

project, methods for determining depreciation, appreciation of depreciation

concept, depreciation rates.

Health and Safety Considerations; General Design Considerations: Health and Safety Hazards,

Loss Prevention: Hazard Assessment Techniques: HAZOP, HAZAN, Fault Tree Analysis, etc.

List of Home Assignments:

Design:

1. Estimation of profitability
2. HAZOP analysis of Urea manufacturing plant
3. Fault Tree analysis of Distillation column
4. Estimation of total product cost
5. Estimation of depreciation

Case Study:

1. Personal safety and industrial safety
2. Recent trends in cost estimation of chemical plant
3. Sustainable energy sources
4. Capital cost estimation of the chemical plant
5. Safety consideration in a particular plant.

Blog

1. Safety-A major issue in chemical industry
2. New trends in chemical industries
3. Importance of pilot plant in chemical industry
4. Cash flow in the chemical industry.
5. Importance of depreciation.

Surveys

1. Market survey of a particular chemical.
2. Various cost indices used in Chemical industry cost estimation
3. Various types of annuities in India
4. Different types of taxes in India
5. Different types of methods for calculation of depreciation

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*	*20*	*20*

MSE - Mid Semester Examination

ESE - End Semester Examination

HA - Home Assignment

VIVA - Viva voice

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

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

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

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

Moocs Links and additional reading material: www.nptelvideos.in

Course Outcomes:
The student will be able to

1. Estimate & predict capital investment of chemical plant
2. Estimate & predict total product cost of chemical plant.
3. Describe and calculate depreciation
4. Describe different health and safety measures 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	1	1	2	1	1	1	1	1	1	0	3	3	3	1
CO:2	1	1	2	1	1	1	1	1	1	0	3	3	3	1
CO:3	1	1	2	1	1	1	1	0	0	0	2	2	3	1
CO: 4	1	1	3	1	1	3	2	1	0	0	2	2	3	1

CO attainment levels

CO	Attainment level

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

Future Courses Mapping:
Project Management

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

FF No. : 654

CH4205::TRANSPORT PROCESS

Course Prerequisites: Fluid Flow Operations, Heat Transfer and Mass Transfer

Course Objectives:

The student will learn to

1. Set up shell momentum balance for chemical engineering systems
2. Set up shell heat balance for chemical engineering systems
3. Set up shell mass balance for chemical engineering systems
4. Study various aspects of turbulent transport phenomena
5. Study various aspects of problems in boundary layer theory

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

Course Relevance:.

1. Chemical engineering systems where space dimensions are considered are studied within the scope of Transport Phenomena.
2. Most of the problems considered in the prescribed textbook are systems of parabolic partial differential equations.
3. In general, the problems in transport phenomena arise in allied engineering sciences such as biochemical, biological, agricultural, pharmaceutical, molecular and material sciences and other areas.
5. The topics focus on studies relevant to transport processes (momentum, heat and mass) and obtain vector field expressions for fluid velocity, temperature and concentration of substances in solids/ liquids.
6. Examples can be drawn from fluid flow operations, mass transfer operations and heat transfer problems of interest in engineering applications and include problems in homogeneous and heterogeneous catalysis and general problems in chemical reaction engineering.

SECTION-1
Dimensions and units, dimensional analysis: Dimensions and units, dimensions and units dimension of an equation, dimensional analysis, settling sphere, Brownian diffusivity, torque on a particle, mass transfer to suspended particles. Dimensional analysis, dimensionless groups and correlations: Heat transfer in a heat exchanger, momentum transfer, flow in a pipe, friction factor, dimensionless groups — ratio of convection and diffusion, Dimensionless fluxes, other dimensionless groups, laminar and turbulent flow in a pipe. Correlations: Momentum transfer: Flow past flat plate, Drag coefficient for flow around an object, correlations for drag coefficient, Flow through packed column, Unit operations for mixing. Correlations: Heat and mass transfer: Droplet breakup, Heat and mass transfer, Colburn and Reynolds analogy, Low Peclet number heat/mass transfer, high Peclet number laminar flow, high Peclet number laminar/turbulent flow. Flow in pipe, flow past flat plate, high Peclet number laminar/turbulent flows. Flow past particles. Correlations: Heat and mass transfer, Diffusion: Flow past mobile interfaces, flow in packed column, Natural convection, Mass diffusion in gasses, mass diffusion in liquids. Diffusion and Dispersion. Unidirectional transport: Cartesian coordinates: Thermal diffusion, momentum diffusion, dispersion, Turbulent dispersion, dispersion in packed column, Taylor dispersion, unidirectional transport, and shell balance.

SECTION-1I

Unidirectional transport: Cartesian coordinates. Steady solutions: Unidirectional transport. Common form of transport equations, steady solutions, constant diffusivity, parallel and series conduction, Steady solutions, internal source, viscous heating, steady solutions, flow down inclined plane, Steady solution, internal source, electrokinetic flow. Unidirectional transport: Cartesian coordinates. Binary diffusion: Steady solutions, internal source, electrokinetic flow, steady solutions, internal source, diffusion-reaction, binary diffusion, correlations in balance equations. Transport by diffusion. Unidirectional transport: Correlations in balance equations: Correlations in balance equations. forced convection, correlations in balance equations, natural convection, correlations in balance equations, packed columns. Unidirectional transport: Cylindrical and Spherical coordinates: Cylindrical coordinates, balance equation, cylindrical coordinates, steady conduction, cylindrical coordinates, heat transfer resistance, cylindrical coordinates, examples, spherical coordinates, balance equation. Pressure-driven flow: Laminar flow in a pipe: Spherical Coordinates. Heat transfer resistance, laminar flow in a pipe. Momentum balance, Laminar flow in a pipe. Velocity profile. Friction factor, laminar flow in a pipe. Friction factor correlation, laminar flow in a pipe. Examples. Pressure-driven flow: Turbulent flow in a pipe: Laminar flow in a pipe. Examples, turbulence, instability, and transition, turbulent flow in a pipe. Dissipation rate, turbulence scales, Turbulent flow in a pipe, turbulence cascade, turbulent flow in a pipe, structure of turbulence. Pressure-driven flow: Bernoulli equation: Bernoulli equation, Discharge from a tank, Bernoulli equation, filling of closed tank, venturi meter, Bernoulli equation. Flow over a weir, macroscopic momentum balance, Bernoulli equation for rotating fluid.

List of Home Assignments:

Design:

1. Design of a viscometer.
2. Design of a spherical gas storage vessel.
3. Design of a multiphase reactor.
4. Design of a membrane bioreactor.
5. Design of a membrane separation unit.

Case Study:

1. Importance of Mass Transfer in industries.
2. Importance of Heat Transfer in industries
3. Advantage and Disadvantage of Laminar and Turbulent in Industries
4. Diffusion in Stagnant fluid
5. Flow through circular tubes and annulus

Blog:

1. Heat flux and temperature distribution for heat sources such as electrical and nuclear.
2. Temperature and pressure distribution of diffusivity
3. Thermal and momentum boundary layer theory
4. Equation of continuity and motion
5. Newton's law of Viscosity.

Survey:

1. Transport phenomena in Biomaterials

2. Transport phenomena during convective drying with superheated steam and moist air.
3. Heat flux through composite wall
4. A linear theory of transdermal transport phenomena
5. Problem in Food Process Engineering

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

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

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

Moocs Links and additional reading material:

1.www.nptelvideos.in

2.https://nptel.ac.in/courses/103108123,

3. https://www.edx.org/course/the-basics-of-transport-phenomena

4. Advanced Transport Phenomena | edX

5. https://www.edx.org/course/analysis-of-transport-phenomena-i-mathematical-met?utm_source=mitopenlearning-mit-open-learning&utm_medium=affiliate_partner,

Course Outcomes:
The student will be able to

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

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

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

Students wishing to apply for higher education in Indian as well as in foreign Universities should take up this course, as they will be learning advanced transport phenomena during MS/ M.Tech. programs. The scope of transport phenomena is such that it covers all chemical engineering subdisciplines and finds applications in real life problems.

Job Mapping:

Once transport phenomena course is completed successfully by a student, s/he will be able to derive a problem statement for applications of fluid flow operations, heat transfer, mass transfer and chemical reaction engineering problems. Thus, the subject is of importance to devise and solve problems in process and plant engineering and so of relevance to industrial design practice and trouble shooting.

FF No. : 654

CH4289::MAJOR PROJECT

Course Prerequisites:

Process Calculation, Chemical Technology, Mass Transfer, 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 waste 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: www.nptelvideos.in

25. https://nptel.ac.in/courses/103/103/103103039/#watch
26. https://www.honeywellprocess.com/en-US/explore/solutions/integrated-technology/Pages/leap.aspx
27. https://www.gtu.ac.in/uploads/GIC%20Compendium%20IDP-UDP.pdf
28. https://www.udemy.com/course/leadership-psychology-cultivate-creativity-and-innovation/
29. https://www.coursera.org/learn/uva-darden-project-management
30. 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 inturnship

Job Mapping:
What are the Job opportunities that one can get after learning this course
Core Chemical Engineering industrial job
Chemical Engineering Design job
Chemical Engg. research jobs

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*	*20*	*20*

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	1	1	1	1	0	1	3	0	1	1	1	2	1	3
CO:2	1	1	1	1	0	1	3	0	1	1	1	2	1	3
CO:3	1	1	1	1	0	1	3	0	1	1	1	2	1	3
CO: 4	1	1	1	1	0	1	3	0	1	1	1	2	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:

The student will be able to

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
Topics and Contents Definition of Nano, Scientific revolution-Atomic Structure and atomic size, emergence and challenge of nanoscience and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ration, surface effects on the properties. One dimensional, Two dimensional and Three dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties.Ferroelectric materials, coating, molecular electronics and nanoelectronics, biological and environmental, membrane based application, polymer based application.
SECTION-1I
Introduction to surface active agents. Theory and applications. Types of surfactants. Classification, synthesis of surfactant - Shape, size and structure of surfactants. Micelle, Emulsions, Microemulsions & Gels. Kraft temperature, surfactant geometry and packing. Introduction to colloidal material, surface properties, origin of colloidal particles, preparation & characterization of colloidal particles. Applications of super hydrophilic hydrophobic surfaces, self-cleaning surfaces. Intermolecular Forces, Van der Waals forces (Kessorn, Debye, and London Interactions). Dynamic properties of interfaces. Contact angle. Brownian motion and Brownian Flocculation. Surface free energy

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

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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*	*20*	*20*

MSE - Mid Semester Examination

ESE - End Semester Examination

HA - Home Assignment

VIVA - Viva voice

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

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

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

Moocs Links and additional reading material: www.nptelvideos.in

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. Comprehend basics of nanotechnology and surface active agent
2. Comprehend effects of different parameters on nanoparticle synthesis size, area to volume ratio etc.
3. Understand effect of surfactants on nanoparticle synthesis
4. Comprehend several dimensions of nanoparticles and understand the behaviour of hydrophilic and hydrophobic nature of surface-active agents
5. Classify nano particle-based on shape size and structure
6. Comprehend different applications of nanoparticles and surfactants

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

CO attainment levels

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

Future Courses Mapping: *Advanced materials*
Job Mapping: *All core chemical industries e.g. Oil and gas, paint, fertilizers, food, industrial chemicals manufacturing, etc*

FF No. : 654

CH4288::MAJOR PROJECT 2

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 waste 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: www.nptelvideos.in

31. https://nptel.ac.in/courses/103/103/103103039/#watch
32. https://www.honeywellprocess.com/en-US/explore/solutions/integrated-technology/Pages/leap.aspx
33. https://www.gtu.ac.in/uploads/GIC%20Compendium%20IDP-UDP.pdf
34. https://www.udemy.com/course/leadership-psychology-cultivate-creativity-and-innovation/
35. https://www.coursera.org/learn/uva-darden-project-management
36. 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	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: *Semester long inturnship*
Job Mapping: *What are the Job opportunities that one can get after learning this course* *Core Chemical Engineering industrial job* *Chemical Engineering Design job* *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
3. Digital record duly signed by competent authority.
4. Total Internship period is minimum 16 weeks or 4 months.

5. Internship undertaken is to be Industrial Internship.
6. Students need to submit monthly reports to Company and Institute.
7. Final presentation (CVV) would be conducted at the end of semester.
8. Distribution of credits and other guidelines are subject to change.

Course Outcomes:

The student will be able to –

1. Apply Chemical Engineering knowledge
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
3. digital record duly signed by competent authority.
4. Total Internship period is minimum 16 weeks or 4 months.
5. Internship undertaken is to be Research Internship.
6. Students need to submit monthly reports on Research Project.
7. Final presentation (CVV) would be conducted at the end of semester.
8. Distribution of credits and other guidelines are subject to change.

Course Outcomes:

The student will be able to –

1. Apply Chemical Engineering knowledge
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
3. digital record duly signed by competent authority.
4. Total Internship period is approximately 16 weeks or 4 months.
5. Internship undertaken to be taken outside India as Industrial Internship or Research Internship.
6. Students need to submit monthly reports on Industry Project/Research Project.
7. Final presentation (CVV) would be conducted at the end of semester.
8. Distribution of credits and other guidelines are subject to change.

Course Outcomes:

The student will be able to –

1. Apply Chemical Engineering knowledge
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.

PROGRAM OUTCOMES:

Engineering Graduates will be able to:

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

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

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

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

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

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

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

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

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

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

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

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

PROGRAM SPECIFIC OUTCOMES 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.