: Fuel Technology

Category	Title	Code	Credits-4			Practical Paper
Departmental Core -DC	Fuel Technology		L	T	P	Max.Marks-50 Duration: 2 hrs.
			2	1	2	

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 interpretations about renewable energy sources.
CO6: explain the current status of fuel consumption and requirements in India.

Text Books:

1. O.P. Gupta (1st Edition 2018, Khanna Publishers) Elements 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

LIST OF EXPERIMENT:

1. To determine the viscosity of the given oil sample using Redwood viscometer
2. To determine the Cloud point and Pour point of a given fuel / lubricant / oil using Cloud and Pour point apparatus
3. To determine the Flash and Fire point of the given sample of oil using Pensky Martens apparatus
4. To determine the carbon residue of the given sample of lubricating oil / fuel using Conradson Apparatus
5. To determine the Smoke point of a given oil using a smoke point apparatus.
6. To determine the Acid value of a given oil
7. To determine the aniline point of a given oil / fuel
8. To determine the calorific value and water equivalent of a supplied sample by using Bomb calorimeter
9. To determine the proximate analysis of coal sample
10. To determine the ultimate analysis of the coal sample

List of Skill based mini Project

1. Practically demonstrate the Characteristics of good fuels.
2. Experimentally find out the flash and fire point of three given liquid fuels/lubricants.
3. Experimentally perform the carbonization process in the lab and interpret the result.
4. Find out the pour point of three different lubricants given.
5. Estimate the viscosity of three different given fuels in the laboratory.
6. Do the proximate analysis of three different coal samples given and interpret the result.
7. Practically compare the properties of solid/liquid fuels.
8. Find out the calorific value of given coal samples in the lab.
9. List out the factors that affect the gasoline and diesel fuel properties.
10. Estimate the Octane/Cetane no. of given gasoline/diesel fuels.

3170221: Chemical Process Calculations

Category	Title	Code	Credits-4			Theory Paper
Departmental Core-DC	Chemical Process Calculation	3170221	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.

3170223: FLUID PARTICLE MECHANICS

Category	Title	Code	Credits-4			Theory Paper
Departmental Core-DC	Fluid Particle Mechanics	3170223	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.

Fluid Particle Mechanics (3170223)

List of Experiments:

1. To analyze the given sample by differential, cumulative methods using standard screen.
2. Determination of size and surface area of irregular particles using a measuring gauge.
3. To study the crushing behavior and to determine the Rittinger's and Bond's constant of the given solid in a jaw crusher.
4. To study the crushing behavior and to determine the Rittinger's and Bond's constant of the given solid in a ball mill.
5. To study the crushing behavior and to determine the Rittinger's and Bond's constant of the given solid in a hammer mill.
6. Determination of mixer effectiveness and mixing index of given slurries.
7. To study the filtration behavior of a given slurry using a Plate and Frame Filter press.
8. To study the filtration behavior of a given slurry using a leaf filter press.
9. To study the filtration behavior of a given slurry using a rotary drum filter press..
10. To study the performance of a Dorr Thickener.
11. To study the characteristics of liquid-solid fluidized bed.
12. To study the characteristics of gas-solid fluidized bed.
13. Study of gas/liquid solid cyclone separator and to evaluate the separation efficiency.

Note: Each student should perform at least 8 experiments out of the above list.

Lab Course Outcomes

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

CO1 Perform the Screen Analysis experiment.

CO2 Illustrate the performance of grinding mill on laboratory scale.

CO3 Illustrate the performance of crushers on laboratory scale.

CO4 Analyze the performance of mixing and filtration equipment.

CO5 Classify and analyze the performance of various conveying equipment.

CO6 Develop a sound knowledge of process equipment associated with fluid particle mechanics.

3170223: FLUID PARTICLE MECHANICS

List of Skill based mini project

1. Compare the various conveyors used in chemical/process industries
2. Classify the crushers used in chemical/process industries with appropriate applications area.
3. Define the laws of crushing with appropriate example
4. Based on experimental study at home, compare the Free & Hindered Settling conditions
5. Explain the Dry & Wet Classification Methods with example
6. Explain the various types of Industrial filters with associated applications
7. Based on the experimental data interpret the Differential and Cumulative Screen Analysis
8. Define Mineral Beneficiation: Jigging. Tabling & Froth Floatation
9. Based on the working principal differentiate the various types of industrial Jaw crushers.
10. Compare the various types of filtration unit used in industry in details with working principal (e.g., centrifuge bowl, Rotary Drum filter, vacuum filter, plate and frame filter, leaf filter, disc filter etc.).
11. Plot the tromp curve for given sieving data (experimental) and estimate the performance parameters d_{10}, d_{50}, d_{80} and d_{90}.
12. Compare the different types of Industrial classifiers with their working principles and applications.
13. Perform the "Float and Sink "experiment at home (with available materials) and interpret the finding.
14. Estimate the factors that affect the settling rate. Calculate/estimate the settling rate for given materials based on experimental study at home.
15. Develop an empirical correlation between response and variables for given set of experimental data (Software based MINITAB/SIGMA plot/ Excel).
16. Explain the need of Industrial dewatering. Compare the various dewatering process involved in process industries (Chemical/metallurgical).
17. Draw a complete flow diagram of comminution, classifying and filtration unit with appropriate symbols.
18. Estimate/predict the size of the given materials based on image processing technique.
19. To estimate the angle of repose of different given samples

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3170311: FLUID MECHANICS

Category	Title	Code	Credits-4			Theory Paper
Departmental Core-DC	Fluid Mechanics	3170311	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

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

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

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3170312: ORGANIC PROCESS TECHNOLOGY

Category	Title	Code	Credits-3			Theory Paper
			L	T	P	
Departmental Core-DC	Organic Process Technology	3170312	3	0	0	Max.Marks-50 Duration-2hrs.

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.

Course Articulation Matrix

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

1 - Slightly; 2 - Moderately; 3 – Substantially

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.

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3170313: Chemical Engineering Thermodynamics

Category	Title	Code	Credit-3			Theory Paper
			L	T	P	
Departmental Core-DC	Chemical Engineering Thermodynamics	3170313	3	0	0	Max.Marks-50 Duration-2hrs.

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.

Course Articulation Matrix

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

1 - Slightly; 2 - Moderately; 3 – Substantially

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

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3170314: HEAT TRANSFER

Category	Title	Code	Credits-4			Theory Paper
Departmental Core-DC	Heat Transfer	3170314	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.

Course Articulation Matrix

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

1 - Slightly; 2 - Moderately; 3 – Substantially

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.

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ITEM-15

List of Experiments and Skill Based Projects

B.Tech III Semester (for batch admitted in 2023-2024)

3170311: FLUID MECHANICS

List of Experiments:

1. To determine the local point pressure with the help of 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-NRe 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.

Course Articulation Matrix

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

CO4		**3**		**3**									**2**
CO5		**3**	**3**	**3**									**2**
CO6	**3**	**3**	**2**	**3**									**2**

1 - Slightly; 2 - Moderately; 3 – Substantially

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3170311: FLUID MECHANICS

Skill Based Mini Project

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

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3170314: 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 Stephan Boltzman 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: Analyzethe modes of heat transfer conduction, convection and radiation

CO2: Apply 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: Demonstrate the thermal conduction in metal rod

CO6: Infer the application of heat exchanging equipment in chemical process industries.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3		2			3		2	2	2			
CO2	3	2		2			3	2	2	2	2		3	

CO3	**3**	**3**												
CO4	**3**	**3**		**2**			**2**	**3**	**2**	**2**	**2**		**3**	
CO5	**3**			**2**				**2**	**3**	**3**	**2**		**3**	
CO6	**3**			**2**				**2**	**3**	**3**	**2**		**3**	

1 - Slightly; 2 - Moderately; 3 – Substantially

MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR

(Deemed to be University)

NAAC Accredited with A++ Grade

3170314: HEAT TRANSFER

Skill Based Mini Project

1. Based on the general operation happening near you, differentiate between variousmodes 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/rods.

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 fluids.

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

MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR

(Deemed to be University)

NAAC Accredited with A++ Grade

3170315: CHEMICAL SYNTHESIS LAB

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, provide you with an opportunity to improve your technical writing.

List of Experiments:

1. To determine BOD & COD for 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 waste water

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.

Course Articulation Matrix

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

1 - Slightly; 2 - Moderately; 3 – Substantially

MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR

(Deemed to be University)

NAAC Accredited with A++ Grade

3170315: CHEMICAL SYNTHESIS LAB

Skill Based Mini Project

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

3170411: INSTRUMENTATION AND PROCESS CONTROL

Category	Title	Code	Credits-4			Theory Paper
			L	T	P	
Departmental Core-DC	Instrumentation& Process Control	3170411	3	-	-	Max.Marks-50 Duration-2hrs.

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 equipment's 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.

CourseArticulationMatrix

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

1-Slightly; 2-Moderately; 3 – Substantially

Text Books:

1. Process system Analysis and Control ByCoughnower and Koppel (Mc- Graw Hill, NewYork)

Reference Books

Automatic Process Control by D. P. Eckman (Mc-Graw Hill, New York)

Process Control by Peter Harriot (Mc- Graw Hill, New York)

Control System Engineering by J. J. Nagrath and M. Gop

3170412: MASS TRANSFER–I

Category	Title	Code	Credits-4			Theory Paper
			L	T	P	
Departmental Core-DC	Mass Transfer– I	3170412	2	1	2	Max.Marks-50 Duration-2hrs.

Course Objective: The purpose of this course is to introduce the undergraduate students with the 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.

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

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.

CourseArticulationMatrix

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

1-Slightly; 2-Moderately; 3 – Substantially

Text Books

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

Reference Books

1. Mc- Cabe, W.L, Smith J.M. - Unit Operation in Chemical Engineering 5thedition TataMc Graw Hill, New Delhi.
2. Coulson J.M. & Richardson J.F. – Chemical Engineering–Vol.2, 2nd Edition, 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 report

3170413: MECHANICAL DESIGN OF PROCESS EQUIPMENT

Category	Title	Code	Credits-4			Theory Paper
Departmental Core-DC	Mechanical Design of Process Equipment	3170413	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.

CourseArticulationMatrix

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

1-Slightly; 2-Moderately; 3 – Substantially

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

3170414: Inorganic Process Technology

Category	Title	Code	Credit-2			Theory Paper
Departmental Core-DC	Inorganic Process Technology	3170414	L	T	P	Max.Marks-50 Duration-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.

Unit II Acids: Sulphur and Sulphuric acid: Mining of sulphur and manufacture of sulphuric acid, 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.

CourseArticulationMatrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3		2	2				2				
CO2	2	2	3		2	2				2				

CO3	2	3	3		2	2				2				
CO4	2	3	3		2	2				2				
CO5	2	3	3		2	2				2				
CO6	3	2	3		2	2				2				

1-Slightly; 2-Moderately; 3 – Substantially

TextBooks:

1. G.T. Austin, N. Shreves, "Chemical Process Industries", 5th Edition, Mc Graw Hill, NewYork, 1984.
2. W.V. Mark, S.C. Bhatia, "Chemical Process Industries volume I and II", 2nd Edition 2007.

References:

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

170412 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 (3170412)

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 (3170415)

1.Design and study of Characteristics of various type of control valves
2.Design and study of characteristics 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