MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR

(A Govt. Aided UGC Autonomous & NAAC Accredited Institute Affiliated to RGPV, Bhopal)

Subject Code: Fuel Technology

Category	Title	Code	Credit	Theory Paper
DC	Fuel Technology	2170121	4	2 hrs

Course Objectives: To introduce the basic knowledge about solid, liquid and gaseous fuels. To provide knowledge about origin, classification and quality control of Fuels. To introduce various renewable energy resources used as an alternative to these fuels.

Syllabus

UNIT-I Solid Fuel: Origin and Classification of coal, analysis and properties of coal, oxidation of coal, hydrogenation of coal, Coal Liquefaction, agro fuels, solid fuel handling.

UNIT-II Coal Carbonization: Mechanism of low and high temperature carbonization, By product recovery from coke oven, Grinding, Pulverization and briquetting of solid fuel.

UNIT-III Liquid Fuel: Classification of petroleum products, Handling and storage of petroleum products, Refining and other conversion processes including cracking, reforming, hydro-treating. Quality control of Petroleum Products.

UNIT-IV Gaseous Fuel: Types of gaseous fuels, natural gases, methane from coal mines, manufactured gases, producer gas, water gas, blast furnace gas, refinery gas, LPG, cleaning and purification of gaseous fuels.

UNIT-V Renewable energy Sources: Introduction to Wind Energy, Solar Thermal Energy, Geothermal Energy and Wave Energy. Status of Renewable Energy Projects in India.

Course outcomes: After the successful completion of this course, students will be able to:

CO1: Differentiate between various Fuels

CO2: Know about Quality Control Parameters for different types of fuels

CO3: Develop process flow for petroleum fuel.

CO4: Analyze the major engineering problems involved in the process.

CO5: Make interpretation about the renewable energy sources.

CO6: explain the current status of fuel consumption and requirement in India.

Text Books:

1. O.P. Gupta (1st Edition 2018, Khanna Publishers) E-lements of Fuel and Combustion Technology

2. R. Prasad (1st Edition 1995, Khanna Publishers)- Petroleum Refining Technology

3. S.C. Bhatia, R. K. Gupta -Textbook of Renewable Energy (Woodhead Publishing India in Energy) 2019)

References:

1. G.D Hobson (9th Edition 198, john Willey & Sons)- Modern Petroleum Technology Part-I & II

2. Mehmet Kanoğlu,Yunus A. Çengel, John M. Cimbala (1st Edition, 2020 McGraw-Hill Education)- Fundamentals and Application of Renewable Energy

2170221: Chemical Process Calculations

Category	Title	Code	Credits-4			Theory Paper
Departmental Core-DC	Chemical Process Calculation	2170221	L	T	P	Max.Marks-50 Duration-2hrs.
			2	1	-	

Course Objective:

To understand and apply the basics of calculations related to material and energy flow in the processes.

Syllabus:

Unit-I: Mathematical and Engineering Calculations:- Units and dimensions, conversion units, expression and equations, Dimensional groups and constants, stochiometric and composition relationships, conversion of mass, mass and volumetric reactions, basis of compositions, Excess reactants , degree of completion.

Unit-II: Ideal Gases & vapor Pressure: Behavior of ideal gases, Gaseous mixtures, vapor pressure , Clausius Clapeyron equation, Cox chart, Duhring's plot, Raoult's law, Humidity and saturation, relative humidity, humid volume, dew point, humidity chart and its use.

Unit-III: Material Balance: Crystallization, dissolution, solving material balance problems with and without simultaneous equations, Recycle, bypass and purge calculations

Unit-IV: Energy Balance: Heat capacity, calculation of enthalpy changes, Energy balance with chemical reactions,

Unit-V: Heat of vaporization, Heat of formation, Laws of thermo chemistry, Heat of combustion of fuels, Heat and Theoretical flame temperature, Case study of selected problems.

Course Outcomes: After the completion of this course, Students will be able to

- CO1 **Implement** different unit system, basic mass volume relationship, conversion of units
- CO2 **Classify** ideal and non –ideal gases.
- CO3 **Solve** energy balance problems.
- CO4 **Analyze** the recycle, bypass, and purge calculation.
- CO5 **Estimate** the raw material requirement for synthesis of a chemical product based on stoichiometry.
- CO6 **Estimate** the performance of chemical equipment using material and energy balance

Text Books

1.O.A. Hougen, K.M. Watson, R.A. Ragatz (CBS publications New Delhi 1995 edition)- Chemical Process Principles**,** part-I

Reference Books

1. David M. Himmelbau(prentice Hall ,sixth edition Feb. 1999)- BASIC PRINCIPLES AND CALCULATIONS IN CHEMICAL ENGINEERING.
2. B. L. Bhatt, S.M. Vora (Tata Mc-Graw –Hill, 1996) STOCHIOMETRY.

MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR (M.P.), INDIA
माधव प्रौद्योगिकी एवं विज्ञान संस्थान, ग्वालियर (म.प्र.), भारत
A GOVT. AIDED UGC AUTONOMOUS INSTITUTE, AFFILIATED TO R.G.P.V. BHOPAL (M.P.), INDIA
NAAC ACCREDITED WITH A++ GRADE

२170223: FLUID PARTICLE MECHANICS

Category	Title	Code	Credits-4			Theory Paper
Departmental Core-DC	Fluid Particle Mechanics	२170223	L	T	P	Max.Marks-50 Duration-2hrs.
			2	1	2	

Course Objective:

To understand basic principles of various mechanical operations & construction and working of the equipments.

Syllabus:

Unit-I: Particulate Solids: Properties of particulate solids, Evaluation of size and shape, surface and population of particles, standard screens and screen analysis of solids.**Size Reduction:** Principles of comminution, size reduction, crushing, grinding, pulverizing and ultra fine size reduction equipment, power requirement in comminution.

Unit-I: Mixing: Mixing of solids, mixing equipment's design and power requirement of mixers, Mixer Effectiveness and Mixing Index.

Unit-III: Separation: Principles of Separation techniques for system involving solids, liquids and gases, Classification, Sedimentation, filtration, separation equipments.

Unit-IV: Transportation and Handling of Solids: Selection and conveying devices for solids: Belt, Chain, Screw- conveyors, elevators and pneumatic conveying devices, Elementary design aspects of the devices

Unit –V: Fluidization & Application: Particulate & aggregative fluidization, Characteristics of fluidized bed due to particle size, size distribution, shape and density, Pressure drop through a fluidized bed, Character of dense phase fluidization as revealed by pressure drop fluctuations, Up flow and down flow fluidization, Fluid Catalytic process, bed drying, Mass transfer in fluidized beds.

Course Outcomes: After the completion of this course, Students will be able to

CO1 **Elucidate** the importance and application of Industrial Screens.

CO2 **Explain** the various methods of size reduction using the various principles.

CO3 **Explain** the different particle separation techniques and equipment employed.

CO4 **Illustrate** the various process like sedimentation, filtration etc.

CO5 **Classify** the various conveying devices.

CO6 **Distinguish** the types of fluidization.

Text Books

1. Badger &Bencharo- INTRODUCTION TO CHEMICAL ENGG- Tata McGrawhill 1998.
2. McCabe Smith- UNIT OPEARATION OF CHEMICAL ENGG, McGraw Hill 2001.

Reference Books

1. Coulson &Richordson Vol. 2-CHEMICAL ENGG. New Delhi Asian Book Pvt. Ltd.
2. G.G. Brown- UNIT OPERATIONS-CBS Publications New Delhi 1995.

2170311: FLUID MECHANICS

Category	Title	Code	Credits-4			Theory Paper
Departmental Core-DC	Fluid Mechanics	2170311	L	T	P	Max.Marks-50 Duration-2hrs.
			2	1	2	

Course Objective:
To understand the basic concept of fluid flow and its application to chemical process industries including pipe flow, fluid machinery like pumps and various flow meters.

Syllabus:

Unit –I: Introduction: Properties of fluid, forces on fluid, stresses, the concept of constitution relations, fluid statics, Normal forces in fluid, pressure measurement, forces on submerged bodies, buoyancy, Stability.

Unit-II: Classification of Fluids: Newtonian and Non – Newtonian fluid, Viscosity measurement, Equations of changes: Equation of Continuity & Equation of Motion, Navier stokes equation, concept of Reynolds number and friction factor: friction for rough and smooth pipes, loss of head due to friction in pipes and fittings.

Unit-III: Boundary layer theory, Bernoulli's equation, fluid machinery, pumps, fans, blowers, compressors and vacuum pumps, Power and head requirement for pumps.

Unit-IV: Flow of incompressible fluid in conduits and thin layers, flow past immersed bodies, Dimensional analysis, Buckingham π- Theorem, dimensionless numbers and their significance, similitude criteria.

Unit-V: Measurement of Flow: Fluid flow Measurement pitot tube, orifice meter, venture meter, rotameter, weirs and notches.

Course Outcomes: After the completion of this course, Students will be able to

CO1	**Explain** the fundamentals of fluid statics & fluid flow.
CO2	**Estimate** pressure drops, forces acting on bodies & power and head requirements of pumps.
CO3	**Apply** equations of change to various fluid flow systems.
CO4	**Formulate** the interdependence of various parameters using dimensional analysis.
CO5	**Determine** the flow rate through different flow measuring devices.
CO6	**Examine** the losses due to friction in pipes and other fluid machinery.

Text Books

1.W.L. McCabe & J.C. Smith- UNIT OPERATIONS IN CHEMICAL ENGG- 7rd edition McGraw Hill.

Reference Books

1. J.M. Coulson & J.F. Richardson- Chemical Engineering- Vol I & II.
2. B.S. Maney, Zel(SI) Van Nostand & Reinhold- Mechanics of Fluid-ELBS, 1970.
3. I. Grannet- Fluid Mechanics for Engineering and Technology.
4. S.K. Gupta- Momentum Transfer- New Age Publication

List of Experiments:

1. To determine the local point pressure with the help of a pitot tube.
2. To find out the terminal velocity of a spherical body in water.
3. To determine the viscosity of a spherical body in water.
4. To find the pressure drop in a packed bed,
5. To study the flow behavior of a Non-Newtonian fluid and to determine the flow constants.
6. To determine the power number- Reynolds Number curve.
7. To differentiate between laminar and turbulent flow using Reynolds experiments.
8. To study the characteristics of an air compressor.
9. To study the characteristics of a centrifugal pump.
10. To study the flow of a fluid in a pipeline and to prepare the friction factor-N_{Re} plot.
11. To determine the friction losses, expansion losses and reduction losses in bends and pipes and verify the Bernoulli equation.
12. To prepare the calibration curve for an orifice meter and Rotameter.
13. To prepare the calibration curve for a Venturimeter.

Note: Every student should perform at least eight experiments out of the above list.

Lab Course Outcomes

After the completion of this lab course, Students will be able to

CO1 Analyze the effects of flow measurement by flow measuring devices.

CO2 Calculate the degree of error in discharge rate of rotameter.

CO3 Calculate the coefficient of discharge for venturimeter and orifice meter.

CO4 Calculate the coefficient of discharge for notches & weirs.

CO5 Analyze the losses in pipe fittings & pressure drop in packed bed

CO6 Analyze transportation of fluids via pumps & other devices.

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2170312: ORGANIC PROCESS TECHNOLOGY

Category	Title	Code	Credits-3			Theory Paper
Departmental Core-DC	Organic Process Technology	2170312	L	T	P	Max.Marks-50 Duration-2hrs.
			3	0	0	

Course Objective:

The purpose of the organic process technology course is to improve knowledge of the chemical processes along with emphasis on recent technological development.

Syllabus:

Unit-I: Pulp and paper industry-Raw Materials, types of pulp and its preparation, Manufacturing of paper, Agro based industries, Fermentation industry, Alcohol by fermentation, Citric acid and Antibiotics like Penicillin.

Unit-II: Intermediates for petrochemicals from petroleum based stocks, phenol, methanol, ethylene propylene, aromatic, toluene and xylene, polymer industries.

Unit-III: Preparation, manufacturing and properties of Fats and oil, man made fiber; rayon, polyester polyamides and acrylics, cellulose and acetate, Rubber industries, Soap and detergent. Insecticides and pesticides, Dyes and dyes intermediate.

Unit-IV: Carbon Technology: Introduction, Classification of activated carbons, raw materials and manufacture of activated carbons, classification of carbon fibers, precursors for carbon fibers, manufacture of carbon fibers from polyacrylonitrile, manufacture of carbon black by furnace black process, applications.

Unit-V: Nanotechnology: Introduction, properties of Nanoparticles like optical properties, reactivity, synthesis, Introduction, Structure and properties of carbon Nanotubes and fabrication of carbon nanotubes & applications.

Course Outcomes: After the completion of this course, Students will be able to

CO1: **Explain** the processing of natural products.
CO2: **Describe** microbial processes and edible oil refining process.
CO3: **Elaborate** the processes for producing petrochemicals.
CO4: **Characterize** polymers and elaborate its production processes.
CO5: **Describe** the production processes of fibers.
CO6: Evaluate the different processes from economical aspects.

Text Books

1. Austin, G.T. Shreve's Chemical Process Industries -5th edition McGraw Hill New York 1984.
2. Dryden C.E., Outlines of chemical technology-3rd edition affiliated East – West Press, New Delhi, 1997.

Reference Books

1.V. B. Gupta & V.K. Kothari- Manufacturing Fiber Technology- Chapman Hall, New York I edition 1997.
2. V.K. Kothari-Process in Textile, science Technology, Vol –I & II –IAFL publication, S-351 Greater Kailash part-I New Delhi.-48 Ed.

2170313: Chemical Engineering Thermodynamics

Category	Title	Code	Credit-3			Theory Paper
Departmental Core-DC	Chemical Engineering Thermodynamics	2170313	L	T	P	Max.Marks-50 Duration-2hrs.
			3	0	0	

Course Objective:
To understand the basic concepts and applications of classical thermodynamics, thermodynamic properties, equations of state, methods used to describe and predict phase and chemical equilibria.

Syllabus

Unit- I The First law of Thermodynamics and Equations of State: Steady and unsteady closed and flow process, Critical properties corresponding state, Compressibility, P-V-T behavior of pure fluids, Virial-equations, Generalized correlations and eccentric factor.
Unit-II The Second and Third Law of Thermodynamics: Entropy of various systems, Thermodynamics equations, Effect of pressure on specific heat, Joule-Thompson effect, Third law of thermodynamics, Compression of ideal gas, Refrigeration capacity, Carnot cycle, Vapor compression cycle, Air refrigeration cycle.
Unit-III Thermodynamic Properties of Fluids: Thermodynamic properties of homogeneous mixtures, Property relations for systems of variable compositions, Partial properties, Fugacity and Fugacity coefficient in ideal solutions, Properties change of mixing, Activity, Heat effects of mixing process, Excess properties, Activity coefficient of gaseous mixtures.
Unit-IV Phase Equilibria: Criteria of phase equilibrium and stability, Phase equilibrium in single component system, Phase rule, Gibbs-Duhem's equation, Vapor-liquid equilibria.
Unit- V Chemical Reaction Equilibria: Chemical potential, Effect of pressure and temperature on heat of reaction and on free energy, Van't Hoff's equation, Clausius-Clapeyron equation, Chemical Reaction Equilibria and its applications

Course Outcomes: After the successful completion of this course, students will be able to

CO1: infer the fundamental concepts of thermodynamics to chemical engineering applications.
CO2: explain the first and second laws of thermodynamics with their practical implications.
CO3: analyze the processes involving refrigeration and compression.
CO4: classify the thermodynamic properties of solutions with their relationships.
CO5: infer the detail of vapor liquid equilibria and its use in practical situations.
CO6: analyze the chemical equilibrium with thermodynamics for predicting behavior of reacting systems.

Text Books

1. Smith J.M. & Van Ness., "Introduction to Chemical Engineering Thermodynamics", McGraw Hill
2. Sandler, S.I., "Chemical Engineering Thermodynamics", John Wiley & Sons
3. Dodge B.F., "Chemical Engineering Thermodynamics", McGraw Hill
4. Narayanan K.V., "Chemical Engineering Thermodynamics", Prentice Hall India Learning Private Limited

Reference Books

1. Balzhiser, Samuels and Eliassen, "Chemical Engineering Thermodynamics", Prentice Hall.
2. Rao Y.V.C, "Chemical Engineering Thermodynamics", University Press (I) Ltd., Hyderabad
3. Kyle B.G., "Chemical Process Thermodynamics", Prentice Hall of India Pvt. Ltd., New Delhi

2170314: HEAT TRANSFER

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Category	Title	Code	Credits-4			Theory Paper
Departmental Core-DC	Heat Transfer	2170314	L	T	P	Max.Marks-50 Duration-2hrs.
			2	1	2	

Course Objective:
To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Syllabus:

Unit – I: Modes of heat transfer one-dimensional and two dimensional, heat rate equations, theory of insulation, critical radius calculations, types of insulation material, conduction through slab, cylindrical and sphere.
Unit-II: Consecutive heat transfer, heat transfer in boundary layer and in film, natural and forced convection, co/ counter /cross current contacting for heat transfer, individual and overall heat transfer coefficient, fouling factor.
Unit- III: Radiative heat transfer, Black body radiation, concept of shape factor, method of determination of shape factor, radiation exchange in enclosure with black surfaces.
Unit-IV: Heat transfer under phase change conditions, boiling and condensation of pure components, heat flux temperature diagram for boiling and condensation under vertical and horizontal surfaces, nucleate and pool boiling, effect of surface condition of condensation, correlation for heat transfer under condensation. Evaporation: Types of evaporators and their applications, single and multiple effect evaporators, Design and operation of forward, backward and mixed feed operations, effect of boiling point elevation and hydrostatic heat vapor recompression.
Unit- V: Heat exchange equipment- General design of shell and tube exchangers, condensers, extended surface equipment, heat exchanger equation – coli to fluid, jacket to fluid, double pipe, shell and finned tube heat exchanger.

Course Outcomes: After the completion of this course, Students will be able to

CO1: Explain the mechanism of heat transfer by conduction, convection and radiation.
CO2: **List** dimensionless Numbers applicable in heat transfer and their physical significance.
CO3: **Illustrate** individual and overall heat transfer coefficient.
CO4: **Explain** all parts of the Heat Exchangers and Evaporators.
CO5: **Analyze** the design of various types of Heat exchangers.
CO6: Analyze the design of various types of Evaporators.

Text Books

1. J. P. Holman – Heat Transfer – P.H.I.

Reference Books

1. Donald Q. Kern- Process Heat Transfer– Tata Mc Graw Hill.
2. Alan J. Chapman- Heat Transfer IV ED. – Collier Mc. Millan.

List of Experiments:

1. To determine the thermal conductivity of metal rod.
2. To determine the equivalent thermal conductivity of composite wall.
3. To determine heat transfer coefficient in forced convection.
4. To determine heat transfer coefficient in natural convection.
5. To determine heat transfer coefficient with the help of Stefan Boltzmann Apparatus.
6. To calculate emissivity of the test plate by emissivity measurement apparatus.
7. To determine heat transfer coefficient in double pipe heat exchangers.
8. To study the heat transfer characteristics of a shell and tube heat exchanger (Heating / cooling) of water.
9. To determine heat transfer coefficient in counter and parallel flow heat exchanger.
10. To measure the rate of evaporation using an open pan evaporator.
11. To measure the rate of condensation of pure water vapor and to determine the heat transfer coefficient.
12. Demonstrate the film wise, drop wise condensation and determination of heat transfer coefficient.
13. To study the single effect evaporator and find out the heat transfer coefficient.

Note: Each student should perform at least eight experiments out of the above list.

Lab Course Outcomes

After the completion of this lab course, Students will be able to

CO1: Able to understand the modes of heat transfer conduction, convection and radiation

CO2: Analyze the application of various experimental heat transfer correlations in engineering applications

CO3: Evaluate the thermal analysis and sizing of heat exchangers.

CO4: Evaluate the emissivity of materials

CO5: Study the thermal conduction in metal rod

CO6: Able to know the application of heat exchanging equipment in chemical process industries.

2170315: CHEMICAL SYNTHESIS LAB

Category	Title	Code	Credits-1			Practical Paper
Departmental Lab-DLC	Chemical Synthesis Lab	2170315	L	T	P	Max.Marks-30 Min.Marks-10.
			-	-	2	

Course Objective

The aim of this course is to give you exposure to advanced synthetic techniques, introduce you to chemical literature searches, give you experience following and expanding on literature preparations, and provide you with an opportunity to improve your technical writing.

List of Experiments:

1. To determine BOD & COD for a given wastewater sample.
2. Preparation of acetic acid from ethyl alcohol.
3. To find out the sucrose content in aqueous solution by polarimeter.
4. To evaluate the viscosity of molasses.
5. To determine the percentage of formaldehyde in formalin.
6. To determine iodine value of the given oil sample.
7. To determine the acetic acid, ethanol concentration in aqueous solutions.
8. To prepare azo dye and find the yield.
9. Prepare a standard phenol solution and estimate the percentage of phenol in the given unknown sample of phenol.
10. To prepare urea formaldehyde resin and report percentage conversion.
11. To determine total dissolved and suspended solids in water and wastewater
12. To determine turbidity in water and waste water
13. To determine hardness of water

Note: Each student should perform at least eight experiments out of the above list.

Course Outcomes: After the completion of this course, Students will be able to

CO1. Research a specific compound, or a family of compounds, to propose a synthetic route for isolation of this compound.

CO2. Perform advanced manipulations of apparatus relevant to a synthetic chemistry laboratory; use a Schlenk line to synthesize oxygen- and moisture-sensitive products.

CO3. Characterize chemical compounds using modern spectroscopic techniques.

CO4. Maintain a laboratory notebook following scientific best practices.

CO5. Communicate findings in a format consistent with the scholarly standards of the chemical sciences.

CO6. Articulate and follow ethical principles in a scientific context, including professional standards of laboratory practice, the communication of literature research without plagiarism, and the crediting of collaborators.

2170311: Fluid Mechanics Lab

- To study the Reynolds's apparatus and verify experimentally
- To find the flow rate of water using V-notch and rectangular notch.
- Determination of Coefficient of discharge of a given orifice meter.
- Determination of Coefficient of discharge of venturimeter.
- To determine friction losses in a Straight pipe.
- Demonstration of Bernoulli's apparatus.
- To study the working principle of a reciprocating pump and to determine the percentage of slip.
- To study the working principle of a centrifugal pump and determine its efficiency.
- To determine the coefficient of velocity, coefficient of discharge and coefficient of contraction of orifice meter using rectangular orifice.
- To find out the metacentric height of a given pantone.
- To determine the coefficient of velocity, coefficient of discharge and coefficient of contraction of orifice meter using circular orifice.

Note: Each student should perform at least eight experiments out of the above list.

After completion of this laboratory course, the student will be able to

CO1: Experiment with flow measurement devices like venturimeter and orifice meter
CO2: Estimate the friction and measure the frictional losses in fluid flow
CO3: Predict the coefficient of discharge for flow through pipes
CO4: Evaluate pressure drop in pipe flow using Hagen-Poiseuille's equation for laminar flow in a pipe
CO5: Calculate the Critical Reynolds's Number through Pipe Set Apparatus
CO6: Explain the working principles of Fluid machines and apply it to various types of machines

Skill Based Mini Project

Fluid Mechanics

1. Study of fluid flow through a pipe with a sudden expansion or contraction.
2. Analysis of laminar and turbulent flow in a pipe using computational fluid dynamics (CFD) software.
3. Design and fabrication of a wind tunnel to study the flow around a model of a car or airplane.
4. Study of the flow characteristics of a fluid in a rotating tank.
5. Analysis of heat transfer in a fluid flow using computational software.
6. Investigation of the flow of a fluid through a packed bed of particles.
7. Design and fabrication of a water turbine to study the effects of blade shape on turbine efficiency.
8. Study of the flow of a fluid through a porous medium.
9. Study of Bird Flight Aerodynamics
10. Drag Estimations on Experimental Aircraft

2170314: Heat Transfer

List of Experiments:

1. To determine the thermal conductivity of metal rod.
2. To determine the equivalent thermal conductivity of composite wall.
3. To determine heat transfer coefficient in forced convection.
4. To determine heat transfer coefficient in natural convection.
5. To determine heat transfer coefficient with the help of Stefan Boltzmann Apparatus.
6. To calculate emissivity of the test plate by emissivity measurement apparatus.
7. To determine heat transfer coefficient in double pipe heat exchangers.
8. To study the heat transfer characteristics of a shell and tube heat exchanger (Heating / cooling) of water.
9. To determine heat transfer coefficient in counter and parallel flow heat exchanger.
10. To measure the rate of evaporation using an open pan evaporator.
11. To measure the rate of condensation of pure water vapor and to determine the heat transfer coefficient.
12. Demonstrate the film wise, drop wise condensation and determination of heat transfer coefficient.
13. To study the single effect evaporator and find out the heat transfer coefficient.

Note: Each student should perform at least eight experiments out of the above list.

Lab Course Outcomes

After the completion of this lab course, Students will be able to

CO1: Able to understand the modes of heat transfer conduction, convection and radiation

CO2: Analyze the application of various experimental heat transfer correlations in engineering applications

CO3: Evaluate the thermal analysis and sizing of heat exchangers.

CO4: Evaluate the emissivity of materials

CO5: Study the thermal conduction in metal rod

CO6: Able to know the application of heat exchanging equipment in chemical process industries.

Skill Based Mini Project

Heat Transfer

1. Based on the general operation happening near you, differentiate between various modes of Heat transfer.
2. Estimate the heat transfer rate within solid metal rod.
3. Estimate the various factors that are responsible for fouling in Heat Exchangers.
4. Compare the emissivity of two different metal plates/rod.
5. List out the different blackbody materials available around us and compare the radiation laws proposed for black bodies
6. Illustrate the different condensation process.
7. Demonstrate the film wise, drop wise condensation.
8. Demonstrate and interpret of Evaporation process of two different fluid.
9. Differentiate the Heat transfer and Thermodynamics with appropriate example/s
10. Compare the various types of industrial Heat Exchangers
11. Explain the importance of Heat transfer in your daily life and industrial aspect.
12. List out the thermal conductivity of the various materials (industrial aspect) and compare other properties.
13. Perform Greenhouse effect experiment –Climate change in a Jar

2170315: Chemical Synthesis Lab

1. Preparation of different types of resins
2. Detailed manufacture process of any chemical product with full block diagram/flow sheet
3. Explain the manufacturing process Urea formaldehyde **(Manufacturing process and formulation with proper flow sheet)**
4. Explain the manufacturing process Phenol formaldehyde **(Manufacturing process and formulation)**
5. Explain the manufacturing process of soap by saponification reaction **(Manufacturing process and formulation)**
6. Explain the process evolved to determine the iodine value for given oil samples **(Manufacturing process and formulation)**
7. Explain the manufacturing process of ester from acetic acid and ethanol **(Manufacturing process and formulation)**
8. Study of different analytical instruments like Refractrometer, Particle Size Analyzers and spectrometer
9. To study the influence of different general parameter on chemical reactions like quality of reactant, reagent, catalyst, reaction condition and reaction kinetics
10. Comparison of detergent and body soap manufacturing process with flow sheet
11. Tablet Manufacturing process in Pharmaceutical industry

Note: Each student should perform at least eight experiments out of the above list.

After completion of this laboratory course, the student will be able to

CO 1: Understand the concept of flow sheeting

CO 2: Synthesize soap using various raw materials and perform quality analysis

CO 3: Synthesize ester and perform quality analysis

CO4: Perform analytical instrumentation test like concentration measurement using refractrometer

CO 5: Synthesize urea formaldehyde and analyze the quality parameters

CO 6: Synthesize phenol formaldehyde and analyze the quality parameters

Skill Based Mini Project
Chemical Synthesis Lab

1. Develop laboratory setup to learn principles of cellulose fiber spinning according to the viscose process
2. Synthesis and application of Indigo dye
3. Synthesis of fuel from rapeseed oil
4. Synthesis of biodiesel from waste cooking oil
5. Synthesis of Alum from waste beverage cans
6. Quantitative determination of functional groups like Acid, Phenol, Nitro, Amino, Ester, Hydroxy, Aldehyde.
7. Organic Preparations and purification through activated charcoal treatment/ crystallization (Single/ two-step) of the following; (1) Acetanilide, (2) p-Nitro-Acetanilide, (3) p- Bromo-Acetanilide, (4) Aspirin,(5) m- Dinitrobenzene, (6) Oxalic Acid.
8. To perform Esterification reaction
9. To perform Sulfonation reactions
10. To synthesize emulsion polymer using emulsion polymerization set up

2170411: INSTRUMENTATION AND PROCESS CONTROL

Category	Title	Code	Credits-4			TheoryPaper
Departmental Core-DC	Instrumentation& Process Control	2170411	L	T	P	Max.Marks-50 Duration-2hrs.
			3	-	-	

Course Objectives: To gain the knowledge of different process instruments, To understand dynamic modeling of a physical process using first principles, To convert the model to a form amenable to solution and analysis, To design various control schemes, and To apply the control system in various processes.

Syllabus:

Unit – I: Introduction of process variables, static and dynamic characteristics of instruments and classification of instruments. Temperature measuring instruments- Principle, construction and operation, Pressure measuring instruments –Bourdon, diaphragm and bellow pressure gauge.

Unit –II: Construction and Characteristics of final control elements such as Proportional, Integral, PD, PID, controllers ,pneumatic control value, principal and construction of pneumatic and electronic controllers.

Unit- III: Process instrumentation diagrams and symbols, process instrumentation for process equipments such as – Distillation column, Heat exchanger, fluid storage vessel.

Unit – IV: Laplace Transform, Linear open system, first and second order system and their transient response, Interacting and non interacting system, Transportation lag and linear closed loop systems block diagram of closed loop transfer function, controllers, transient response of closed loop system.

Unit-V: Stability concept, Routh stability criterion, relative stability, Hurwitz stability criterion, Nyquist’s stability criterion. Root locus technique, introduction to frequency response, Bode diagram, Bode stability criterion, gain and margins, Ziegler Nichols controller setting.

Course Outcomes: After the completion of this course, Students will be able to:

CO1: **Explain** the importance of process control in industrial process plants.
CO5: **Compare** the Linear open loop and Closed loop system.
CO2: **Develop** block diagrams & the mathematical model for control systems.
CO3: **Identify** controller for specific problems in chemical industry.
CO4: **Analyze** the transient and frequency response of systems.
CO6: **Test** the stability of a given system.

TextBooks:

1.ProcesssystemAnalysisandControlByCoughnower andKoppel(Mc- GrawHill,NewYork)

ReferenceBooks

AutomaticProcessControlbyD.P.Eckman(Mc-GrawHill,New York)
Process Control by Peter Harriot (Mc- Graw Hill, New York)
ControlSystemEngineeringbyJ.J.NagrathandM.Gopal.

2170412: MASS TRANSFER–I

Category	Title	Code	Credits-4			Theory Paper
Departmental Core-DC	Mass Transfer– I	2170412	L	T	P	Max.Marks-50 Duration-2hrs.
			2	1	2	

Course Objective: Thepurposeofthiscourseistointroducetheundergraduatestudentswiththe most important separation equipments in the process industry, and provide proper understanding of unit operations.

Syllabus:

Unit-I: Diffusion Phenomenon: Molecular and eddy diffusion in gases, liquid and solids, interface mass transfer, Mass transfer theories; film theory, penetration theory and surface renewal theory, Concept of mass transfer coefficient: Individual and film coefficients, overall mass transfer coefficient and their inter relationship. Continuous contact and differential contact.**Unit –II: Absorption:** Absorption in continuous contact columns, co- current, counter current and cross current contacting of fluids, Absorption in packed column, calculation ofNTU and HTU, concept of HETP.

Unit –III: Humidification: Humidification: general theory , psychometric chart, fundamental concepts in humidification and dehumidification, wet bulb temperature adiabatic saturation temperature, measurement of humidification calculation of humidification operation, cooling tower and related equipments.

UNIT- IV: Drying: Equilibrium mechanism, theory of drying, drying rate curve, batch and continuous drying for tray dryers, drum dryers , spray and tunnel dryers.

Unit-V: Crystallization: Factor governing nucleation and crystal growth rate, controlled-growth of crystals, super saturation curve, principal and design of batch and continuous type equipment.

CourseOutcomes: Afterthecompletionofthiscourse,Studentswillbeableto:

CO1: **Explain** the basics of absorption, humidification, drying, crystallization & diffusion.
CO2: **Identify** the necessary information required in design of mass transfer equipment.
CO3: **Analyze** the different cases of diffusion phenomena.
CO4: Compute the parameters for mass transfer operations
CO5: Solve drying and humidification problems using psychometric charts & equilibrium data.
CO6: **Analyze** favorable conditions for a separation to be carried out.

TextBooks

1. TreybalR.E.–MassTransferOperation–3rdEdition, Mc- Graw Hill.

ReferenceBooks

1. Mc- Cabe, W.L. SmithJ.M.- Unit OperationinChemicalEngineering- 5theditionTataMc Graw Hill, New Delhi.
2. CoulsonJ.M.&RichardsonJ.F. -ChemicalEngineering–Vol.2,2ndEdition,Oxford,New Delhi

List of Experiments:

1. To determine the diffusion coefficient of liquid vapor in air by Stefan's tube.
2. To study the rate of dissolution of rotating cylinder and then to calculate the mass transfer coefficient.
3. To investigate the mass transfer characteristics of a wetted surface column unit.
4. To investigate the characteristics of a cooling tower.
5. To study the drying characteristics of wet granular material using natural and forced circulation in a tray dryer.
6. To prepare the drying rate curve for fluidized dryer.
7. To study the characteristics of spray dryer.
8. To study the characteristics of drum and tunnel dryer.
9. To find out the crystal yield with and without seeds.
10. To draw the tie lines and plot equilibrium curve for given ternary system.

Note: Each student should perform at least eight experiments out of the above list.

Lab Course Outcomes

After the completion of this lab course, Students will be able to

CO1: Determine the mass transfer coefficient from wetted wall column.
CO2: Demonstrate the mechanism of diffusion through Stefan's tube.
CO3: Make use of the theoretical concepts in humidification to operate a cooling tower.
CO4: Prepare effective technical reports.

2170413: MECHANICAL DESIGN OF PROCESS EQUIPMENTS

Category	Title	Code	Credits-4			Theory Paper
Departmental Core-DC	Mechanical Design of Process Equipments	2170413	L	T	P	Max.Marks-50 Duration-2hrs.
			3	1	-	

Course Objective: The objective of this course is to acquire basic understanding of design parameter, complete knowledge of design procedures for commonly used process equipment and their attachments (e.g. internal and external pressure vessels, tall vessels, high pressure vessels, supports etc.), and different types of equipment testing methods.

Syllabus:

Unit-I: Mechanics of materials: Stress – strain relationship of elastic materials: Thermal stress, membrane stresses and stress concentrations, Theories of failures. Design stress, Welded joints, efficiencies, Corrosion allowances.

Unit-II: General Design Consideration: Design of storage tanks for liquids and gases -classification, design of shell, bottom and roofs and other accessories.

Unit-III: Unfired Pressure Vessel: Pressure codes, classification of pressure vessels, design of cylindrical and spherical shells under internal and external pressures; Selection and design of flat plate, ellipsoidal, torispherical and conical closures, compensation of openings.

High pressure vessel: stress analysis of thick walled cylinder shell, Design of monoblic and multilayer vessels.

Unit-IV: Tall Vertical & Horizontal Vessels: pressure, deadweight, wind, earthquake and eccentric loads and induced stress; combined stresses, shell design of skirt supported vessels. **Vessel Supports:** Design of skirt, lug and saddle supports.

Unit-V: Bolted Flanges: Types of flanges, and selection, Gasket, Design of non standard flanges, specification of standard flanges, fabrication of equipment: Major fabrication steps; welding, non destructive tests of welded joints, inspection and testing, vessel lining, material used in fabrication of some selected chemical industries.

Course outcomes: After the completion of this course, Students will be able to:

CO1: **Evaluate** the important parameters of process equipment design.
CO2: **Design** internal and external pressure vessels.
CO3: **Evaluate** stress distribution in process vessels.
CO4: **Design** tall vessels and columns.
CO5: **Design** various parts of equipments such as supports, closure and heads.
CO6**: Analyze** the equipment fabrication and testing methods.

Text Books:

1. Process equipment design by Brownell, N.E. and Young, H.E. (John Wiley1959).
2. Introduction of chemical equipment design by Bhattacharaya, B.C. (CBS Publishers)

Reference Books

1. Code for unfired vessels by I.S.:2825-1969
2. Code of practice for Design, Fabrication by I.S.803-19 Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks
3. Process Equipment Design by Joshi, M.V.

2170414: Inorganic Process Technology

Category	Title	Code	Credit-2			Theory Paper
Departmental Core-DC	Inorganic Process Technology	2170414	L	T	P	Max.Marks-50Duration-2 hrs.
			3	-	-	

Course Objectives: To impart the basic concepts of Inorganic process technology. To develop concepts of unit process and unit operations in various industries. To learn manufacturing processes and flow sheets of Inorganic chemicals, its applications and major engineering problems encountered in the processes.

Syllabus

Unit I Alkalies: Chlor - alkali Industries: Manufacture of Soda ash, Manufacture of caustic soda and chlorine-common salt.

UnitIIAcids:SulphurandSulphuricacid: Miningofsulphurandmanufactureofsulphuricacid, Manufacture of hydrochloric acid, Phosphoric acid.

Unit III Fertilizers: Nitrogen Fertilizers: Synthetic ammonia, nitric acid, Urea, Ammonium Chloride, Ammonium Sulphate ; Phosphorus Fertilizers: Phosphate rock, phosphoric acid, Super phosphate and Triple Super phosphate, MAP, DAP; Potassium Fertilizers: Potassium chloride, Potassium sulphate and Bio-fertilizers.

Unit IV: Cement, Glass and Industrial Gases: Cement: Types and Manufacture of Portland cement, Glass: Manufacture of glasses and special glasses, Industrial gases: manufacture of Nitrogen, Oxygen, Hydrogen, Helium and Argon**.**

Unit V: Inorganic Chemicals: Manufacture of Bromine, Iodine and Fluorine, Alumina and Aluminum chloride, Inorganic pigments**.**

Course Outcomes: After the successful completion of this course, students will be able to

CO1: **Explain** the basics of heavy and inorganic chemical industry.
CO2: **Discuss** the importance of different unit operation and unit processes involved in heavy and inorganic chemical industry.
CO3: **Draw** process flow diagram.
CO4: **Analyze** the major engineering problems involved in the process.
CO5: **Evaluate** types of processes based on the conversion and yield of desirable products.
CO6: **Explain** the importance of fertilizer and cement technology.

TextBooks:

1. G.T. Austin, N.Shreves, “ChemicalProcessIndustries”,5thEdition,McGrawHill,NewYork, 1984.
2. W.V. Mark, S.C. Bhatia, “Chemical Process Industries volume I and II”, 2ndEdition2007.

References:

1. R. Gopal and M. Sittig, “Dryden's Outlines of Chemical Technology: For the 21stCentury”, Third Edition, Affiliated East-West Publishers, 1997.
2. S.D. Shukla and G. N. Pandey, “Textbook of Chemical Technology” Vol2,1984

Experiment List of IVth Semester

2170412 Mass Transfer –I

List of Experiments:

1. To determine the diffusion coefficient of liquid vapor in air by Stefan's tube.
2. To study the rate of dissolution of rotating cylinder and then to calculate the mass transfer coefficient.
3. To investigate the mass transfer characteristics of a wetted surface columnunit.
4. To investigate the characteristics of a coolingtower.
5. To study the drying characteristics of wet granular material using natural and forced circulation in a traydryer.
6. To prepare the drying rate curve for fluidizeddryer.
7. To study the characteristics of spraydryer.
8. To study the characteristics of drum and tunneldryer.
9. To find out the crystal yield with and withoutseeds.
10. Todrawthetielinesandplotequilibriumcurvefor giventernarysystem.

Note: Each student should perform at least eight experiments out of the abovelist.

Lab Course Outcomes

After the completion of this lab course, Students will be able to

CO1: **Determine** the mass transfer coefficient from wetted wall column.

CO2: **Demonstrate** the mechanism of diffusion through Stefan's tube.

CO3: **Interpret** the mass transfer characteristics in turbulent flows.

CO4: **Make use of** the theoretical concepts in humidification to operate a cooling tower.

CO5: **Compare** the drying operation in tray dryer, rotary dryer & fluidized bed dryer.

CO6: **Decide** on various factors governing crystal yield in both batch as well as continuous crystallization.

2170415 Process Control Lab

List of Experiments:

1. To study the Characteristics of control valves (linear, quick opening,etc.)
2. To Study the dynamics of liquid level control systems of non - interacting and interacting types.
3. To study the response of mercury in glass thermometer with and without a thermowell.
4. To study the characteristics of an electronic PIDController.
5. To study the characteristics of a current to pneumaticconverter.
6. To study the effectiveness of computer control of a distillationcolumn.
7. To study the effectiveness of computer control of a heatexchanger.
8. To study the effectiveness of computer control of a chemicalreactor.
9. To study the dynamics of pressuretanks.
10. To calibrate an air purged liquid levelindicator.

Note: Each student should perform at least eight experiments out of the above list.

Lab Course Outcomes

After the completion of this lab course, Students will be able to
CO1: Inculcate the importance of process control in industrial process plants.
CO2: Demonstrate the working of a level control trainer and its applications.
CO3: Demonstrate the working of a flow control trainer and its applications.
CO4: Select the controller that can be used for specific problems in chemical industry.
CO5: Visualize the Dynamic behavior of first and second order control system.
CO6: Differentiate between interaction and non-interacting systems.

List of Skill Based Mini Projects

Mass Transfer-I (2170412)

1. Compare the various mass transfer theories with appropriate examples where needed.
2. Demonstrate any mass transfer process experimentally at your home and interpret the operation.
3. List out the some mass transfer operation happening around you.
4. Differentiate between humidification and dehumidification with real time examples.
5. Explain the role of mass transfer in drying process and demonstrate experimentally at your home.
6. Compare the various types of industrial driers with their limitations.
7. Explain any Crystallization unit in details with flow diagram.
8. Demonstrate the crystallization process experimentally at your home.
9. Analyze the Phase Equilibrium diagram of different components.
10. Design of simple solar dryer system using household waste material.
11. Design of diffusion of coke and milk binary system.
12. Design of simple lab model for distillation column using household waste material.
13. Predict and optimize of Extraction of Nicotine from tobacco.
14. Design of simple prototype of Gas Absorption column.
15. Explain the working principle of a cooling tower with application area & limitation.

Process Control Lab (2170415)

1. Design and study of Characteristics of various type of control valves
2. Design and study of ccharacteristics of control valve with and without positioner
3. Design of ON/OFF, PI and PID controller for the pressure process
4. Design of ON/OFF, PI and PID controller for the level process
5. Design of ON/OFF, PI and PID controller for the flow process
6. Design of ON/OFF, PI and PID controller for the temperature process
7. Design and Study for Tuning of controllers
8. Design and Study of complex control system
9. Study for Responses of different order processes with transportation lag
10. Study for Responses of different order processes without transportation lag

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2170513: Chemical Reaction Engineering – I

Category	Title	Code	Credit-4			Theory Paper
Departmental Core-DC	Chemical Reaction Engineering – I	2170513	L	T	P	Max.Marks-50 Duration-2hrs.
			2	1	1	

Course Objectives: To examine reaction rate data and determine the rate laws for designing chemical reactors with/ without temperature and heat effects & account for non-idealities prevailing in real reactors.

Syllabus

Unit-I Basic Concepts in Chemical Reaction Engineering and Classification of reactions: Definition of reaction rate, Variables affecting the rate, Concept of reaction equilibria, Order of reaction and its determination, Theoretical study of reaction rate, collision and activated complex theories, Mechanism of series reaction, Parallel or consecutive reactions, Autocatalytic reactions, Chain reactions & Polymerization reactions.

Unit-II Reactions Kinetics and Interpretation of data: Interpretation of kinetic data, integral and differential method of analysis, variable volume reactions, total pressure method of kinetic analysis.

Unit-III Reactor Design for Single Reactions: Classification of reactors, Concept of ideality, Development of design equation s for Batch, Semi batch, Continuous Stirred Tank & Plug Flow Reactors, Design of isothermal and non isothermal Batch reactor, CSTR & PFR, Combination of reactors, Reactors with recycle.

Unit-IV Reactor Design for Multiple Reactions: Multiple Reactions in Batch, Continuous stirred tank and Plug flow reactors, Yield and selectivity in multiple reactions. **Temperature & Heat Effects:** Multiple steady states in continuous stirred tank reactor, Optimum temperature progression and thermal characteristics of reactors. **Unit- V Basics of Non-Idea Flow:** Non ideal reactors, RTD, Dispersion model, Tank in Series Model, Recycle Reactor, Segregated flow, Evaluation of RTD characteristics.

Course Outcomes: After the successful completion of this course, Students will be able to:

CO1: Apply the basic concepts in the analysis of homogeneous systems and deviation from ideal behavior.

CO2: Propose the different steps in reaction mechanisms and identify the Rate-determining step.

CO3: Develop Batch, CSTR, and PFR performance equations from general material balances.

CO4:Analyze Non-Isothermal operation in industrial Reactors

CO5: Determine conversion, selectivity & yield for Multiple chemical reactions.

CO6: **Analyze** the Non-Ideal behavior for any flow reactor.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	2	2	1	2	1	2	2		2		1
CO2	2	2	2	1		1	2	2	2	1	1	2		1
CO3	2	2	2	2		2	3	1		2		2		
CO4	3	3	2	1		2	2			2		2	1	2
CO5	3	3	2	2			2		2	2		2		1
CO6	3	2	1	1			2		2	2		2		1

1 - Slightly; 2 - Moderately; 3 – Substantially

Text Books

1. Octave Levenspiel, “Chemical Reaction Engineering”, John Willey & Sons
2. H. S. Fogler., “Elements of Chemical Reaction Engineering”, Prentice Hall of India Pvt. Ltd., New Delhi.

Reference Books

1. J.M. Smith, "Chemical Reaction Kinetics", McGraw Hill
2. K.G. Denbigh & K.G. Turner, "Chemical Reaction Theory an Introduction", United Press & ELBS

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2170514: Computational Methods in Chemical Eng

Category	Title	Code	Credit-4			Theory Paper
Departmental Core-DC	Computational Methods in Chemical Engg.	2170514	L	T	P	Max.Marks-50 Duration-2hrs.
			2	1	1	

Course Objectives: To get the exposure about finite differences and interpolation, to find numerical solutions of ordinary differential equations and unsteady state heat and mass transfer problems and also find numerical solutions of partial differential equations.

Syllabus

Unit-I Treatment of Engineering Data: Graphical representation, Empirical equation, Interpolation, Newton's formula, Lagrange's Interpolation formula, Extrapolation, Integration, Graphical integration, Graphical construction of integral curves, Numerical integration.

Unit-II Interpretation of Engineering Data: Significant figures, Classification of measurements, Propagation of error, Variation and distribution of random errors, Properties of variance, Confidence limit for small samples.

Unit-III Ordinary Differential Equation: Formulation, Application of law of conservation of mass- mixing in flow process, Classification of ordinary-differential equations and its application of common chemical engineering problems.

Unit-IV Numerical Solution of Ordinary Differential Equations: Linear second order equation with variable coefficients, Numerical solution by Runge-Kutta method and its application to higher order equations.

Unit-V Formulation of Partial Differential Equations: Finite difference, Linear finite difference equations, Non linear difference equations, Optimization types and methods, its application related to chemical processes.

Course outcomes: After the successful completion of this course, students will be able to:

CO1: Explain the mathematical problems as applied to Chemical Engineering.

CO2: Interpret the engineering data& the features of different numerical methods.

CO3: Illustrate the use of numerical methods in Chemical Engineering scenarios.

CO4: Outline the scope of optimization in chemical processes & use of numerical solution of the ODEs.

CO5: Simplify the solution of engineering problems using PDEs & ODEs.

CO6: Solve PDEs & ODEs in various physico-chemical systems.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	1	1			2		2	2	3
CO2	3	2	2	2	2					2		2	1	1
CO3	3	3	2	2	3				2	2		2	3	3
CO4	3	3	2	2	2	1	1			2		2	2	3
CO5	3	2	2	2	2					2		2		1
CO6	3	2	2	2	3					2		2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Text Books:

1. Jenson and Jeffrey's, "Mathematical Methods in Chemical Engineering", Academic Press
2. S. K. Gupta, "Numerical Methods for Engineers", New Academic Science

Reference Books:

1. H.S. Mickley, T.K. Sherwood, C.R. Reed, "Applied Mathematics in Chemical Engineering", McGraw Hill publication

2. Alan Myers and Warren Seider, "Introduction to Chemical Engineering and Computer Calculations", Prentice Hall.

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2170515: Process Engineering & Costing

Category	Title	Code	Credit-2			Theory Paper
Departmental Core-DC	Process Engineering & Costing	2170515	L	T	P	Max.Marks-50 Duration-2 hrs.
			2	-	-	

Course Objectives: To understand the basic concepts of flow sheeting, material and energy balances and process development, To apply algorithms for feasibility and optimization of flow sheet, To gain knowledge of estimation of capital investment, , total product costs, depreciation, cash flows, and profitability, To carry out process optimization based on economic profitability by connecting economics with design principles for real chemical engineering processes.

Syllabus

Unit I: System and subsystem in process engineering, system analysis, Economic degree of freedom, various algorithms, Synthesis of processes, Flow sheeting, Mathematical representation of steady state flow sheet.

Unit II: Equal time value of money, equivalence comparisons, discrete interest and continuous interest, develop0ment of its formula, comparison of alternative investment based on capitalized cost.

Unit III: Design Criteria Terms involved in profitability analysis, Gross income, depreciation, taxes, net profit, rate of return, venture profit, payout time, break even point.

Unit IV: Time value of money, net present value and venture worth. Capital cost and manufacturing cost estimation methods, Economic analysis and evaluation. Sensitivity & risk analysis, simplifying scale –up cost estimation.

Unit V: Analysis of R&D investment, Technological Forecasting for the process industries, interaction between design and cost equation for optimal design of equipment's, inflation, energy conservation and environmental control.

Course Outcomes: After the successful completion of this course, students will be able to

CO1 **Explain** the flowsheet and synthesis of process.

CO2 **Comparing** the various alternate methods for investments.

CO3 **Illustrate** the various methods of depreciation and its impact.

CO4 **Analyse** the rate of return, venture profit, payout time, breakeven point for the any investment.

CO5 **Describe** the capital cost and manufacturing cost estimation methods.

CO6 **Analyse** of R&D investment and technological for recasting for the process industries.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	2	1	1					2	2		2
CO2	3	2	2		2						2	2		2
CO3	3		2		2						2	2		
CO4	3				2						2	2		
CO5	2										2	2		
CO6		2		2										

1 - Slightly; 2 - Moderately; 3 – Substantially

Text Books:

Peters, M.S. and Timmerhause, K.D. – PLANT DESIGN AND ECONOMICS FOR CHEMICAL ENGINEERS –Ed. Mc. Graw- Hill.

References:

Schwery H.E. – PROCESS ENGINEERING ECONOMICS – Mc. Graw Hill (1955)

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2170512-MassTransferLab-II

1. Preparation of the Vapor Liquid Equilibrium and Boiling point diagram for binary liquid mixture
2. Determination of relative volatility of a given system of acetic-acid water
3. To verify Rayleigh equation for differential distillation of binary system
4. To determine height equivalent to a Theoretical Plate (HETP) of a Packed Distillation Column
5. To study Steam distillation Process
6. To study Batch distillation Process
7. To study Continuous distillation Process
8. Experimental study on packed tower distillation unit
9. Experimental study on Sieve plate distillation unit
10. To study Bubble cap distillation column
11. To estimate percentage leaching of oxalic acid from sand using water as a solvent.
12. To estimate percentage leaching of oxalic acid from sand using water as a solvent using three stages cross current operation
13. To study the adsorption of a gas in a packed column and calculation of NTU and HTU
14. To perform Batch Adsorption and verify Freundlich Law and Langmuir Isotherm.

Note: Each student should perform at least eight experiments out of the above list.

After completion of this laboratory course, the student will be able to

CO1: demonstrate an understanding of mass transfer modes and models.

CO 2: formulate the idea of the different types of distillation columns

CO3: apply principles of mass transfer phenomena to chemical process industries.

CO4: enable solving the problems on process and materials related combined mass transfer phenomena.

CO5: demonstrate surface phenomena like adsorption

CO6: apply comparative analysis in choice of types of plate and packing in a distillation column

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	1	2	1	2	2		2	3	3
CO2	2	2	2	2	2				2	2	1	2	2	2
CO3	3	3	2	2	2					2		2	2	2
CO4	3	3	3	2	2	1	2	1	2	2		2	3	3
CO5	3	3	2	2	2				2	2		2	3	2
CO6	3	2	2	2	2	2	2	2	2	2	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

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2170513-CHEMICAL REACTION ENGINEERING – I

1. To determine the rate constant of hydrolysis of an ester-catalyzed by acid.
2. To determine temperature dependency of rate constant evaluation of activation energy and verification of Arrhenius law.
3. To study a homogeneous reaction in semi- batch reactor under isothermal conditions.
4. To determine the order of reaction (n) and the reaction rate constant (k) for the given saponification reaction of ethyl acetate in aqueous sodium hydroxide solution in a Batch Reactor
5. Study of non-catalytic homogeneous saponification in CSTR.
6. To study a non-catalytic homogeneous reaction in a plug flow reactor.
7. To determine the residence time distribution behaviour of backmix-reactor.
8. To determine the RTD behaviour of tubular reactor.
9. To determine the RTD behaviour of CSTR.
10. To determine the velocity rate constant of the hydrolysis of ethyl acetate by sodium hydroxide.
11. To determine the conversion in PFTR, for Saponification of ethyl acetate with NaOH at ambient conditions.
12. Determine the rate constant and order of reaction between potassium persulfate and potassium iodide.
13. To study a homogeneous catalytic reaction in a batch reactor under adiabatic conditions.
14. Study of catalytic saponification reaction in a tubular flow reactor.

Note: Each student should perform at least eight experiments out of the above list.

After completion of this laboratory course, the student will be able to

CO1: Demonstrate the basic concepts of chemical reaction engineering like estimation of order of a reaction

CO2: Compare various reactors for a particular reaction in terms of conversion and time of completion.

CO 3: Analyze the Optimum temperature progression for single reaction, Isothermal, adiabatic, non adiabatic operation.

CO4: Determine the residence time distribution of fluid in vessel & concept of micro and macro mixing.

CO 5: Identify related calculation and solutions to chemical reaction engineering problems for designing chemical reactors.

CO6: Design industrial scale reactor on the basis of kinetic data obtained at lab scale.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	1	1			2		2	2	3
CO2	3	2	2	2	2					2		2	1	1
CO3	3	3	2	2	3				2	2		2	3	3
CO4	3	3	2	2	2	1	1			2		2	2	3
CO5	3	2	2	2	2					2		2		1
CO6	3	2	2	2	3					2		2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

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2170514 – Computational Methods in Chemical Engineering Lab

1. Data representation and treatment by graphical methods, pressure volume, temperature and concentration relationship for gases and their mixtures
2. Redlich-Kwong equation of state and other Viral equations to estimate thermodynamic properties like compressibility factor, molar volume and P-V-T relationship
3. Estimation of properties from empirical correlations
4. Estimation of critical properties from group contribution method
5. Measurement errors their propagation and minimization of random errors, selection of confidence limits
6. Numerical solutions of quadratic and linear algebraic equations using various methods on the solvers in MATLAB
7. Numerical solutions of batch reactor problems using Euler Algorithm
8. Polynomial root finding using "Newton Raphson method and Secant method"
9. Numerical integration by Trapezoidal rule, Simpsons 1/3rd and 3/8rd rule
10. Approximate solutions of ordinary differential equations by Runge - Kutta algorithm and its application in chemical engineering
11. Numerical solution of transient flow temperature profile of fluid using different computational methods on MATLAB solver
12. Mass balance problem using continuity equation applied to a dynamic system. Formation of differential equations (component balance) and their solutions

Note: Each student should perform at least eight experiments out of the above list.

After completion of this laboratory course, the student will be able to

CO1: solve problems of algebraic and differential equations, simultaneous equation, partial differential equations

CO2: convert problem solving strategies to procedural algorithms and to write program structures

CO3: solve engineering problems using computational techniques

CO4: assess reasonableness of solutions for selecting appropriate levels of solution sophistication

CO5: apply basics of MATLAB for solving ODE and PDE forms of modeling equations

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	3	1	1	1	2	2	1	2	1	2
CO2	3	3	2		2				2			2	2	2
CO3	3	2	2		2					2		2	1	1
CO4	2	3	2	2	2					2		2	2	1
CO5	3	3	2	2	2					2		2	2	2
CO6	3	3	1	1	2					2		2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

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(Deemed to be University)

NAAC Accredited with A++ Grade

2170511: Data Science

1. Introduction to Python for data analytics science
2. Basic Statistics and Visualization in Python by-
   a. Write a Python script to find basic descriptive statistics using summary
   b. Write a Python script to find subset of data set by using subset
3. K- means Clustering
4. Association Rules
5. Linear Regression
6. Logistic Regression
7. Naïve Bayesian Classifier
8. Decision Trees
9. Simulate Principal component analysis
10. Simulate Singular Value Decomposition
11. Classification model
    a. Install relevant packages for classification.
    b. Choose a classifier for classification problems.
    c. Evaluate the performance of the classifier.
12. Clustering model
    a. Clustering algorithms for unsupervised classification.
    b. Plot the cluster data using Matplotlib

Note: Each student should perform at least eight experiments out of the above list.

After completion of this laboratory course, the student will be able to

CO1: Apply the Python Programming Language.

CO2: Solve data science problems.

CO3: Differentiate the classification and Regression Model.

CO4: Simulate component analysis

CO5: Apply Regression to data set

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	3						1	2	1	
CO2	3	3	2		2							2	2	
CO3	3	2	2		2							2	1	
CO4	2	3	2	2	2							2	2	
CO5	3	3	2	2	2							2	2	
CO6	3	3	1	1	2							2	2	

1 - Slightly; 2 - Moderately; 3 – Substantially

MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR

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Item 11

Skill Based Mini Projects V Semester

2170511 MC Data Science

1. Design an AI Healthcare Bot System using Python
2. Design Chronic Obstructive Pulmonary Disease Prediction System
3. Design College Placement System Using Python
4. Design Face Recognition Attendance System for Employees using Python
5. Design Liver Cirrhosis Prediction System using Random Forest
6. Design Multiple Disease Prediction System using Machine Learning
7. Design Secure Persona Prediction and Data Leakage Prevention System using Python
8. Design Stroke Prediction System using Linear Regression
9. Design Heart Failure Prediction System
10. Design Yoga Poses Detection using OpenPose
11. Design Credit Card Fraud Detection System Python
12. Design Recipe Recommendation from the Ingredients Flutter App

2170512 DC Mass Transfer –II

1. Design Application of distillation in extraction of essential oil
2. Design Application of Vapour liquid equilibrium
3. Design application of Mc Cabe Thiele for determining number of stages
4. Design role of reflux ratio in distillation column
5. Design comparative columns (plate vs packed) for distillation
6. Study of breakthrough curves with experimental runs
7. Designing enthalpy concentration diagram
8. Design Application of azeotropic distillation (positive or negative deviation)
9. Design Application of extractive distillation
10. Design Application of Batch column Adsorption

2170513 DC Chemical Reaction Engineering – I

1. Case study on various theories of reaction arte
2. Design application of variable volume reactors
3. Design application of batch reactor
4. Design application of Semi Batch reactors
5. Design application of continuous reactors
6. Design application of Optimum Temperature Progression
7. Design application of Recycle Reactors
8. Design application of Tank in Series Model
9. Design application of Dispersion Model
10. Design application of Residence time distribution

MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR

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NAAC Accredited with A++ Grade

2170514 DC Computational Methods in Chemical Engg

1. Design application of Interpolation in Chemical Engineering with case study
2. Design application of Extrarpolation in Chemical Engineering with case study
3. Design application of Graphical Integration in Chemical Engineering with case study
4. Design Application of law of conservation of mass in mixing flow process
5. Design application of ODE to common chemical engineering problems.
6. Design role of Propagation of error, Variation and distribution of random error in specific chemical engineering case study
7. Design application of Linear second order equation with variable coefficients,
8. Design application of Numerical solution by Runge-Kutta method to higher order equations.
9. Design application of Finite difference,
10. Design any one Optimization method with its application related to chemical processes.

2170615: PROCESS MODELING AND SIMULATION

Category	Title	Code	Credit-3			Theory Paper
Departmental Core	PROCESS MODELING AND SIMULATION	2170615	L	T	P	Max.Marks-50 Duration-2hrs.
			3	-	-	

Course Objectives: To provide an adequate knowledge of modeling in chemical engineering process system and to develop solutions for these models.

Syllabus

Unit I Modelling Role & Analysis: Chemical Engineering Problems, Basic concepts of analysis, the analysis process, a simple example of estimating an order, Source of the model equations, Conservation equations, Constitutive equations, Control volumes, Dimensional analysis, System of units, Dimensional consistency in mathematical descriptions, Dimensional analysis and constitutive relationships, Final observations.

Unit II Non-Reacting and Reacting Liquid Systems: Introduction, Equation of continuity, Simple mass balance, Application of the model equations, Component mass balances, Model behavior, Steady state and unsteady state behavior, density assumptions, Numerical integration methods of ordinary differential equation. **Reacting Liquid Systems:** Introduction, basic model equations for a Tank-Type reactor, the reaction rate, the batch reactor, Pseudo First-order reactions, Reversible reactions, **Multiple reactions:** consecutive reactions, parallel reactions, complex reactions, constant density assumption, order and stoichiometry.

Unit III Treatment of Experimental Data: Introduction, Criteria for Best Fit, Best Slope-I, Best Slope-II, Best straight line, Physical property correlations, Fitting a quadratic, Simulation examples of gravity fluid flow, heat and mass transfer, Monte-Carlo simulation.

Unit IV Dynamic Modeling of Simple Processes: Sequential, Simultaneous modular and equation oriented approaches, Partitioning and tearing.

Unit V Computer Programming of Various Processes: Iterative convergence methods such as Newton- Raphson, False position, Wegstein, Muller methods.

Course Outcomes:

After the successful completion of this course, students will be able to:
CO1: **Explain** the basic concepts involved in process analysis & simulation.
CO2: **Formulate** a chemical engineering problem as a mathematical model from basic engineering principles.
CO3: **Apply** the conservation equations in various physico – chemical systems.
CO4: **Analyze** the experimental data for further processing.
CO5: **Compare** iterative convergence methods and numerical solution of ODEs.
CO6: **Analyze** different approaches involved in dynamic modeling of process systems.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	2	1				1			1	1		1	1	2
CO2	2	2	2			1						1	2	2
CO3	2	1	1	2		1	1	1				1	1	2
CO4	2	1	2	2		1		1	1			1	1	1
CO5	2	3	3	3	2	1	1	1	1		2	2	2	2
CO6	2	3	3	3	3	1		1	1			3	2	1

Text Books

1. W.L. Luyben, "Process Modeling Simulation and Control for Chemical Engineers", McGraw Hill
2. T.W.F. Russell, "Introduction to Chemical Engineering Analysis", John Wiley & Sons New-York
3.

Reference Books

1. Ismail Tosun, "Modeling in Transport Phenomena-A Conceptual Approach", Elsevier Publications
2. A.K. Jana,"Chemical Process Modeling & Computer Simulation", PHI learning PrivateLtd
3. M.E. Davis, "Numerical Methods and Modeling for Chemical Engineers", Wiley, NewYork

2170616: PROCESS EQUIPMENT DESIGN

Category	Title	Code	Credit-3			Theory Paper
Departmental Core	PROCESS EQUIPMENT DESIGN	2170616	L	T	P	Max.Marks-50 Duration-2hrs.
			3	-	-	

Course Objective:

The objective of this course is to acquire basic understanding of design parameter, complete knowledge of design procedures for commonly used process equipment.(e.g. evaporator, flash drum, cooling tower, etc.).

Syllabus

Unit I Scale up and scale down of chemical process equipment. Process design calculations for heat exchanges equipment shell and tube heat exchangers general description, heat transfer coefficients and pressure drop by Kern's & Bells methods rating on existing unit.

Unit II Design of a new system having one or more units in series: single effect evaporation, Multiple effect evaporator with boiling point elevation.

Unit III Process design calculations for mass exchange equipment plate (tray) and packed column for distillation and absorption including column diameter and height.

Unit IV Detailed process and mechanical design, Flash drum, Kettle reboiler, Condenser, cooling tower, rotary drier.

Course Outcomes: After the successful completion of this course, students will be able to

CO1: **Discuss** the aspects of design, flowsheets and scaleup in chemical plant design
CO2: **Design** heat exchangers by selecting a suitable method
CO3: **Determine** the property values at various process conditions.
CO4: **Analyze** the final design parameters in any process design.
CO5: **Choose** between different methods employed in design calculations & designs available for specific equipment.
CO6: **Formulate** rules of thumb to decide parameters encountered in process design.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1		1	1	1	1	1			1	1	1	1	1	2
CO2	2	2	2	1		1			2		1	1	2	2
CO3	2	1	1	2	1	1	1	1	1			1	1	2
CO4	2	1	2	2	1	1		1	1		1	1	1	1
CO5	2	3	3	1	2	1	1	1	1		2	2		2
CO6	2		1	1	1	1		1	1		1	3		1

Suggested Reading:

1. Dawande, S.D., “Process Design of Equipments”, Central Techno Publications, Nagpur, 2000
2. R. H. Perry, "Chemical Engineers' Handbook", 7th Edn., McGraw Hill , NewYork, 1998.
3. R. K. Sinnott, "Chemical Engineering Design", Coulson and Richardson’s Chemical Engineering Series, Volume-6, Fourth Edition, Butterwoth-Heinemann, Elsevier, NewDelhi,2005.
4. D.Q. Kern “Process Heat Transfer”, Tata McGraw Hill Edn.,2004.
5. Chemical Engg. Vol-6 By Coulson J. M. Richardson

2170617 ARTIFICIAL INTELLIGENCE & MACHINELEARNING

COURSE OBJECTIVES:

1. To provide the fundamental knowledge of Artificial Intelligence, Neural Network and Machine Learning.
2. To present the basic representation and reasoning paradigms used in AI &ML.
3. To understand the working of techniques used in AI &ML.

Unit – I:

Introducing Artificial Intelligence: Definition,Goals of AI, Task of AI, Computation, Psychology and Cognitive Science. Perception, Understanding, and Action. Artificial intelligence vs machine learning vs deep learning and other related fields. Applications of Artificial intelligence and Machine Learning in the real world.

Unit – II:

Problem, Problem Space and Search:

Production System, Blind Search: BFS & DFS, Heuristic Search, Hill Climbing, Best First Search

Introduction to Neural Networks:

History, Biological Neuron, Artificial Neural Network, Neural Network Architectures, Classification, & Clustering

Unit – III:

Introduction to Machine Learning: Traditional Programming vs Machine learning. Key Elements of Machine Learning: Representation, process (Data Collection, Data Preparation, Model selection, Model Training, Model Evaluation and Prediction), Evaluation and Optimization. Typesof Learning: Supervised, Unsupervised and reinforcement learning. Regression vs classification problems.

Unit – IV:

Supervised Machine Learning: Linear regression: implementation, applications & performance parameters. Decision tree classifier, terminology, classification vs regression trees, tree creation with Gini index and information gain, IDE3 algorithms, applications and performance parameters.Random forest classifier.Case study on regression and classification for solving real world problems.

Unit –V:

Unsupervised Machine Learning: Introduction, types: Partitioning, density based, DBSCAN, distribution model-based, hierarchical, Agglomerative and Divisive, Common Distance measures, K-means clustering algorithm. Case study on clustering for solving real world problems.

COURSE OUTCOMES: After completing the course, the student will be able to:
CO1: **Explain** basics of Artificial Intelligence & Machine Learning.
CO2: **Discuss** techniques for search and processing.
CO3: **Describe** types of machine learning problems and techniques.
CO4: **Analyze** various techniques in Artificial Intelligence & Machine Learning.
CO5: **Apply** AI and ML techniques to solve real world problems.
CO6: **Build** AI enabled intelligent systems for solving real world problems.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	1				1	1			1		1	1	1	2
CO2	1	1	1	1	2	1			2		1	1	2	2
CO3	1		1	2	1	1	1	1	1	1		1	1	2
CO4	1	1	2	2	1	1		1	1		1	1	1	1
CO5	2	1	2	1	2	1	1	1	1			2	1	2
CO6	2	1	1	1	1	1		1	1		1	2	1	1

RECOMMENDED BOOKS:

1. Artificial Intelligence: A Modern Approach by Stuart J. Russell and Peter Norvig, PrenticeHall.
2. Artificial Intelligence: Elaine Rich, Kevin Knight, Mc-GrawHill.
3. Introduction to AI & Expert System: Dan W. Patterson,PHI.
4. Pattern Recognition and Machine Learning, Christopher M.Bishop
5. Introduction to Machine Learning using Python: Sarah Guido
6. Machine Learning in Action: Peter Harringto

1000007 INTELLECTUAL PROPERTY RIGHTS

(Offered by Humanities Department: MC)

1000007	Intellectual Property Rights	Theory	Midterm	Quiz/Assignment	TOTAL	L	T	P	C
		70	20	10	100	2	-	-	02

COURSE OBJECTIVES

- To acquaint the learners with the basic concepts of Intellectual Property Rights.
- To develop expertise in the learners in IPR related issues and sensitize the learners with emerging issues in IPR and the rationale for the protection of IPR.

UNIT – I: Introduction

Introduction to IPRs, Basic concepts and need for Intellectual Property – Meaning and practical aspects of Patents, Copyrights, Geographical Indications, IPR in India and Abroad. Nature of Intellectual Property, Industrial Property, technological Research, Inventions and Innovations – Important examples of IPR.

UNIT – II: Intellectual Property Rights

The IPR tool kit, Patents, the patenting process, Patent cooperation treaties: International Treaties and conventions on IPRs, TRIPS Agreement, PCT Agreement, Patent Act of India, Patent Amendment Act, Design Act, Trademark Act, Geographical Indication Act.

UNIT – III: Intellectual Property Protections

IPR of Living Species, protecting inventions in biotechnology, protections of traditional knowledge, biopiracy and documenting traditional knowledge, Digital Innovations and Developments as Knowledge Assets – IP Laws, Cyber Law and Digital Content Protection. **Case studies: The basmati rice issue, revocations of turmeric patent, revocation of neem patent.**

UNIT – IV: Exercising and Enforcing of Intellectual Property Rights

Rights of an IPR owner, licensing agreements, criteria for patent infringement. Case studies of patent infringement, IPR – a contract, unfair competitions and control, provisions in TRIPs,

UNIT- V: Role of Patents in Product Development & Commercialization

Recent changes in IPR laws impacting patents and copy rights, intellectual cooperation in the science and allied industry. Patentable and non-patentable research. Case studies

माधव प्रौद्योगिकी एवं विज्ञान संस्थान, ग्वालियर (म.प्र.), भारत
MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR (M.P.), INDIA
Deemed University
(Declared under Distinct Category by Ministry of Education, Government of India)
NAAC ACCREDITED WITH A++ GRADE

Department of Chemical Engineering

CHEMICAL ENGINEERING

Course Outcomes: At the end of this course, the student will be able to

1. Imbibe the knowledge of Intellectual Property and its protection through various laws
2. apply the knowledge of IPR for professional development
3. develop a platform for protection and compliance of Intellectual Property Rights & knowledge
4. create awareness amidst academia and industry of IPR and Copyright compliance
5. deliver the purpose and function of IPR and patenting.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	1				1	1			1		1	1		
CO2	1	1	1	1	2	1			2		1	1		
CO3	1		1	2	1	1	1	1	1	1		1		
CO4	1	1	2	2	1	1		1	1		1	1		
CO5	2	1	2	1	2	1	1	1	1	1		2		

References

1. P.B. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy. Tata Mc Graw Hill, 2001. Steve Smith, The Quality Revolution.1st ed., Jaico Publishing House, 2002.
2. Kompal Bansal and Praishit Bansal. Fundamentals of IPR for Engineers, 1st Edition, BS Publications, 2012. Prabhuddha Ganguli. Intellectual Property Rights. 1st Edition, TMH, 2012.
3. R Radha Krishnan & S Balasubramanian. Intellectual Property Rights. 1st Edition, Excel Books, 2012. M Ashok Kumar & Mohd. Iqbal Ali. Intellectual Property Rights. 2nd Edition, Serial Publications, 2011. VinodV. Scople, Managing Intellectual Property. Prentice Hall of India PvtLtd, 2012.
4. Deborah E. Bouchoux. Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets. Cengage Learning, 3rd ed. Edition, 2012.

5. Prabuddha Ganguli. Intellectual Property Rights: Unleashing the Knowledge Economy. McGraw Hill Education, 2011. Edited by Derek Bosworth and Elizabeth Webster.The Management of Intellectual Property. Edward Elgar Publishing Ltd.,2013.

6. B.S. Patil, Legal Aspects of Building and Engineering Contracts, 1974. Wadhera (2004), Intellectual Property Rights, Universal Law Publishing Co. Ramappa (2010), Intellectual Property Rights Law in India, Asia Law House

: Fuels & Combustion

Category	Title	Code	Credit-3			Theory Paper
Open Course I – OC(i)	**Fuels & Combustion**		L	T	P	Max.Marks-50 Duration-2 hrs.
			3	0	0	

Course Objectives:

To understand processing and limitations of fossil fuels (coal, petroleum and natural gas) and necessity of harnessing alternate energy resources such as solar, wind, nuclear, geothermal, tidal and biomass. Also, to understand and practice various characterization techniques for fuels.

Unit-I Solid Fuels: Coal and lignite reserves in India, Classification of coal, washing of coal, analysis of coal, proximate and ultimate analysis**.**

Unit-II Coal Carbonization, Mechanism of low temperature carbonization and high temperature carbonization, by- product recovery from coke oven, properties of coke, coal, grinding, pulverization, briquetting of solid fuels.

Unit-III Liquid Fuels: Origin of Petroleum production, Indian petroleum resources and their nature, Petroleum processing, distillation, cracking- thermal and catalytic, coking, reforming, Isomerization, crude Oil Classification, Reserves of Hydrocarbon in India, Introduction to petroleum refining and processing, atmospheric and vacuum crystallization.

Unit-IV Petroleum product and their utilization, blending of petrol for octane number boosting, Transport fuels: Diesel, Petrol, AVL (Aviation Liquid Fuel), Kerosene, fuel and furnace oil, Testing of petroleum product: Flash Point, pore point, fire point, Octane number, cetane number, viscosity and viscosity index, API.

Unit-V Gaseous fuels: Natural gas, synthetic gases, their composition & properties, producer gas, water gas, coal gas, LPG.

Course Outcomes:

After completion of this course, the student will be able to CO 1. Explain the origin of fossil fuels

CO 2. Classify fossil fuels and their reserves in India

CO 3. Analyze various alternate energy options available in earth

CO 4. Explain various fuel-processing techniques used in solid, liquid and gaseous fuels

CO5 Assess characterization techniques for fuels

CO6 Compare quality of fuels based on its properties and possible utilization

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	2					3		2		1
CO2	3	3	3	1		1		1	1	2	1	2	2	2
CO3	3	2	2	2	2	1	1		1	2	1	2	2	2
CO4	3	2	2	2	2	1	1			1	1	1	1	2
CO5	3	3	2	1	1	1				1	1	2	1	
CO6	3	3	1	2	2				1	2	1	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Suggested Reading:

Sarkar S. –FUEL AND COMBUSTION- 2nd ed. ORIENT Longmen, Mumbai, 1996.
Gupta O.P. FUEL & COMBUSTION-3rd ed. Khanna Publishers, New Delhi, 1996.
Francis W. & Peters M. C. – Fuel & Fuel Technology – 2nd Edn., Pergamon, 1980.

2170615:ProcessModeling&Simulation Lab

ListofExperiments

1. Process dynamics experiments like flow of incompressible fluids at a variable flow rate.
2. Dynamics of a tank draining through an orifice in the bottom. Differential equation formulation and verification with the experimental data.
3. Mass balance in a tank filling at certain rate and emptying at another rate. Rectangular and wedge-shaped tank and incompressible fluid
4. Modeling a batch reactor-verification of 1st and 2nd order ratekinetics.
5. Counter current double pipe heat exchanger modeling-data analysis by iterative methods.
6. Simulation of a distillation column-binary systems, equimolal overflow, constant relative, volatility.
7. Input-Output response study in non-ideal flow reactors.
8. Simulation of a perfectly mixed reactor with heat transfer. Derivation of a mathematical model and solving for steady state heat transfer
9. Simulation of False Position method.
10. Simulation of Newton-Raphson method.
11. Simulation of Muller method.
12. Simulation of Euler’s & R-K methods.

Note: ***All the lab classes mentioned above are software based and will be conducted on MATLAB platform***

Course Outcomes: Process Modeling & Simulation Lab

After completion of this laboratory course, the student will be able to

CO1: Develop fundamental understanding of chemical engineering problems.

CO2: Develop dynamic model equations of chemical engineering systems.

CO3: Solve the differential equations by using different convergence methods.

CO4: Develop MATLAB code to solve dynamic model equations.

CO5: Analyze the plotted data generated by MATLAB code.

CO6: Analyze the variation of state variable with respect to time.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	2	1	1	1	1	1	2	1	1		2	1	1	2
CO2	2	2	2	1	1	1	1	2	1		2	1	2	2
CO3	2	1	1	2	2	1	1	1			1	1	1	2
CO4	2	1	2	2	1	1	1	1			2	1	1	1
CO5	2	3	3	3	2	1	1	1			2	2	2	2
CO6	2	3	3	3	3	1	1	1	1		2	3	2	1

2170615: Process Modeling & Simulation Lab

Skill Based Mini Project

List of Experiments

1. Consider a stirred tank heater where the tank inlet stream is received from another process unit. The objective is to raise the temperature of the inlet stream to a desired value. A heat transfer fluid is circulated through a jacket to heat the fluid in the tank. Develop model equations for the system by taking suitable assumptions & perform simulations using MATLAB.

2. Consider a perfectly mixed tank where a liquid phase chemical reaction is taking place. The reaction is assumed to be irreversible and of first order. The feed enters the reactor with volumetric rate $F_f(m^3/sec)$, density $\rho_f(kg/m^3)$and concentration $C_{Af}(mol/m^3)$. The output comes out of the reactor at volumetric rate $F_0(m^3/sec)$, density $\rho_O(kg/m^3)$ and concentrations $C_{A0}(mol/m^3)$ and $C_{B0}(mol/m^3)$. Develop model equations for the system by taking suitable assumptions & perform simulations using MATLAB.

3. Consider the catalytic hydrogenation of ethylene : A+B ----------->P,where A represents hydrogen, B represents ethylene and P is the product (ethane). The reaction is taking place in a CSTR. Two streams are feeding the reactor. One concentrated feed with flow rate F1(m^3/sec)and concentration CB1(mol/m^3)and another dilute stream with flow rate F2(m^3/sec concentration CB2(mol/m^3).The effluent has flow rate F0(m^3/sec)and concentration CB(mol/m^3). The reactant A is assumed to be in excess. Develop modelequations for the system by taking suitable assumptions & perform simulations using MATLAB.

4. A perfectly mixed, isothermal CSTR has an outlet weir. The flow rate over the weir is proportional to the height of liquid over the weir to the 1.5th power. The weir height is hw. The cross-sectional area of the tank is A. Assume constant density. A first orderreaction takes place in the tank. Develop model equations for the system by taking suitable assumptions & perform simulations using MATLAB.

5. Consider the following elementary gas phase reversible reaction taking place in a perfectly mixed vessel: A←------>2B.The influent to the vessel has volumetric rate Ff(m^3/sec), density (kg/m^3) and mole fraction yf. Product comes out of the reactor with

volumetric rate F_0, density ρ_0 and mole fraction y_0.The temperature and pressure inside the vessel are constant. The reactor effluent passes through a control valve whichregulates the gas pressure at constant pressure P_S. Develop model equations for the system by taking suitable assumptions & perform simulations using MATLAB.

6. A fluid stream is continuously fed to the mixed reactor and another fluid stream is continuously removed from the reactor. Since the reactor is perfectly mixed, the exit stream has the same concentration and temperature as the reactor fluid. A jacket surrounding the reactor also has feed and exit stream. The jacket is assumed to be perfectly mixed and at lower temperature, then passes through the reactor walls into the jacket, removing the heat generated by reaction. Develop model equations for the system by taking suitable assumptions & perform simulations using MATLAB.

7. An exothermic reaction : A ------------>B takes place in a CSTR and the heat generated in the reactor is removed by a cooling coil. The effluent temperature is different from the inlet temperature due to heat generation by the exothermic reaction. Develop model equations for the system by taking suitable assumptions & perform simulations using MATLAB.

8. Develop model equations for non-isothermal jacketed CSTR system by taking suitable assumptions& perform simulations using MATLAB.

9. Consider a batch reactor. Reactant is charged into the vessel. Steam is fed into the jacket to bring the reaction temperature up to the desired level. Then afterwards cooling water must be added to the jacket to remove the exothermic heat of reaction and to make the reactor temperature follow the prescribed temperature profile. First order consecutive reactions with rate constants k1and k2:A----------->B-->C takes place in the reactor. Assume that the density of the reacting liquid is constant. Develop model equations for the system by taking suitable assumptions & perform simulations using MATLAB.

10. A semi-batch reactor is run at constant temperature by varying the rate of addition of one of the reactants, A. The irreversible exothermic is first order in reactants A and B. A+B----------> C. The tank is initially filled to its 40 % level with pure reactant B at a concentration C_{B0} maximum. Cooling water flow is begun and reactant A is slowly added to the perfectly stirred vessel. Develop model equations for the system by taking suitable assumptions & perform simulations using MATLAB.