UG and PG Scheme

UG Course Plan

B. Tech. 3 rd Semester

CH 212-INTRODUCTIONS TO CHEMICAL ENGINEERING

Class- B.Tech **Branch-** Chemical Engineering **Semester -**III
Course Code-CHE -212 **Corse name:** Introductions to Chemical Engineering **Credit-** 03
Name of Course Coordinator : Dr. Sunny Kumar **Session-**July-Dec 2019

Course Objective:
This course will introduce basic knowledge of Chemical Engineering. The content of the course explain about the various topic of introduction of the all chemical subjects and the development of recent technologies used in the chemical process industries. It provides the importance of Chemical engineers and what are the contributions to society especially as chemical engineers in the world.

S. No.	Topics	Number of Lectures
1	Concepts of unit operations and unit processes	03
2	Recent developments in chemical engineering	
3	Fuels –Solid, liquid and Gaseous fuels	
4	Introduction to chemical kinetics	03
5	Constant Rate constant order and molecularity of a reaction	
6	Zero, 1st, 2nd, and 3rd order reactions	
7	Kinetics of opposing reactions	
8	Methods of determination of order of reactions	
9	Integral Analysis	02
10	Differential Analysis	03
11	Reaction rate theories	03
12	Arrhenius Parameters	03
13	Collision Theory	03
14	Catalysis (including enzyme catalysis)	03
15	Effect of catalysis on reaction rate	
16	Problems of Chemical Kinetics	
17	Introduction to Heat Transfer	01
18	Conduction	01
19	Convection	01
20	Radiation	01
21	Flow Arrangement in Heat Exchangers	01
22	Variation of Fluid Temperature in Heat Exchangers	01

23	Heat Transfer Equipment	01
24	Evaporation	01
25	Introduction to Mass Transfer	01
26	Crystallization	01
27	Distillation	01
28	Evaporation	01
29	Absorption	01
30	Problems on Heat Transfer	03
31	Problems on Mass Transfer	03
32	Software introduction for chemical engineering	03
	Total Lecture	45

Marks Distribution

Mini test/Surprise Test: 10%

Mid Term: 20%

Quiz: 5%

Home assignment: 5%

Final: 60 %

Course Outcomes:

After completion of this course the student would be able

- This course provides the chemical engineering aspects for students
- The structure of the course covers both theory and problems.
- An brief introduction for various subjects is defined in the form of diagram and inspirational stories.

Reference Books

1. Ghoshal, S. K., Sanyal, S. K., Datta, S**.** Introduction to Chemical Engineering
2. Enderson & Belzil, Introduction to Chemical Engineering
3. R. M. Felder and R.W. Rousseau, Elementary Principles of Chemical Processes
4. Bezer & Banchoro, Introduction to Chemical Engineering

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CH 213-CHEMICAL PROCESS CALCULATIONS

Course Plan

- **Course Objectives/Description:** The main objective of this subject is to get preliminary information to design the process industry on the basis of material and energy balance calculations.
- **Course Details**

Course Code	CH 213
Course	Chemical Process Calculations

- **Syllabus:**

Stoichiometry: Introduction- Units and Dimensions - stoichiometric principles composition relations, density, specific gravity and basis of calculation. Ideal gases and vapor pressure: Behaviors of Ideal gases -kinetic theory of gases -application of ideal gas law- gaseous mixtures - volume changes with change in composition. Vapor pressure-effect of Temperature on vapor pressure. Humidity and solubility: Humidity - saturation - vaporization - condensation – wet and dry bulb temperature, dew point, adiabatic saturation temperature, Solubility and Crystallization-Dissolution -solubility of gases. Material balance: Material Balance - Processes involving with chemical reaction and without chemical reaction - Combustion of coal, fuel gases and sulphur - Recycling operations -bypassing streams - Degree of conversion -excess reactant - limiting reactant, Energy balance: Thermo chemistry - Hess's law of summation - heat of formation, reaction, combustion and mixing - mean specific heat -Theoretical flame Temperature.

- **Course Faculty: Dr. Jay Mant Jha**
- **Course Timetable:**

S. No	Topic	No. of lecture
1	Introduction About the Subjects	1
2	Stoichiometry Introduction- Units and Dimensions	1
3	stoichiometric principles composition relations, density, specific gravity and basis of calculation	1
4	Problem and solution	1
5	Ideal gases and vapor pressure	1
6	Behaviors of Ideal gases –kinetic theory of gases	1
7	application of ideal gas law	1
8	gaseous mixtures - volume changes with change in composition	1
9	Problem and solution	1
10	Problem and solution	1
11	Vapor pressure- effect of Temperature on vapor pressure	1
12	Problem and solution	1
13	Humidity - saturation - vaporization - condensation – wet and dry bulb temperature	1
14	dew point, adiabatic saturation temperature	1

15	Problem and solution	1
16	Solubility and Crystallization-Dissolution -solubility of gases	1
17	Problem and solution	1
18	Material Balance – Processes involving without chemical reaction	1
19	Material Balance – Processes involving without chemical reaction	1
20	Problem and solution	1
21	Problem and solution	1
22	Material Balance – Processes involving with chemical reaction	1
23	Material Balance – Processes involving with chemical reaction	1
24	Problem and solution	1
25	Problem and solution	1
26	Recycling operations -bypassing streams	1
27	Recycling operations -bypassing streams	1
28	Problem and solution	1
29	Problem and solution	1
30	Degree of conversion -excess reactant - limiting reactant	1
31	Degree of conversion -excess reactant - limiting reactant	1
32	Problem and solution	1
33	Problem and solution	1
34	Energy balance: Thermo chemistry - Hess's law of summation	1
35	Energy balance: Thermo chemistry - Hess's law of summation	1
36	Problem and solution	1
37	heat of formation, reaction, combustion and mixing - mean specific heat - Theoretical flame Temperature	1
38	heat of formation, reaction, combustion and mixing - mean specific heat - Theoretical flame Temperature	1
39	heat of formation, reaction, combustion and mixing - mean specific heat - Theoretical flame Temperature	1
40	Problem and solution	1

- **Programme Educational Outcomes (PEOs):**

1. To prepare students to achieve professional engineering competence.
2. To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
3. To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices

- **Programme Outcomes (POs):**

1. Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
2. Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
3. Ability to command chemical engineering fundamentals such as mass and energy balances, chemical thermodynamics, fluid dynamics, solid and fluid transport, mass

and energy transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.

4. Ability to design equipments and process considering the economic efficiency, safety, ethics and environmental responsibilities.
5. Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bio-energy, biochemical engineering, pharmaceutical engineering, material engineering.
6. Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation

- **Course Outcomes (COs):**
  After completion of subject students will able to:
  CO.1 Make stoichiometric calculation for various processes
  CO.2 Apply material balance for various unit operations involved in the chemical processes
  CO.3 Apply energy balance calculations for various chemical engineering processes
  CO.4 Calculate humidification and dehumidification effects on the material and energy requirements
  CO.5 Calculate the material and energy balance calculations for recycling and bypassing streams operations.
- **Mapping of course outcomes with program outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	✓		✓		✓	
CO2	✓		✓			✓
CO3		✓			✓	
CO4	✓			✓		
CO5		✓				✓

- **Recommended Resources:**

1.	Chemical Process Principles, 1957	O.A.Hougen, K. M. Watson and R. A.
2.	Basic Principles and Calculations in Chemical Engineering, 8th edition, 2012	D. Himmelblau
3.	Process Calculations, 2nd edition, 2011	V.Venkataramani & N. Anantharaman
4.	Stochiometry, 5th edition, 2011	Bhutt & Vora

- **Course Grading:**
  Mini Test: 10%
  Mid Term: 20%
  Assignment: 10%
  End Term: 60%

CH 214-FLUID MECHANICS

COURSE OUTLINE

The basic purpose of this course is to introduce 2nd year Chemical Students to the concepts of fluid mechanics.
First few lectures will review the fundamentals of fluid mechanics, while subsequent lectures will focus on its applications in chemical engineering.
Briefly the course will include microscopic & macroscopic balances, Navier-Stokes' equations.
Introduction to turbulence, concept of boundary layer, friction factor, pipe flow, pressure loss in fittings, flow past an immersed body, packed & fluidized beds, pump & compressors.

Contents:
Introduction of fluid mechanics; Fluid statics-Pressure distribution in a fluid; integral balances for a control volume - mass, energy and momentum balances.
Bernoulli equation; Differential balances (Navier-Stokes equations); viscous flow in a pipe, Friction factor, Introduction to turbulence, losses in pipe systems, Flow meters, Flow past immersed bodies, Introduction to turbulence.
Mixing and Agitation, Flow through packed and fluidized bed, Filtration, Compressible flows, Pumps and Compressors, Centrifuges & Cyclones.
Engineering mathematics: Differential and integral calculus, ordinary differential equations, vector mathematics.

REFERENCES

1. Frank M. White, Fluid Mechanics (Sixth Edition), Tata McGraw-Hill, New Delhi (2008).
2. J. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall (1999).
3. W. L. McCabe, W. L. Smith, and P. Harriot, Unit Operations of Chemical Engineering, McGraw-Hill International Edition (Sixth edition) (2001).
4. R. B. Bird, W. L. Stewart and E. L. Lightfoot, Transport Phenomena (Secondedition), Wiley Singapore (2002).
5. M. M. Denn, Process Fluid Mechanics, Prentice Hall (1980).
6. Ron Darby, Chemical Engineering fluid Mechanics, Marcel Dekker Inc, NY (1996).

Course Outcome: Real time problems like weather forecast, floods, artificial organs could be understood
2. Design of Fluidized bed reactor packed bed reactor
3. Basic information for the CFD

Lecture Plan (CH214)

S.No	Topics	No. of Hours
1	Introduction to Fluid Mechanics - Fluid, Fluid types, Thermodynamic properties, Introduction of Viscosity.	2
2	Fluid statics - pressure distribution in a static fluid, hydrostatic forces on plane surfaces, Illustration by examples.	2
3	Macroscopic Balances - Control Volume, Reynolds transport theorem, Conservation of mass, Energy and linear momentum balances. Kinetic energy correction factor, Bernoulli equation, illustration by examples.	5
4	Application of macroscopic balances: Losses in expansion, Force on a reducing bend, Diameter of a free jet; Jet ejector.	2
5	Differential Balances: Differential equation of mass conservation, Differential equation of linear momentum, Navier-Stokes equations. Applications to Couette flow between a fixed and a moving plate, flow due to pressure gradient between two fixed plates, Fully developed laminar pipe flow.	4
6	Dimensional analysis and similarity: Buckingham Pi theorem, Nondimensionalization of continuity and Navier-Stokes equations, Introduction of dimensionless numbers.	2
7	Introduction to turbulence.	3
8	Viscous flow in a pipe/duct: Head loss, friction factor, frictional loss in high Reynolds no. flow, Effect of wall roughness, the Moody chart, illustration by examples.	3
9	Losses in pipe systems: pipe entrance/exit, expansion/contraction, Fittings, valves.	2
10	Fluid Meters: Local velocity measurement, Volume flow measurement, Thin- Plate orifice, flow nozzle, venture meter.	2
11	Flow past immersed bodies: Introduction to boundary layer, boundary layer thickness, Karman's momentum integral theory, Drag on a flat plate for laminar and turbulent flow, Drag on immersed bodies.	5
12	Flow through packed and fluidized beds: Flow through beds of solids, motion of particles through the fluid, Particle settling, Fluidization, minimum fluidization velocity.	2
13	Mixing and Agitation- power consumption, mixing times, scale up.	2
14	Filtration: Governing equations, constant pressure operation, constant flow operation, cycle time, types of filters.	2
15	Compressible flow: Isothermal flow, Adiabatic flow, Choked flow.	2
16	Pumps and Compressors:Pump types and characteristics, Required head, Cavitation and NPSH, isothermal compression, isentropic compression, Staged operation, Efficiency.	3
17	Centrifuges and Cyclones: Gravity settling, centrifugal separation, cyclone separations, separation efficiency, pressure loss.	2
	Total	40

CH 215-CHEMICAL PROCESS TECHNOLOGY 1

- **Course Details:**

Course Code	CH-215
Course	Chemical Process Technology 1
Locations	Department of Chemical Engineering
Contact	Anshika Rani (8718852151)

- **Course Objectives/Descriptions:** Chemical process industries has been playing important role in the development of a country in order to meet the basic needs of mankind. The aim of the course is to study process technologies, availability of raw materials, production trends, preparation of flow sheets engineering and environmental problems of various chemical industries.
- **Programme Educational Objective (PEOs):**

1. To prepare students to achieve professional engineering competence.
2. To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
3. To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices.

- **Programme Outcomes (POs):**

1. Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
2. Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
3. Ability to command chemical engineering fundamentals such as mass and energy balance, mass and energy transport, chemical thermodynamics , fluid dynamics, solid and fluids transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
4. Ability to design equipment and process considering the economic efficiency, safety, ethics and environmental responsibilities.
5. Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bioenergy, biochemical engineering, pharmaceutical engineering, material engineering.
6. Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation.

- **Course Outcomes (COs):**
    1. The purpose of the chemical technology course is to improve knowledge of the chemical processes along with emphasis on recent technological development.
    2. Draw the qualitative flow sheets for the manufacturing process of the various chemicals involved.
    3. Give the process design information for a particular manufacturing process.

4. The aim of the course is to study process technologies, availability of raw materials, production trends, preparation of flow sheets engineering and environmental problems of various chemical industries.

- **Mapping of course outcomes with program outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	√	√		√		
CO2		√	√		√	
CO3	√		√	√		√
CO4	√	√	√	√	√	√

- **This course will provide provide students with an opportunity to develop the Graduate Attribute(s) specified below:**

S. No.	N0. Of LEC.	TOPICS
1.	**5**	Chlor –alkali Industries - Manufacture of Soda ash, Manufacture of caustic soda and chlorine - common salt
2.	**5**	Sulphur and sulphuric acid- Mining of sulphur and manufacture of sulphuric acid, Hydrochloric acid
3.	**5**	Cement- Types and Manufacture of Portland cement
4.	**5**	Glass industries- Manufacture of glasses and special glasses
5.	**5**	Ceramics- Refractories
6.	**3**	Industrial gases- Carbon dioxide, Nitrogen, Hydrogen, Oxygen and Acetylene
7.	**2**	Manufacture of Paints- Pigments.
8.	**5**	Nitrogen Fertilizers- Synthetic ammonia, nitric acid, Urea, Ammonium Chloride, CAN, Ammonium Sulphate
9.	**3**	Potassium Fertilizers- Phosphate rock, phosphoric acid, Super phosphate and Triple Super phosphate, MAP, DAP. Potassium Fertilizers: Potassium chloride and Potassium sulphate
10.	**2**	Introduction to Chemical Process Software –Aspen plus, ChemCad, UniSim
	40	Total Lectures

- **Recommended Resources:**

Text Book

1. Austin. G.T.,"Shreve's Chemical Process Industries", McGraw-Hill, 5th Edition, 1985.

2. Gopal Rao M. and Sittig M., "Dryden's Outlines of Chemical Technology", 3rd Edition, East– West Press Pvt Ltd., New Delhi, 2000.

3. Moulijn J. K; Makkee M. and van Diepen A; "Chemical Process Technology", Wiley, 2001.

4. Shukla S.D. and Pandey G.N., Textbook of Chemical Technology, Vikas Publishing House Private, Limited, 1977.

CH 216-CHEMICAL ENGINEERING THERMODYNAMICS

- **Course Objectives/Description:** After studying this subjects students will be able to make calculation based on heat and work effects on any physical and chemical processes.
- **Course Details**

Course Code	**CH 216**
Course	**Chemical Engineering Thermodynamics**

- **Syllabus:**

Fundamental Concepts and Definitions. PVT relationships. First law of Thermodynamics. Application of law to different processes in closed systems. Second Law of Thermodynamics. Physical meaning of entropy. T-S diagrams. Relations among thermodynamic properties. Thermodynamic functions in terms of measurable properties. Construction of thermodynamic charts. Third Law of Thermodynamics. Thermodynamics of flow processes. Application of first law to flow processes. Power and Refrigeration Cycles. Single Component Systems. Multicomponent Systems. Phase Equilibria. Thermodynamics of Electrolytes. Statistical Thermodynamics

- **Course Faculty: Dr. Jay Mant Jha**
- **Course Timetable:**
-

S. No	Topic	No. of lecture
1	Fundamental Concepts and Definitions	1
2	First law of Thermodynamics: Energy balance for closed system, Thermodynamic state ans state functions Numerical Examples	1
3	Phase rule, Reversible process, Constant Vand P Process, Enthalpy, Numerical Examples	1
4	Heat capacity, Mass and Energy balance for open system, Numerical Examples	1
5	PVT relationships, Numerical Examples	1
6	Virial Equation of State	1
7	Virial Equation of State, Numerical Examples	1
8	Heat Effects	1
9	Heat Effects: Numerical Examples	1
10	Second Law of Thermodynamics T-S diagrams	3
11	Relations among thermodynamic properties	3
12	Thermodynamic functions in terms of measurable properties	3
13	Construction of thermodynamic charts.	3
14	Third Law of Thermodynamics	1
15	Thermodynamics of flow processes	3
16	Power and Refrigeration Cycles	3

17	Single Component Systems	3
18	Multicomponent Systems	3
19	Phase Equilibria	4
20	Thermodynamics of Electrolytes	2
21	Statistical Thermodynamics	3
	Total no of lecture	**43**

- **Programme Educational Outcomes (PEOs):**

1. To prepare students to achieve professional engineering competence.
2. To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
3. To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices

- **Programme Outcomes (POs):**

1. Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
2. Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
3. Ability to command chemical engineering fundamentals such as mass and energy balances, chemical thermodynamics, fluid dynamics, solid and fluid transport, mass and energy transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
4. Ability to design equipments and process considering the economic efficiency, safety, ethics and environmental responsibilities.
5. Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bio-energy, biochemical engineering, pharmaceutical engineering, material engineering.
6. Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation

- **Course Outcomes (COs):**
  After completion of subject students will able to:
  CO.1 Describe the basic concepts (system, surrounding, point function, path function and different types of processes etc.,)
  CO.2 Formulate the relationship between different thermodynamic parameters for different processes
  CO.3 Solve problems involving various thermodynamic power cycles
  CO.4 Evaluate the thermodynamic properties (Such as Partial molar properties, Fugacity coefficients, activity coefficients etc.) of pure fluid and fluid mixtures
  CO.5 Predict equilibrium composition of mixtures under phase and chemical-reaction equilibria

- **Mapping of course outcomes with program outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓			✓	
CO2			✓			✓
CO3			✓			
CO4	✓			✓	✓	
CO5		✓	✓			✓

- **Recommended Resources:**

1.	Introduction to Engineering Thermodynamics, 7th edition, 2009	J. M. Smith and Van Ness.
2.	Introduction to Chemical Engineering Thermodynamics, 2004	Rao Y.V.C.
3.	Chemical Engineering Thermodynamics 1994	B. F. Dodge

- **Course Grading:**

  Mini Test: 10%
  Mid Term: 20%
  Assignment: 10%
  End Term: 60%

B. Tech. 5th Semester

CH 311-HEAT TRANSFER 2

Course Objective:

This course is designed to introduce a basic study of the phenomena of heat transfer, to develop methodologies for solving a wide variety of practical engineering problems, and to provide useful information concerning the performance and design of particular systems and processes. A knowledge-based design problem requiring the formulations of solid conduction and fluid convection and the technique of numerical computation progressively elucidated in different chapters will be assigned and studied in detail. As well, to gain experience in designing experiments for thermal systems, the design, fabrication, and experimentation of a heat exchangers will be attempted. To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Sr. No.	Topics to be covered	No. of Lectures
1	Heat Exchanger: Classification	1
2	Design of shell- tube heat exchanger	1
3	Design of double pipe heat exchanger	1
4	Design of compact heat exchanger	1
5	Design of plate heat exchanger	1
6	Fouling	1
7	Extended surface for heat transfer	1
8	Effectiveness and NTU of heat exchanger	2
9	Boiling: Boiling characteristics,	2
10	Nucleate pool boiling	2
11	Forced convection boiling	2
12	Boiling mechanism	2
13	Boiling curve	2
14	Heat transfer correlations	2
15	Condensation: mechanism	2
16	Types of condensation	2
17	Nusselt equation for film wise condensation on vertical surface	2
18	Nusselt equation for extension to horizontal surfaces	2
19	Nusselt equation for extension to inclined surfaces	2
20	Film condensation inside horizontal tubes	2
21	Condensation number	2
22	Evaporator: classification and its use in process industries	2
23	Evaporator calculation in process industries	2

24	Effect of boiling point elevation on evaporator performance	2
25	Effect of hydrostatic head on evaporator performance	1
26	Fouling in evaporator	1
27	Estimation of surface area in multiple effect evaporator	2
	Total Lectures	**45**

Reference Books

1. Heat Transfer, 10th edition, 2010 Holman J.P
2. Fundamentals of Heat & Mass Transfer, 7th edition, 2013 Incropera F.P and Dewitt D.P
3. Unit operations of chemical engineering, 7th edition McCabe W.L., Smith J.C., Harriott. P
4. Fundamentals of heat & mass transfer, 2008, Foust A.S., Wemzel L.A., Clump C.W., Maus L., and Anderson L.B

Course Outcomes

CO1. Ability to **Understand** and **Solve** conduction, convection and radiation problems in Chemical Engineering.

CO2. Ability to **Design** and **Analyze** the performance of heat exchangers and evaporators in production plants.

CO3. Ability to **Design** and **Analyze** reactor heating and cooling systems in chemical industry.

CO4. Ability to **Acquire** basic understanding of **Design parameters**, complete knowledge of **design procedures** for commonly used process equipment and their attachments.

CO5. Ability to **Calculate** overall heat transfer coefficient and **apply** its significance in the various types of heat exchanger equipment's (Shell & Tube HE, condenser, Evaporator).

CO6. Ability to **Estimate** the economic feasibility of heat transfer equipment in chemical process industries.

Programme Educational Objectives (PEOs):

1. To prepare students to achieve professional engineering competence.
2. To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
3. To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices

Programme Outcomes (POs):

1. Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
2. Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
3. Ability to command chemical engineering fundamentals such as mass and energy balances, chemical thermodynamics, fluid dynamics, solid and fluid transport, mass and energy transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.

4. Ability to design equipments and process considering the economic efficiency, safety, ethics and environmental responsibilities.
5. Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bio-energy, biochemical engineering, pharmaceutical engineering, material engineering.
6. Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation.

COs & POs Mapping Table

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	✓	✓	✓	✓	✓	
CO2	✓	✓	✓	✓		
CO3	✓		✓	✓	✓	✓
CO4		✓	✓		✓	✓
CO5	✓	✓		✓	✓	✓
CO6	✓	✓	✓	✓	✓	✓

CH 312-MASS TRANSFER 2

- **Course Objectives/Description:**
  The course is about getting acquaintance with different mass transfer mechanisms and familiarize with different contacting equipment in Chemical Process Industry. Current course deals with separation of Vapor-Liquid, Liquid –Liquid and Liquid-Solid separation technologies.
- **Course Details:**

Course Code	**CH 312**
Course	**Mass Transfer II**

- **Course Faculty: Dr Subhajit Patra**

- **Programme Educational Outcomes (PEOs):**

❖ To prepare students to achieve professional engineering competence.
❖ To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
❖ To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices

- **Programme Outcomes (POs):**
  - ❖ Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
  - ❖ Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
  - ❖ Ability to command chemical engineering fundamentals such as mass and energy balances, chemical thermodynamics, fluid dynamics, solid and fluid transport, mass and energy transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
  - ❖ Ability to design equipments and process considering the economic efficiency, safety, ethics and environmental responsibilities.
  - ❖ Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bio-energy, biochemical engineering, pharmaceutical engineering, material engineering.
  - ❖ Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation

- **Course Outcomes (COs):**
  After completion of subject students will able to
  - Analyze the behavior of different phase in mixture at particular temperature and pressure.
  - Identify different modes of mass transfer.
  - Design contact equipment for a particular parameter constraints.
  - Estimate different options for choosing correct equipment for real life examples.

- **Mapping of course outcomes with program outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			✓			
CO2		✓				
CO3			✓	✓		
CO4				✓		

S. No.	LEC. No.	TOPICS
1.	**1-2**	Review of different available mass transfer processes: diffusion, absorption, adsorption, drying. Utility of the current course. Brief idea about distillation, liquid-liquid extraction and Leaching.
2.	**3-6**	Vapor Liquid Equilibria: Constant pressure, Constant temperature. VLE for ideal solution, deviation from ideality, Relative volatility, azeotrope.
3.	**7-8**	Enthalpy-concentration diagram, multicomponent system.
4.	**9-11**	Flash vaporization, steam distillation, partial distillation
5.	**12-15**	Differential distillation, Fractionation, Feed tray location, Reflux ratio, condenser, reboiler, side stream
6.	**16-18**	Multistage tower: Ponchon Savarit method, Mccabe Thiele method
7.	**19-20**	Azeotropic distillation and Extractive distillation, Reactive distillation, divided wall.
8.	**21-24**	Liquid-Liquid Extraction: usefulness, Liquid – Liquid Equilibrium, Ternary diagram, Choice of solvent
9.	**25-29**	Stagewise-contact : Fractional extraction, Agitated vessel, Emulsion and Dispersion, Sieve tray(perforated plate)
10.	**30-32**	Continuous contact: Spray tower, packed tower, Mechanically agitated,counter current extractor, Centrifugal extractor
11.	**33-34**	Leaching: preparation of solid, method of operation and equipment, solid-liquid equilibrium.
12.	**35-37**	Percolation tank, retention, Countercurrent contact: shank, batch settling
13.	**38-42**	Continuous countercurrent decanters, continuous settling, hydrocyclone, thickeners,

- **Recommended Resources:**

1 Treybal R.E., “Mass transfer operations”, 3rd Edition, McGraw Hill, 1980.
2. Geankoplis C.J., “Transport processes and unit operations”, 4th Edition, PHI, 2006.
3. Henley E.J and Sieder, J “Separation Processes Principles”, Wiley Publishers, 1998.
4. Dutta B. K., “Principles of Mass Transfer and Separation Process” PHI, 2013.

- **Course Grading:**

  Mini Test: 10%
  Mid Term: 20%
  Surprise Quiz: 10%
  End Term: 60%

CH 313-CHEMICAL REACTION ENGINEERING 2

Course Details:

Course Coordinator	Dr. S. Suresh
Course Code	CH-313
Course	Chemical Reaction Engineering-II
Location	Department of Chemical Engineering
Contact	8989005393

- **Course Objectives/Descriptions:** This course will introduce fundamental principles and practical applications of Catalysis, Kinetics, and Chemical Processes explains the basic concepts of green engineering and reactor design fundamentals, and provides key knowledge for students at technical universities and professionals already working in the industry.
- **Programme Educational Objective (PEOs):**
  1. To prepare students to achieve professional engineering competence.
  2. To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
  3. To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices.
- **Programme Outcomes (POs):**
  1. Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
  2. Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
  3. Ability to command chemical engineering fundamentals such as mass and energy balance, mass and energy transport, chemical thermodynamics , fluid dynamics, solid and fluids transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
  4. Ability to design equipment and process considering the economic efficiency, safety, ethics and environmental responsibilities.
  5. Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bioenergy, biochemical engineering, pharmaceutical engineering, material engineering.
  6. Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation.
- **Course Outcomes (COs):**
  1. Describe the algorithm that allows the student to solve chemical reaction engineering problems through logic rather than memorization.
  2. Size isothermal and non-isothermal reactors for homogeneous and heterogeneous reactions.
  3. Analyze multiple reactions carried out both isothermally and non-isothermally in flow, batch and semi batch reactors to determine Selectivity and yield.
  4. Determine the reaction order and specific reaction rate from experimental data.
  5. Describe the steps in a catalytic mechanism and how one goes about deriving a rate law, mechanism, and rate-limiting step that are consistent with experimental data.
  6. Work together to solve both open-ended and closed-ended reaction engineering problems.
  7. Write questions that demonstrate critical and creative thinking on reaction and reactor safety.
- **Mapping of course outcomes with program outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	√	√		√		
CO2		√	√		√	
CO3	√		√	√		
CO4		√			√	

CO5	√	√	√	√	√	
CO6	√					

- **This course will provide provide students with an opportunity to develop the Graduate Attribute(s) specified below:**

S. No.	LEC. No.	TOPICS
1	**1-2**	**Heterogeneous processes:** Catalysis and adsorption; Classification of catalysts, Preparation of catalysts.
2	**3-5**	Promoters and Inhibitors, General mechanism of catalytic reactions surface area and pore size distribution
3	**6-9**	Rate equation of fluid solid catalytic reactions, Hougen-Watson & law models.
4	**10-12**	Procurement and analysis ofkinetic data, kinetics of catalyst deactivation. External transport processes and their effects on heterogeneousreactions yield and selectivity
5	**13-14**	Reaction and diffusion in porous catalysts, isothermal and non-isothermaleffectiveness factors,
6	**15-17**	Effect of intraphase transport on yield, selectivity and 30 poisoning, Global reaction rate.
7	**18-20**	Design of catalytic reactors
8	**21-22**	Iso thermal & adiabatic fixed bed reactor staged adiabatic reactors.
9	**23-25**	Non-Isothermal non-adiabatic fixed bed reactors, Fluidized bed reactors, Slurry reactors, Trickle bed reactors.
10	**26-29**	Modelsfor fluid-solid non-catalytic reactions, controlling mechanisms, Diffusion through gas film controls.
11	**30-32**	Diffusionthrough ash layer controls, Chemical reaction controls, fluidized bed reactors with and without elutriation.
12	**33-34**	Gas-liquid reactions and liquid-liquid reaction,
13	**35-36**	Rate equation based on film theory,
14	**37-38**	Reaction design forinstantaneous reactions ad slow reactions, Aerobic Fermentation,
15	**39-40**	Application to Design Tools for FastReactions..
16	**41-42**	Environmental catalysis, monolithic reactors,
17	**43-45**	Pressure and temperature swing reactors,Zeolites catalyst

- **Recommended Resources:**

1. O. Levenspiel, Chemical Reaction Engineering, 3rd edition, 2006.
2. H.S.Fogler, Elements of Chemical Reaction Engineering,5th edition,2016.
3. J.M. Smith,Chemical Engineering Kinetics, 2nd edition, 1981.
4. K.G. Denbig& K.G. Turner,Chemical Theory–An Introduction to Reactors,3rd edition, 1984.
5. G. Cooper & G.V.J. Jefferys,Chemical Kinetics and Reactor Engineering, 1971.
6. Daizō Kunii and Octave Levenspiel,FluidizationEngineering, 2nd edition, 1991.
7. Y T Shah, M M Sharma,Chemical Reaction and Reactor Engineering.

Department Electives for 5th semester

CH 337-NOVEL SEPARATION TECHNIQUES

- **Course Details:**

Course Code	CHE -337
Course	Novel Separation Techniques
Locations/s	Department of Chemical Engineering
Contact	Dr. Sapana Madan (7000215564)

- **Course Objectives/Descriptions:** This course will introduce newer separation processes like, membrane based techniques, chromatographic separation, super critical fluid extraction, etc., are gaining importance in modern days plants. The present course is designed to emphasize on these novel separation processes. and its control in chemical process industries. Learn the fundamentals of adsorptive separations and modeling. Learn different membrane separation technological processes and their design

- **Programme Educational Objective (PEOs):**
  1. To prepare students to achieve professional engineering competence.
  2. To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
  3. To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices.

- **Programme Outcomes (POs):**
  1. Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
  2. Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
  3. Ability to command chemical engineering fundamentals such as mass and energy balance, mass and energy transport, chemical thermodynamics , fluid dynamics, solid and fluids transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
  4. Ability to design equipment and process considering the economic efficiency, safety, ethics and environmental responsibilities.
  5. Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bioenergy, biochemical engineering, pharmaceutical engineering, material engineering.
  6. Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation.
- **Course Outcomes (COs):**

At the end of the course, the students will be able to:

1. Explain different types of adsorptive separations and derive the equations for the same.
2. Develop design equations for membrane separation processes such as RO&UF.
3. Explain concepts of surfactant based separations.
4. Design separation system for the effective solution of intended problem.
5. Analyze the separation system for multi-component mixtures

- **Mapping of course outcomes with program outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	√	√		√		
CO2		√	√		√	
CO3	√		√	√	√	

- **This course will provide provide students with an opportunity to develop the Graduate Attribute(s) specified below:**

S. No.	Topics	Number of Lectures
1	Limitations of common separation techniques	
2	Sedimentation and Filtration	03
3	Screening	
4	Evaporation	03
5	Distillation	
6	Absorption	03
7	Liquid-liquid and solid-liquid extraction	
8	Principles of membrane separation process classification	03
9	Principle of membrane separation process, preparation of membrane and Characterization	04
10	Analysis and modelling of membrane separation	
11	Membrane modules and application	04
12	Microfiltration, Ultrafiltration	
13	Reverse Osmosis, Nanofiltration	04
14	Membrane characteristics and applications	
15	Ion- selective membranes and their application in electrolysis	
16	Per vaporization and gas separation using membranes	
17	Liquid membrane and Industrial applications	03
18	Liquid membrane separation, critical extraction	
19	Pressure swing adsorption	04
20	Freeze drying	
21	Pervaporation and Gas separation	04
22	Nano-separation	
23	Foam and bubble separation principle and classification	
24	Foam and surfactants	03

25	Separation techniques, Column Separations, Multi-component separation	02
26	Electrophoresis, desalting by freezing, centrifugation, Zone melting and Zone refining	
	Total Lectures	40

- **Recommended Resources:**

Text Book

1. Separation Process Principles, 3rd edition Seader J. D. and Henley E. J .

2. Textbook of Separation Processes Suresh S, Keshav A

3. Separation Processes, 2nd edition King C. J. 4. Water Purification By Ion-exchange, 1968 Arden T.V.

CH 338-ENVIRONMENTAL PROTECTION AND POLLUTION CONTROL

- **Course Details:**

Course Code	CH-338
Course	Environmental Pollution And Pollution Control
Locations/s	Department of Chemical Engineering
Contact	Anshika Rani (8718852151)

- **Course Objectives/Descriptions:** This course will introduce for environmental pollution and its control in chemical process industries. The content of the course explain about the various effluent and wastewater emission source, proper treatment of all kind of its pollution discharge from the chemical process industries. It provides the basic knowledge of their treatment of wastewater effluent and its conventional method to control the pollution in the environment.
- **Programme Educational Objective (PEOs):**

1. To prepare students to achieve professional engineering competence.
2. To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
3. To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices.

- **Programme Outcomes (POs):**

1. Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
2. Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
3. Ability to command chemical engineering fundamentals such as mass and energy balance, mass and energy transport, chemical thermodynamics , fluid dynamics, solid and fluids transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
4. Ability to design equipment and process considering the economic efficiency, safety, ethics and environmental responsibilities.
5. Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bioenergy, biochemical engineering, pharmaceutical engineering, material engineering.
6. Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation.

- **Course Outcomes (COs):**

1. Students are able to understand the meaning of environmental management.
2. Students are also able to understand the importance of environmental management in development of society and country.
3. It also explains how we can use natural resources in sustainable manner.

4. Students are able to understand the air pollution, Water pollution and solid waste disposal.

- **Mapping of course outcomes with program outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	√	√		√		
CO2		√	√		√	
CO3	√		√	√	√	

- **This course will provide provide students with an opportunity to develop the Graduate Attribute(s) specified below:**

S. No.	N0. Of LEC.	TOPICS
1.	**5**	Interaction of man and environment, overall picture of environmental pollution, environmental air and water quality criteria
2.	**5**	Standards and acts, effects of pollution. Air Pollution: dispersion of pollutant in the atmosphere
3.	**5**	Meteorological factors of air, stability and inversion of atmosphere, control of air pollution, air pollution control equipment.
4.	**5**	Methods of measuring and sampling of gaseous and particulate pollutants in ambient air and industrial waste gases.
5.	**5**	Water Pollution: Sources, types of pollutants in liquid wastes of chemical industries. Methods for the treatment of liquid wastes to control pollution,
6.	**3**	Selection of pollution control equipment. Methods of sampling of wastewater. Odour and its control.
7.	**2**	Solid Waste Disposal: Characterization of solid wastes. Problems of collection and handling.
8.	**5**	Various processing techniques used in solid waste management, solid waste as resource material,
9.	**3**	Noise pollution: noise control criteria,
10.	**3**	Noise Exposure index, Control.
11.	**41**	Total Lectures

- **Recommended Resources:**

Text Book

1. C. S .Rao Environment Pollution Control and Environmental Engg., 2nd edition
2. Peavy and Row Environmental Engineering, 1985
3. A.C. Stern Air Pollution – Engg. Control of Air Pollution Vol IV
4. J. O .M. Bockris, Environmental Chemistry

B. Tech. 7th Semester

CH 411-PROCESS EQUIPMENTS DESIGN &DRAWING 2

(All Tables/Chemical Engineers Handbook/Data Books/Graph Sheets are permitted during the Examinations.)

Course Objectives:

The course will enable the students to:

1. Understand general design considerations involving process design development.
2. Learn basic concepts of economic analysis for process, involving equipment cost, and profitability.
3. Acquire basic understanding of design parameters, knowledge of design procedures for pressure vessels.
4. Acquire knowledge of shell & tube heat exchanger Design.
5. Demonstrate procedures in designing of tray distillation columns including minimum reflux ratio, number of stages, feed stage, and column diameter.

Sr. No.	Topics to be covered	No. of Lectures
1	Scale up criteria and scale up of process equipment	2
2	Process design calculations for heat exchange equipment shell and tube heat exchangers general description	2
3	Process design calculations for heat exchange equipment shell and tube heat exchangers-numerical	2
4	Heat transfer coefficients and pressure drop by Kerm‘s Bells methods rating on existing unit-1	3
5	Heat transfer coefficients and pressure drop by Kerm‘s Bells methods rating on existing unit-2	3
6	Design of a new system having one or more units in series single effect evaporation	3
7	Multiple effect evaporator with boiling point elevation	3
8	Process design calculations for mass exchange equipment plate for distillation including column diameter and height	3
9	Process design calculations for packed column for distillation including column diameter and height	3
10	Process design calculations for mass exchange equipment plate for adsorption including column diameter and height	3
11	Process design calculations for packed column for adsorption including column diameter and height	3
12	Detailed process and mechanical design	3
13	Flash drum	3
14	Kettle reboiler	3
15	Condenser	2
16	Cooling tower	2
17	Rotary drier	2
	Total Lectures	**45**

Course Outcomes:

At the end of the course, the students will be able to:

CO1. Design analysis of various process equipment (shell & tube heat exchanger, evaporator, distillation column, condenser and reboiler).

CO2. Perform economic **analysis** for process to **calculate** equipment cost, and profitability for process.

CO3. Analyze the present materials and procedures adopted in the mechanical design of chemical process equipment.

CO4. Identify & selection of chemical equipment based on the particular type of unit operation and unit process.

CO5. Identify and **solve** engineering problems during production in chemical industry.

CO6. Calculate the optimum dimensions required for different components of equipment is used to be in chemical processes.

Text Books:

1. Scale up of Chemical Processes: Conversion from Laboratory Scale Tests to Successful Commercial Size Design, Bisio, A., Kabel, R.L., , John Wiley & Sons,1985
2. Chemical Engineering Vol-1 Coulson J.M. Richardson J.F.
3. Chemical Engineering Handbook, 8th edition Perry, Robert H., Green Don W
4. Applied Process Design in Chemical Petrochemical Plants, Vol–3,3rd edition E.E. Ludwig
5. Design of Equilibrium Stages, 1963 B.D. Smith

Programme Educational Objectives (PEOs):

1. To prepare students to achieve professional engineering competence.
2. To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
3. To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices

Programme Outcomes (POs):

1. Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
2. Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
3. Ability to command chemical engineering fundamentals such as mass and energy balances, chemical thermodynamics, fluid dynamics, solid and fluid transport, mass and energy transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
4. Ability to design equipments and process considering the economic efficiency, safety, ethics and environmental responsibilities.
5. Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bio-energy, biochemical engineering, pharmaceutical engineering, material engineering.
6. Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	✓		✓	✓		✓
CO2		✓	✓		✓	✓
CO3	✓	✓		✓	✓	
CO4		✓	✓		✓	✓
CO5	✓		✓	✓	✓	
CO6	✓	✓		✓		✓

Department Electives for 7th Semester

CH 434-PROCESS PIPING DESIGN

- **Course Objectives/Description:**
- Objective of this subject is to expose students to understand basic piping engineering and its application to chemical engineering
- **Course Details:**

Course Code	CH 434
Course	Process Piping Design

- **Course Faculty: Dr Rajeev Parmar**
- **Course Lecture plan:**

Topics to be Covered	No. of Lectures
Classification of pipes and tubes	2
IS & BS codes for pipes used in chemical process industries and utilities	2
Pipes for Newtonian and non-Newtonian fluids, sudden expansion and contraction effects	4
Pipe surface roughness effects, pipe bends, Shearing characteristics	2
Pressure drop for flow Newtonian and non-Newtonian fluids through pipes. Resistance to flow and pressure drop	4
Effect of Reynolds and apparent Reynolds number	2
Pipes of circular and non-circular cross section – velocity distribution, average velocity and volumetric rate of flow	4
Flow through curved pipes (Variable cross sections). Effect of pipe-fittings on pressure losses	2
Non-Newtonian fluid flow through process pipes	2
Shear stress, Shear rates behavior, apparent viscosity and its shear dependence	3
Power law index, Yield Stress in fluids, Time dependant behavior, Thixotropic and rheopetic behaviour	3
Mechanical analogues, velocity pressure relationships for fluids, line.	3

Pipe line design and power losses in compressible fluid flow	4
Multiphase flow, gas-liquid, solid-fluid, flows in vertical and horizontal pipelines, Lockhart Martinelli relations, Flow pattern regimes	5

- **Programme Educational Outcomes (PEOs):**

❖ To prepare students to achieve professional engineering competence.
❖ To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
❖ To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices

- **Programme Outcomes (POs):**
  - ❖ Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
  - ❖ Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
  - ❖ Ability to command chemical engineering fundamentals such as mass and energy balances, chemical thermodynamics, fluid dynamics, solid and fluid transport, mass and energy transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
  - ❖ Ability to design equipment's and process considering the economic efficiency, safety, ethics and environmental responsibilities.
  - ❖ Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bio-energy, biochemical engineering, pharmaceutical engineering, material engineering.
  - ❖ Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation

- **Course Outcomes (COs):**
  After completion of subject students will able
  - Analyze practical problem for fluid through the pipes.
  - Formulate the differential forms of the equations of change for momentum for steady-state and unsteady state flows in pipes.
  - Create original solutions for the flow of Newtonian and non-Newtonian fluids
  - Design an efficient transport of process fluid through the pipes

- **Mapping of course outcomes with program outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		✓				
CO2			✓			
CO3				✓		
CO4				✓	✓	

- **Recommended Resources:**
  - ❖ Chemical Engineering – Vol I, Coulson JM and Richardson J.F.
  - ❖ The flow of Complex Mixtures In Pipe. Govier, G.W. and Aziz K
  - ❖ Process Piping Design, Volume 2 Rip Weaver.
  - ❖ Advanced Transport Phenomena L. Gary Leal

- **Course Grading:**

  Mini Test: 10%
  Mid Term: 20%
  Assignment: 10%
  End Term: 60%

CH 436-FUELS AND COMBUSTION

- **Course Objectives/Description:**
- Objective of this subject is to expose students to understand basic fuels and combustion process to chemical engineering
- **Course Details:**

Course Code	**CH – 436**
Course Titel	**Fuels and Combustion**

- **Course Faculty: Dr. Bharat Modhera**
- **Course Lecture plan:**

Module No.	Topic	No. of Sessions
1.	**INTRODUCTION** History of Fuels, History of solid fuel, History of liquid fuels and gaseous fuels, Production, present scenario and consumption pattern of fuels, Fundamental definitions, properties and various measurements, Definitions and properties of solid fuels, Definitions and properties of liquid and gaseous fuels, Various measurement techniques	6
2.	**SOLID FOSSIL FUEL (COAL)** Coal classification, composition and basis, Coal mining, Coal preparation and washing, Combustion of coal and coke making, Action of heat on different coal samples, Different types of coal combustion techniques, Coal tar distillation, Coal liquefaction, Direct liquefaction, Indirect liquefaction, Coal gasification	9
3.	**LIQUID FOSSIL FUEL (PETROLEUM)** Exploration of crude petroleum, Evaluation of crude, Distillation, Atmospheric distillation, Vacuum distillation, Secondary processing, Cracking, Thermal cracking, Visbreaking, Coking, Catalytic cracking, Reforming of naphtha, Hydrotreatment, dewaxing, deasphalting,	10
4.	**GASEOUS FUEL** Natural gas and LPG, Producer gas, Water gas, Hydrogen, Acetylene, Other fuel gases	6
5.	**COMBUSTION TECHNOLOGY** Fundamentals of thermo-chemistry, Combustion air calculation, Calculation of calorific value of fuels, Adiabatic flame temperature calculation, Mechanism and kinetics of combustion, Flame properties, Combustion burners, Combustion furnaces, Internal combustion engines	9
	Total Hours	**40**

- **Programme Educational Outcomes (PEOs):**

❖ To prepare students to achieve professional engineering competence.

- ❖ To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
- ❖ To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices

- **Programme Outcomes (POs):**

  PO 1 Function effectively as an engineering professional, individual and member or leader in diverse technical teams.

  PO 2 Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.

  PO 3 Ability to command chemical engineering fundamentals such as mass and energy balances, chemical thermodynamics, fluid dynamics, solid and fluid transport, mass and energy transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.

  PO 4 Ability to design equipment's and process considering the economic efficiency, safety, ethics and environmental responsibilities.

  PO 5 Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bio-energy, biochemical engineering, pharmaceutical engineering, material engineering.

  PO 6 Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation

- **Course Outcomes (COs):**
  After completion of subject students will able

  CO 1 Basic knowledge of fuels and combustion.

  CO 2 Identify which fuel suitable and where.

  CO 3 Calculation and analytical skill related fuels calculation. Analysis of each fuel properties.

  CO 4 Advanced and renewable fuels.

- **Mapping of course outcomes with program outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1		✓				
CO2			✓			
CO3				✓		
CO4				✓	✓	

- **Recommended Resources:**

1. The Elements of Fuel Technology by G. W. Himus
2. Combustion Engineering and Fuels Technology By A. K. Shaha
3. Principles of Energy conversion By Archie W. Culp
4. Energy resources and supply By J. T. McMullan, R. Morgan, R. B. Murray

- **Course Grading:**

  Mini Test: 10%
  Mid Term: 20%
  Assignment: 10%
  End Term: 60%

Open Electives for 7th Semesters

CH 451-BIO ENERGY TECHNOLOGY

- **Course Details:**

Course Code	CH-451
Course	Bio Energy Technology
Locations	Department of Chemical Engineering
Contact	Dr. Sapana S. Madan (7000215564)

- **Course Objectives/Descriptions:** This course will provide in-depth knowledge of fuel characterisation, treatment and conversion technologies, environmental consequences, and resource utilizations related to bioenergy. Moreover, the course gives insight into different bioenergy systems, including bioheat, biopower, biofuel and biogas, and their combinations, with consideration of process integration for heat and material recovery.
- **Programme Educational Objective (PEOs):**
  1. To prepare students to achieve professional engineering competence.
  2. To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
  3. To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices.
- **Programme Outcomes (POs):**
  1. Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
  2. Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
  3. Ability to command chemical engineering fundamentals such as mass and energy balance, mass and energy transport, chemical thermodynamics , fluid dynamics, solid and fluids transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
  4. Ability to design equipment and process considering the economic efficiency, safety, ethics and environmental responsibilities.
  5. Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bioenergy, biochemical engineering, pharmaceutical engineering, material engineering.
  6. Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation.
- **Course Outcomes (COs):**
  1. Students are able to form a technical point of view of energy plants where biomasses and organic wastes are used.
  2. Students are capable to apply the acquired knowledge to design biomass energy plants and to evaluate their performances.

3. The student will became capable to judge the different options available given the nature of the feedstock 2/3 available (kind of biomass, kind of organic waste) and the technological opportunities to valorize it as bioenergy.
4. The aim of the course is to study efficiently communicate concerning bio-energy options, processes and plants that face the bio-energy market.

- **Mapping of course outcomes with program outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	√	√		√		
CO2		√	√		√	
CO3	√		√	√		√
CO4	√	√	√	√	√	√

- **This course will provide provide students with an opportunity to develop the Graduate Attribute(s) specified below:**

S. No.	No. of Lec.	TOPICS
1.	8	**Sources and Classification**: Chemical composition, properties of biomass, energy plantations, size reduction, briquetting, drying, storage and handling of biomass
2.	10	**Biochemical aspects**: Feedstock for biogas, Microbial and biochemical aspects- operating parameters for biogas production. Kinetics and mechanism- High rate digesters for industrial waste water treatment
3.	12	**Thermochemical aspects**: Thermochemical conversion of lignocelluloses biomass. Incineration, Processing for liquid fuel production. Pyrolysis -Effect of particle size, temperature, and products obtained. Thermo chemical Principles: Effect of pressure, temperature, steam and oxygen.
4.	10	**Fixed and fluidized bed Gasifiers**: Partial gasification of biomass by CFB. combustion of woody biomass-design of equipment, cogeneration using bagasse- case studies: combustion of rice husk.
	40	Total Lectures

- **Recommended Resources:**

Text Book

1. Chakraverthy, A., Biotechnology and Alternative Technologies for Utilization of Biomass, South Asia Books, ISBN-13: 978-8120404182, 1989.
2. Mital, K.M. Biogas Systems: Principles and Applications, Newagepublishers, ISBN-13: 978-8122409475, 1996.
3. Venkata, R.P., Srinivas, S.N. Biomass Energy Systems, Tata Energy Research Institute, 1996.
4. Rezaiyan, J., Cheremisinoff, N. P. Gasification Technologies, A Primer for Engineers and Scientists, CRC Press; 1st Edition, ISBN-13: 978-0824722470, 2005.
5. Shukla S.D. and Pandey G.N., Textbook of Chemical Technology, Vikas Publishing House Private, Limited, 1977.

CH 454- ADVANCED ANALYTICAL TECHNIQUES

Course objectives: This subject of chemical Engineering is focused on material characterization through various analytical techniques including different spectroscopy methods. This course is an interdisciplinary branch like: Material science, physics, chemistry and mechanical Engineering. Main objective of the course is to learn the student about most of the application of AT to find the material information

Course outcome:

The characterization of any product is must hence after studying this course student will be able to find out the properties of produced product. By study this course student may be able to control the quality of produced product through said techniques.

Program specific outcome: Product quality is always important in any industries. Through various techniques, any trained person can find out.

Program outcome: Most of the quality problem may be sorted out by studying the course.

Lecture Plan:

S.No.	Topics	Number of Hours
1.	Introduction to spectroscopic methods of analysis	5
2.	Electromagnetic radiation and quantitative spectroscopy	5
3.	Molecular Spectroscopy	6
4.	UV, IR, Atomic Spectroscopy	5
5.	AAS, Electrometric Methods of Analysis	5
6.	XRD Analsyis	4
7.	Thermal Methods: DSC, DTA	5
8.	Chromatographic Methods: GC	4
9.	HPLC	3
10	GCMS	3
	Total	45

References:

S.No.	Title	Author
1.	Instrumental methods of analysis, 1988	Willard, H.H., Merritt. I.I., Dean J.a., and Settle, F.A
2.	Instrumental Methods of Analysis, 2000	Sharma, B.K
3.	Absorption spectroscopy of organic molecules, 1974	Parikh V.M
4.	Fundamentals of Analytical Chemistry	Skoog D.A. and West D.M.,
5.	Fundamentals of molecular spectroscopy,4th edition, 1994	1994 Banwell, G

PG Course Plan

CH 512-ADVANCED TRANSPORT PHENOMENA

- **Course Objectives/Description:**
  This course mainly deals with application of knowledge gain by students in fluid mechanics, heat transfer and mass transfer. Emphasis will be placed on the use of fundamental laws, and a judicious blend of experimental, analytical and numerical methods to develop required understanding and necessary mathematical models for essential portions of engineering problems involving transport processes
- **Course Details:**

Course Code	**CH 522**
Course	**ADVANCED TRANSPORT PHENOMENA**

- **Course Faculty: Dr Rajeev Parmar**

- **Course Lecture plan:**

Topics to be Covered	**No. of Lectures**
Summary of vector and tensor Notation	1
Vector operations from a geometrical view point	1
Vector operation from an analytical view point	1
the vector differential operations	1
second order tensors	1
vector and tensor components in curvilinear coordinates	1
differential operations in curvilinear coordinates.	1
Momentum Transport: Viscosity	2
the mechanism of momentum transport,	1
Newton"s law of viscosity	1
Energy Transport: Thermal Conductivity	2
the Mechanism of Energy Transport	1
Fourier"s Law of heat conduction	1
Mass Transport: Definition of concentrations	1
velocities and mass fluxes	1
fick"s law of diffusion,	1
theory of ordinary diffusion in gases at low density	1
theory of ordinary diffusion in liquids	1
Turbulence Phenomena: Basic theory of turbulence	2
time averaging	1
intensity and correlation coefficients	1
isotropic turbulence	1
Equations of continuity, motion and energy for turbulent condition.	2
Reynolds stresses	1

Phenomenological theories of turbulence	1
velocity profile in circular conduits	1
Convective Transport: Free and forced convective heat transfer and mass transfer,	2
interphase mass transport,	1
mass transfer coefficients-individual and overall,	1
mass transfer theories-film, penetration and surface renewal	1
Macroscopic studies: momentum and heat balance equation,	1
Kinetics energy calculation. Constant area and variable area flow problems.	1
Flow through bends. Time determination for emptying of vessels.	1

- **Programme Educational Outcomes (PEOs):**

❖ To prepare students to achieve professional engineering competence.
❖ To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
❖ To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices

- **Programme Outcomes (POs):**
  - ❖ Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
  - ❖ Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
  - ❖ Ability to command chemical engineering fundamentals such as mass and energy balances, chemical thermodynamics, fluid dynamics, solid and fluid transport, mass and energy transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
  - ❖ Ability to design equipments and process considering the economic efficiency, safety, ethics and environmental responsibilities.
  - ❖ Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bio-energy, biochemical engineering, pharmaceutical engineering, material engineering.
  - ❖ Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation
- **Course Outcomes (COs):**
  After completion of subject students will able
  - Analyze practical problems into mathematical equations
  - Identify transport properties and examine the mechanisms of molecular momentum, energy and mass transport.
  - Formulate the differential forms of the equations of change for momentum, heat and mass transfer problems for steady-state and unsteady flows.
  - Create original solutions to fluid flow, heat transfer and mass transfer problems, and solve problems combining these transport phenomena
- **Mapping of course outcomes with program outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**

CO1		✓				
CO2			✓			
CO3			✓			
CO4				✓		

- **Recommended Resources:**
  - ❖ Transport Phenomena ", R. Byron Bird, Warren E. Stewart and Edwin N Lightfoot, 2nd Edition, Wiley, 2001.
  - ❖ Fundamentals of Momentum, Heat and Mass Transfer Welty J R, Wilson R E and Wicks C E
  - ❖ Momentum, Energy and Mass transfer in continua John C Slattery.
  - ❖ Advanced Transport Phenomena L. Gary Leal

- **Course Grading:**

  Mini Test: 10%
  Mid Term: 20%
  Assignment: 10%
  End Term: 60%

CH 513-HETEROGENEOUS CATALYSIS AND REACTOR DESIGN

Course Coordinator	Dr. S. Suresh
Course Code	CH-513
Course	Heterogeneous Catalysis And Reactor Design
Locations	Department of Chemical Engineering
Contact	8989005393

A. **Course Objectives/Descriptions:** This course gives the knowledge of how to design industrial Catalyst Information about various reactor designs for high-pressure reactions Catalyst characterization with hand on practice.

B. **Programme Educational Objective (PEOs):**

1. To prepare students to achieve professional engineering competence.
2. To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
3. To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices.

C. **Programme Outcomes (POs):**

1. Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
2. Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
3. Ability to command chemical engineering fundamentals such as mass and energy balance, mass and energy transport, chemical thermodynamics, fluid dynamics, solid and fluids transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
4. Ability to design equipment and process considering the economic efficiency, safety, ethics and environmental responsibilities.
5. Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, Nano-science and technology, bioenergy, biochemical engineering, pharmaceutical engineering, material engineering.
6. Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation.

D. **Course Outcomes (COs):**

1. Describe the algorithm that allows the student to solve chemical reaction engineering problems through logic rather than memorization.
2. Size isothermal and non-isothermal reactors for homogeneous and heterogeneous reactions.
3. Analyze multiple reactions carried out both isothermally and non-isothermally in flow, batch and semi batch reactors to determine Selectivity and yield.
4. Determine the reaction order and specific reaction rate from experimental data.
5. Describe the steps in a catalytic mechanism and how one goes about deriving a rate law, mechanism, and rate-limiting step that are consistent with experimental data.

E. Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	√	√		√		
CO2		√	√		√	
CO3	√		√	√	√	
CO4		√			√	
CO5	√	√	√	√	√	

F. This course will provide provide students with an opportunity to develop the Graduate Attribute(s) specified below:

S. No.	LEC. No.	TOPICS
1.	**1-2**	Solid Catalyst: Role of catalyst components and other constituents, characterization of catalyst andits support.
2.	**3-5**	Heterogeneous Catalysis: Mechanism and kinetic models of surface reactions.
3.	**6-9**	Determination of kinetics parameters through experiments,
4.	**10-12**	Analysis of complex reactions, synthesis of kinetic structure.
5.	**13-14**	External and Internal Transport Processes: Effect of heat and mass transfer.
6.	**15-17**	Internal effectiveness factor, generalized effectiveness factor, point effectiveness, multiple reactions,
7.	**18-20**	Transport criteria. Deactivation of Catalyst: Physical deactivation, surface diffusion.
8.	**21-22**	Sintering mechanism and kinetics, chemical deactivation-types and kinetics, regeneration of catalyst.
9.	**23-25**	Selectivity and Stability: Effect of transport processes and deactivation on selectivity
10.	**26-29**	Stability of a single pellet Multiphase Reactions: Mass transfer coefficients, effect of transport and global rates.
11.	**30-32**	Design of Catalytic Reactors: Design and analysis of fixed bed reactors.
12.	**33-34**	Auto thermic operation and Stability.
13.	**35-36**	Fluidized bed reactors
14.	**37-38**	Two phase and multiphase models.
15.	**39-40**	Introduction to slurry reactors.
16.	**41-42**	Introduction to trickle-bed reactors.

G. Recommended Resources:

1. Lee H. Heterogeneous Reactor Design, 1985.
2. Carberry J. J. and Verma A Chemical Reaction and Reactor Engineering.
3. Doraiswamy L. K. and Sharma M.M.,Heterogeneous Reactions", Vol. 1 and 2.
4. Gordon and BreachThree – Phase Catalytic Reactors.
5. Froment G. F. and Bischoff K. V.Chemical Reactor Analysis and Design,3rd edition, 2010.
6. Jackobsen H. A.Chemical Reactor modeling: Multiphase ReactiveFlows, 2nd edition.

Department Electives

CH 531- POLYMER SCIENCE AND ENGINEERING

- **Course Objectives/Description:**
- Objective of this subject is to expose students to understand basic polymers, its preparation, its techniques and characterizations.

- **Course Details:**

Course Code	**CH – 531**
Course Title	**Polymer Science and Engineering**

- **Course Faculty: Dr. Bharat Modhera**

- **Course Lecture plan:**

Module No.	**Topic**	**No. of Sessions**
1.	Basic concepts on polymers, Polymer raw materials, Polymerization principles and processes (step, chain and other polymerizations, polymer kinetics).	7
2.	Polymerization techniques, Polymer manufacture (unit operations, polymer reactors, polymer isolation, handling and storage)	9
3.	Polymer structure and property, Polymer characterization, Polymer testing (sample preparation, testing standards and methods, analysis of polymer and additives).	9
4.	Multicomponent polymeric materials (polymer miscibility, polymer blends and alloys, filled plastics, polymer composites), Polymer compounding and fabrication (polymer additives, Compounding processes, fabrication techniques, post fabrication operations)	6
5.	Polymer applications: Biodegradable polymers, biomedical polymers, conducting polymers, Problems with polymers (thermo oxidative degradation, fire hazards, toxicity, effluent disposal, feedstock scarcity).	9
	Total Hours	**40**

- **Programme Educational Outcomes (PEOs):**

❖ To prepare students to achieve professional engineering competence.
❖ To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
❖ To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices

- **Programme Outcomes (POs):**

PO 1 Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
PO 2 Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
PO 3 Ability to command chemical engineering fundamentals such as mass and energy balances, chemical thermodynamics, fluid dynamics, solid and fluid transport, mass and energy transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
PO 4 Ability to design equipment's and process considering the economic efficiency, safety, ethics and environmental responsibilities.
PO 5 Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bio-energy, biochemical engineering, pharmaceutical engineering, material engineering.
PO 6 Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation

- **Course Outcomes (COs): After completion of subject students will able**

CO 1 Chemistry of polymeric reaction, functionality, poly-condensation, addition free radical and chain polymerization, copolymerization, block and graft polymerizations, stereo specific polymerization.
CO 2 Students will get the ideas about the kinetics of polymerization, kinetics of radial, chain and ionic polymerization and co-polymerization systems.
CO 3 How to estimate molecular weight, number average and weight average, theoretical distributions, methods for the estimation of molecular weight.
CO 4 Process of polymerisation, such as bulk, solution, emulsion and suspension polymerization. Thermoplastic composites, fibre reinforcement fillers, surface treatment, reinforced thermoset composites-resins, fibers additives, fabrication methods.

CO 5 Rheological studies, such as simple rheological equations, simple linear viscoelastic models-maxwell, voigt; materials response time, temperature dependence of viscosity.

- **Mapping of course outcomes with program outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		✓				
CO2			✓			
CO3				✓		
CO4				✓	✓	
CO5					✓	

- **Recommended Resources:**

1. Fundamentals of Polymer Engineering By Anil Kumar and Rakesh Gupta
2. Textbook of Polymer Science By Fred W. Billmeyer Jr.
3. Polymer Science and Technology By Joel R. Fried
4. Polymer Science By V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar

- **Course Grading:**

  Mini Test: 10%
  Mid Term: 20%
  Assignment: 10%
  End Term: 60%

CH 532-NANO TECHNOLOGY

Class- M.Tech **Branch-** Chemical Engineering **Semester -**I
Course Code-CHE -532 **Corse name:** Nano Technology **Credit-** 03

Name of Course Coordinator : Dr. Sunny Kumar **Session-**July-Dec 2019

Course Objective:
This course will introduce basic knowledge of nano technology application in Chemical Engineering. The content of the course explain about the various introductive of nanotechnology subjects and the recent development of nano technologies used in the chemical process industries. It provides the importance of Chemical engineers which can contribute to society especially as chemical engineers in the world.

S. No.	Topics	Number of Lectures
1	Supramolecular Chemistry	04
2	Definition and examples of the main intermolecular forces	
3	Used in supramolecular chemistry.	
4	Self-assembly processes in organic systems	04
5	Main supramolecular structures.	
6	Physical Chemistry of Nanomaterials	
7	Basics of nanomaterials; a series of nanomaterials	
8	Methods of Synthesis of Nanometerials	
9	Equipment and processes needed to fabricate Nano devices	05
10	Structures such as bio-chips, power devices	03
11	Opto-electronic structures	03
12	Bottom-up (building from molecular level)	03
13	Top-down (breakdown of microcrystalline materials) approaches.	03
14	Biologically-Inspired nanotechnology basic biological concepts	03
15	Principles that may lead to the development of technologies for Nano engineering systems.	
16	Coverage will be given to how life has evolved sophisticatedly	
17	Molecular nanoscale engineered devices,	03
18	Nanoscale biotechnologies	03
19	Instrumentation for nanoscale characterization.	03
20	Instrumentation required for characterization of properties on the nanometer scale.	03
21	The measurable properties and resolution limits of each technique	02
22	With an emphasis on measurements in the nanometer range.	03
	Total Lecture	45

Marks Distribution
Mini test/Surprise Test: 10%

Mid Term: 20%
Quiz: 5%
Home assignment: 5%
Final: 60 %

Course Outcomes:

After completion of this course the student would be able

- This course provides the nano engineering aspects for chemical engineers.
- The structure of the course covers both theory and problems.
- An easy procedure is defined in the form of diagram that gives meaningful estimation of the properties and synthesis of nanomaterial for various applications.

Reference Books

1. Jean-Marie Lehn, Supramolecular Chemistry, 2011.
2. Jonathan Steed & Jerry Atwood, Supramolecular Chemistry, 2nd edition.
3. Jacob Israelachvil, Intermolecular and Surface Forces, 3rd edition.

Open Electives

CH 552-MODELING & SIMULATION OF CHEMICAL ENGG. SYSTEMS

- **Course Objectives/Description:**
  This course will guide the student to implement different mathematical technique in building a model for a particular chemical process system and solve the model using different model tools.
- **Course Details:**

Course Code	CH 552
Course	Modeling and Simulation of Chemical Engineering Systems

- **Course Faculty: Dr Subhajit Patra**

- **Programme Educational Outcomes (PEOs):**

❖ To prepare students to achieve professional engineering competence.
❖ To acquaint with the principles of basic chemical engineering and utilize them to formulate, solve and analyze industrial problems as well as to prepare them for advanced multidisciplinary research.
❖ To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices

- **Programme Outcomes (POs):**
  - ❖ Function effectively as an engineering professional, individual and member or leader in diverse technical teams.
  - ❖ Apply knowledge of chemical engineering to identify, formulate & solve recent industrial problems using modern engineering tools.
  - ❖ Ability to command chemical engineering fundamentals such as mass and energy balances, chemical thermodynamics, fluid dynamics, solid and fluid transport, mass and energy transport, chemical kinetics and integrate into a functional chemical process along with instrumentation and process control.
  - ❖ Ability to design equipments and process considering the economic efficiency, safety, ethics and environmental responsibilities.
  - ❖ Ability to carry out interdisciplinary research and engage in life-long learning process in the fields of environmental engineering, nano-science and technology, bio-energy, biochemical engineering, pharmaceutical engineering, material engineering.
  - ❖ Ability to develop proficiency in applying modern computational tools such as ASPEN, MATLAB, ANSYS for successful modeling and simulation
- **Course Outcomes (COs):**
  After completion of subject students will able
  - Formulate proper model using technical knowledge for particular systems.
  - Estimate the accuracy associated with use of different mathematical techniques.
  - Solve differential equations subjected to boundary conditions.

- Estimate different options for choosing correct equipment for real life examples.

- **Mapping of course outcomes with program outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		✓				
CO2			✓			
CO3			✓			
CO4						✓

Lecture Plan

S. No.	LEC. No.	TOPICS
1.	**1-4**	Basics of modeling and simulation for chemical engineering processes, theoretical, empirical and semi-empirical model, steady state and dynamic state, Lumped parameter and distributed parameter, deterministic and probabilistic model.
2.	**5-7**	Statistical model building, ill conditioned system, initial and boundary conditions
3.	**8-12**	Linear algebraic equation, Matrix properties, Jacobi method, LU decomposition, TDMA (Thomas algorithm), Iterative method, Least square method.
4.	**13-15**	Sensitivity study, Fourier transform, laplace transform, Over and under estimation
5.	**16-20**	Lumped parameter approach, Ordinary differential method, Implicit and explicit method, Predictor and corrector method, Transforming higher order ODE, system of ODE's
6.	**21-22**	Boundary value problem, Shooting Method
7.	**23-27**	Distributed parameter approach, Partial differential equation, Forward difference method, Backward difference method, Crank Nicolson method
8.	**28-33**	Statistical analysis, Variance, correlation matrix, t-test, Analysis of variance (ANOVA) table, residual plot, multiple regression, case study
9.	**34-38**	Finite difference method, Finite element method, adaptive mess strategies, solving of equation with help of MATLAB and Simulink
10.	**39-42**	ANSYS solver for fluid related problems, geometry and meshing, Boundary and initial condition, Solving and post processing of data.

- **Recommended Resources:**
  - ❖ Process Modelling, Simulation and Control for Chemical Engineers, 1972 W.L. Luyben,
  - ❖ Computational Methods for Process Simulation, 2 nd edition, 1997 W. F. Ramirez
  - ❖ Mathematical modelling in chemical Engineering, A. Rasmuson, B. Andersonn, L. Olsson, R. Andersonn,; Cambridge University Press.

- **Course Grading:**

  Mini Test: 10%
  Mid Term: 20%
  Assignment: 10%
  End Term: 60%