VEER MADHO SINGH BHANDARI UTTARAKHAND TECHNICALUNIVERSITY
(Formerly Uttarakhand Technical University, Dehradun Established by Uttarakhand State Govt. wide Act no. 415 of 2005)
Suddhowala, PO-Chandanwadi, Premnagar, Dehradun, Uttarakhand (Website- www.uktech.ac.in)

SYLLABUS

For

B.TECH

(Chemical Engineering)

2ND Year

Effective From – Session 2023-24

B.Tech. Model Curriculum Structure

SEMESTER-III

S.N.	Subject Codes	Category	Subject	Periods			Evaluation Scheme					Subject Total	Credit
							Sessional Exam			ESE			
				L	T	P	CT	TA	Total	TE	PE		
1	MET 007	BSC	Strength of Material	3	1	0	30	20	50	100		150	4
2	AHT-007 / AHT - 008	HSC	Technical Communication/ Universal Human Values	2 / 3	1 / 0	0 / 0	30	20	50	100		150	3
3	CHT 001	DC	Material and Energy Balance	3	1	0	30	20	50	100		150	4
4	CHT 002	DC	Chemical Engineering Fluid Mechanics	3	1	0	30	20	50	100		150	4
5	CHT 003	DC	Heat Transfer Operations	3	1	0	30	20	50	100		150	4
6	CHP 001	DLC	Chemical Engineering Fluid Mechanics Lab	0	0	2		25	25		25	50	1
7	CHP 002	DLC	Heat Transfer Operations Lab	0	0	2		25	25		25	50	1
8	CHP 003	DLC	Soft Computing Lab	1	0	2		25	25		25	50	1
9	CHP 004	DLC	Mini Project-I or Internship-I*	0	0	2			50			50	1
10	CST006/ CST005	MC	Cyber Security/Python Programming	2	0	0	15	10	25	50			
11	GP03	NC	General proficiency						50				
			Total									**950**	**23**
12			Minor course (Optional)	3	1	0	30	20	50	100			

*The Mini Project-I or Internship-I (3-4 weeks) conducted during summer break after II semester and will be assessed during III semester

MOOCs Course

SEMESTER-IV													
S.N.	**Subject Codes**	**Category**	**Subject**	**Periods**			**Evaluation Scheme**					**Subject Total**	**Credit**
							Sessional Exam			**ESE**			
				L	**T**	**P**	**CT**	**TA**	**Total**	**TE**	**PE**		
1	AHT-008 AHT - 007	HSC	Universal Human Values /Technical Communication	3 2	0 1	0 0	30	20	50	100		150	3
2	AHT - 006	BSC	Advanced Applied Mathematics	3	1	0	30	20	50	100		150	4
3	CHT 004	DC	Mass Transfer Operation-I	3	1	0	30	20	50	100		150	4
4	CHT 005	DC	Mechanical Operations	3	1	0	30	20	50	100		150	4
5	CHT 006	DC	Chemical Engineering Thermodynamics	3	1	0	30	20	50	100		150	4
6	CHP 005	DLC	Mechanical Operations Lab	0	0	2		25	25		25	50	1
7	CHP 006	DLC	Mass Transfer Operations Lab I	0	0	2		25	25		25	50	1
8	CHP 007	DLC	Numerical Methods of Analysis Lab	0	0	2		25	25		25	50	1
9	CST005 /CST006	MC	Python Programming/Cyber Security	2	0	0	15	10	25	50			
10	GP04	NC	General proficiency						50				
			Total									**900**	**22**
11			Minor course (Optional)	3	1	0	30	20	50	100			**4**
		DLC	Mini Project-II / Internship- II	To be completed at the end of fourth semester (during Summer Break) & its evaluation/credit to be added in Fifth semester.									
MOOCs Course													

SEMESTER-III
Syllabus
Material and Energy Balance (CHT 001)

L:3 T:1 P:0 **CREDITS:4**

COURSE OBJECTIVES

To provide basic calculation knowledge of principles of material and energy balances for analyzing and apply for designing chemical processing equipment and systems.

COURSE OUTCOMES

After successful completion of the course the students will be able to:

1. Apply steady-state and unsteady state material and energy balance on a system.
2. Ability to implement material and energy balance for system with or without chemical reactions.
3. Analyze and apply all the stoichiometric and balances being applied on a system undergoing chemical process.
4. Estimation and design equipment with inlet and outlet; including recycle-bypass and purging streams for a chemical process.
5. Able to formulation and interpretation of material and energy balances on various chemical process schemes.

COURSE DETAILS

UNIT-I **(8 hours)**

Introduction and Material Balance: Units and dimension in chemical engineering, unit conversion of dimensional equations, stoichiometric and composition relations, concept of degrees of freedom and linear independence of a set of equations. Concept of material balance, open and closed systems, steady state and unsteady state, multiple component system, selection of a basis, problem solving strategy.

UNIT – II **(8 hours)**

Material Balance with and without Chemical Reaction: Conservation of mass/atom, material balance for Systems without chemical reactions involving single unit and multiple units.Concept of excess reactant, extent of reaction, Material balance for systems with chemical reactions involving single unit and multiple units.

UNIT – III **(8 hours)**

Recycle, Bypass, and Purge their Industrial Applications: Calculations for a cyclic processes involving recycle / purge / bypass, material balances involving gases, vapours, liquids and solids and use of real gas relationships, material balance involving gases, vapours, liquids and solids and uses of real gas relationships, vapor-liquid equilibrium and concepts of humidity and saturation, analysis of systems with bypass, recycle and purge, analysis of processes.

UNIT – IV **(8 hours)**

Energy Balance application: Conservation of energy with reference to general energy balance with and without chemical reactions, chemical engineering problems involving reversible processes and mechanical energy balance. Calculations of heat of change of phase (solid – liquid and liquid – vapour), heat of reaction, heat of combustion, heat of solutions and mixing, determination of temperatures for adiabatic and non-adiabatic reactions, use of psychometric and enthalpy-concentration diagrams.

UNIT – V **(8 hours)**

Simultaneous Material and Energy Balances: Degrees of freedom analysis for multicomponent systems, combined steady state material and energy balances for units with multiple sub-systems. Excel based problem solutions

Text Books

1. Bhatt B.I. and Vora S.M., Stoichiometry, 5th Ed., Tata McGraw-Hill
2. Narayanan K.V. and Lakshmikutty B., Stoichiometry and Process Calculations, Prentice Hall of India.

Reference Books

1. Himmelblau D.M. and Riggs J. B.,Principles and Calculations in Chemical Engineering, 8th Ed., Prentice Hall of India.
2. Felder R.M. and Rousseau R.W., Elementary Principles of Chemical Processes, 3rd Ed., John Wiley.
3. Hougen D.A., Watson K.M. and Ragatz R.A., Chemical Process Principles, Part-I, 2nd Ed., CBS Publishers.

Chemical Engineering Fluid Mechanics (CHT 002)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVES

To present the fundamental insights of fluids and their static and dynamic behaviours and fluid machineries correlations, etc.

COURSE OUTCOME

On completion of this course, the students will be able to...

1. Identify the various basic fluid properties and different flow regimes of fluids and express in basic terms related to fluid flow phenomena.
2. Formulate and establish the basic equations of fluid flow, integral equation of flow, momentum equation under steady state and unsteady sate condition, Bernoulli's equation and Navier-Stokes etc.
3. Understand and apply dimensionless analysis and its signification in chemical Engineering Problems.
4. Describe effects of roughness, restriction, head loss, friction of flow, etc. on incompressible fluid.
5. Select and evaluate the performance of various fluid transport and metering devices like mixers, agitated vessels, pumps, compressors, orificemeter, venturimeter, rotameter, and pitot tube, etc.

COURSE DETAILS

UNIT-I **(8 hours)**

Introduction and fluid statics: Fundamental concepts of fluids; Fluid statics, kinematics and dynamics; Properties of fluids. The basic equation of fluid statics; Pressure – depth relationship; Pressure forces on plane and curved surfaces; Buoyancy and stability; Forces on immersed and submerged bodies; Pressure measurements; Pressure in accelerated rigid body motions.

UNIT – II **(8 hours)**

Elementary Fluid Kinematics and analysis of flow: Lagrangian and Eulerian descriptions; Flow visualization – streamline, path-line, streakline and timeline, profile plots; Description and classification of fluid motions; Rotational, irrotational, inviscid and potential flows; Deformation of fluids; System and control volume representation; Reynolds transport theorem. Conservation of mass, linear and angular momentum, and energy; Eulers equation of motion, Bernoulli theorem; Navier-Stokes equations.

UNIT – III **(8 hours)**

Dimensional Analysis, Similitude and Modelling: Dimensional homogeneity and analysis; Methods of finding dimensionless numbers; Selection of variables, Rayleigh and Buckingham's π method; Common dimensionless numbers and their physical significance; Model and Prototypes; Complete and incomplete similarity.

UNIT – IV **(8 hours)**

Internal Incompressible Viscous Flow: General characteristics of pipe flow – laminar, turbulent, entrance region, fully developed; Fully developed laminar/turbulent flow in pipe – shear stress distribution and velocity profiles; Energy correction factors; Energy and hydraulic grade lines; Major and minor losses in pipes, fittings, pipe network; Friction factor.

UNIT – V **(8 hours)**

Flow Measurements and Fluid Handling Machinery: Flow rate and velocity measurements – Pitot tube, orifice meter, venturimeter, rotameter, notches and weirs. Positive displacement pumps and compressors, centrifugal pumps and compressors, Axial flow pumps and compressors, compressor efficiency. Characteristics of centrifugal pumps; NPSH; Selection of pumps. Simulation of Fluid Flow

Text Books

1. Modi P.N. and Seth S.M., Hydraulics and Fluid Mechanics including Hydraulics Machines, Standard Book House, New Delhi.
2. Balachandran P., Engineering Fluid Mechanics, PHI Learning Pvt Ltd., New Delhi

Reference Books

1. Nevers N.D., Fluid Mechanics for Chemical Engineers, 3rd Ed., McGraw Hill Higher Education.
2. Cengel Y.A. and Cimbala J.M., Fluid Mechanics: Fundamentals and Applications, 2nd Ed., McGraw-Hill
3. White F.M., Fluid Mechanics, 7th Ed., Tata McGraw-Hill

Heat Transfer Operations (CHT 003)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVES

This course will provide extensive knowledge on heat transfer by conduction, convection and radiation and their applications. Course helps to design and categorize heat exchangers, condensers and boilers. It also gives a brief idea of Condensation and Heat exchangers their types;it also includes heat transfer application in fluidized bed and combustion calculation.

COURSE OUTCOMES

After the successful completion of the course student should be able to...

1. Identified heat transfer by conduction in steady and unsteady condition. Apply Fourier's law of heat conduction in various geometries and its applications.
2. Classified free and force convection with the help of dimensionless numbers. Derive analogy for laminar and turbulent flow.
3. Apply principles of heat and mass transfer to predict transfer coefficients
4. Application of radiation heat transfer and its governing laws. Define shape factor and solve problem related with it.
5. Classified and design heat exchangers, condensers, boilers and evaporators.

COURSE DETAILS

UNIT-I **(8 hours)**

Heat transfer by conduction: One-dimensional Heat Conduction equation, Boundary conditions; One dimensional steady state heat conduction for slab, cylinder, sphere, composite medium, Thermal conduct resistance, critical thickness of insulation, Fourier law, Finned surfaces, temperature dependent K (T), Transient conduction and use of temperature charts. Lumped system analysis for slabs and long cylinder and spheres.

UNIT – II **(8 hours)**

Heat Transfer by convection: Flow over a body, flow inside a duct. Forced Convection: Hydrodynamic and thermal boundary layer, simultaneously developing laminar flow, turbulent flow inside ducts, Heat transfer to liquid metals. Free Convection: Dimensionless parameters of Free Convection, Correlations of free convection on a vertical plate, Free Convection on a horizontal plate.

UNIT – III **(8 hours)**

Boiling and Condensation: Boiling: Boiling of liquids. Nucleate and film boiling.Nusselt equation for horizontal and vertical condenser, Drop and film type condensation, Effect of non-condensable gases.

UNIT – IV **(8 hours)**

Heat Transfer by Radiation: Concept of black body, Kirchoff's Law Emissivity, absorptivity, black body and grey body radiation. View factors.

UNIT – V **(8 hours)**

Heat Exchangers and Evaporation: Classification, temperature distribution in heat exchangers, Overall heat transfer co-efficient, the LMTD method for heat exchanger analysis, correction for LMTD for use with cross flow and multipass exchanger. Double pipe heat exchangers, 1-2 shell and tube exchangers, Finned tube exchangers, fouling factor. Classification and application, evaporator feeding mechanism, operation of single effect evaporators. Solving heat transfer problem in MS Excel

Text Books

1. Dutta B.K., Heat transfer - Principles and applications, Prentice Hall India

2. Holman J.P., Bhattacharya S., Heat Transfer, McGraw Hill Education Pvt. Ltd

Reference Books

1. Kern, D.Q., Process Heat Transfer, 1st Edition, Tata McGraw Hill Education Private Ltd.
2. Cengel Y.A. and Ghajar A.J., Heat and Mass Transfer: Fundamentals and Applications, 4th Ed., McGraw Hill
3. McCabe W.L, Smith J.C, and Harriot P, Unit Operations in Chemical Engineering, 7th Edition, McGraw-Hill, Inc.

Chemical Engineering Fluid Mechanics Lab (CHP 001)

L:0 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVES

To determine the various parameters related to fluid flow in pipes and in open channels.

LAB OUTCOMES

On completion of the experiments, the students will be able to

1. Calculate coefficient of discharge through v-notch, venturimeter, and orificemeter.
2. Determine friction losses through different pipes and fittings.
3. Calculate the efficiency of centrifugal pump.
4. Study different types of flow and analyse Bernoulli's law.

LIST OF EXPERIMENTS

1. To find the flow rate using a V notch
2. To find the friction losses in a Straight pipe and in a Bend pipe.
3. Study of Pipe fittings and Valves
4. To study the working principle of a centrifugal pump and determine its efficiency experimentally.
5. To determine the pressure drop in a packed bed.
6. Determination of discharge coefficient with Reynolds Number in case of an orifice meter and a venturimeter.
7. Study and verification of the flow pattern in a Bernoulli's apparatus
8. To determine the minimum fluidization velocity in a fluidized bed.
9. Determination of the fluidization index, segregation index in a fluidized bed
10. Determine the Reynolds number and study different types of flow.

Heat Transfer Operations Lab (CHP 002)

L:0 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVES

To determine the amount of heat exchange in various modes of heat transfer including condensation & boiling for several geometries.

LAB OUTCOMES

On completion of this course, the students will be able to

1. Determine the thermal conductivity of different materials.
2. Calculate the rate of heat transfer through different types of heat exchangers in different flow patterns.
3. Study the natural convection phenomena and temperature distribution in various setups (like composite wall, lagged pipe etc.).

LIST OF EXPERIMENTS (Perform any 10)

1. To find out the thermal conductivity of liquids.
2. To find out the thermal conductivity of a metal rod.
3. Find out the Heat Transfer Coefficient during drop wise and film wise condensation.
4. Find out the Heat Transfer Coefficient in a vertical and a horizontal condenser.
5. To find out the emissivity of a surface.
6. To find out the overall thermal conductance and plot the temperature distribution in case of a composite wall.
7. To find out the average heat transfer co-efficient of vertical cylinder in natural convection.
8. To find out the Stefan Boltzmann's constant and compare with the theoretical value.
9. To find out the relation between insulation thickness and heat loss.
10. To find out the overall heat transfer co-efficient of a double pipe heat exchanger.
11. To find out the overall heat transfer co-efficient of 1-2 shell & tube heat exchanger.
12. Study heat transfer through logged pipe.

Soft computing Lab (CHP 003)

L:1 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVES
To use different software for solving basic problems of engineering.

LAB OUTCOME
On completion of this course, the students will be able to
1. Understand the importance of software.
2. Solve basic chemical engineering problems using MS-EXCEL and MATLAB.

LIST OF EXPERIMENTS

Experiment using MS-EXCEL and MATLAB.

1. To apply material balance on any chemical engineering unit operation.
2. To apply energy balance on any chemical engineering unit operation.
3. To work on heat transfer problems.
4. To work on a exchanger or evaporator designing using kern's method.
5. To find out effect on conversion and time of operation in a batch reactor.
6. To solve material and energy balance in a simple distillation column.

Mini project-I or Internship-I (CHP 004)

L:0 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVES

- To inculcate research attitude amongststudents.
- To develop presentationskills.

LAB OUTCOME

On completion of this course, the students will be able to:

- Understand and workout the projectproblem.
- Gain experience to make a projectreport.
- Acquire the necessary confidence to carry out main project in the finalyear.

SEMESTER-IV

MASS TRANSFER OPERATIONS – I (CHT 004)

L:3 T:1 P:0 **CREDITS: 4**

OBJECTIVES

To teach the fundamental concepts of mass transfer operations and principles, and apply those concepts to chemical engineering problems. The goal is to provide students with the theoreticalandanalytical background to understandexisting mass transfer operations in chemical industries.

COURSE OUTCOMES

After successful completion of the course the students will be able to:

1. Discuss the basic principles of Mass transfer and diffusion, and understand its laws and theories.
2. Able to apply mass transfer and separation principles in several unit operations including absorption.
3. Understand humidification and dehumidification, analyse and solve mass transfer problems
4. Understand drying operation and apply equilibrium relationship.
5. Understand crystallization operation and apply equilibrium relationship

COURSE DETAILS

UNIT-I **(8 hours)**

Diffusion: Molecular and turbulent diffusion, diffusion coefficient, Fick's Law of diffusion, Dependence of diffusion coefficient on temperature, pressure and composition; measurement and estimation of diffusivity. Diffusion in multi-component gas mixtures.Diffusion in Solids: Molecular, Knudsen and surface diffusion. Interphase mass transfer: Mass transfer coefficients, Diffusion between phases, Equilibrium solubility of gases in liquids, Mass transfer theories, Mass transfer in fluidized beds, Flow past solids and boundary layers.

UNIT – II **(8 hours)**

Absorption and Stripping: Equipments, Gas-liquid equilibria, Henry's law, Selection of solvent, Absorption in tray column, Graphical and analytical methods, Absorption in packed columns, HTU, NTU and HETP concepts, Design equations for packed column, Absorption with chemical reaction and mass transfer.

UNIT – III **(8 hours)**

Humidification and Dehumidification: Vapour liquid equilibrium and enthalpy for a pure substance, vapour pressure temperature curve, Vapour gas mixtures, Definition and derivations of relationships related with humidity.

Fundamental concept of humidification, Dehumidification and water cooling, Wet bulb temperature, Adiabatic and non-adiabatic operations, Evaporative cooling, Classification and design of cooling towers.

UNIT – IV **(8 hours)**

Drying: Solid-gas equilibria, Different modes of drying operations, Definitions of moisture contents, Types of batch and continuous dryers, Rate of batch drying, Time of drying, Mechanism of batch drying, Continuous drying, Design of continuous dryers.

UNIT – V **(8 hours)**

Crystallisation: Equilibrium yield of crystallization, Heat and mass transfer rates in crystallization, Theories of crystallization, Factors governing nucleation andcrystal growth rates, Controlled growth of crystal, Classification, and design of crystallizers. MATLAB basics for mass transfer solutions.

Text Book

1. Treybal, R "*Mass Transfer Operations*", 3rd Ed., McGraw-Hill New York, 1980.

Reference

1. Sherwood T. K., Pigford R. L. and _ilke P. "*Mass Transfer*" McGraw Hill, 1975.
2 Foust A. S. et.al., "*Principles of Unit Operations*" John Wiley, 1980.
3 Geankoplis, C.J.."*Transport Processes and Unit Operations*", 3rd Ed. Prentice Hall. 1993.

Reference link

1. NPTEL video lectures

Mechanical Operations (CHT 005)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVE

To impart Knowledge on particle size analysis, size reduction, their storage and transport, separation of solid particles from fluids and flow through porous media along with behaviour of solid particles in fluidized state.

COURSE OUTCOME

On completion of this course, the students will be able to

1. Measure the particle size.
2. Estimate the crushing efficiency of different type's crushers.
3. Explain the process involved and results obtained by filtration.
4. Explain the methods for storage and handling of solids.
5. Design the methods involved in transport of solid in any industrial process.

COURSE DETAILS:

UNIT-I **(8 hours)**

Particle characterization: General characteristics of solids; Different techniques of size analysis; Shape factor; Surface area determination; Estimation of particle size; Screening methods and equipment; Screen efficiency.

UNIT – II **(8 hours)**

Size Reduction: Methods of size reduction; Classification of equipment's; Crushers; Grinders, Intermediate and fine grinding; Laws of size reduction; Energy relationships in size reduction; power requirement; Work index

UNIT – III **(8 hours)**

Particle Separation: Gravity settling; Sedimentation; Elutriation; Centrifugal separation; Cyclones; Hydro cyclones; Electrostatic - Magnetic separators; Floatation

UNIT – IV **(8 hours)**

Storage and conveying of solids: Silos; Bins; Hoppers; Transportation of solids in bulk; Types of conveyers; Belt Conveyor; Bucket conveyor; Screw conveyor; Pneumatic conveyor. Mixing and agitation: Agitated vessels; Blending and mixing; Suspension of solid particles; Dispersion operations; Agitator selection and scale up.

UNIT – V **(8 hours)**

Filtration, Filtration equipment's; Filter aids. Flow through filter cake and Filter media and pressure drop. Fluidization characteristics, aggregative and particulate fluidization, minimum fluidization velocity, terminal velocity of particles; pressure drop in fluidization.

Text Books

1. Backhurst, J.R. and Harker J.H. Coulson and Richardson Chemical Engineering", Vol. II", 5Ed., Butterworth- Heinemann.
2. Narayanan C.M. & Bhattacharya B.C., "Mechanical Operation for Chemical Engineers – Incorporating Computer Aided Analysis", Khanna Publishers.

REFERENCE BOOKS

1. McCabe W. L., Smith J.C, Harriott P., "Unit Operations of Chemical Engineering", 7 Ed., McGraw Hill.

Reference link

1. NPTEL video lectures

Chemical Engineering Thermodynamics(CHT 006)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVES

To enable undergraduate students to learn basic concepts of thermodynamics and their application in solving problems related to flow processes and phase equilibrium of heterogeneous and reacting systems.

COURSE OUTCOMES

On completion of this course, the students will be able to

1. Explain various forms of energy related transformation as unit operation or unit process in chemical process industries.
2. Study about different terminology used in Chemical Engineering Thermodynamics.
3. Identify and relate the thermodynamic property of the pure substance and mixture.
4. Explain the phase equilibrium, equilibrium conversion for homogeneous and chemical reaction systems.
5. Know the basic principles of refrigeration and liquefaction process.

COURSE DETAILS:

UNIT-I **(8 hours)**

Introduction: Thermodynamic Laws and Property Relations: Laws of thermodynamics and their applications; PVT behaviour of pure substances; PVT behaviour of mixtures; Generalized equations of state;Joule's experiment; Carnot cycle and Carnot theorems; Thermodynamic property relations; Maxwell relations; Partial derivatives and Jacobian method; Residual properties; Partial molar properties; Excess properties of mixtures; Thermodynamic property tables and diagrams.

UNIT – II **(8 hours)**

Properties of Solutions and Phase Equilibria: Criteria for equilibrium between phases in multi component non-reacting systems in terms of chemical potential and fugacity; Application of phase rule; Vapour-liquid equilibrium; Phase diagrams for homogeneous systems and for systems with a miscibility gap; Effect of temperature and pressure on azeotrope composition; Liquid-liquid equilibrium; Ternary liquid-liquid equilibrium.

UNIT – III **(8 hours)**

Correlation and Prediction of Phase Equilibria: Activity coefficient; Composition models; thermodynamic consistency of phase equilibria; Application of the correlation and prediction of phase equilibria in systems of engineering interest particularly to distillation and liquid extraction processes.

UNIT – IV **(8 hours)**

Chemical Reaction Equilibria: Definition of standard state; standard free energy change and reaction equilibrium constant; evaluation of reaction equilibrium constant; prediction of free energy data; equilibria in chemical reactors, calculation of equilibrium compositions for homogeneous chemical reactors; thermodynamic analysis of simultaneous reactions.

UNIT – V **(8 hours)**

Refrigeration: Refrigeration: Principles of refrigeration; methods of producing refrigeration; liquefaction process; coefficient of performance; evaluation of the performance of vapour compression and gas refrigeration cycles.

Text Books

1. Narayanan K.V, Text Book of Chemical Engineering Thermodynamics, PHI Learning Pvt. Ltd-New Delhi.
2. Smith, J.M., VanNess, H.C., & Abbot M.C, Introduction to Chemical Engineering Thermodynamics, 7th Edition, Tata Mcgraw Hill Education Private Limited.
3. Rao Y.V.C., Chemical Engineering Thermodynamics,

Reference Books

1. Hougen, O.A., Watson, K.M., and Ragatz, R.A., Chemical Process Principles Part II", Thermodynamics, John Wiley.
2. Dodge, B.F., Chemical Engineering Thermodynamics, 1st Edition, 6th im edition McGraw-Hill,.
3. Sandler, S.I., Chemical,Biochemical and Engineering Thermodynamics, 4th Edition, Wiley.

Reference link

1. NPTEL video lectures

Mechanical Operations Lab (CHP 005)

L:0 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVES

To be familiar with process equipment and develop engineering decision making capability.

LAB OUTCOME

On completion of this course, the students will be able to

1. Measure the particles size.
2. Estimate the crushing efficiency of different types of crushers.
3. Calculate medium and filter medium resistance of different types of filters.
4. Estimate the pressure drop in packed and fluidized bed
5. Estimate the efficiency of gas solid separator

LIST OF EXPERIMENTS

1. Determination of average particle size of a mixture of particles by screening.
2. Study the operation of Jaw crusher and thereby verify Rittinger's constant.
3. Determination of reduction ratio, maximum feed size and theoretical capacity of crushing rolls.
4. Study the operation of a cyclone separator and thereby finding its efficiency of separation.
5. To find the cake and filter medium resistance of Plate and Frame Filter press.
6. To find the filter medium resistance of a Vacuum Leaf Filter.
7. To find the cake and filter medium resistance of a Rotary drum Filter.
8. To find minimum fluidization velocity of solid in liquid medium.

Mass Transfer Operation Lab I (CHP 006)

L:0 T:0 P:2 **CREDITS: 1**

Course Objective:

This lab gives an overall idea of various mass transfer operations used in the industry.

Lab Outcomes:

Students completing the course will be able to

1. Experimentally verify various theoretical principles
2. Develop confidence in handling mass transfer equipment's in chemical process industries.
3. Develop experimental skills
4. Work in team and develop interpersonal skills
5. Develop skills for technical writing

List of experiments (any 10)

1. Determination of diffusivity of acetone in air.
2. Determination of mass transfer coefficient in an agitated vessel.
3. Determination of mass transfer coefficient for steady state surface evaporation of water at different temperature.
4. Determination of mass transfer coefficient in a wetted wall column.
5. Determination of T-x-y diagram for a binary batch distillation.
6. Verification of Rayleigh equation in a binary batch distillation process.
7. Verification of steam distillation equations.
8. Determination of ternary curve for the system acetic acid-water-carbon tetrachloride.
9. Determination of distribution coefficient of a solute in two immiscible liquids.
10. Solid-Liquid extraction – Soxhlet‟s experiment.
11. Liquid - liquid extraction in packed bed.
12. Determination of adsorption kinetics and isotherm at solid-liquid interface.
13. Determination of the rate of drying in a tray dryer.
14. Estimation of efficiency of the fluidized bed dryer

Numerical Methods of Analysis Lab (CHP007)

L:0 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVES

To teach the student various numerical methods toanalysis the problems of linear, nonlinear and ODE equations, interpolation and approximation, numerical differentiation and integration etc.

LAB OUTCOME

On completion of this lab, the students will be able to

1. Compare the different computational methods for calculations,
2. Implement the computational methods using any of existing programming languages, test such methods and compare between them,
3. Identify the suitable computational technique for a specific type of problems

LIST OF EXPERIMENTS

Use of following Techniques in C/C++ Language or MATLAB software

1. Solution of single non-linear algebraic equations by Newton Raphson method.
2. Solution of single non-linear equations by Regulafalsi method.
3. Solution of system of linear simultaneous by Gauss Elimination method.
4. Solution of system of linear simultaneous equation by gauss seidel method and successive over relaxation method.
5. Solution of single first order ordinary differential equations by fourth order Runge-Kuttamethod.
6. Solution of Heat equations (Parabolic equations) by finite difference method.
7. Solution of Laplace equations (elliptic equation) by finite difference method.
8. Solution of wave equations (Hyperbolic equation) by finite difference method.
9. Finding Newton’s interpolatory polynomial for n points.
10. Finding Newton’s interpolatory polynomial based on finite difference table for n points.Simpson’s 3/8-rule.9.

Advanced Applied Mathematics (AHT-006)

L:T:P:: 3:1:0 **Credits-4**

Course Objectives:

The students will learn:
1. The idea of Laplace transform of functions and their applications.
2. The idea of Fourier transform of functions and their applications.
3.To evaluate roots of algebraic and transcendental equations.
4. Interpolation, numerical differentiation& integration and the solution of differential equations.
5.Acquaintance with statistical analysis and techniques.

Course Outcome(s):

At the end of this course, the students will be able to:
1. Remember the concept of Laplace transform and apply in solving real life problems.
2. Apply the concept of Fourier transform to evaluate engineering problems.
3. Understand to evaluate roots of algebraic and transcendental equations.
4. Solve the problem related interpolation, differentiation, integration and the solution of differential equations.
5. Understand the concept of correlation, regression, moments, skewness and kurtosis and curve fitting.

Course Contents:

Module 1: Laplace Transform: **(8 hours)**

Definition of Laplace transform, Existence theorem, Laplace transforms of derivatives and integrals, Initial and final value theorems, Unit step function, Dirac- delta function, Laplace transform of periodic function, Inverse Laplace transform, Convolution theorem, Application to solve linear differential equations.

Module 2: Fourier Transforms:
(8 hours)

Fourier integral, Fourier sine and cosine integral, Complex form of Fourier integral, Fourier transform,Inverse Fouriertransforms, Convolution theorem, Fourier sine and cosine transform, Applications of Fourier transform to simple one dimensional heat transfer equations.

Module 3: Solution of Algebraic & Transcendental equations and Interpolation:
(8 hours)

Number and their accuracy, Solution of algebraic and transcendental equations: Bisection method, Iteration method, Newton-Raphson method and Regula-Falsi method. Rate of convergence of these

methods (without proof), Interpolation: Finite differences, Relation between operators, Interpolation using Newton's forward and backward difference formula, Interpolation with unequal intervals: Newton's divided difference and Lagrange's formula.

Module 4: Numerical differentiation & Integration and Solution of ODE: (8 hours)

Numerical Differentiation, Numerical integration: Trapezoidal rule, Simpson's 1/3rd and 3/8 rule,Runge-Kutta method of fourth order for solving first order linear differential equations, Milne's predicator-corrector method.

Module 5: Statistical Techniques: (8 hours)

Introduction: Measures of central tendency, Moments, Skewness, Kurtosis, Curve fitting: Method of least squares, Fitting of straight lines, Fitting of second degree parabola, Exponential curves. Correlation and rank correlation, Regression analysis: Regression lines of y on x and x on y, Regression coefficients, Properties of regressions coefficients and non-linear regression.

Reference Books:

1. E. Kreyszig: Advanced Engineering Mathematics, John Wiley & Sons,10th ed.
2. B.V. Ramana: Higher Engineering Mathematics,McGrawHill.
3. Peter V.O'Neil: Advanced Engineering Mathematics, Cengage Learning,7th ed.
4. B.S. Grewal: Higher Engineering Mathematics, Khanna Publishers, 44th ed.
5. T.Veerarajan: Engineering Mathematics (for semester III), McGrawHill, 3rd ed.
6. R.K. Jain and S.R.K. Iyenger: Advance Engineering Mathematics,Narosa PublishingHouse,Std. ed.
7. P. Kandasamy, K. Thilagavathy, K. Gunavathi: Numerical Methods, S. Chand.
8. S.S. Sastry: Introductory methods of numerical analysis, Prentice Hall India, 5thed.
9. N.P. Bali and Manish Goyal: Computer Based Numerical and Statistical Techniques,Laxmi Publications, 5th ed.
10. J.N. Kapur: Mathematical Statistics, S. Chand &Company.
11. D.N.Elhance,V. Elhance&B.M. Aggarwal: Fundamentals of Statistics,Kitab Mahal.

Universal Human Values (AHT-008)

L:T:P:: 3:0:0 **Credits-3**

Course objectives:

The objective of the course is four fold:

1. Development of a holistic perspective based on self- exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence.
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

Course Outcomes :

1. Students are expected to become more aware of themselves, and their surroundings (family, society, nature)

2. They would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.

3. They would have better critical ability.

4. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society).

5. It is hoped that they would be able to apply what they have learnt to their own self in different day-to- day settings in real life, at least a beginning would be made in this direction.

COURSE TOPICS: The course has 28 lectures and 14 practice sessions in 5 modules:

Module 1: Introduction - Value Education

Universal human values; self exploration, natural acceptance an experimental validation; Human aspirations, right understanding, relationship and physical facility, current scenario; Understanding and living in harmony at various levels.

Module 2: Harmony in the Human Being

Understanding human being, needs of self(I) and body; body as an instrument of 'I'; characteristics and activities of 'I' and harmony in 'I'; harmony of I with the Body: Sanyam and Health, Physical needs an prosperity; Programs to ensure Sanyam and Health.

Module 3: Harmony in the Family and Society

Values in human-human relationship; nine universal values in relationships; justice, truth, respect, trust; Difference between intention and competence; Respect and differentiation, Harmony in society: resolution, prosperity, fearlessness and coexistence; Universal harmonious order in society.

Module 4: Harmony in the Nature and Existence
Harmony in the nature. Four orders of nature; existence as co-existence, harmony at all levels of existence.

Module 5: Harmony in the Professional Ethics
Natural acceptance of human values, Definitiveness of Ethical Human Conduct; Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order; Competence in professional ethics; Case studies; transition from the present state to Universal Human Order: at individual level and societal level.

READINGS: Text Book

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010

Reference Books

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karam chand Gandhi.
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj - PanditSunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi - Romain Rolland (English)

Technical Communication (AHT-007)

L:T:P:: 2:1:0 **Credits-3**

COURSE OBJECTIVES:

Students should be able to:

1. To produce technical documents that use tools commonly employed by engineering and computer science professionals.
2. To communicate effectively in a professional context, using appropriate rhetorical approaches for technical documents, adhering to required templates, and complying with constraints on document format.
3. To clarify the nuances of phonetics, intonation and pronunciation skills.
4. To get familiarized with English vocabulary and language proficiency.

COURSE OUTCOMES:

1. Students will be enabled to **understand** the nature and objective of Technical Communication relevant for the work place as Engineers.
2. Students will **utilize** the technical writing for the purposes of Technical Communication and its exposure in various dimensions.
3. Students would imbibe inputs by presentation skills to **enhance** confidence in face of diverse audience.
4. Technical communication skills will **create** a vast know-how of the application of the learning to promote their technical competence.
5. It would enable them to **evaluate** their efficacy as fluent & efficient communicators by learning the voice-dynamics.

COURSE CONTENTS:

Unit -1 Fundamentals of Technical Communication:

Technical Communication: Introduction, Features; Distinction between General and Technical Communication; The flow of Communication: Downward; upward, Lateral or Horizontal; Barriers to Communication, Importance of communication

Unit - II Forms of Technical Communication:

Technical Report: Definition & importance; Thesis/Project writing: structure & importance; synopsis writing: Methods; Technical research Paper writing: Methods & style; Seminar & Conference paper writing; 7 Cs of effective business writing: concreteness, completeness, clarity, conciseness, courtesy, correctness, consideration.

Unit - III Technical Presentation: Strategies & Techniques

Presentation: Forms; interpersonal Communication; Class Room presentation; style;method, Public Speaking: method; Techniques: Clarity of substance; emotion; Humour; Modes of Presentation; Overcoming Stage Fear: Confident speaking; Audience Analysis & retention of audience interest; Methods of Presentation: Interpersonal; Impersonal; Audience Participation: Quizzes & Interjections

Unit - IV Technical Communication Skills

Interview skills; Group Discussion: Objective & Method; Seminar/Conferences Presentation skills: Focus; Content; Style; Argumentation skills: Devices: Analysis; Cohesion & Emphasis; Critical thinking; Nuances, exposition, narration and description

Unit - V Kinesics & Voice Dynamics:

Kinesics: Definitions; importance; Features of Body Language; Voice Modulation: Quality, Pitch; Rhythm; intonation, pronunciation, articulation, vowel and consonants sounds

Reference Books

1. Technical Communication – Principles and Practices by Meenakshi Raman & Sangeeta Sharma, Oxford Univ. Press, 2007, New Delhi.
2. Business Correspondence and Report Writing by Prof. R.C. Sharma & Krishna Mohan, Tata McGraw Hill & Co. Ltd., 2001, New Delhi.
3. Practical Communication: Process and Practice by L.U.B. Pandey; A.I.T.B.S. Publications India Ltd.; Krishan Nagar, 2014, Delhi.
4. Modern Technical Writing by Sherman, Theodore A (et.al); Apprentice Hall; New Jersey; U.S.
5. A Text Book of Scientific and Technical Writing by S.D. Sharma; Vikas Publication, Delhi.
6. Skills for Effective Business Communication by Michael Murphy, Harward University, U.S.
7. Business Communication for Managers by Payal Mehra, Pearson Publication, Delhi.

Python Programming (CST-005)

L:T:P:: 2:0:0 **Credits-0**

Course Objectives: The objectives of this course is to:

1. Introduce the basic principles and concepts of python programming, and how python programming concepts are useful in problem-solving.
2. Write clear and effective python code.
3. To perform file operations to read and write data in files.
4. To create applications using Python Programming.

Course Outcomes: On successful completion of the course, the student will be able to:

1. Develop essential programming skills in computer programming concepts like data types.
2. Examine Python syntax and semantics and be fluent in the use of Python flow control and functions.
3. Illustrate the process of structuring the data using lists, tuples, and dictionaries.
4. Demonstrate using built-in functions and operations to navigate the file system.
5. Interpret the concepts of modules and user-defined functions in Python.

Syllabus:

UNIT – I: Introduction and Syntax of Python Program: Features of Python, Interactive, Object-oriented, Interpreted, platform-independent, Python building blocks -Identifiers, Keywords, Indention, Variables, Comments, Python environment setup – Installation and working of IDE, Running Simple Python scripts to display a welcome message, Python variables.

Python Data Types: Numbers, String, Tuples, Lists, Dictionary. Declaration and use of datatypes, Built-in Functions.

UNIT – II: Python Operators and Control Flow statements: Basic Operators: Arithmetic, Comparison/ Relational, Assignment, Logical, Bitwise, Membership, Identity operators, Python Operator Precedence.

Control Flow: Conditional Statements (if, if...else, nested if), Looping in python (while loop, for loop, nested loops), loop manipulation using continue, pass, break, else.

UNIT – III: **Data Structures in Python: String:** Concept, escape characters, String special operations, String formatting operator, Single quotes, Double quotes, Triple quotes, Raw String, Unicode strings, Built-in String methods.

Lists: Defining lists, accessing values in lists, deleting values in lists, updating lists, Basic List Operations, and Built-in List functions.

Tuples: Accessing values in Tuples, deleting values in Tuples, and updating Tuples, Basic Tuple operations, and Built-in Tuple functions.

Sets: Accessing values in Set, deleting values in Set, and updating Sets, Basic Set operations, Built-in Set functions.

Dictionaries: Accessing values in Dictionary, deleting values in Dictionary, and updating Dictionary, Basic Dictionary operations, Built-in Dictionaries functions.

UNIT – IV: Python Functions, modules, and Packages: Use of Python built-in functions (e.g., type/data conversion functions, math functions etc.).

User-defined functions: Function definition, Function call, function arguments and parameter passing, Return statement, **Scope of Variables:** Global variable and Local Variable.

Modules: Writing modules, importing modules, importing objects from modules, Python built-in modules (e.g., Numeric, mathematical module, Functional Programming Module), Packages.

UNIT – V: File Handling: Opening files in different modes, accessing file contents using standard library functions, Reading, and writing files, closing a file, Renaming, and deleting files, File related standard functions.

TEXTBOOKS:

1. Charles R. Severance, “Python for Everybody: Exploring Data Using Python 3”, 1st Edition, CreateSpace Independent Publishing Platform, 2016.
2. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist”, 2nd Edition, Green Tea Press, 2015.

3. ChSatyanarayana, “Python Programming”, 1st Edition, universities press (India) private limited 2018.

REFERENCE BOOKS:

1. Charles Dierbach, "Introduction to Computer Science Using Python", 1st Edition, Wiley India Pvt Ltd. ISBN-13: 978-8126556014
2. Mark Lutz, “Programming Python”, 4th Edition, O’Reilly Media, 2011.ISBN-13: 978-9350232873
3. Wesley J Chun, “Core Python Applications Programming”, 3rd edition, Pearson Education India, 2015. ISBN-13: 978-9332555365
4. Roberto Tamassia, Michael H Goldwasser, Michael T Goodrich, “Data Structures and Algorithms in Python”,1stEdition, Wiley India Pvt Ltd, 2016. ISBN-13: 978- 8126562176
5. ReemaThareja, “Python Programming using problem-solving approach”, Oxford university press, 2017.

Cyber Security (CST-006)

L:T:P:: 2:0:0 **Credits-0**

Course Objectives: The objectives of this course is to:

1. Familiarize with network security, network security threats, security services, and countermeasures.
2. Be aware of computer security and Internet security.
3. Study the defensive techniques against these attacks.
4. To familiarize with cyber forensics, cybercrimes, and Cyberspace laws.
5. Understand ethical laws of computers for different countries, Offences under cyberspace and the Internet in India.

Course Outcomes: On successful completion of the course, the student will be able to:

1. Understand cyber-attacks and types of cybercrimes, and familiarity with cyber forensics
2. Realize the importance of cyber security and various forms of cyber-attacks and countermeasures.
3. Get familiar with obscenity and pornography in cyberspace and understand the violation of the Right to privacy on the Internet.
4. Appraise cyber laws and how to protect themselves and, ultimately, the entire Internet community from such attacks.
5. Elucidate the various chapters of the IT Act 2008 power of the Central and State Governments to make rules under IT Act 2008

Syllabus:

UNIT – I: Introduction to Cyber Security: Basic Cyber Security Concepts, layers of security, Vulnerability, threat, Harmful acts, the motive of attackers, active attacks, passive attacks, Software attacks, hardware attacks, Spectrum of attacks, Taxonomy of various attacks, IP spoofing, Methods of defense, Security Models, risk management, Cyber Threats-Cyber Warfare, Cyber Crime, Cyber terrorism, Cyber Espionage, etc., CIA Triad

UNIT – II: Cyber Forensics: Introduction to cyber forensic, Historical background of Cyber forensics, Digital Forensics Science, The Need for Computer Forensics, Cyber Forensics and Digital evidence, Forensics Analysis of Email, Digital Forensics Lifecycle, Forensics Investigation, Challenges in Computer Forensics, Special Techniques for Forensics Auditing.

UNIT – III: Cybercrime (Mobile and Wireless Devices): Introduction, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication service Security, Attacks on

Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Organizational Security Policies and Measures in Mobile Computing Era, Laptops and desktop.

UNIT – IV: Cyber Security (Organizational Implications): Introduction cost of cybercrimes and IPR issues, web threats for organizations, security and privacy implications, social media marketing: security risks and perils for organizations, social computing, and the associated challenges for organizations.

Cybercrime and Cyber terrorism: Introduction, intellectual property in cyberspace, the ethical dimension of cybercrimes, the psychology, mindset and skills of hackers and other cybercriminals.

UNIT – V: Cyberspace and the Law &Miscellaneous provisions of IT Act.: Introduction to Cyber Security Regulations, International Law. The INDIAN Cyberspace, National Cyber Security Policy. Internet Governance – Challenges and Constraints, Computer Criminals, Assets and Threats. Other offences under the Information Technology Act in India, The role of Electronic Evidence and miscellaneous provisions of the IT Act.2008.

TEXTBOOKS:

1. Nina Godbole and SunitBelpure, Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Wiley.
2. B. B. Gupta, D. P. Agrawal, Haoxiang Wang, Computer and Cyber Security: Principles, Algorithm, Applications, and Perspectives, CRC Press, ISBN 9780815371335, 2018.

REFERENCE BOOKS:

1. Cyber Security Essentials, James Graham, Richard Howard and Ryan Otson, CRC Press.
2. Introduction to Cyber Security, Chwan-Hwa(john) Wu,J. David Irwin, CRC Press T&F Group.
3. Debby Russell and Sr. G.T Gangemi, "Computer Security Basics (Paperback)", 2ndEdition, O' Reilly Media, 2006.
4. Wenbo Mao, "Modern Cryptography – Theory and Practice", Pearson Education, New Delhi, 2006.
5. Cyberspace and Cybersecurity, George Kostopoulos, Auerbach Publications, 2012.
6. Cyber Forensics: A Field Manual for Collecting, Examining, and Preserving Evidence of Computer Crimes, Second Edition, Albert Marcella, Jr., Doug Menendez, Auerbach Publications, 2007.
7. Cyber Laws and IT Protection, Harish Chander, PHI, 2013.

VEER MADHO SINGH BHANDARI UTTARAKHAND TECHNICALUNIVERSITY
(Formerly Uttarakhand Technical University, Dehradun Established by Uttarakhand State Govt. wide Act no. 415 of 2005)
Suddhowala, PO-Chandanwadi, Premnagar, Dehradun, Uttarakhand (Website- www.uktech.ac.in)

SYLLABUS

For

B.TECH

(Chemical Engineering)

3RD Year

Effective From – Session 2024-25

SEMESTER-V													
S.N.	Subject Codes	Category	Subject	Periods			Evaluation Scheme					Subject Total	Credit
							Sessional Exam			ESE			
				L	T	P	CT	TA	Total	TE	PE		
1	CHT 007	DC	Mass Transfer Operation –II	3	1	0	30	20	50	100		150	4
2	CHT 008	DC	Chemical Reaction Engineering -I	3	1	0	30	20	50	100		150	4
3	CHT 009	DC	Process Dynamics and Control	3	0	0	30	20	50	100		150	3
4		DE	Departmental Elective - 1	3	1	0	30	20	50	100		150	4
5		DE	Departmental Elective - 2	3	0	0	30	20	50	100		150	3
6	CHP 008	DLC	Mass Transfer Operation Lab-II	0	0	2		25	25		25	50	1
7	CHP 009	DLC	Chemical Reaction Engineering Lab	0	0	2		25	25		25	50	1
8	CHP 010	DLC	Process Dynamics and Control Lab	0	0	2		25	25		25	50	1
9	CHP 011	DLC	Mini Project-II or Internship-II*	0	0	2			50			50	1
10	AHT009/AHT 010	MC	Constitution of India / Essence of Indian Traditional Knowledge	2	0	0	15	10	25	50			
11	GP05	NC	General proficiency						50				
			Total	**17**	**3**	**8**						**950**	**22**
			Minor Course (Optional)	3	1	0	30	20	50	100			**4**
*The Mini Project-II or Internship-II (4-6 weeks) conducted during summer break after IV semester and will be assessed during V semester													
MOOCs course													

Department Elective-I		Department Elective-II	
CHT 51	Renewable Energy Technology and its challenges	CHT 55	Interfacial Science and Technology
CHT 52	Electrochemical system for Energy application	CHT 56	Process Flow Sheet Simulation
CHT 53	Polymer Science and Engineering	CHT 57	Statistical Methods for Chemical Engineers
CHT 54	Optimization Techniques	CHT 58	Materials Science and Engineering

SEMESTER-VI													
S.N.	**Subject Codes**	**Category**	**Subject**	**Periods**			**Evaluation Scheme**					**Subject Total**	**Credit**
							Sessional Exam			**ESE**			
				L	**T**	**P**	**CT**	**TA**	**Total**	**TE**	**PE**		
1	CHT 010	DC	Transport Phenomena	3	1	0	30	20	50	100		150	4
2	CHT 011	DC	Chemical Reaction Engineering II	3	1	0	30	20	50	100		150	4
3	CHT 012	DC	Chemical Technology	3	1	0	30	20	50	100		150	4
4		DE	Departmental Elective - 3	3	0	0	30	20	50	100		150	3
5	AHT 011	HSC	Open Elective-1	3	0	0	30	20	50	100		150	3
6	CHP 012	DLC	Chemical Technology Lab	0	0	2		25	25		25	50	1
7	CHP 013	DLC	Process Plant Design Lab	0	0	2		25	25		25	50	1
8	CHP 014	DLC	Process Modelling and Simulation lab	0	0	2		25	25		25	50	1
9	AHT010/AHT009	MC	Essence of Indian Traditional Knowledge / Constitution of India	2	0	0	15	10	25	50			0
10	ATH 014	NC	Happiness and well being	2	0	0	25	25	50			50	0
11	GP 06	NC	General proficiency						50				
			Total	**17**	**3**	**6**						**900**	**21**
12			Minor course (Optional)	3	1	0	30	20	50	100			**4**
		DLC	Mini Project-III or Internship-III*	To be completed at the end of the sixth semester (during Summer Break) & its evaluation/credit to be added in seventh semester.									
MOOCs course													

Department Electives III	
CHT59	Water Conservation and Management
CHT510	Safety & Hazard Analysis
CHT511	Fertilizer Technology
CHT 512	Petroleum Refining Technology

Open Elective-I	
CHT013	Renewable Energy and it’s challenges
CHT014	Polymer Science & Engineering
CHT015	Industrial Safety

SEMESTER - V
Syllabus
Mass Transfer Operation – II (CHT 007)

L:3 T:1 P:0 **CREDITS: 4**

Course objectives:
The objective of this course module is to apply principles of mass transfer with a focus on solid-liquid, liquid-liquid and distillation.

Course Outcomes: Students will be able to
1. Separation by solid – liquid and liquid - liquid extraction. Graphical and analytical calculations
2. Use of McCabe Theile method and Ponchon-Savarit method for distillation
3. Continuous contact equipments like packed towers, sieve, bubble cap towers etc. Determination of number of transfer units and height of transfer units
4. Use of vapour – liquid equilibrium data
5. Determination of efficiency for distillation column

COURSE DETAILS:

UNIT-I **(8 hours)**

Extraction: Solid – Liquid, Rate of solid – liquid extraction, contacting strategy, contacting equipment, Equilibrium, extraction calculation, super critical extraction

UNIT – II **(6 hours)**

Liquid – Liquid : Ternary liquid equilibria, solvent selection, single and multistage and cross current extraction, design calculation for stage wise extraction

UNIT – III **(6 hours)**

Distillation: Introduction – Vapour liquid equilibrium, T-x-y diagram, bubble and dew point calculation, concept of volatility, deviation from ideality, minimum and maximum boiling azeotrope mixture, enthalpy – concentration diagram

UNIT – IV **(10 hours)**

Flash vaporization, steam distillation, batch distillation, continuous multistage fractionation of binary mistures, multistage batch distillation with reflux, minimum and total reflux. Tray efficiency, Reboiler types.

UNIT – V **(10 hours)**

McCabe Thiele method, PonchanSavarit method, Distillation in packed column, Introduction to multi component distillation, azeotropic distillation, extractive distillation

TEXT BOOKS:

1. Treybal. R. E, .” Mass Transfer Operation “, McGraw –Hill International Edition, 3rd Edition
2. McCabe, W. L. Smith, J, and Harriot, P., “ Unit operation of Chemical Engineering”, McGraw –Hill International Edition , 6th Edition
3. Geankoplis, C.J., “ Transport Process and Unit operation” Prentice Hall 3rd Edition, India
4. Dutta, B. K., “Principles of Mass Transfer and Separation Processes”, Prentice Hall, India
5. Seader, J.D Henley, J.E, “Separation Process Principles”, 2nd Edition, Wiley India Edition.

Chemical Reaction Engineering-I (CHT 008)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVES

To provide the comprehensive knowledge of reaction engineering and chemical reactors.

COURSE OUTCOMES

On completion of this course, the students will be able to

1. Identify the reaction type and their kinetics.
2. Design the reactor for the batch and continuous chemical process.
3. Understand the Ideal and Non – Ideal Reactors.
4. Analyse of chemical reacting systems
5. Applies the concepts of reaction rate, stoichiometry, and equilibrium

COURSE DETAILS

UNIT-I **(8 hours)**

Rate Equations: Rate equation - elementary - non-elementary reactions - theories of reaction rate and temperature dependency - Design equation for constant and variable volume batch reactors - analysis of experimental kinetics data - integral and differential analysis.

UNIT – II **(8 hours)**

Design of Reactors: Design of continuous reactors – stirred tank and tubular flow reactor, recycle reactors - combination of reactors - size comparison of reactors.

UNIT – III **(8 hours)**

Design of Multiple Reactors: Design of reactors for multiple reactions – consecutive - parallel and mixed reactions – factors affecting choice - optimum yield and conversion - selectivity, reactivity and yield.

UNIT – IV **(8 hours)**

Non – isothermal Reactors: Non-isothermal homogeneous reactor systems - adiabatic reactors - rates of heat exchanges for different reactors - design for constant rate input and constant heat transfer coefficient - operation of batch and continuous reactors - optimum temperature progression.

UNIT – V **(8 hours)**

Non-Ideal Reactors: The residence time distribution as a factor of performance; residence time

functions and relationship between them in reactor; basic models for non-idealflow; conversion in non-ideal reactors.

Text Books

1. Levenspiel O, Chemical Reaction Engineering, 3rd Edition, Wiley India Pvt Ltd. 2010
2. Smith J.M, Chemical Engineering Kinetics, 3rd Edition McGraw. 2014
3. FoglerH.S., Elements of Chemical Reaction Engineering, 4th Edition, PHI Learning Pvt Ltd (RS). 2009

Reference Books

1. Froment. G.F. and K.B. Bischoff, Chemical Reactor Analysis and Design, 3rd Edition, Wiley. 2010.
2. Butt, J.B., Reaction Kinetics and Reactor Design, 2nd Ed., CRC Press. 2000

Reference link

1. NPTEL video lectures

Process Dynamics and Control (CHT 009)

L:3 T:0 P:0 **CREDITS: 3**

COURSE OBJECTIVE:

Objective is to introduce the fundamentals of process control with applications using P, PI, andPID controllers. The course will teach the students about mathematical models based on transferfunction approach for single loop systems, how to obtain dynamic response of open loop andclosed loop systems, stability analysis in transient and frequency domains, and controller tuningmethods. The course would end with more advanced concepts like feed-forward control, ratiocontrol, model-predictive control, ratio control, dead-time compensation, etc.

Course Outcomes:

Students will be able to

1. Demonstrate fundamental understanding of process control.
2. Develop transfer function (input-output) and models for linear dynamical processes.
3. Characterize the dynamics and stability of processes based on mathematical analysis.
4. Explain different control modes and their application in controlling various processes.
5. Explain the working of different controllers and valves.

COURSE DETAILS:

UNIT-I **(8 hours)**

Introductory Concepts: Need for control and automation, control logic, servo and regulatory Control, block diagrams, control structures (feedback vs. feedforward), process and instrumentation diagrams. Laplace transforms, solution of ODEs using Laplace transform,

UNIT – II **(6 hours)**

Transfer function approach, response of first order systems: step, impulse and sinusoidal response, first order systems in series Second order systems, higher order systems, transportation lag and dead time, Linear closed loop systems, development of block diagrams, classical feedback controllers.

UNIT – III **(6 hours)**

Final control element (control valves), block diagram reduction techniques Closed loop response, servo and regulatory problems Stability analysis, Routh stability criterion, Root locus diagrams (rule based),

UNIT – IV **(10 hours)**

Introduction to frequency response, notion of stability, Bode diagrams, Nyquist plots, Bode and Nyquist stability criterion, Controller tuning: Ziegler-Nichols method, Cohen-Coon method

UNIT – V **(10 hours)**

Introduction to advanced controllers: cascade control, feed forward control, ratio control, Smith-predictor, IMC, MPC, dead-time compensation, Introduction to digital control

Reference Books:

1. Coughnaowr, D. R., “Process Systems Analysis and Control”, McGraw-Hill, Inc.
2. Stephanopolous, G., “Chemical Process Control”, Prentice-Hall.

Renewable Energy Technology and its challenges (CHT 51)

L:3 T:1 P:0 **CREDITS: 4**

Objectives:
Objective is to introduce the fundamentals of different renewable energy resources and their limitation for practical application. Also students will be understanding of important energy storage technologies such as pumped hydro, batteries, and hydrogen.

Course Outcomes
Students will be able to

1. Classify different renewable energy resources and their applications
2. Understand solar energy application and limitations
3. Apply Thermo-electrical and thermionic Conversions
4. Classify and understand wind energy systems
5. Understand biomass energy resources and applications

COURSE DETAILS:

UNIT-I **(8 hours)**

Introduction (world energy status, current energy scenario in India, environmental aspects of energy utilization, energy and sustainable development

UNIT – II **(6 hours)**

Solar Thermal Energy: Solar radiation, flat plate collectors and their materials, applications and performance, focussing of collectors and their materials, applications and performance; solar thermal power plants, thermal energy storage for solar heating and cooling, limitations.

UNIT – III **(6 hours)**

Thermo-electrical and thermionic Conversions: Principle of working, performance and limitations. Wind Energy: Wind power and its sources, site selection, criterion, momentum theory, classification of rotors, concentrations and augments, wind characteristics. Performance and limitations of energy conversion systems.

UNIT – IV **(10 hours)**

Wind energy- availability, wind power plants, wind energy conversion systems, site characteristics, types of wind turbines

UNIT – V **(10 hours)**

Energy from biomass (biomass resources, biomass conversion technologies - direction combustion, pyrolysis , gasification, anaerobic digestion, bioethanol and biodiesel production); Other Renewable Sources(Tidal energy; geothermal energy; hydroelectric).

Textbook:

1. Raja etal, 'Introduction to Non-Conventional Energy Resources' Scitech Publications.
2. John Twideu and Tony Weir, 'Renewal Energy Resources' BSP Publications, 2006.
3. M.V.R. Koteswara Rao, 'Energy Resources: Conventional & Non-Conventional' BSP Publications,2006.
4. D.S. Chauhan,'Non-conventional Energy Resources' New Age International.
5. C.S. Solanki, 'Renewal Energy Technologies: A Practical Guide for Beginners' PHI Learning.
6. Peter Auer, "Advances in Energy System and Technology". Vol. 1 & II Edited by Academic Press.

Electrochemical system for Energy application (CHT 52)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVES

This course introduces principles of electrochemical energy conversion and storage techniques including applications to batteries, fuel cells, super capacitors for present day application.

COURSE OUTCOME: On successful completion of course, students will be able to

1. Understand principles and mathematical models of electrochemical energy conversion and storage.
2. study equivalent circuits for different systems
3. To perform voltage and current calculation for different systems
4. Utilizes knowledge of thermodynamics, electrochemistry and electrical circuits to analyze and design power generation and energy systems.
5. Understand key types of batteries, the range of storage capacity and the applications for each type

COURSE DETAILS:

UNIT-I **(8 hours)**

Electrochemical energy conversion:Introduction of subject, Basics of galvanic cell, Electrochemical energy conversion, energy storage, Global Energy Status: Demands, Challenges, and Future Perspectives, Driving Forces behind Clean and Sustainable Energy Sources, Greenhouse Gases Emission and the Associated Climate Changes, Electrochemical Rechargeable Batteries and Supercapacitors,

UNIT – II **(6 hours)**

Circuit dynamics:Equivalent circuit diagram, Impedance study, AC Circuit Theory and Representation of Complex Impedance Values, Physical Electrochemistry and Circuit Elements, Common Equivalent Circuit Models

UNIT – III **(6 hours)**

Thermodynamic study: Voltage calculation, Nernst equation, Pourbaix Diagram, Origin of potential – electrical double layer – reversible electrode potential – standard hydrogen electrode – emf series – measurement of potential – reference electrodes (calomel and silver/silver chloride) indicator and ion selective electrodes – Nernst equation – irreversible processes.

UNIT – IV **(10 hours)**

Kinetics study: Faradaic Reactions, Butler-Volmer Equation, Electrocatalysis, Activation losses, kinetic treatment – ButlerVolmer equation – Overpotential, activation, concentration and IR overpotential – its practical significance – Tafel equation and Tafel plots – exchange current density and transfer coefficients.

UNIT – V **(10 hours)**

Electrochemical devices: Batteries-Chemistry and principles, Types-Primary and secondary batteries, Performance, capacity and discharge. Fuel cell-types, Applications. Super capacitor-Design, types, application

Text Books:

1. Newman, John, and Karen E. Thomas-Alyea. Electrochemical Systems. 3rd ed. Wiley-Interscience, 2004. ISBN: 9780471477563.
2. Bard, Allen J., and Larry R. Faulkner. Electrochemical Methods: Fundamentals and Applications. 2nd ed. Wiley, 2000. ISBN: 9780471043720.
3. O' Hayre, Ryan, Suk-Won Cha, et al. Fuel Cell Fundamentals. 2nd ed. Wiley, 2009. ISBN: 9780470258439.
4. Huggins, Robert A. Advanced Batteries: Materials Science Aspects. Springer, 2008. ISBN: 9780387764238.
5. Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications, B. E. Conway. Springer Science & Business Media, 2013. ISBN: 1475730586, 9781475730586

Polymer Science and Engineering (CHT 53)

L:3 T:1 P:0 **CREDITS: 4**

Course Objective:
To introduce fundamentals of synthesis, characterization, properties and also include discussion on the applications of polymers.

Course Outcome:
After successful completion of course students will be able to:

1. Connect properties of polymeric materials to their structures and explain how different material parameters and external factors affect the mechanical properties
2. Correlate structure-processing-properties relationships for polymers, blends and composites
3. Select a suitable processing and manufacturing technique for a given polymer.
4. Identify methods for rheological measurements and analysis of the rheological data using models for polymeric material
5. Understand different polymer manufacturing methods

COURSE DETAILS:

UNIT-I **(8 hours)**

Classification of polymers: Natural and synthetic polymers; Thermosets and thermoplasts; Copolymers; Terpolymers; Degradable and non-degradable polymers.Additionpolymerization; Condensation polymerization; Ring opening polymerization; Copolymerization; Polymerization by coordination catalyst; Molecular weight distribution of polymers.

UNIT – II **(6 hours)**

Manufacturing processes of important polymers: Plastics-polyethylene; polypropylene, polyvinyl chloride and copolymers, polystyrene; phenol-formaldehyde, epoxides; urethane; Teflon; Rubbers and elastomers; Fibres - cellulosic (rayon), polyamides (6;6 Nylon), polyesters (Dacron), acrylic; Polymeric oils. Micro-structure of polymer chains: Configuration and conformation; Simple and hindered rotation; End-to-end distances;

UNIT – III **(6 hours)**

Crystallinity and melting; Glass transition temperature; Physical states of polymers and mode of motion of polymer chains; Measurement of viscosity; Cohesive energy density; Compatibility and solubility parameters; Polymer additives, blends and composites. Flow properties of polymers: Bulk deformation, elongational and shear flow; Non-Newtonian

flow.

UNIT – IV **(10 hours)**

Polymer fabrication techniques: Formation of flat sheets and films; Laminations; Foam formation; Extrusion, injection molding, blow molding, compression and transfer molding; Spinning of fibres.

UNIT – V **(10 hours)**

Mechanical properties of polymers: Rheology of polymers; Rubber elasticity; Visco-elasticity; Creep and stress relaxation; Dynamic behavior; Stress and fracture of rubber and glassy polymers. Polymer degradation. Conducting polymers; Smart polymers, Ecology and environmental aspects of polymer industries.

Text Book:

1. Fried, J.R., "Polymer Science and Technology", Prentice Hall, Inc, 2nd Ed., 2003.

References

1. McCrum, N.G., Buckley, C.P. and Bucknall, C.B., "Principles of Polymer Engineering",
   Oxford University Press, 2nd Ed., 2009.
2. Tadmore, , and Gogvs, C.G., "Principles of Polymer Processing" John Wily & Sons.
3. Billmeyer, F.W., "Text Book of Polymer Science", John Wiley & Sons, 3rd Ed., 2002.

Optimization Techniques (CHT 54)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVE:

1. To provide fundamental knowledge to optimized a process plant.
2. To teach the essential features of optimization problems.
3. To introduce basics of linear programming and the principle of optimality.

COURSE OUTCOME:

1. On completion of this course, the students will be able to:
2. Understand the role of optimization in a chemical process plants.
3. Formulate mathematical models for optimization problems.
4. Analysis of degree of freedom and complexity of solutions to an optimization problem.
5. Understand and analyze the various methods used for unconstrained one dimensional search.

COURSE DETAILS:

UNIT-I **(8 hours)**

Optimization, Degree of freedom, Optimization formulation of theProblem, Analytical Method, Necessary and sufficient conditionsfor optimum in single and multi-variable unconstrained andconstrained problems.

UNIT – II **(6 hours)**

Unconstrained one-dimensional search, Newton, Quasi-Newtonand Secant method for uni-dimensional search, Region eliminationmethods (Golden Section Fibonacci, Dichotomous etc),Unconstrained multivariable optimization with special focus toPowell's conjugate direction method.

UNIT – III **(6 hours)**

Linear Programming, graphical simplex method, revised simplex method, duality and transportation problems, unconstrained multivariable search, Direct methods, Indirect method.

UNIT – IV **(10 hours)**

Forward, Backward and Divided Differences Table, CentralDifferences, Newton's Forward, Backward and DividedDifferences Interpolation Formula, Interpolation Polynomials,Lagrange Interpolation Formula, Sensitivity analysis.

UNIT – V **(10 hours)**

Principle of optimality, discrete and continuous dynamicprogramming.Algorithms & Computer Programming: Newton-Raphson Method,Gauss Elimination, Trapezoidal Rule, Simpson's 1/3rd, 3/8th Rule,Runge-Kutta 2nd Order, and R-K 4th Order Methods in reference otthe Applications in Chemical Engineering.

Reference books:

1. S.S. Rao "Engineering Optimization", Wiley.
2. Asghar Husain and Kota Gangiah "Optimization Techniques for Chemical Engineers", Macmillan.
3. T.F. Edgar and D.M. Himmelblau "Optimization of Chemical Process", Mc Graw Hill.

Interfacial Science and Technology(CHT 55)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBEJCTIVE:
The objective of this course is to basic understanding of different boundaries and properties. Also give a background of the interfacial forces, surfactants, the self assembly of various structures and the basic properties of these systems which are useful in applications.

COURSE OUTCOME: Students will be able to

1. Have basic concepts about surface and interfacial energies, Stability of equilibrium solutions and thin films and forces governing them.
2. Understand the Mie and Lennard-Jones potential curve
3. Prepare microscale patterned of surfaces using microfabrication techniques with various soft polymers. Will be able to design a microscale roughness having long-term stability with selective applications.
4. Understand the recent advances in nanotechnology and its large-scale application.
5. Understand measurement for surface properties.

COURSE DETAILS:

UNIT-I **(8 hours)**

Surface and Interfacial Tension: Surface tension of liquids, Calculation, and measurements of surface tension. Measurement of interfacial tension. Concepts of surface and interfacial energies and tensions; van der Waals and acid-base components of interfacial tensions, Young-Laplace equation of capillarity, Stability of equilibrium solutions and thin films; Contact angle and Young's equation, Free energies of adhesion, kinetics of capillary flows.

UNIT – II **(6 hours)**

Intermolecular and Surface Forces: van der Waals force, Mie and Lennard-Jones potentials, Electrostatic Interaction- Electric Interaction in Colloidal Particles, electrostatic interaction (Double Layer),Gouy Chapman Theory, Debye Huckel approximation, charge Density, forces between two particles, potential Energy, Zeta potential.

UNIT – III **(6 hours)**

Smart Materials (polymers): Technological Aspects of thin films, Methods for thin film coating; Spin Coating, Dip Coating, Electrodeposited coatings, Thermal sprayed coatings, Introduction to structural colour and Hydrophobicity.

UNIT – IV **(10 hours)**

Advanced instruments for measuring surface properties – Contact Angle Goniometer, Atomic Force Microscopy, Optical Profiler

UNIT – V **(10 hours)**

Modern Applications of nanomaterials and Interfacial science in detergents, personal products,

Pharmaceuticals, food, textile, paint and petroleum industries.

Syllabus:

Reference Books:

1. Nanospectrum: A Current Scenario by Prof. (Dr.) Sampa Chakrabarti,
2. Introduction to Nanotechnology, Charles P. Poole, Jr., Frank J. Owens

Process Flow Sheet Simulation (CHT 56)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVE:

The objective of this course is to create use of the open source process simulator "DWSIM". The course will cover basic aspects of creating flow sheet in DWSIM and simulation of simple units such as Mixer, Heat Exchanger, Equilibrium Reactor, CSTR, Distillation Column etc.

COURSE OUTCOME:

On completion of this course, the students will be able to:

1. Synthesize a flowsheet for the process on paper and implement this in a simulation program.
2. Deal with ASPEN PLUS/DWSIM for simulation application.
3. Use process flowsheet simulations to solve problems in the chemical industry.
4. Estimate the thermo-physical properties for the chemical species and identify the correct models to use.
5. Design a distillation column, feed height and number of trays in a column.

COURSE DETAILS:

UNIT-I **(8 hours)**

Introduction to Process Simulation: Background and history of process simulation; Steady State and Dynamic Simulation; Different approaches to process simulation; modules and components in a process simulation package, integration of simulation tools, structure and functionality of commercial simulation tools, selection of flowsheet and simulation software. Process Flow sheeting: Approaches to flow sheeting, collection and estimation of thermo-physical properties for the chemical species of the system, thermo-physical properties banks, computer aided flow-sheeting, manual calculations with recycle streams, partitioning and tearing a flowsheet.

UNIT – II **(8 hours)**

Fundamentals of systems engineering: System definition, system properties, aggregation/decomposition, hierarchies of systems; Introduction of canonical modeling concepts: devices, connections, equations, variables. Formalizing the modeling process : Methods of structuring complex chemical processes, procedures for process modeling; degrees of freedom in a flow sheet. Numerical properties of the model equations.Numerical methods for steady-state and dynamic systems: Differential Algebraic Equations; Synthesis of reaction systems and synthesis of azeotropic separation systems.

UNIT – III **(8 hours)**

Processing Simulation with software: ASPEN PLUS/HYSIS/PRO II/Design II/UniSim/OLI Pro/Aspen Custom Modeler/TK-Solver: Introduction to the Simulation Package; Features of simulation packages; Introduction to the simulation package Graphical User Interface; Example 1:

Flashing of Light Hydrocarbons; Survey of unit operation models; Example-2: Vinyl chloride monomer (VCM) flow sheet.

UNIT – IV **(8 hours)**

Flow sheet Calculations and Model Analysis Tools: Sensitivity and casestudy runs; Design specifications and calculator blocks; Example-3: VCM flow sheet sensitivity run / design-spec run. Inorganic chemicals and electrolyte modeling; Example-4: sour water systems (CO2 and H2S removal for example)

UNIT – V **(8 hours)**

Physical Properties: Overview of physical property system; Property model specifications; Property data requirements and input; Physical property analysis; Example-1: Introducing a non-databank component. Multistage Separation: RADFRAC: Rigorous rating and design fractionation model; Example-2: Using RADFRAC in the VCM flow sheet. Introduction to ICARUS (an economic evaluation package inside ASPEN PLUS), Flow sheet Convergence: Example-3: VCM flow sheet convergence

REFERENCE BOOKS:

1. Dimian A. C., “Integrated Design and Simulation of Chemical Processes”, Elsevier
2. Westerberg, A. W., Hutchison, H. P., Motard, R. L. & Winter, P., “Process Flowsheeting”, Cambridge University Press.
3. K.M. Hangos and I. T. Cameron, “Process Modelling and Model Analysis”, Aca
4. Kumar, A., “Chemical Process Synthesis and Engineering Design”, Tata McGraw Hill. demic Press.
5. W. F. Ramirez, “Computational Methods for Process Simulation”, 2nd ed., Butterworths.

Statistical Methods for Chemical Engineers(CHT 57)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVE:

This course covers common numerical algorithms and statistical methods used by chemical engineers to solve typical problems arising in industrial and research. This course aim to provide insight of mathematical modelling of chemical processes or exploratory chemometrics to undergraduate students.

COURSE OUTCOME: On completion of this course, the students will be able to:

1. Understand data statics and data visualisation
2. Understand theoretical foundations of statistical analysis
3. Apply Regression and concepts of data modelling
4. **Apply Modelling Stochastic Processes with Time Series Analysis**
5. **Understand modelling for dynamic processes**

COURSE DETAILS:

UNIT-I **(8 hours)**

Introduction to Statistics and Data Visualisation, fundamentals of descriptive statistics and data visualisation, statistics focus on the development of methods for describing a given data set, Data visualisation focuses on developing a set of rules for effectively displaying data visually. Common data visualisation methods such as bar charts, histograms, pie charts, line charts, time series plots, box-and-whisker plots, scatter plots, probability plots, tables, and spark plots are explained with detailed examples and methods of construction

UNIT – II **(8 hours)**

Theoretical foundations of statistical analysis by presenting a rigorous, multivariate, set-based approach to probability and statistical theory, Probability density functions, sample space, moments, the expectation operator, common statistical distributions, including the normal, Student's t-, $\chi 2$-, F-, binomial, and Poisson distributions

UNIT – III **(8 hours)**

Regression, concepts of data modelling using least-squares, regression analysis through a simplified framework consisting of three iterative steps, model selection, parameter estimation, and model validation

UNIT – IV **(8 hours)**

Time series analysis using transfer functions, state-space models, and spectral decomposition, theoretical properties of different model types, including standard autoregressive moving-average models, integrating models, and seasonal models

UNIT – V **(8 hours)**

Modelling Dynamic Processes Using System Identification Methods, develop a generalised framework for the development of deterministic and stochastic models for complex chemical processes for application to control, linear models, including the prediction error model with its simplifications and the impulse response model

Textbook:

1. Statistics for Chemical and Process Engineers, A Modern Approach, Yuri A.W. Shardt

Materials Science and Engineering (CHT 58)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVE:

This course aim to give importance to materials available to engineers in their profession to the many mechanical and electrical properties of materials important to their use in various engineering fields. Also, to explores the structure of a wide variety of materials with current-day engineering applications.

COURSE OUTCOMES

After the successful completion of the course student should be:

1. Able to distinguish between different classes of engineering materials based on their properties, structures etc. and select proper material for a particular job.
2. Analyze the structure of solid materials, relation between structure and properties of materials and the defects in crystal structure of solids.
3. Able to analyze the causes of different types of corrosion and select a suitable preventive method to reduce or combat this.
4. To understand the role of different engineering materials (like Ferrous and Non-ferrous etc.) in various field of applications.
5. Able to test different properties of materials before recommending the material for a specific task.

COURSE DETAILS:

UNIT-I **(8 hours)**

Class of engineering materials-selection of materials-level of structure-bonding in solids.

UNIT – II **(8 hours)**

Crystal Structure: Crystal geometry, structure of solids, methods of determining structures. Imperfections in crystals-types of imperfection. Point imperfection, diffusion in solids-Fick's law, self-diffusion

UNIT – III **(8 hours)**

Electrical and magnetic properties of materials-Chemical, thermal and technological properties of materials-corrosion, theories of corrosion-control and prevention of corrosion

UNIT – IV **(8 hours)**

Engineering materials-ferrous metals-Iron and steel, Iron-carbon equilibrium diagram, on-ferrous metals and alloys-Aluminium, copper, zinc, lead, nickel and their alloys with special

reference to the application in chemical industries

UNIT – V **(8 hours)**

Inorganic materials: Ceramic, glass and refractories-organic materials: wood, plastic and rubber with special reference to the application in chemical industries

Text Books:

1. Fontana-Corrosion Engineering,McGraw Hill
2. V Raghavan-Materials Science and Engineering,5thed,Pretince Hall India
3. S.K. Hazra Choudhury-Material Science and Processes

Mass Transfer Operation Lab (CHP 008)

L:0 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVES

To provide the comprehensive knowledge of Mass Transfer Operations.

Lab Outcomes:

Students completing the course will be able to

1. Experimentally verify various theoretical principles
2. Develop confidence in handling mass transfer equipment's in chemical process industries.
3. Develop experimental skills
4. Work in team and develop interpersonal skills
5. Develop skills for technical writing

List of experiments: (any 10)

1. Determination of diffusivity of acetone in air.
2. Determination of mass transfer coefficient in an agitated vessel.
3. Determination of mass transfer coefficient for steady state surface evaporation of water at different temperature.
4. Determination of mass transfer coefficient in a wetted wall column.
5. Determination of T-x-y diagram for a binary batch distillation.
6. Verification of Rayleigh equation in a binary batch distillation process.
7. Verification of steam distillation equations.
8. Determination of ternary curve for the system acetic acid-water-carbon tetrachloride.
9. Determination of distribution coefficient of a solute in two immiscible liquids.
10. Solid-Liquid extraction – Soxhlet‟s experiment.
11. Liquid - liquid extraction in packed bed.
12. Determination of adsorption kinetics and isotherm at solid-liquid interface.
13. Determination of the rate of drying in a tray dryer.
14. Estimation of efficiency of the fluidized bed dryer

Chemical Reaction Engineering Lab (CHP 009)

L:0 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVES

To provide the comprehensive knowledge of reaction engineering and chemical reactors.

LAB OUTCOMES

On completion of the experiments, the students will be able to

1. Demonstrate and analyse the reaction type and their kinetics in batch reactor
2. Demonstrate and analyse the reaction type and their kinetics in PFR
3. Demonstrate kinetics in CSTR
4. Analyse the concentration versus time data and determine the specific rate constant and the order of the reaction.

LIST OF EXPERIMENTS

1. Find out kinetic constant and study conversion of a given reaction in a batch reactor
2. Find out kinetic constant and study conversion of a given reaction in a plug flowreactor
3. Find out kinetic constant and study conversion of a given reaction in a CSTR
4. Study and operation of an adiabatic batch reactor
5. Study of a reversible reaction in a batch reactor
6. To determine energy of activation of reaction of ethyl acetate with sodium hydroxide
7. Find out specific rate constant and activation energy of a reaction in a plug flow reactor
8. To determine reaction equilibrium constant of reaction of acetic acid with ethanol.
9. To determine changes in free energy, enthalpy and entropy for the reaction of potassiumiodide with iodine.
10. Study and operation of a cascade CSTR

Process dynamic and control lab(CHP 010)

L:0 T:0 P:2 **CREDITS: 1**

Course Objectives:

Objective of the course is to introduce the basics of instrumentation and process control through ahands-on practical experience. Principles of operation of different measuring devices for temperature,level, pressure, flow, pH, humidity, density, and viscosity will be introduced to impart knowledge oftransmitters, transducers, converters, control valves, digital and analog components related to PLC,DCS, SCADA systems.

Lab Outcomes:

Students will be able to

1. Well-familiar with instrumentation and automation as relevant to modern chemical plant operation.
2. Understand basics of instrumentation and process control
3. Understand and apply principles of operation of different measuring devices
4. Understand and apply principles of control valves
5. Understand and apply different types of control stra

List of Experiments: (any 10)

1. Basics of control system components, signals and standards.
2. Pressure measuring instruments/sensors.
3. Level measurement.
4. Flow measuring instruments.
5. Temperature measuring devices.
6. Humidity, density, viscosity and pH measuring devices.
7. Pressure controllers: regulators, safety valves.
8. Flow control actuators: different types of valves.
9. Electrical and pneumatic signal conditioning and transmission.
10. Control valves.
11. Open loop systems: lagged thermometer, stirred-tank heater.
12. Temperature, level, and pressure control trainers.
13. Flow-level cascade control.

Mini Project or Internship Assessment (CHP 011)

L:0 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVE:

1. To inculcate research attitude amongststudents.
2. To develop presentationskills.
3. To teach how to study and solve practicalproblems

COURSE OUTCOME:

On completion of this course, the students will be able to:

1. Understand and workout the projectproblem.
2. Gain experience to make a projectreport.
3. Acquire the necessary confidence to carry out main project in the finalyear.

VI SEMESTER

Syllabus
Transport Phenomenon (CHT 010)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVES:

Introduce students with knowledge to look into the underlying concepts of processes, which often take place simultaneously, and will help to apply concepts to a variety of real-life problems. Students will be able to model the processes and make quantitative statements.

COURSE OUTCOMES:

After end of course student will be able to:

1. Understand basic concepts of transport phenomena and thus analyze the role of intermolecular forces in transport process.
2. Demonstrate the role of molecular transport mechanism and thus draw the analogy between heat, mass and momentum transport.
3. Apply the conservation concept and construct the property balance equation, applying both molecular and convective transport.
4. Apply the property balance equation to solve real plant problems like flow through pipes and between parallel plates and show important relationships.
5. Apply concepts of continuity and Navier–Stokes equation and used in solving the real in plant problems.

COURSE DETAILS:

UNIT-I **(8 hours)**

Introduction: Transport phenomena and Unit Operation, Equilibrium and rate processes, Role of intermolecular forces.

UNIT – II **(8 hours)**

Molecular Transport Mechanisms: Heat, mass and momentum transport by molecular mechanism. The Analogy – Case of Heat Transfer, Case of Mass Transfer, Case of Momentum Transfer, the analogous forms. Heat Transfer. Mass Transfer – Equimolar Counter Diffusion, Partial Pressure. Momentum transfer.

UNIT – III **(8 hours)**

General Property Balance: The balance or conservation concept- input-output balance, generation, accumulation, the balance equation in differential form. The one directional

balance equation including molecular and convective transport. The three-dimensional balance equation. The continuity equation. The general property balance equation for an incompressible fluid.

UNIT – IV **(8 hours)**

Molecular Transport and the General Property Balance: Steady transport in one dimension involving input-output with no generation (constant area and variable area transport). Steady transport with generation (Heat and mass transport with constant generation, momentum transfer with generation at steady state – laminar flow in a tube, Hagen-Poiseuille Equation, laminar flow between parallel plates).

UNIT – V **(8 hours)**

Transport with net convective flux: Convective flux caused by forced convection. Relation between shear stress and shear rate. Navier-Stoke's Equation. Fick's Law.

Text Books:

1. Brodkey, R.S. & Hershey, H.C., Transport Phenomena – An Unified Approach, McGraw-Hill.
2. Bird, Stewert& Lightfoot, Transport Phenomena, John Wiley.

Reference Books:

1. Introduction to Transport Phenomena: Momentum, Heat and Mass, Bodh Raj, PHI

Chemical Reaction Engineering – II (CHT 011)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVE:

1. To impart the basic concepts of chemical reaction engineering, reactors and contacting pattern
2. To develop understanding about reactor analysis and design for heterogeneous reactions
3. To impart knowledge about the Biochemical reactions and Bio processing

COURSE OUTCOME:

After successful completion of the course the students will be able to:

1. Classify catalysts and predict physical properties of catalyst, surface area, void volume, solid density pore volume distribution.
2. Understand the nature and mechanism of catalytic reactions and predict the rate controlling step reactions.
3. Analyze the various contacting pattern for two phase system.
4. Predict the rate equation for heterogeneous reactions and understand the effect of velocity, particle size and fluid properties on rate of reactions controlled by mass transfer
5. Understand the nature and mechanism of Bio chemical reactions.

COURSE DETAILS:

UNIT-I **(8 hours)**

Introduction to Homogeneous and Heterogeneous reactions, catalysts and Nature of catalysis, Physical properties of catalysts, determination of surface area, void volume and solid density, pore volume distribution; Classification, preparation, testing and characterization of solid catalysts, catalyst selection, catalyst promoters and inhibitors, catalyst poisoning and catalyst deactivation (no kinetics). Adsorption, physical adsorption and chemisorption, adsorption isotherms, mechanisms of catalytic reactions, Shifting of equilibrium in chemical reactions

UNIT – II **(6 hours)**

Solid catalysed reactions, the rate equations for surface kinetics, Reaction and diffusion within porous catalysts, Pore diffusion resistance combined with surface kinetics, effectiveness factor and Thiele modulus, various Resistances to transfer of reactants to the catalyst site, intrinsic and global rate of reaction, kinetic regimes, heat effects during reaction, Performance equations for reactors containing porous catalyst particles, design of solid catalytic reactors.

UNIT – III **(6 hours)**

Fluid-solid reactions, experimental methods for finding rates, selection of a model, shrinking core

model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles, determination of rate controlling step, kinetics and design, Design of packed bed and fluidized bed reactors.

UNIT – IV **(10 hours)**

Fluid-Fluid Reactions, Rate equation, rate equation for straight mass transfer, kinetic regimes of mass transfer and chemical reaction, rate equation for mass transfer and chemical reactions, fluid-fluid reactor design, deciding the contactor type and contacting pattern.

UNIT – V **(10 hours)**

Introduction to Biochemical reactions: Kinetics of Enzyme Fermentation and Microbial Fermentation, understanding of Biochemical Reactors and study of polymerization reactors, Bioprocessing of edible oils.

REFERENCE BOOKS

1. Levenspiel, O., “Chemical Reaction Engineering”, 3rd Edition, John Wiley, (1998).
2. Fogler H.S., Elements of Chemical Reaction Engineering, 4th edition, Prentice Hall of India, (2008)
3. Daizo Kunii & Octave Levenspiel, “Fluidization Engineering” 2nd Edition, Elsevier (India Print 2005)

Chemical Technology (CHT 012)

L:3 T:1 P:0 **CREDITS: 4**

COURSE OBJECTIVES:

Introduce fundamental concepts of production and existing processes for different chemicals and their importance in chemical process industries.

COURSE OUTCOMES:

After successful completion of the course, student will be able to:

1. Compare production of different acids and will be able to classify different fermentation products.
2. Classify different manufacturing processes of chloro-alkali industries and categorize different cements and manufacturing processes
3. Compare and classify different fertilizers based on their manufacturing processes and uses.
4. Classify processing of fats and oils. Compare different manufacturing processes for paper production.
5. Explain basics of polymers and polymerization reactions and their utilization.

COURSE DETAILS:

UNIT-I **(8 hours)**

Acid Industries, Fermentation processes: Introduction to the subject, Unit process and operations, manufacturing of acid: sulphuric acid, Manufacturing of hydrochloric acid with process flow diagram, Manufacture of nitric acid with process flow diagram. Introduction to fermentation, process and production, Some special products of fermentation.

UNIT – II **(8 hours)**

Chlor-alkali industries, Cement: Introduction to chlor-alkali industries: manufacture of soda ash, Manufacture of caustic soda with process flow diagram and major engineering problem related to its production, Manufacture of chlorine and common salt Introduction to cement and its types, Portland cement and its production, major engineering problems related to it, Special types of cement, Setting and hardening of cement, difference between dry process and wet process to manufacture cement.

UNIT – III **(8 hours)**

Fertilizer: Introduction to fertilizer, Nitrogen fertilizer: manufacture of urea, ammonia, ammonium carbonate with process flow diagram, Phosphatic fertilizer: Manufacture of

superphosphate and triple superphosphate with flow diagram, Potassium fertilizer.

UNIT – IV **(8 hours)**

Paper, Fats and Oils: Production and processing of pulp by using different methods, kraft process, Production of different types of paper Introduction to fats and oils of vegetable and animal origin, Processing of oil, hydrogenation, essential oil, Soaps and detergents, common terms related to processing of oil and fat.

UNIT – V **(8 hours)**

Polymers: Introduction to polymers, basics and functionality concept, Classification of polymers, Methods of production of polymers, Manufacture of polyethylene, Naming of nylons and their manufacture, Manufacture of PF and MF resin, epoxy resin, Some common uses of polymers

Text Books:

1. Outlines of Chemical Technology by Dryden.
2. Chemical Technology by Shukla&Pandey.
3. Chemical Process Industries by Shreve.
4. Polymer Science and Technology, Fried, 2nd Ed, Prentice Hall
5. Polymer science by V. Gowarikar

Water conservation and management(CHT 59)

L:3 T:0 P:0 **CREDITS: 3**

COURSE OBJECTIVE:

Learn about the importance of water resources and how water conservation measures are used in different contexts.

COURSE OUTCOMES

After successful completion of the course, student will be able to:

1. Compare different water conservation techniques.
2. Classify different water conservation and quality
3. Compare and classify different water quality testing and control.
4. Understand water audits.
5. Compare water conversation in different industries.

COURSE DETAILS:

UNIT-I **(8 hours)**

Introduction: water cycle, water storage, water quality; water conservation in homes.

UNIT – II **(8 hours)**

Water conservation in the work place; water management-water quality, controlling use and quality of water, water flow measurement.

UNIT – III **(8 hours)**

Water quality control, testing water salinity, preserving waterquality, minimising evaporation, water sanitation

UNIT – IV **(8 hours)**

Water audits; water conservation in agriculture; water conservation in process industries.

UNIT – V **(8 hours)**

Water conservation in construction industry; water conservation in service industry.

Textbooks:

1. Soil and Water Conservation Engineering by Rodney L. Huffman
2. Water Conservation and Environmental Stability, Keith Wheatly

Safety and Hazard analysis (CHT 510)

L:3 T:0 P:0 **CREDITS: 3**

COURSE OBJECTIVE:

To learn hazard and types also their identification process.

COURSE OUTCOMES:

After successful completion of the course, student will be able to:

1. Understand different accident causation
2. Understand system safety management
3. Understand different types of hazards
4. Apply Fire prevention and protection
5. Apply Industrial hygiene

COURSE DETAILS:

UNIT-I **(8 hours)**

History of safety movement; Development of safety programmes in process industry. Accident causation: Heinrich-Domino theory; Human error model; Petersen's accident/ incident model; Epidemiological models; System models; Multiple causation.

UNIT – II **(8 hours)**

Systems safety management: Management task; Managerial roles and skills; Management by objective.

UNIT – III **(8 hours)**

Hazard: Identification; Occupational hazard; Preliminary hazard analysis; Hazard and operability review (HAZOP) Hazard control: Engineering and management controls; Fault tree analysis; Risk analysis and management.

UNIT – IV **(8 hours)**

Fire prevention and protection: Chemistry of fire; Production of fire; Fire development; Severity and duration; Effect of enclosure and heat transfer.

UNIT – V **(8 hours)**

Industrial hygiene; Routes of entry of foreign substance; Long term medical disorders andepidemiology; Stress and the workplace; Industrial noise; Hazardous waste. Case studies of safety and hazard assessment in different industries; Disaster management planning; Insurance

tariffs in hazardous industries; Design for safety, maintenance and fault diagnosis

Text Book:

1. Crowl, D.A. and Louvar, J.F., "Chemical Process Safety: Fundamentals with Applications", Prentice Hall, Inc, 2nd Ed., 2010

References

1. Wills, G.L., "Safety in Process",

Fertilizer Technology (CHT 511)

L:3 T:0 P:0 **CREDITS: 3**

COURSE OBJECTIVE:

To Overview the most used fertilizer and their production technologies.

COURSE OUTCOMES:

After successful completion of the course, student will be able to:

1. Understand different types of fertilizer and their uses.
2. Differentiate between different processes for fertilizer making
3. Understand nitrogen and potash-based fertilizer
4. Understand Complex fertilizer
5. Understand Phosphorous based fertilizer

COURSE DETAILS:

UNIT-I **(8 hours)**

Introduction to chemical fertilizers: Chemical inorganic Fertilizers and Organic manures. Types of fertilizer-, mixed, complex and granulated, plant nutrients

UNIT – II **(8 hours)**

Processes for raw materials: Processes for manufacture of ammonia, nitric acid, phosphoric acid.

UNIT – III **(8 hours)**

Nitrogenous and potassic fertilizers: Processes for urea and di-ammonium phosphate. Recovery of Potassium salts processes for ammonia chloride and ammonium phosphate.

UNIT – IV **(8 hours)**

Complex fertilizers: Processes for nitro - Phosphorous and complex NPK fertilizers, liquid fertilizers.

UNIT – V **(8 hours)**

Phosphatic fertilizers and Indian fertilizer industry: Single and Triple super phosphate, bio-fertilizer. Fertilizer Industry in India.

Text Books:

1. Outlines of Chemical Technology by Dryden.
2. Chemical Technology by Shukla&Pandey.

Petroleum Refining Technology (CHT 512)

L:3 T:0 P:0 **CREDITS: 3**

COURSE OBJECTIVE: the students will understand the fundamentals of crude oil productions, characteristics, quality parameters and processes.

COURSE OUTCOMES:

On successful completion of course,

1. Students will be able to describe the process of crude oils production & refining and Characteristics of crude oils
2. Understand the various quality Control parameters of Petroleum Products
3. They can describe the physical properties of petroleum products and thermal conversion of petroleum
4. They can understand the process involved in catalytic conversion
5. They can demonstrate the different methods available for lube oil manufacturing process

Unit-I **(6 hours)**

Petroleum Exploration: Production and Refining of Crude oils; Crude oils: Chemistry and composition (Characteristics and constituents of crude oils, Classification of crude oils).

Unit-II **(10 hours)**

Quality Control of Petroleum Products: Classification of laboratory tests, distillation, vapour pressure, flash and fire points, octane number, performance number, cetane number, aniline point, viscosity index, calorific value, smoke point, char value, viscosity, viscosity index, penetration tests, cloud and pour points, drop point of grease, melting and settling points of wax, softening point of Bitumen, induction period of gasoline, thermal stability of jet fuels, gum content, Total Sulphur, Acidity and Alkalinity, Copper Strip Corrosion Test, Silver – Strip Corrosion Test for ATF, Ash, Carbon Residue (Conradson method, Ramsbottom method) Colour, Density and Specific gravity, Refractive index of hydrocarbon liquids, water separation index (modified) (WSIM), ductility.

Unit-III **(8 hours)**

Petroleum Products: Composition, Properties & Specification of LPG, Naphthas, motor spirit, Kerosine, Aviation Turbine Fuels, Diesel Fuels, Fuel Oils, Petroleum Hydrocarbon Solvents, Lubricating oils (automotive engine oils, industrial lubricating oils electrical insulating oils, Jute Batching oils, white oils, steam turbine oils, metal working oils, etc.) Petroleum Waxes Bitumens, Petroleum coke. Crude Oil Distillation, Desalting of crude oils, Atmospheric distillation of crude oil, Vacuum distillation of atmospheric residue.

Thermal Conversion Process: Thermal Cracking Reactions Thermal Cracking, Visbreaking, (Conventional Visbreaking and Soaker Visbreaking) Coking (Delayed Coking, Fluid Coking, Flexicoking), Calcination of Green Coke.

Unit-IV **(8 hours)**

Catalytic Converson Process: Fluid catalytic cracking; Catalytic reforming; Hydrocracking Catalytic Alkylation, Catalytic Isomerization; Catalytic Polymerization. Finishing Process, Hydrogen sulphide removal processes; Sulphur conversion processes; Sweetening processes (Caustic treatment, Solutizer process; Doctor treating process; Copper chloride sweetening,; Hypochlorite sweetening ;Air and inhibitor treating process; Merox processes; Sulphuric acid treatment; Clay treatment); Solvent extraction processes (Edeleanu process, Udex process, Sulfolane process), Hydrotreating processes

Unit-V **(8 hours)**

Lube Oil Manufacturing Process: Evaluation of crude oils for lube oil base stocks, Vacuum distillation, Solvent deasphalting Solvent extraction of lube oil fractions (Furfural, NMP and Phenol), Solvent dewaxing, Hydrofinshing, Manufacture of petroleum waxes (Wax sweating, Solvent deoiling)

Manufacture of Bitumens: Selection of crude oil, Methods of manufacture of bitumens, (Distillation, Solvent precipitation, Air blowing).

Text Book:

1. Nelson, W.L., "*Petroleum Refining Engineering*", McGraw Hill, 4th Ed., 1958,

References

1. Mall, I D , "*Petrochemical Process Technology*", McMillan India, 4th Ed., 1998.
2. Sarkar, G.N., "*Advance Petroleum Refining*", Oscar Publication, 4th Ed., 1998.

Chemical Technology lab (CHP 012)

L:0 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVES:

This course mainly deals with the understanding the basic fundamental principles of different chemical process industries by performing different experiments for characterization of raw materials or products.

COURSE OUTCOMES:

After the successful completion of the course student should be able to:

1. Ability to characterize different grades of cement.
2. Ability to identify soap quality by free moisture content.
3. Ability to characterize oil by saponification value.
4. Ability to characterize oil by iodine value

LIST OF EXPERIMENTS:

1. Analysis of Portland cement.
2. Determination of free moisture content in a given sample of soap.
3. Determination of Iodine value in a given sample of oil.
4. Determination of saponification value in a given sample of oil.
5. Determination of acid value of given oil sample.
6. Determination of peroxide value of given oil sample.

Text book:

1. Outlines of Chemical Technology by Dryden.
2. Chemical Technology by Sukla& Pandey.

Process Plant Design lab (CHP 013)

L:0 T:0 P:2 **CREDITS: 1**

Lab Outcomes:

After the successful completion of the course student should be able to:

1. Design basic chemical industry equipment's, with manual and computer aided software
2. Learn basic piping design and code
3. Work individual as well as in team.

List of Experiments:

1. Design of piping & piping networks.
2. Selection, specification & power requirements of process pumps, fans and blowers.
3. Design of settling equipments like Dor thickeners, dust chambers, cyclone separators and centrifuges.
4. Design of agitated vessels using various types of impellers.
5. Design of Conveyor system for solids.
6. Process design and specifications of double pipe heat exchanger, shell and tube heat exchanger, plate type heat exchanger, condenser and reboiler.
7. Design of distillation column, calculation of number of plates, height and design of fractionator internal sieve tray

Process modelling and simulation lab (CHP 014)

L:0 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVES:

To introduce students to use of software packages such as CHEMCAD/ASPEN/DWSIM, MATLAB, FLUENT/ for simulation, and also analysing flowsheets

COURSE OUTCOMES:

Students will be able to

1. Solve chemical engineering problems using advanced programming software
2. Use simulation software's like ASPEN/DWSIM/CHEMCAD.
3. Analyse the techno-economic feasibility of chemical manufacturing facility

List of Experiments

1. Introduction to process simulation software (Prediction of multicomponent VLE using Aspen, columndesign, rating, reactor balances).
2. Heat transfer: triple effect evaporator, STHE design.
3. Separation processes: Design of crystallizers, Distillation, Chromatography, spray dryers etc.
4. Design of multiphase reactors: stirred vessels, Bubble columns.
5. ASPEN/DWSIM simulation: azeotropic distillation, reactive distillation, column sizing.
6. Sensitivity analysis for processes.

CONSTITUTION OF INDIA (AHT-009)

L:T:P:: 2:0:0 **Credits-0**

COURSE OBJECTIVE:

1. To acquaint the students with legacies of constitutional development in India and help to understand the most diversified legal document of India and philosophy behind it.
2. To make students aware of the theoretical and functional aspects of the Indian Parliamentary System.
3. To channelize students' thinking towards basic understanding of the legal concepts and its implications for engineers.

COURSE OUTCOMES

The course should enable the students to:

1. Understand the basic knowledge and salient features of Indian Constitution.
2. Identify and explore the basic features and modalities about Indian constitution.
3. Discusses the essence of Union and its territories, Citizenship, Fundamental Rights, DPSP and Fundamental Duties.
4. Differentiate and relate the functioning of Indian parliamentary system at the center and state level.
5. Differentiate different aspects of Indian Legal System and its related bodies.

Unit-1 Constitutional Framework

Meaning of Terms and Phrases frequently used in political system like constitution, constitutionalism, Rule of Law, Federal system, Government and so on. Historical Background of Indian Constitution, Making of Indian Constitution, Salient features of Indian Constitution, Preamble of Indian Constitution.

Unit-2 Different Parts, Articles, and their significance

Part I to IVA (Union and its territories w.r.t. Indian States, Citizenship, Fundamental Rights conferred to citizens and foreigners, Directive Principles of State Policy– Its importance and implementation and Fundamental Duties and its legal status), Article 1 to 51A and their significance.

Unit-3 System of Government

Parliamentary Form of Government in India – The constitution powers and status of the President of India, Federal structure and distribution of legislative and financial powers between the Union and the States, Emergency Provisions: National Emergency, President Rule, Financial Emergency and Amendment of the Constitutional Powers and Procedure and the significance of basic structure in Indian Judicial system

Unit-4 Working of Central, State & Local Self Government as per constitution

Framework for central government (President, Vice president, Prime Minister, Central council of ministers, Parliament, Supreme court and so on), Framework for state government (Governor, Chief Minister, state legislature, High court and so on) and Framework for local self government (Panchayatiraj, Municipalities) and Union Territories.

Unit-5 Constitutional, Non-Constitutional and other bodies

Discussion on Various constitutional bodies like Election Commission, UPSC, SPSC, Finance commission, NCSC, NCST, NCBC, CAG and AGI. Discussion on Various non-constitutional bodies like NITI Aayog, NHRC, CIC, CVC, CBI, Lokpal and Lokayukta. Discussion on Various other constitutional bodies like Co- operative societies, Official Language, Tribunals etc.

Text/Reference books-

1. M. Laxmikanth, "Indian Polity", McGraw- Hill, 6th edition, 2020
2. D.D. Basu, "Introduction to the Indian Constitution", LexisNexis, 21st edition, 2020
3. S.C. Kashyap, " Constitution of India", Vitasta publishing Pvt. Ltd., 2019

ESSENCE OF INDIAN TRADITIONAL KNOWLEDGE (AHT-010)

L:T:P:: 2:0:0 **Credits-0**

COURSE OBJECTIVES:

The course should enable the students to:

1. To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the Importance of roots of knowledge system.
2. To make the students understand the traditional knowledge and analyse it and apply it to their day to day life.
3. To make the students know the need and importance of protecting traditional knowledge.
4. To make the students understand the concepts of Intellectual property to protect the traditional knowledge.
5. This course is also concentrating on various acts in protecting the environment and Knowledge management impact on various sectors in the economy development of the country.

COURSE OUTCOMES:

The course should enable the students to:

1. Understand the concept of Traditional knowledge and its importance.
2. Know the need and importance of protecting traditional knowledge.
3. Know the various enactments related to the protection of traditional knowledge.
4. Understand the concepts of Intellectual property to protect the traditional knowledge.
5. Know the contribution of scientists of different areas.

Unit – 1 Introduction to Traditional and Culture Knowledge

Define culture, traditional, civilization and heritage knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, the physical and social contexts in which traditional knowledge develop, the historical impact of social change on traditional knowledge systems. Indigenous Knowledge (IK). Indigenous traditional knowledge Vs western traditional knowledge vis-à-vis formal knowledge.

Unit-2 Protection of Traditional Knowledge

Protection of traditional knowledge: The need for protecting traditional knowledge Significance of traditional knowledge Protection, value of traditional knowledge in global economy, Role of Government to harness traditional knowledge.

Unit – 3 Traditional Knowledge and Intellectual Property

Systems of traditional knowledge protection, Legal concepts for the protection of traditional knowledge, Certain non IPR mechanisms of traditional knowledge protection, Patents and traditional knowledge, Strategies to increase protection of traditional knowledge, Global legal forums for increasing protection of Indian Traditional Knowledge.

Unit – 4 Traditional Knowledge in Different Sectors

Traditional knowledge in engineering, biotechnology and agriculture, traditional medicine system, Traditional societies depend on it for their food and healthcare needs, Importance of conservation and sustainable development of environment, Management of biodiversity, Food security of the country and protection of traditional knowledge.

Unit – 5 Education System in India

Education in ancient, medieval and modern India, aims of education, subjects, languages, Science and Scientists of Ancient India, Scientists of Medieval India, Scientists of Modern India. The role Gurukulas in Education System, Value based Education.

Text/Reference Books:

1. Traditional Knowledge System in India by Amit Jha Atlantic publishers, 2002.
2. "Knowledge Traditions and Practices of India" Kapil Kapoor1, Michel Danino2.
3. Traditional Knowledge System in India, by Amit Jha, 2009.
4. Satya Prakash, “Founders of Sciences in Ancient India”, Vijay Kumar Publisher, 1989
5. Traditional Knowledge System and Technology in India by Basanta Kumar Mohanta and Vipin Kumar Singh Pratibha Prakashan 2012.

Happiness and well being (AHT-014)

L:T:P:: 2:0:0 **Credits-0**

Course Objectives:

1. To obtain a basic understanding of Positive emotions, strengths and virtues; the concepts and determinants of happiness and well-being.
2. To bring an experience marked by predominance of positive emotions and informing them about emerging paradigm of Positive Psychology
3. Build relevant competencies for experiencing and sharing happiness as lived experience and its implication.
4. To become aware of contextual and cultural influences on health and happiness.

Course Outcomes:

1. This course provide an insight to see the importance of positive emotions, Strength and Virtues in everyday life and society.
2. It helps to use the strength and virtues in improving human behavior and mental health.
3. This course helps to understand the biological, social, psychological and spiritual determinants of Happiness and well-being.
4. This course throws light on research findings related to effects of happiness and well-being on mental illness and stress.
5. Give an insight of the Indian philosophy of happiness and life satisfaction in context of Karma, Moksha and destiny and role of socio-demographic and cultural factors in Happiness and well-being.
6. Helps in establishing work life balance in an individual's life.

UNIT I: Introduction to Positive Psychology

Importance of positive emotions in everyday life and society, Positive Emotions and well being: Hope & Optimism, Love. The Positive Psychology of Emotional Intelligence, Influence of Positive Emotions Strength and Virtues; implications for human behavior and mental health.

UNIT II: Happiness

Determinants of Happiness and well-being – biological, social, psychological and spiritual, Types of happiness- Eudaimonic and Hedonic, Traits associated with Happiness, Setting Goals for Life and Happiness, Research findings on effects of happiness and well-being on mental illness and stress.

UNIT III: Resilience and Well Being

Meaning, Nature and Approaches Theories of Resilience, Positive Response to loss, Post Traumatic Growth, Models of PTG as Outcome, Models of PTG as a Coping Strategy Benefit Finding, Mindfulness and Positive Thinking, Building Resilience and Wellbeing.

UNIT IV: Happiness and Well-being in the Indian context

Indian philosophy of happiness and life satisfaction. – Karma, Moksha and destiny. theory of happiness and wellbeing in Taittiriya Upanishad, Role of socio-demographic and cultural factors in Happiness and well-being. Health and Happiness in contemporary India – rural and

urban differences and similarities.

UNIT V: Positive work life

Employee engagement- what causes individuals to join an organization and why they stay or leave, person-centered approach to engagement Understand the concept of work as meaning, Impact of employee well-being on the organization and impact of feelings about work on the individual's well-being. Bringing Positive Psychology to Organizational Psychology

SUGGESTED READINGS:

- Dandekar, R. N. (1963). On dharma. In De Bary (ed.) Sources of Indian Tradition. Delhi, India: Motilal Banarasidass Publishers.
- Dandekar R. N. (1981). Exercises in Indology. Delhi, India: Ajanta Publishers.
- Snyder, C.R., &Lopez,S.J.(2007). Positive psychology: The scientific and practical explorations of human strengths. Thousand Oaks, CA: Sage. Snyder, C. R., & Lopez, S. (Eds.). (2002). Handbook of positive psychology. New York: Oxford University Press.
- Seligman, M. (2011). Flourish: A Visionary New Understanding of Happiness and Well-being, Atria Books.
- Peterson, C. A. (2006). A Primer in Positive Psychology, Oxford University Press.
- Nettle, D.S. (2006). Happiness: The Science Behind Your Smile, Oxford University Press.
- Lyubomirsky, S. (2013). The Myths of Happiness: What Should Make You Happy, but Doesn't, What Shouldn't Make You Happy, but Does, Penguin

Open Elective

INDUSTRIAL SAFETY AND HAZARD MANAGEMENT (AHT-013)

L:T:P: 3:0:0 **Credits 3**

Course Objective

The course should enable the students to:

1. To impart knowledge about various aspects of industrial safety and occupational health.
2. To impart knowledge aboutOccupational Health and Toxicology.
3. To enable the students to identity hazard and assess risk.
4. To understand Acts and Rules of industrial safety and hazard management.
5. To teach about various safety acts and rules along with safety education and training.

Course Outcomes

Upon successful completion of the course, the student will be able to:

1. Identify the key aspects of industrial safety and mitigating them.
2. Describe various types of solution to problems arising in safety operations and hygiene.
3.Apply principles of OSHA in controlling industrial disasters and losses.
4. Identify various Acts and Rules of industrial safety and hazard management.
5. Assess the overall performance of safety protocols of chemical industries and hazard management.

Course Content

Unit I **(08 hours)**

Concepts and Techniques: History of safety movement -Evolution of modern safety concept - Incident Recall Technique (IRT), disaster control, safety analysis, safety survey,safety inspection, safety sampling. Safety Audits - components of safety audit, types of audit,audit methodology, non - conformity reporting (NCR), audit checklist- identification of unsafe acts of workers and unsafe conditions in the industry.

Unit II **(08 hours)**

Occupational Health and Toxicology: Concept and spectrum of health, functional units and activities of occupational health services, occupational related diseases and levels of prevention of diseases. Toxicology- local, systemic and chronic effects, temporary and cumulative effects, carcinogens entry into human systems.

Unit III **(08 hours)**

Hazard Identification and Risk Assessment: The process of risk management, hazard identification, evaluation (risk assessment, risk matrix), risk control implementation, action and recommendation.

Unit IV **(08 hours)**

Acts and Rules: Indian boiler Act 1923, static and mobile pressure vessel rules (SMPV). motor vehicle rules, mines act 1952, workman compensation act, rules - electricity act and rules - hazardous wastes (management and handing) rules, 1989, with amendments in 2000 the building and other construction workers act 1996, Petroleum rules, Explosives Act 1963 Pesticides Act. Factories Act 1948 Air Act 1981 and Water Act 1974.

Unit IV **(08 hours)**

Safety Education and Training: importance of training - identification of training needs training methods - programmes, seminars, conferences, competitions - method of promoting sale practice motivation communication - role of government agencies and private consulting agencies in safety training creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign - domestic Safety and Training.

Books and References

1. Industrial Accident Prevention by H.W Heinrich, McGraw - Hi 1980.
2. Safety Management in industry by NV. Krishnan, Jaico Publishing House, Bombay, 1997.
3. Loss Prevention in Process Industries by FP Lees, Butterworth London, 1990.
4. Safety at Work by J.R. Ridey Butterwort London 1983.

Open Elective-I

Renewable Energy Technology and its Challenges (CHT013)

L:3 T:0 P:0 **CREDITS:3**

Course Objective: To give the students an understanding about renewable energy such as Hydrogen, Biomass, Solar and Tidal energy.

Course Outcome:

After successful completion of course students will be able to:

1. Understand the energy demand and resources to fulfil the demand.
2. To study hydrogen energy and its application
3. To study biomass and its conversion process.
4. Study tidal Geothermal and hydroelectrical energy application.
5. Explain solar energy and its types and application.

Course Details:

UNIT-I (8 hours)

Introduction:Introduction (world energy status, current energy scenario in India, environmental aspects of energy utilization, energy and sustainable development; Solar energy (basic concepts, flat plate and concentrating collectors, solar desalination, solar pumping, solar photo voltaic conversion, solar cells).

UNIT-II (8 hours)

Hydrogen energy:Wind energy (availability, wind power plants, wind energy conversion systems, site characteristics, types of wind turbines); Energy from biomass (biomass resources, biomass conversion technologies Hydrogen energy, and its storage challenges, Types of hydrogen storage techniques, hydrogen fuel and its challenges, application of hydrogen in PEM Fuel cell.

UNIT-III (9hours)

Biomass:Biomass gasification, gasification chemistry, reaction stages, conversion of biomass to liquid fuels and chemicals via the Fischer–Tropsch synthesis route, biomass to liquids (BTL), syngas derived from biomass, conversion of syngas to alcohols, Biomass pyrolysis, reactor and process technologies.

UNIT-IV (9 hours)

Other Renewable Sources:Hydrothermal processing of biomass, hydrothermal liquefaction, Tidal energy and conversion process, geothermal energy and its application hydroelectric plants.

UNIT-V (8 hours)

Solar energy:Application of solar energy, types of solar materials, application of nanomaterial in solar energy,

DSSC and its types, challenges of solar energy, performance measurement of solar cell

Text Books:

Brame J.S.S. and King J.G., Edward Arnold “Fuel Solid, Liquid and Gases” Edward Arnold, 1967.

References

Sukhatme S.P, "Solar Energy - Principles of Thermal Collection and Storage",2nd Ed., Tata McGraw- Hill, 1996.

Open Elective-I

Polymer Science and Engineering (CHT014)

L:3 T:0 P:0 **CREDITS: 3**

Course Objective: To introduce fundamentals of synthesis, characterization, properties and also include discussion on the applications of polymers.

Course Outcome:

After successful completion of course students will be able to:

Connect properties of polymeric materials to their structures and explain how different material parameters and external factors affect the mechanical properties

Correlate structure-processing-properties relationships for polymers, blends and composites

Select a suitable processing and manufacturing technique for a given polymer.

Identify methods for rheological measurements and analysis of the rheological data using models for polymeric material

Understand different polymer manufacturing methods

COURSE DETAILS:

UNIT-I (8 hours)

Classification of polymers: Natural and synthetic polymers; Thermosets and thermoplasts; Copolymers; Terpolymers; Degradable and non-degradable polymers.Additionpolymerization; Condensation polymerization; Ring opening polymerization; Copolymerization; Polymerization by coordination catalyst; Molecular weight distribution of polymers.

UNIT – II (6 hours)

Manufacturing processes of important polymers: Plastics-polyethylene; polypropylene, polyvinyl chloride and copolymers, polystyrene; phenol-formaldehyde, epoxides; urethane; Teflon; Rubbers and elastomers; Fibres - cellulosic (rayon), polyamides (6;6 Nylon), polyesters (Dacron), acrylic; Polymeric oils. Micro-structure of polymer chains: Configuration and conformation; Simple and hindered rotation; End-to-end distances;

UNIT – III (6 hours)

Crystallinity and melting; Glass transition temperature; Physical states of polymers and mode of motion of polymer

chains; Measurement of viscosity; Cohesive energy density; Compatibility and solubility parameters; Polymer additives, blends and composites. Flow properties of polymers: Bulk deformation, elongational and shear flow; Non-Newtonian flow.

UNIT – IV (10 hours)

Polymer fabrication techniques: Formation of flat sheets and films; Laminations; Foam formation; Extrusion, injection molding, blow molding, compression and transfer molding; Spinning of fibres.

UNIT – V (10 hours)

Mechanical properties of polymers: Rheology of polymers; Rubber elasticity; Visco-elasticity; Creep and stress relaxation; Dynamic behavior; Stress and fracture of rubber and glassy polymers. Polymer degradation. Conducting polymers; Smart polymers, Ecology and environmental aspects of polymer industries.

Text Book:

1. Fried, J.R., “Polymer Science and Technology”, Prentice Hall, Inc, 2nd Ed., 2003.

References

McCrum, N.G., Buckley, C.P. and Bucknall, C.B., “Principles of Polymer Engineering”,

Oxford University Press, 2nd Ed., 2009.

Tadmore, , and Gogvs, C.G., “Principles of Polymer Processing” John Wily & Sons.

Billmeyer, F.W., “Text Book of Polymer Science”, John Wiley & Sons, 3rd Ed., 2002.

Open Elective-I

Industrial Safety (CHT015)

L:3 T:0 P:0 **CREDITS: 3**

COURSE OBJECTIVES:

This course also emphasis on the knowledge of loss prevention, personal safety, industrial safety, hazard analysis, toxicology and personal proactive equipment's.

COURSE OUTCOME:

On completion of this course, the students will be able to...

Types, sources and characteristics of safety data and their integration for organization-wide safety centric data model, safety related decision making.

Safety data visualization and exploration, safety performance evaluation and monitoring, safety predictive models,

Evaluate and apply the various risk assessment methods in industries.

To evaluate the hazard analysis for different industries using HAZOP.

To studies numerous case study related to hazardous industries.

COURSE DETAILS

UNIT-I (8 hours)

Introduction: History of safety movement; Development of safety programmes in process industry. Accident causation: Heinrich-Domino theory; Human error model; Petersen's accident/ incident model; Epidemiological models; System models; Multiple causation.

UNIT-II (8 hours)

Safety Management:Systems safety management: Management task; Managerial roles and skills; Management by objective.

UNIT-III (9 hours)

Hazard Analysis & Risk Management:Hazard: Identification; Occupational hazard; Preliminary hazard analysis; Hazard and operability review (HAZOP) Hazard control: Engineering and management controls; Fault tree analysis; Risk analysis and management.

UNIT-IV (9 hours)

Fire Prevention & Protection:Fire prevention and protection: Chemistry of fire; Production of fire; Fire development; Severity and duration; Effect of enclosure and heat transfer. Industrial hygiene; Routes of entry of

foreign substance; Long term medical disorders and epidemiology; Stress and the workplace

UNIT-V (8 hours)

Industrial Hygiene & Case Studies:Industrial noise; Hazardous waste. Case studies of safety and hazard assessment in different industries; Disaster management planning; Insurance tariffs in hazardous industries; Design for safety, maintenance and fault diagnosis.

Text Book:

Crowl, D.A. and Louvar, J.F., "Chemical Process Safety: Fundamentals with Applications", Prentice Hall, Inc, 2nd Ed., 2010

References Book:

Wills, G.L., "Safety in Process",

Lees, F.P., "Loss Prevention in Process Industries, Volume I & II", Butterworth Heinemann. 2nd Ed., 1995.

Pandey, C.G., "Hazards in Chemical Units: A Study", Oxford IBH Publishing Co., New Delhi.

VEER MADHO SINGH BHANDARI UTTARAKHAND TECHNICALUNIVERSITY

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SYLLABUS

For

B.TECH

(Chemical Engineering)

4TH Year

Effective From – Session 2025-26

SEMESTER-VII													
S. N.	**Subject Codes**	**Category**	**Subject**	**Periods**			**Evaluation Scheme**					**Subject Total**	**Credit**
							Sessional Exam			**ESE**			
				L	**T**	**P**	**CT**	**TA**	**Total**	**TE**	**PE**		
1	AHT014/AHT015	HSC	HSMC -1 / HSMC-2	3	1	0	30	20	50	100		150	3
2		DE	Departmental Elective-4	3	0	0	30	20	50	100		150	3
3		DE	Departmental Elective-5	3	0	0	30	20	50	100		150	3
4		OE	Open Elective-2	3	0	0	30	20	50	100		150	3
5	CHP 016	DLC	Project Seminar	0	0	2			50			50	1
6	CHP 017	DLC	Design Project	0	0	4			100			100	2
7	CHP 018	DLC	Mini Project-III or Internship-III*	0	0	2			50			50	1
8	AHT 017	MC	Disaster Management	3	0	0		50	50			100	3
9	AHT 018	NC	Innovations and Problem Solving	2	0	0	15	10	25	50			0
10	GP07	NC	General proficiency						50				
			Total	**12**	**1**	**12**						**900**	**19**
11			Minor course (Optional)	3	1	0	30	20	50	100			**4**
*The Internship-III (4-6 weeks) conducted during summer break after VI semester and will be assessed during VII semester													
MOOCs course													

Department Electives IV		**Department Electives-V**	
CHT 513	Process Equipment Design	CHT 517	Nanotechnology for Chemical Engineering
CHT 514	Industrial Pollution abatement and waste management	CHT 518	Hazardous Waste Management
CHT 515	Heterogeneous catalysis and catalytic reactors	CHT 519	Advance Separation Technique
CHT 516	Plant Design & Economics	CHT 520	Process Utility & Safety

Open elective - II	
CHT016	Operations Management
CHT017	Project Management
CHT018	Intellectual property rights & Standardization

SEMESTER-VIII													
S.N.	Subject Codes	Category	Subject	Periods			Evaluation Scheme					Subject Total	Credit
							Sessional Exam			ESE			
				L	T	P	CT	TA	Total	TE	PE		
1	AHT015/AHT014	HSC	HSMC-2 /HSMC-1	3	0	0	30	20	50	100		150	3
2		DE	Departmental Elective-6	3	0	0	30	20	50	100		150	3
3		OE	Open Elective-3	3	0	0	30	20	50	100		150	3
4		OE	Open Elective-4	3	0	0	30	20	50	100		150	3
5	CHP 019	DLC	Project	0	0	12			100		200	300	6
6	GP08	NC	General proficiency						50				
			Total	**12**	**0**	**14**						**900**	**18**
7			Minor course (Optional)	3	1	0	30	20	50	100			**4**
MOOCs course													

Department Elective VI	
CHT 521	Quality Assurance & Control
CHT 522	Chemical Engineering Design, Drawing and Operations
CHT 523	Computational Fluid Dynamics
CHT 524	Process Integration

Open elective - III		**Open elective - IV**	
CHT019	Research Methodology	CHT022	Optimization Techniques
CHT020	Design of Experiments	CHT023	Quality Assurance & Control
CHT021	Process Utilities & Safety	CHT024	Industrial Pollution abatement and waste management

Process Equipment Design (CHT513)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVES

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.

COURSE OUTCOMES

After successful completion of the course the students will be able to:

Understand the basics of process equipment design and important parameters of equipment design

To design internal pressure vessels and external pressure vessels

To design special heat transfer and mass transfer equipment's.

To design Mechanical equipment and their various components.

To design Liquid storage tanks and its components by using adequate software.

COURSE DETAILS

UNIT-I (8 hours)

Introduction: Introduction to various mechanical properties of materials to be used as material of construction, resistance of metals to corrosion under varying conditions of temperature and pressure etc. Application and use of various codes and standards in design.

UNIT-II (10 hours)

Basic Geometries for Design:Design of non-pressure storage vessel, tall vertical vessels, unfired pressure vessels with internal pressure, Design of unfired pressure vessels with external pressures, end closures, flat plates, domed ends, torispherical, ellipsoidal, hemispherical and conical ends.

UNIT-III (10 hours)

Chemical Engineering Equipment's:Design of nozzles, openings and reinforcements, Bolts, flanges, gaskets. Bolted flanges, pipe line design and process design of a few equipments like heat exchangers, Evaporators, Distillation columns, Absorbers, Reactors and Dryers.

UNIT-IV (9 hours)

Mechanical Design:Mechanical design of selected process equipments such as heat exchangers, Evaporators, Distillation columns, Absorbers, Reactors and Dryers and Crystallizers.

UNIT-V (8 hours)

Practical Applications:Liquid storage tanks: Storage tank codes; Classification; Design of shell, bottom plates, self-supported, and column supported roofs. Use of software (Chem CAD and Pro Sim) for design of equipment.

Text Book:

Coulson, J. M. and Richardson J. F. “Chemical Engineering, Vol. 6” Pargamon Press. 1989.

Reference

Peters Max. S., Timmerhaus Klaus D.and Ronald E West “Plant Design and Economics for Chemical Engineers”, 5th Ed. McGraw Hill, 2003.

Brownel and Young, “Process Equipment Design ”, Wiley, 1968.

Indian and American Codes Used in Designing of equipments (TEMA and IS Codes)

Evans, F. L., “Equipment Design Handbook”, Gulf Publishing Company, 1979.

Industrial Pollution Abatement and Waste Management (CHT514)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVE: The aim of this course is that the students will learn the essential principles used in industrial pollution abatement and understand important issues in industrial pollution abatement and pertinent environmental legislations.

COURSE OUTCOME:

On completion of this course, the students will be able to:

1. Understand the different types of wastes generated in an industry, their effects on living and non-living things.
2. Understand environmental regulatory legislations and their sources.
3. To study solid waste and their treatments methods.
4. To understand the different process involved in industrial waste water treatment.
5. To evaluate atmospheric dispersion of air pollutants, operating principles, and design calculations of particulate control devices.

COURSE DETAILS

UNIT-I (8 hours)

Introduction: Introduction (types of pollution, water standards for potable and agricultural streams, air standards)

UNIT-II (8 hours)

Air & Water pollution:Air pollution - air pollutants and interaction products, preventive and control measures; Water pollution-waste water sampling and analysis, primary, secondary and tertiary treatment methods

UNIT-III (9 hours)

Solid waste management: Solid waste management- collection, storage and transport, processing and transformation, incineration, composting and sanitary land filling;

UNIT-IV (10 hours)

Waste Water Treatment:Pollution control in chemical process industry. Desalination and Water Purification, Cellular Garbage Disposal, Biological Treatment of Wastewater: Activated Sludge Process, Anaerobic treatment processes, Bio filters for biological odor control.

UNIT-V (9 hours)

Industrial Waste Water Treatment:Pulp & Paper Industry, Sugar Industry, Iron and steel Industry, Textile Industry, Coal-based Thermal Power Plants, Aluminum smelter, Cement industry, Battery industry.

Text Book:

Peavy, H.S., Rowe D.R. and Tchobanoglous, G., “Environmental Engineering”, McGraw-

Hill Book Co., New Delhi, 5th Ed., 2003.

References:

Metcalf &Eddy, Inc., “Waste Water Engineering-Treatment, Disposal, Reuse”, Mcgraw-Hill, Inc., 4thEd., 2003.

Nevers, Noel de, “Air Pollution Control Engineering”, McGraw-Hill, Inc.

“Pollution Control Acts, Rules and Notifications”, CPCB, Delhi. 1995.

Conway R.A. & Ross R.D., “Handbook of Industrial Waste Disposal”, Van-Nostrand Reinhold, 1980.

Kreith F. and Tchobanoglous G., “Handbook of Solid Waste Management”, Mc Graw Hill, 2nd Ed., 2002.

Heterogenous Catalysis and Catalytic Reactors (CHT515)

L:3T:0P:0 **CREDITS:3**

COURSE OBJECTIVES: This course examines the detailed structures, preparation methods and reactivities of solid catalysts like zeolites, solid state inorganics, supported metals and metal-support interactions, carbon catalysts, anchored catalysts and others. Several important catalyst properties and their determination techniques such as surface area and pore size measurements, temperature Programmed desorption (TPD), acidity and various spectroscopic techniques used in surface science such as X-ray photoelectron spectroscopy (ESCA), electron microprobe, scanning electron microscopy, Fourier-transform infrared, enhanced laser Raman spectroscopy will be described for characterization of the catalytic surfaces.

COURSE OUTCOME:

On completion of this course, the students will be able to

1. Explain various types of catalyst and their kinetic models.

2. Study of synthesis and characterization of catalysts.

3. To synthesis of zeolite catalyst and their application in modern industry.

4.To study commercial reactor and their application in petroleum industries.

5. To detail study of catalyst use in modern renewable technologies.

COURSE DETAILS

UNIT-I (8 hours)

Introduction: Introduction to basic concepts Acid-base catalysis Application of catalyst functionality concepts for control of reaction selectivity and kinetic models Steps in catalytic reaction (Adsorption, Kinetic models, interparticle and intraparticle transport process

UNIT-II (8 hours)

Design and characterization:Selection and design of catalysts Preparation and characterization of catalysts Properties of catalysts Catalyst deactivation various deactivation model.

UNIT-III (8 hours)

Zeolites catalyst:Application of functionality concepts for control of reaction selectivity and kinetic models Zeolites their application Preparation and characterization of various Zeolite catalysts

UNIT-IV (8 hours)

Commercial Reactors:Commercial Reactors (Adiabatic, fluidized bed, trickle bed, slurry etc.) Industrially important catalysts and processes such oxidation, processing of petroleum and hydrocarbons, synthesis gas and related processes

UNIT-V (8 hours)

Application of catalyst:Application of catalyst in renewable energies such hydrogen storage, fuel cell application, bio-refinery

Text Book:

Catalytic Chemistry: Bruce Gates

Reference

Optimal distribution of catalyst in a pellet: Morbidelli and Verma

Catalysis of Organic reactions: editor M.E.Ford, Marcel Dekker Inc.

Heterogeneous Reactions Vol 1 and Vol II : M. M. Sharma and Doraiswamy

Principles and practice of heterogeneous Catalysis: Thomas, J.M., Thomas W.J

Plant Design and Economics (CHT516)

L:3T:0P:0 **CREDITS:3**

COURSE OBJECTIVE: Studying this subject the students will learn about manufacturing a product, costing and finally optimization its tools.

COURSE OUTCOME:

On completion of this course, the students will be able to

To study all types of plants details such as Plant Design, layout, safety operation.

To evaluate cost of a process and depreciation.

To calculate all types of cost, its important types and application in process industries.

To develop skills to apply optimization and its tools in process plant.

To apply optimization techniques design and compare selected major chemical engineering equipment e.g., distillation, reactor, heat exchanger and absorption.

COURSE DETAILS

UNIT-I (8 hours)

Process Development:Process selection, study of alternative processes, pilot plant, scale up methods, Flow sheet preparation, sketching techniques, Equipment numbering, Stream designation, Material and energy balances.Plant Design: Design basis, Process Selection, Selection of equipment, specification and design of equipment's, material of construction, Plant location, Plant layout and installation, Safety, Start up, Shutdown and Operating guidelines.

UNIT-II (8 hours)

Cost Engineering:Time value of money and equivalence, Interest, cost comparisons by present worth, Annual equivalent cost and capitalized cost methods, Uniform gradient and series. Depreciation, Taxes and Insurances Nature of depreciation, Methods of determining depreciation, depreciation rates in current Indian situation, Types of taxes and insurance's, Procedure for cost comparison after taxes.

UNIT-III (10 hours)

Cost Estimation:Types of cost estimation, capital investment cost, fixed capital cost, working capital cost, start-up costs, process equipment cost estimation, cost index, Equipment costs due to inflation, Battery limit investments, estimation of plant cost, Estimation of total product cost, Manufacturing cost, General expenses.Profitability: Criteria of profitability, Pay-out period, Return on investment, Present value, Cash flow analysis, Alternative investment analysis, Sensitive analysis in project profitability.

UNIT-IV (8 hours)

Economic Optimization and Optimum Design:Nature of optimisation, Uni-variable and multivariable systems, Analytical, graphical and incremental methods of solution, LaGrange multiplier method, Linear programming and dynamic programming establishing optimum conditions, Break even chart for production schedule, Optimum production rates in plant operation, Optimum conditions in batch, cyclic and semi-cyclic operation, Sensitivity and response analysis.

UNIT-V (8 hours)

Optimization of Different Process Equipment:Transportation systems, heat exchangers, evaporators, mass transfer equipments and reactors. Determination of height and diameter of different process equipments at conditions of optimum cost. Pinch Technology analysis. Preparation of techno-economic feasibility report.

Text Book

Peters M., Timmerhaus K. & Ronald W., "Plant Design & Economics for Chemical Engineers", McGraw Hill, 5th Ed., 2003.

References Book

Couper, J. R., "Process Engg. Economics (Chemical Industries)" CRC Press, 4th Ed. 1998.

Aries & Newton, "Chemical Engg. Cost Estimation", McGraw Hill, 4th Ed., 1998.

Nanotechnology for Chemical Engineering (CHT517)

L:3T:0P:0 **CREDITS:3**

COURSE OBJECTIVE: To introduce the application of nanotechnology in the area of Chemical engineering.

COURSE OUTCOMES:

On completion of this course, the students will be able to

1. Understanding basics and scale of nanotechnology.
2. Basic methodologies of synthesis of nanoparticles.
3. Application of Nanotechnology in Heat Transfer.
4. Application of Nanotechnology in Solar Energy.
5. Application of Nanotechnology in Oil and Gas industries.

COURSE DETAILS:

UNIT-I (8 hours)

Introduction:Basics and scale of nanotechnology, different classes of nanomaterials, synthesis of nanomaterials, fabrication, and characterization of nanostructures, applications. Nanofluids: Preparation Methods and Challenges in Stability, Thermophysical Properties.

UNIT-II (8 hours)

Theoretical Perspectives:Size effects on structure and morphology of nanoparticles, phase transition in nanocrystals, features of nanoscale growth, supercritical fluid and cryo chemistry of metal nanoparticle, synthesis of nanoparticles. Nanofluids: Synthesis and Flow behaviour in Ducts with Various Shapes, Viscosity of Nanofluid Systems.

UNIT-III (8 hours)

Nanotechnology in Thermal Applications:Application of Nanotechnology in Heat Transfer, Enhancement of Refrigeration Systems, Graphene-Based Hybrid Nanofluids and Its Application in Heat Exchangers

UNIT-IV (10 hours)

Nanotechnology in Solar Applications: An Insight of nano fluids Flow and Heat Transfer behavior for Solar Energy Applications, Nano fluid-Based Direct Absorption Solar Collectors, Applications of Nano fluids in Solar Thermal Systems, Nano fluids for Solar Steam Generation,

UNIT-V (8 hours)

Nanotechnology in Oil and Gas Industry:Application of Nanotechnology in Enhanced Oil Recovery industries. Future for Oil and Gas Industry, CO2 Capture via Nanofluids.

Text Books:

Nanofluids and Their Engineering Applications, By K.R.V. Subramanian, Tubati Nageswara Rao, Avinash Balakrishnan, CRC Press, 2021

Nanofluids: Science and Technology, Sarit K. Das, Stephen U. S. Choi, Wenhua Yu, T. Pradeep, John Wiley & Sons, Inc. 2008

Introduction to nano: basics to nanoscience and nanotechnology, Sengupta, Amretashis; Sarkar, Chandan Kumar., SpringerLink, 2015

References Book

Nanotechnology, the brain, and the future by Hays, Sean A., SpringerLink, 2013

Hazardous waste management (CHT518)

L:3T:0P:0 **CREDITS: 3**

COURSE OBJECTIVES: This course introduces fundamental concepts in different hazards, their management and their importance in Chemical Industries. This course also emphasis on the knowledge of waste minimization.

COURSE OUTCOMES:

After the successful completion of the course student should be able to...

1. To study Hazardous wastes, and board classification of Hazardous wastes and non- Hazardous wastes.
2. To examine different treatment process of non-hazardous wastes.
3. To studies different treatment process of hazardous waste.
4. To evaluate risk assessment, waste minimization and biomedical waste and its treatment.
5. Ability to familiarize with case study with respect to air, water and solid waste.

COURSE DETAILS:

UNIT-I (8 hours)

Introduction: Characterization: Introduction to Hazardous wastes, Definition of Hazardous waste, The magnitude of the problem. Characterization of industrial wastes; hazardous and non-hazardous wastes. Waste disposal and management laws and guidelines.

UNIT-II (8 hours)

Non-hazardous Waste Management:Non-hazardous Waste Management: Non-hazardous industrial wastes-treatment, disposal, utilization and management. Thermal gasification, combustion and landfill.

UNIT-III (9 hours)

Hazardous Waste Management:Hazardous Waste Management: Hazardous wastes – handling, storage. Treatment and disposal methods: Physico-chemical and biological, stabilization and solidification, thermal methods, land disposal, Waste site remediation and clean-up technologies. Wastes from electroplating, lead batteries/cells, soldering and electro winning operations,

UNIT-IV (9 hours)

Risk Assessment & Management:Risk assessment, Environmental legislation, Dose-response assessment, exposure assement, Waste minimisation and Value-extraction from the wastes. Medical / biomedical and infectious waste management;

UNIT-V (8 hours)

Case Studies:Case Studies: Case studies of a few real scenarios of hazardous waste management in industries. Wastes from refineries and petrochemical units. Ground water contamination. Transportation of hazardous waste.

Text Books:

1. Shah K. L., "Basics of Solid and Hazardous Waste Management Techniques", Prentice Hall.1999
2. Tedder D. W. &Pohland F. G. (Editors), "Emerging Technologies in Hazardous Waste Management", ACS.1990

References:

1. Conway R. A. & Ross R. D., "Handbook of Industrial Waste Disposal", Van-NostrandReinhold.1980
2. Side G. W., "Hazardous Materials and Hazardous Waste Management", John Wiley,1993
3. Pichtel J., "Waste Management Practices: Municipal, Hazardous and Industrial", CRC.2005

Reference link

NPTEL video lectures

Advance Separation Technique (CHT519)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVES: This subject aims to extend your knowledge of basic fluid separation processes to more complex systems commonly encountered in the chemical processing industry.

COURSE OUTCOMES:

On completion of this course, the students will be able to

1. Understand the principles of separation processes.
2. Utilize mass transfer concepts for separation systems.
3. Discuss and explain the basics of separation process and its application
4. Perform design calculations for advanced separation processes.
5. Analyse and use the concept of modern separation techniques in various applications.

COURSE DETAILS

UNIT-I (8 hours)

Introduction: Principle of advance separations process; Classification, characterization. Types and choice of membranes, their merits and demerits. Laboratory membrane permeators. Commercial & pilot plant.

UNIT-II (8 hours)

Membrane based separation processes, Modelling and Economics: Ultra-Filtration, Reverse osmosis, Micro-filtration, Nano-filtration and Dialysis.Analysis and modelling of membrane separation processes; Economics of Membrane operations. Preparation of membranes.

UNIT-III (9 hours)

Mechanisms of various membrane separation processes:Membrane modules and application; Ion selective membranes and their application in electro-dialysis; Pervaporation and gas separation using membranes; Electrophoresis; Liquid membranes and its industrial applications.

UNIT-IV (9 hours)

Industrial Applications:Foam and bubble separation: Principle; Classification; Separation techniques; Column operations. Zone melting, zone refining and zone leveling. Pressure and temperature swing adsorption.

UNIT-V (8 hours)

Cryogenic & Super- critical separation:Cryogenic separation; Super- critical extraction. Parametric pumping: Batch, continuous and semi-continuous pumping; Thermal, pH and heatless parametric pumping. Multicomponent separation.

Text Books:

1. Seader, J.D, and Henley E.J., “Separation Process Principles”, John Wiley & Sons, Inc.
2. Handbook of Separation Process Technology by R W Rousseau (John Wiley & Sons).
3. Supercritical FluidExtraction by M A Mchugh& V J Krukonis (Butterworth Heinmann).
4. Large Scale Adsorption & Chromatography by W C Wankat (CRC Press Inc).Advanced Membrane Technology and Applications by N N Li (Wiley).

References:

1. King, C.J., “Separation Processes”, McGraw-Hill, Inc.

2. H. M. Schoen, " New Chemical Engineering Separation Techniques", Inter Science Publications, New York, 1972.

3. C. Loeb and R. E. Lacey, "Industrial Processing with Membranes", Wiley InterScience, 1972.

Process Utility and Safety (CHT520)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVE: This course introduces fundamental concepts in process utilities and their importance in Chemical Industries. This course also emphasis on the knowledge of loss prevention, and safety of operation.

COURSE OUTCOME:

On completion of this course, the students will be able to

1. Explain and select the importance of process utilities in chemical industries.
2. Discuss water as a utility in process industry and explain conservation and recycle of water, cooling water and spray pond.
3. Examine the importance of steam in various utilities, discuss and characterize boiler, steam engine, fire and safety in chemical industry.
4. Define safety elements of safety in process plants.
5. To study prevention of hazardous in process plants.

COURSE DETAILS:

UNIT-I (8 hours)

Introduction: Various process utilities, their role and importance in chemical plants. Sources of water and their characteristics; Treatment storage and distribution of water; water for use in boilers, cooling purposes, drinking and process; Reuse and conservation of water; Water resource management.

UNIT-II (8 hours)

Steam Generation and Utilization: Steam Generation and Utilization: Steam generation and its application in chemical process plants, distribution and utilization; Design of efficient steam heating systems; steam economy, Steam condensers and condensate utilization Expansion joints, flash tank design, steam traps their characteristics, selection and application, waste heat utilization; Lagging, selection and thickness

UNIT-III (8 hours)

Boiler and their subcomponents:Selection and sizing of boilers; waste heat boilers. Compressors, blowers and Vacuum Pumps: Compressors, blowers and vacuum pumps and their performance characteristics.

UNIT-IV (9 hours)

Elements of Safety:Elements of Safety: Elements of safety, safety and site selection; Plant layout and unit plot planning; Definition of risk and hazard, Identification and assessment of the hazards, distinction between hazards and risk, Hazard operability (HAZOP) hazard analysis (HAZAN);Assessment of the risk, fault tree, event tree, scope of risk assessment; Control ofhazards, controlling toxic chemicals and controlling flammable materials.Prevention of losses: Prevention of losses, Pressure relief, Provision of firefighting equipments, Technology selection and transfer, Choosing the right process.

UNIT-V (9 hours)

Control of Process:Control of Process:Control of process, Prevention of hazardous deviation in process variables, e.g. pressure, temperature flow by provision of automatic control systems- interlocks, alarms, trips together with good operating practices and management.Regulations: Regulations and legislation, Role of government role, risk management routines and tackling disaster

Text Books

1. Nordell, Eskel, “Water Treatment for Industrial and Other Uses”, Reinhold Publishing Corporation, New York., 1961.
2. Crowl, D.A. &Louvar, J.F. “Chemical Process Safety: Fundamentals with Applications”. New Jersey: Prentice-Hall.(1989).
3. Goodall, P. M., “The Efficient Use Of Steam” IPC Science and Technology, 1980.

Reference Books

4. Lees, F. P., “Loss Prevention in Process Industries 3 volume set” Butterwort - Heinemann, Oxford, 1996.
5. Kellogg, M. W Company., “Design of Piping Systems”, Pullman Power Products, New York, 1976.

Project Seminar (CHP016)

L:0 T:0 P:2 **Credits:1**

COURSE OBJECTIVE: To give the students' knowledge and practice for presentation skills on various Chemical Engg. topics

COURSE OUTCOME:

At the end of the course, students will demonstrate the ability to

1. Perform task as team and individual.
2. Perform basic presentation skills
3. Perform basic calculations and writing skill
4. Communicate in technical language
5. Explore new research areas in Chemical Engg., field.

List of Experiments:

1. Basic calculations for Chemical Engg. Equipments
2. Presentation on new and emerging fields in Chemical Engg.
3. Report writing on various topics.

DESIGN PROJECT (CHP 017)

L:0 T:0 P:4 **Credits:2**

COURSE OBJECTIVE: To give the students an understanding the fundamentals concepts of basic design approach of chemical engineering equipments.

COURSE OUTCOME:

At the end of the course, students will demonstrate the ability to

1. To design a packed bed column and examine effect of packing.
2. To study role of catalyst in biomass conversion or fuel cell. Finally design a catalyst in laboratory scale. Choose appropriate physical systems, mathematical models and solvers to design chemical engineering equipments
3. To study overall plant layout with the help of software.
4. Understand the practical issues in design of distillation column with the Modern Design software's.
5. Design waste water treatment system experiment by well-known processes.

List of Experiments:

1. Process of column design and specific role of packing making material in column design. Finally design a prototype for laboratory scale.
2. Design a heterogeneous catalyst for bio-mass conversion or fuel cell or any other process.
3. Design overall plant layout with help of software.
4. To study extraction of chemical compounds from natural plants.
5. To study a Mathematical program for the design of distillation columns for binary mixtures and the diameter and cost calculations.
6. Design experiments for Waste water treatment by well know process.

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Mini project-III or Internship-III (CHP 018)

L:0 T:0 P:2 **CREDITS: 1**

COURSE OBJECTIVES

To inculcate research attitude among ststudents.

To develop presentation skills.

LAB OUTCOME

On completion of this course, the students will be able to:

1. Understand and workout the project problem.
2. Gain experience to make a project report.
3. Acquire the necessary confidence to carry out projects in Chemical Engg. domain.

COURSE DETAILS

The student jointly or individually is required to prepare a project report based on experimental or theoretical research work The key features such as literature survey, Problem formulation, solving methodologies and future aspects of industries are the major necessities of the report under the supervision of a guide.

The project report is to be submitted by the end of the semester and the work will be assessed based on the report and the presentation of the work.

The assessment of all the projects should be done by a committee consisting of three or four faculty members - the students will present their project work before the committee - the relative grading and group average marks for the various projects will be fixed by the committee - the guides will award the marks for the individual students in the project maintaining the group average.

Each group will submit the project report to the department through the guide - the head of the department will certify the copies and keep one copy in the departmental library.

Quality Assurance and Control (CHT521)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVE:

To impart knowledge about the quality control and quality assurance in chemical industries for products for quality management with control charts. Also to provide conceptual knowledge of the aspects like QC tests, documentation, quality certifications, ISO and SQC.

COURSE OUTCOME:

On completion of this course, the students will be able to

1. Appreciate the importance of quality assurance and control in chemical industry.
2. Understand the role of ISO for process plants.
3. Learn the manufacturing operations and controls of process plants.
4. Understand the importance of documentation and the scope of quality certifications applicable to industries.
5. Understand the responsibilities of QA & QC departments

COURSE DETAILS:

UNIT-I (8 hours)

Quality:Definition, History, Importance, Cost of Quality, Approaches of Quality Management, Hierarchy of Quality management: Inspection & Test, Quality Control. Total Quality Management: Definition, Models of TQM, Elements of TQM, Principles of TQM. Deming's approach, PDCA cycle, Training for Quality management. Quality Circle: Quality Circle structure, Its operation, Characteristics of Quality Circle, Basic problem solving techniques. Introduction to Six Sigma and Taguchi concepts.

UNIT-II (8 hours)

Quality Assurance (QA): Introduction, Definition, Management principles in QA, Forms of QA, QA in different stages. Quality in material management, Vendor selection & development. ISO: Introduction, ISO 9000 series of standard, ISO:9001 clauses, ISO:17025, Registration process, Benefits of ISO.

UNIT-III (9 hours)

Statistical Quality Control: SQC tools, Benefits of SQC, Concept of variation, Assignable & Chance causes, Attributes & variables, Frequency distribution curve & its types. Normal Distribution curve, Problems on FD curve & ND curve. Control chart for variable: Definition, Formulae & its problems. Control chart patterns, Process capability. Problems on x & R chart and Process capability.

UNIT-IV (9 hours)

Quality Improvement Programme: Histogram, Charts, Brain-storming, Cause & Effect diagram, Pareto analysis.

Quality survey: Scope, Types of audit, inspection methods, Quality budget, Vendor Quality Rating. Control chart for attribute : Definition, Formulae & its problems. Problems on p, c charts. Sampling: Definition, types of sampling, importance, benefits and limitations of sampling.

UNIT-V (8 hours)

Manufacturing operations and controls: Sanitation of manufacturing premises, processing of intermediates and bulk products, packaging operations, release of finished product, time limitations on production, expiry date calculation, calculation of yields, production record review, packaging, salvaging, handling of waste and scrap disposal.

Text Books:

1. Ram Babu Sao " Perfect: Quality Assurance and Quality Control", Create Space Independent Publishing Platform.

Reference Books:

1. Weinberg S., Good Laboratory Practice Regulations, Vol. 69, Marcel Dekker Series.

2. Piotr Konieczka and Jacek Namiesnik "Quality Assurance and Quality Control in the Analytical Chemical Laboratory", CRC Press.

3. P.L. Jain " Quality Control and Total quality Management", McGraw Hill.

Chemical Engineering Design, Drawing and Operations (CHT522)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVE: Objective of the course is to provide knowledge of materials, basic design of equipment and finally chemical engineering equipment design so that students can design various industrial equipment.

COURSE OUTCOME:

On completion of this course, the students will be able to

1. To understand selection of material for different chemical operation and identified various design approach and their application.
2. To draw specific equipment and their components.
3. To design absorption and dying equipment.
4. To design distillation columns and their components.
5. Application of Humidification, Dehumidification and design of Cooling tower.

COURSE DETAILS:

UNIT-I (8 hours)

Material selection: Material selection and equipment Design: Material selection for various columns, packing materials, effect of environmental condition on materials stability. Introduction to various codes used in CPI (Chemical Process Industry) and their application. Basic Engineering design approach and selection of internal and external pressure vessels components such as shell, end-closures, dished ends, flat ends, flanges, gaskets nozzles and manholes, etc.

UNIT-II (8 hours) Equipment drawing: Design of storage tanks for liquid and liquefied gases. Concept of site fabricated tanks. Non-destructive testing sonication, radiography and dye test for lead bonds vessel. Fabrication drawings of pressure vessel component such as end-closure, nozzles, flanges, etc. Storage vessel details with bottom layout and shell layout.

UNIT-III (9 hours)

Design of absorption column: Absorption and Drying: Process design of absorption equipment's, performance evaluation of absorbers. Plate and packed columns, packing characteristics / selection, estimation of drying time and process design of dryers e.g., spray, rotary, tunnel, tray, fluid bed and thin film, performance evaluation of dryers.

UNIT-IV (9 hours)

Design of various component in distillation:Design aspects of packed columns: sizing, packing selection, design of other internals, efficiency calculations, Design aspects of tray columns: regime of operation in tray towers, sizing of tray towers, efficiency and entrainment calculations

UNIT-V (8 hours)

Design of cooling tower:Humidification/Dehumidification and Cooling Tower: Method of changing humidity and equipments, cooling tower process design, counter-current, co-current and cross current, mass and heat balances in bulk and interfaces, estimation of air quality, performance evaluation of cooling towers, Solution of problem using computer tool.

Text Books:

1. Unit Operations of Chemical Engineering, McCabe W. L., Smith J.C., Harriot P

Reference Books:

1. Chemical Engineering vol. 1 - 7 Coulson Richardson
2. Principles of Mass Transfer and Separation Processes, Dutta, B.K.
3. Fundamentals of Modelling and Separation Processes, Holland C.D.
4. Fundamentals of Multicomponent Distillation, Holland C.D. Distillation, Kister H.Z.
5. Mass Transfer Operations, Treybal R.E. Mass Transfer Sherwood T.K. Separation Processes, King J. C

COMPUTATIONAL FLUID DYNAMICS (CHT522)

L:3 T:0 P:0 **CREDITS:3**

OBJECTIVES:

1. To describe the common methods for numerically solving fluid equations.

2. To spread knowledge of current CFD trends and problems that can occur when solving these equations.

3. To stress the value of "learning by doing.

COURSE OUTCOME: After completing this course, students will be able to:

1. Sort the fundamental equations of fluid dynamics.

2. Recognize fundamental techniques for space and time discretization. - Advection, diffusion, and stationary problems solved numerically.

3. Grid generation and FDM numerical solution.

4. Examine the stability and accuracy of finite difference techniques for solving model equations. 5. Engage in programming tasks.

Unit-I (8 Hours)

Basic Fluid Flow Concepts: Computational Fluid Dynamics (CFD) philosophy, review of the equations governing heat transfer and fluid flow, simplification of flow models like incompressible, inviscid, potential, and creeping flow, and flow classification.

Unit-II (6 Hours)

Grid Generation: Choosing the best grid, grid transformation of equations, structured and unstructured grids, and some recent advancement in grid generation to address engineering issues.

Unit-III (10 Hours)

Finite Difference Method (FDM): Applications to engineering problems, discretization of ODE and PDE, approximation for first, second, and mixed derivatives, application of boundary conditions, discretization errors.

Unit-IV (8 Hours)

Finite Volume Method: Discretization techniques, volume and surface integral approximations, differential interpolation techniques, use of boundary conditions, application to engineering issues.

Unit-V (8 Hours)

Flow and heat transfer in pipes and channels, square cavity flows, reacting flow, reactive flow, multiphase flow, heat transfer in rotary kiln reactors, fluid mixing, etc. are some examples of case studies using FDM and FVM. Finite element method (FEM) essentials.

REFERENCE BOOKS

1. Fletcher C.A.J. “Computational Techniques for Fluid Dynamics, Vol. 1: Fundamental and General Techniques”, Springer-Verlag. 1998

2. Fletcher C.A.J. “Computational Techniques for Fluid Dynamics,Vol . 2: Specific Techniques for Different Flow Categories”, Springer-Verlag . 1998

3. Anderson. J.D., “Computational Fluid Dynamics”, McGraw Hill. 1995

4. Ghoshdastidar P.S., “Computer Simulation of Flow and Heat Transfer”, Tata McGraw Hill 1998

5. Patankar S.V., “Numerical Heat Transfer and Fluid Flow”, Taylor and Francis 2004

PROCESS INTEGRATION (CHT523)

L:3 T:0 P:0 **CREDITS:3**

OBJECTIVES:

1) To increase awareness of the energy and mass targets in process design

2) To impart the fundamentals of process integration and its use

COURSE OUTCOME: Upon completion of this course, the students will be able to:

1. Understand of the fundamentals of process integration.
2. Perform pinch analysis.
3. Analyze and design heat exchanger networks.
4. Minimize the water consumption and waste generation.

COURSE DETAILS

Unit-I (8 Hours)

Process Integration and its Building Blocks: Definition of process integration (pi), school of thoughts, areas of application and techniques available for pi, onion diagram.

Unit-II (8 Hours)

Pinch Technology: Basic idea, comparison to energy auditing, application of thermodynamic principles, and problem it solves. Data extraction, targeting, designing, optimizing, and supertargeting are the main Pinch Technology steps.

Unit-III (8 Hours)

Grid diagram, composite curve, problem table algorithm, and grand composite curve are the fundamental components of pinch technology. Heat Exchanger Network (HEN) Targeting Area, number of units, number of units targeted, number of shells targeted, cost targeted.

Unit-IV (8 Hours)

Pinch design techniques, heuristic rules, stream splitting, maximum energy recovery (MER), design of multiple utilities and pinches, design for threshold problem, loops, and paths are all part of the HEN design process.

Unit-V (8 Hours)

Equipment Heat Integration: Heat engines, heat pumps, distillation columns, reactors, evaporators, dryers, and refrigeration systems. Integration of heat and power using cogeneration, steam turbines, and gas turbines.

REFERENCE BOOKS

1. Kemp I. C., “Pinch Analysis and Process Integration: A user Guide on Process Integration for the Efficient Use of Energy”, 2nd Ed., ButterworthHeinemann. 2007

2. Smith R.., “Chemical Process Design and Integration”, 2nd Ed., Wiley. 2005

3. Shenoy U. V., “Heat Exchanger Network Synthesis”, Gulf Publishing Company. 1995

4. El Halwagi M. M., “Process Integration”, 7th Ed., Academic Press. 2006

Project (CHP019)

L:0 T:0 P:12 **CREDITS:6**

COURSE OBJECTIVES: The objective of this course is to inculcate research attitude amongst students and develop presentation skills.

COURSE OUTCOME:

On completion of this course, the students will be able to:

1. Understand and workout the project problem.
2. Gain experience to make a project report.
3. Acquire the necessary confidence to carry out main project in the final year.

COURSE DETAILS

The student jointly or individually is required to prepare a project report based on experimental or theoretical research work The key features such as literature survey, Problem formulation, solving methodologies and future aspects of industries are the major necessities of the report under the supervision of a guide.

The project report is to be submitted by the end of the semester and the work will be assessed based on the report and the presentation of the work.

The assessment of all the projects should be done by a committee consisting of three or four faculty members - the students will present their project work before the committee - the relative grading and group average marks for the various projects will be fixed by the committee - the guides will award the marks for the individual students in the project maintaining the group average.

Each group will submit the project report to the department through the guide - the head of the department will certify the copies and keep one copy in the departmental library.

Open Elective-II

Operational Managements (CHT016)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVE: To understand the role of Operations in overall Business Strategy challenges of Operations of the business firm.

COURSE OUTCOMES

1. Understand the role of operations in the firm's overall business strategy - the application of OM policies andtechniques to both service and manufacturing firms.
2. Recognize and put into practise the ideas of TQM perspectives, supply chain management, and materialmanagement.
3. Analyze and comprehend the current business environment's trends and challenges in Operations Management.
4. Applied techniques for making the best use of operational resources and managing processes to produce high-qualityproducts and services at reasonable prices.

COURSE DETAILS:

UNIT-I (8 hours)

Production Concept: Difference between Production and Operations Management, Productivity, Work Study, Productivity measurement, Factors affecting Productivity. Production Technology – Types of Manufacturing processes

UNIT-II (8 hours)

Operations Concept: Difference between product and service, Product and service design, Characteristics of service, Classification of service, factors affecting service operations, Service capacity planning, SERVQUAL model of measuring service quality

UNIT-III (9 hours)

Material and Inventory Management: Types of production planning, process of Production planning and control (PPC) – Routing, Scheduling, Loading, Just-in-time (JIT), KANBAN. Types of inventories, Inventory control techniques- EOQ, ABC and others. (Simple numerical on Inventory control techniques) Factors affecting Plant Location, Types of Plant layout

UNIT-IV (9 hours)

Supply Chain Management: Conceptual model of SCM, Supply chain drivers, Demand forecasting in Supply Chain – Simple moving average, weighted moving average, exponential smoothening method, Supply Chain efficiency, Core and reverse Supply Chain, International Supply Chain, Aggregate planning, inbound and outbound SCM, bullwhip effect in SCM. Latest trend in Production and operation – Lean manufacturing, Agile manufacturing

UNIT-V (8 hours)

Productivity and Quality:TQM, Deming's 14 principles, PDCA cycle - KAIZEN, Quality Circles, 7QC tools and its

advancements, ISO 9000-2000 clauses, Six Sigma, Total Productive Maintenance (TPM), 5S.

Text books

1. MAHADEVAN: Operations Management: Theory and Practice (PEARSON) (with MLSA)
2. Chase, Shankar, Jacobs – Operations & Supply Chain Management (Tata McGraw-Hill, 14th Edition)
3. Chary - Production and Operations Management (Tata McGraw-Hill, 1997, 9th Edition)
4. Bisen& Singh - Operation & Logistics Management (Excel Books)

Reference book

1. Adam JrEverett E. R J – Production and Operations Management (Prentice-Hall, 2000, 5th Edition)

Open Elective-II

Project management (CHT017)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVE: To understand the role of project management for future sustainability of business firm or any other operation.

Course Outcomes:

1. To study project management and its life cycle fulfils future demands.
2. To examine project costing and its effect on risk and project sustainability.
3. To evaluate role of balance sheet in project management.
4. To study different aspect of Entrepreneurship.

COURSE DETAILS:

UNIT-I (8 hours)

Project Management: Meaning, scope & importance, role of project manager; project life-cycle Project appraisal: Preparation of a real time project feasibility report containing technical appraisal, Environmental appraisal, Market appraisal (including market survey for forecasting future demand and sales) and Managerial appraisal.

UNIT-II (8 hours)

Project Financing: Project cost estimation & working capital requirements, sources of funds, capital budgeting, Risk & uncertainty in project evaluation,

UNIT-III (9 hours)

Cash and income statement: Preparation of projected financial statements viz. Projected balance sheet, projected income statement, projected funds & cash flow statements, Preparation of detailed project report, Project finance.

UNIT-IV (9 hours)

Entrepreneurship: Social Sector Perspectives and Social Entrepreneurship, Social Entrepreneurship Opportunities and Successful Models, Social Innovations and Sustainability, Marketing Management for Social Ventures, Risk Management in Social Enterprises, Legal Framework for Social Ventures.

Text Book:

1. Innovation and Entrepreneurship by Drucker, P.F.; Harper and RowBusiness,
2. Entrepreneurship and Management: Rao, V.S.P. ;Vikas
3. Text Book of Project Management: Gopalkrishnan, P. and Ramamoorthy, V.E.; McMillan

Reference Book:

1. Project Management for Engineering, Business and Technology: Nicholas, J.M., and Steyn, H.;
2. PHI Project Management: The Managerial Process: Gray, C.F., Larson, E.W. and Desai, G.V.; MGH

Open Elective-II

Intellectual property rights& standardization (CHT018)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVE: To understands current trends of Intellectual property rights and it regulation and final application in industries.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:

1. The students once they complete their academic projects, shall get an adequate knowledge on patent and copyrightfor their innovative research works
2. During their research career, information in patent documents provide useful insight on novelty of their idea fromstate-of-the art search. This provides further way for developing their idea or innovations
3. Pave the way for the students to catch up Intellectual Property (IP) as a career option
4. Gives awareness of international standards to students.
5. Study various laws application for IPR.

COURSE DETAILS:

UNIT-I (8 hours)

Overview of Intellectual Property: Introduction to intellectual property right (IPR), intellectual property and its protection, Forms of Protection depending on product; Patent, copyright, trademark, design knowhow, trade secrets etc

UNIT-II (8 hours)

Patents: Concept of quality mark and standardization, development in quality mark, bureau of Indian standards (BIS) and its role, IS, Ag Mark, BIS Hallmark, ECO mark, FPO mark, geographical indication mark under WTO /TRIPS, Bharat stage emissions, Toxicity labels; and vegetarian and non-vegetarian mark

UNIT-III (9 hours)

Copyrights: Quality council of India and its role, National accreditation body NABCB (National accreditation board for certification bodies), benefits of accreditation, Important legislations; National and International

UNIT-IV (9 hours)

Trademarks: Patenting systems in India, requirements of filing a patent application, patents in R&D, opposition to grant of patent under Indian Patent act 1970, protection of chemical pharmaceutical and biotechnological inventions

UNIT-V (8 hours)

Other forms of IP Design: Management of intellectual property right (IPR's), quality management systems (QMS),

ISO-9000 for manufacturing, ISO-14000 for environment, ISO -5000 for energy management systems, ISO - 22000 for Food safety management systems (FSMS), Information security management system(ISMS), Cyber Law and Digital Content Protection – Unfair Competition – Meaning and Relationship between Unfair Competition IP Laws

Text Book:

1. Nithyananda, K V. Intellectual Property Rights: Protection and Management. India, IN: Cengage Learning IndiaPrivate Limited.

Reference Book:

1. Neeraj, P., &Khusdeep, D.. Intellectual Property Rights. India, IN: PHI learning Private Limited.

2. Ahuja, V K.. Law relating to Intellectual Property Rights. India, IN: Lexis Nexis

Open Elective-III

Research Methodology (CHT019)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVES: Objective of this course is to demonstrate knowledge of research processes reading, evaluating, and developing to students.

COURSE OUTCOMES

Upon completing this course, each student will be able to:

1. Perform literature reviews using print and online databases and Identify, explain, compare, and prepare the key elements of a research proposal/report.
2. Define and develop a possible HIED research interest area using specific research designs and Compare and contrast quantitative and qualitative research paradigms, and explain the use of each in HIED research.
3. Describe sampling methods, measurement scales and instruments, and appropriate uses of each.
4. Explain the rationale for research ethics, and the importance of and local processes for Institutional Review Board (IRB) review.
5. Demonstrate how educational research contributes to the objectives of your doctoral program and to your specific career aspirations in HIED.

COURSE DETAILS

UNIT-I (8 hours)

Objectives and types of research: Motivation and objectives, research methods vs methodology. Types of research – descriptive vs analytical, applied vs fundamental, quantitative vs qualitative, conceptual vs empirical. Introduction to drug discovery & development research, objectives, flowchart from discovery to post-marketing research, overview of research methodology in various areas of drug discovery and development research.

UNIT-II (8 hours)

Research formulation – Defining and formulating the research problem, selecting the problem, necessity of defining the problem, importance of literature review in defining a problem, Literature review - primary and secondary sources, reviews, monographs, patents, research databases, web as a source, searching the web, critical literature review, identifying gap areas from literature review and research databases, development of working hypothesis.

UNIT-III (9 hours)

Research design and methods: Research design – basic principles, need of research design, features of good design, important concepts relating to research design, observation and facts, laws and theories, Prediction and explanation, research databases, development of models, developing a research plan – exploration, description, diagnosis, and experimentation.

UNIT-IV (9 hours)

Execution of the research, data collection and analysis: Aspects of method validation, observation and collection of data, methods of data collection, sampling methods, data processing and analysis strategies and tools, data analysis with statistical packages (Sigma STAT, SPSS for Student t-test, ANOVA, etc), hypothesis testing, generalization and interpretation.

UNIT-V (8 hours)

Reporting and thesis writing: Structure and components of scientific reports, types of report, Technical reports and thesis. Thesis writing – different steps and software tools (Word processing, etc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing and footnotes. Oral presentation – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication.

Research ethics, IPR and scholarly publishing: Ethics – ethical issues, ethical committees (human & animal); IPR - intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS); Scholarly publishing – IMRAD concept and design of research paper, citation and acknowledgement, plagiarism, reproducibility and accountability.

Text Books:

1. Tuckman, B. W. & Harper, B. E. (2012). Conducting educational research (6th ed.). Lanham, MD: Rowan &Littlefield Publishers. (ISBN: 978-1-4422-0964-0)

Reference Books

1. Kothari, C.R., Research Methodology: Methods and Techniques

2. Walker, I. Research Methods and Statistics

Open Elective-III

Design of Experiments (CHT020)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVE: To establish optimal process performance by finding the right sceneries for key process input variables.

COURSE OUTCOME: Students completing the course will be able to:

1. To understand the broad scope of design engineering and evaluate/analyse products, systems through various engineering tools.
2. Apply some basic concepts of optimization and methods from design engineering to explore creative solutions to clearly defined real world problems.
3. To apply modelling tools and application.
4. To recognize the main drivers for design engineering & Attain problem solving skills through modelling /simulation and optimize design.
5. To study variance in experiments.

COURSE DETAILS

UNIT-I (8 hours)

Design of Experiments Introduction to statistical analysis, Design of experiment definition, objective, strategies, factorial design, designing engineering experiments, ANOVA, EVOP, Fractional, Full and Orthogonal Experiments, Taguchi methods for robust design, response surface methods, data validation with predicted values

UNIT-II (8 hours)

Engineering Optimization Engineering Optimization definition, need and application, formulation of optimization problems, new generation optimization techniques- Genetic algorithm and simulated annealing, neural network based optimization, optimization of fuzzy systems, multicriteria decision making (MCDM)

UNIT-III (9 hours)

Modelling tools and data analysis Mathematical Model, types of Mathematical models and properties, Procedure of modelling.

UNIT-IV (9 hours)

Simulation from discrete probability distributions, computation work, use of software tools, spread sheet, generating charts, graphs and tables, application of theoretical and system modelling for respective area of problems.

UNIT-V (8 hours)

Measures of variability, Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples.

Text Books:

1. D G Montgomery, Design and analysis of Experiments, John Willy India Edition

2. Phillip Ross, Taguchi Techniques for Quality Engineering, McGraw-Hill Education

3. J R Timothy, Fuzzy Logic with Engg. Application, John Willy Publication

References:

1. Edward A. Bender,An Introduction to Mathematical Modeling.

2. A. C. Fowler, Mathematical Models in Applied Sciences, Cambridge University Press.

3. J. N. Kapoor, Mathematical Modeling, Wiley eastern Limited.

Open Elective-III

Process Utility and Safety (CHT021)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVE: This course introduces fundamental concepts in process utilities and their importance in Chemical Industries. This course also emphasis on the knowledge of loss prevention, and safety of operation.

COURSE OUTCOME:

On completion of this course, the students will be able to

1. Explain and select the importance of process utilities in chemical industries.
2. Discuss water as a utility in process industry and explain conservation and recycle of water, cooling water and spray pond.
3. Examine the importance of steam in various utilities, discuss and characterize boiler, steam engine, fire and safety in chemical industry.
4. Define safety elements of safety in process plants.
5. To study prevention of hazardous in process plants.

COURSE DETAILS:

UNIT-I (8 hours)

Introduction: Various process utilities, their role and importance in chemical plants. Sources of water and their characteristics; Treatment storage and distribution of water; water for use in boilers, cooling purposes, drinking and process; Reuse and conservation of water; Water resource management.

UNIT-II (8 hours)

Steam Generation and Utilization: Steam Generation and Utilization: Steam generation and its application in chemical process plants, distribution and utilization; Design of efficient steam heating systems; steam economy, Steam condensers and condensate utilization Expansion joints, flash tank design, steam traps their characteristics, selection and application, waste heat utilization; Lagging, selection and thickness

UNIT-III (8 hours)

Boiler and their subcomponents:Selection and sizing of boilers; waste heat boilers. Compressors, blowers and Vacuum Pumps: Compressors, blowers and vacuum pumps and their performance characteristics.

UNIT-IV (9 hours)

Elements of Safety:Elements of Safety: Elements of safety, safety and site selection; Plant layout and unit plot planning; Definition of risk and hazard, Identification and assessment of the hazards, distinction between hazards and risk, Hazard operability (HAZOP) hazard analysis (HAZAN);Assessment of the risk, fault tree, event tree, scope of risk assessment; Control of hazards, controlling toxic chemicals and controlling flammable materials. Prevention of

losses: Prevention of losses, Pressure relief, Provision of firefighting equipments, Technology selection and transfer, Choosing the right process.

UNIT-V (9 hours)

Control of Process:Control of Process:Control of process, Prevention of hazardous deviation in process variables, e.g. pressure, temperature flow by provision of automatic control systems- interlocks, alarms, trips together with good operating practices and management.Regulations: Regulations and legislation, Role of government role, risk management routines and tackling disaster

Text Books

1. Nordell, Eskel, "Water Treatment for Industrial and Other Uses", Reinhold PublishingCorporation, New York., 1961.
2. Crowl, D.A. &Louvar, J.F. "Chemical Process Safety: Fundamentals with Applications". New Jersey: Prentice-Hall.(1989).
3. Goodall, P. M., "The Efficient Use Of Steam" IPC Science and Technology, 1980.

Reference Books

1. Lees, F. P., "Loss Prevention in Process Industries 3 volume set" Butterwort - Heinemann, Oxford, 1996.
2. Kellogg, M. W Company., "Design of Piping Systems", Pullman Power Products, New York, 1976.

Open Elective-IV

Optimization Techniques (CHT022)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVES: Objective of this course is to provide fundamental knowledge to optimize a process plant and to teach the essential features of optimization problems.

COURSE OUTCOME: On completion of this course, the students will be able to:

1. Understand the role of optimization in a chemical process plants.
2. Formulate mathematical models for optimization problems.
3. Analysis of degree of freedom and complexity of solutions to an optimization problem.
4. Understand and analyze the various methods used for unconstrained one-dimensional search.
5. Solution of discrete and continuous dynamic programming by algorithms & Computer Programming.

UNIT-I (8 hours)

Introduction of Optimization:Optimization, Degree of freedom, Optimization formulation of the Problem, Analytical Method, Necessary and sufficient conditions for optimum in single and multi-variable unconstrained and constrained problems.

UNIT-II (8 hours)

Unconstrained one-dimensional optimization:Unconstrained one-dimensional search, Newton, Quasi-Newton and Secant method for uni-dimensional search, Region elimination methods (Golden Section Fibonacci, Dichotomous etc), Unconstrained multivariable optimization with special focus toPowell's conjugate direction method.

UNIT-III (9 hours)

Linear Programming:Linear Programming, graphical simplex method, revised simplex method, duality and transportation problems, unconstrained multi variable search, Direct methods, Indirect method.

UNIT-IV (9 hours)

Principle of optimality, discrete and continuous dynamic:Forward, Backward and Divided Differences Table, Central Differences, Newton's Forward, Backward and Divided Differences Interpolation Formula, Interpolation Polynomials, Lagrange Interpolation Formula, Sensitivity analysis.

UNIT-V (8 hours)

Principle of optimality, discrete and continuous dynamic:Principle of optimality, discrete and continuous dynamic programming. Algorithms & Computer Programming: Newton-Raphson Method, Gauss Elimination, Trapezoidal Rule, Simpson's 1/3rd, 3/8th Rule, Runge-Kutta 2nd Order, and R-K 4th Order Methods in reference ot the

Applications in Chemical Engineering.

Reference books:

1. S.S. Rao “Engineering Optimization”, Wiley.
2. Asghar Husain and Kota Gangiah “Optimization Techniques for Chemical Engineers”,
3. Macmillan. T.F. Edgar and D.M. Himmelblau “Optimization of Chemical Process”, Mc Graw Hill.

Open Elective-IV

Quality Assurance and Control (CHT023)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVE:

To impart knowledge about the quality control and quality assurance in chemical industries for products for quality management with control charts. Also to provide conceptual knowledge of the aspects like QC tests, documentation, quality certifications, ISO and SQC.

COURSE OUTCOME:

On completion of this course, the students will be able to

1. Appreciate the importance of quality assurance and control in chemical industry.
2. Understand the role of ISO for process plants.
3. Learn the manufacturing operations and controls of process plants.
4. Understand the importance of documentation and the scope of quality certifications applicable to industries.
5. Understand the responsibilities of QA & QC departments

COURSE DETAILS:

UNIT-I (8 hours)

Quality:Definition, History, Importance, Cost of Quality, Approaches of Quality Management, Hierarchy of Quality management: Inspection & Test, Quality Control. Total Quality Management: Definition, Models of TQM, Elements of TQM, Principles of TQM. Deming's approach, PDCA cycle, Training for Quality management. Quality Circle: Quality Circle structure, Its operation, Characteristics of Quality Circle, Basic problem solving techniques. Introduction to Six Sigma and Taguchi concepts.

UNIT-II (8 hours)

Quality Assurance (QA): Introduction, Definition, Management principles in QA, Forms of QA, QA in different stages. Quality in material management, Vendor selection & development. ISO: Introduction, ISO 9000 series of standard, ISO:9001 clauses, ISO:17025, Registration process, Benefits of ISO.

UNIT-III (9 hours)

Statistical Quality Control: SQC tools, Benefits of SQC, Concept of variation, Assignable & Chance causes, Attributes & variables, Frequency distribution curve & its types. Normal Distribution curve, Problems on FD curve & ND curve. Control chart for variable: Definition, Formulae & its problems. Control chart patterns, Process capability. Problems on x & R chart and Process capability.

UNIT-IV (9 hours)

Quality Improvement Programme: Histogram, Charts, Brain-storming, Cause & Effect diagram, Pareto analysis.

Quality survey: Scope, Types of audit, inspection methods, Quality budget, Vendor Quality Rating. Control chart for attribute : Definition, Formulae & its problems. Problems on p, c charts. Sampling: Definition, types of sampling, importance, benefits and limitations of sampling.

UNIT-V (8 hours)

Manufacturing operations and controls: Sanitation of manufacturing premises, processing of intermediates and bulk products, packaging operations, release of finished product, time limitations on production, expiry date calculation, calculation of yields, production record review, packaging, salvaging, handling of waste and scrap disposal.

Text Books:

1. Ram Babu Sao " Perfect: Quality Assurance and Quality Control", Create Space Independent Publishing Platform.

Reference Books:

1. Weinberg S., Good Laboratory Practice Regulations, Vol. 69, Marcel Dekker Series.

2. Piotr Konieczka and Jacek Namiesnik "Quality Assurance and Quality Control in the Analytical Chemical Laboratory", CRC Press.

3. P.L. Jain " Quality Control and Total quality Management", McGraw Hill.

Open Elective-IV

Industrial pollution abatement and waste management (CHT024)

L:3 T:0 P:0 **CREDITS:3**

COURSE OBJECTIVE: The aim of this course is that the students will learn the essential principles used in industrial pollution abatement and understand important issues in industrial pollution abatement and pertinent environmental legislations.

COURSE OUTCOME: On completion of this course, the students will be able to:

1. Understand the different types of wastes generated in an industry, their effects on living and non-living things.
2. Understand environmental regulatory legislations and their sources.
3. To study solid waste and their treatments methods.
4. To understand the different process involved in industrial waste water treatment.
5. To evaluate atmospheric dispersion of air pollutants, operating principles, and design calculations of particulatecontrol devices.

COURSE DETAILS:

UNIT-I (8 hours)

Introduction (types of pollution, water standards for potable and agricultural streams, air standards)

UNIT-II (8 hours)

Air pollution - air pollutants and interaction products, preventive and control measures; Water pollution-waste water sampling and analysis, primary, secondary and tertiary treatment methods

UNIT-III (9 hours)

Solid waste management- collection, storage and transport, processing and transformation, incineration, composting and sanitary land filling;

UNIT-IV (9 hours)

Pollution control in chemical process industry. Desalination and Water Purification, Cellular Garbage Disposal, Biological Treatment of Wastewater: Activated Sludge Process, Anaerobic treatment processes, Bio filters for biological odor control.

UNIT-V (8 hours)

Pulp & Paper Industry, Sugar Industry, Iron and steel Industry, Textile Industry, Coal-based Thermal Power Plants,

Aluminum smelter, Cement industry, Battery industry.

Text Books:

1. Peavy, H.S., Rowe D.R. and Tchobanoglous, G., "Environmental Engineering", McGraw-Hill Book Co., New Delhi, 5th Ed., 2003.

Reference Books:

1. Metcalf &Eddy, Inc., "Waste Water Engineering-Treatment, Disposal, Reuse", Mcgraw-Hill, Inc., 4thEd., 2003.Nevers,
2. Noel de, "Air Pollution Control Engineering", McGraw-Hill, Inc. "Pollution Control Acts, Rules and Notifications", CPCB, Delhi. 1995.
3. Conway R.A. & Ross R.D., "Handbook of Industrial Waste Disposal", Van-Nostrand Reinhold, 1980.
4. Kreith F. and Tchobanoglous G., "Handbook of Solid Waste Management", Mc Graw Hill, 2nd Ed., 2002.

HSMC-1

Rural Development: Administration and Planning (AHT-015)

L:T:P:: 3:1:0 **Credits-3**

Course Objectives

This course enables the students to:

1. Gain knowledge on the concepts related to administration, its importance and various approaches of Development Administration.
2. Gain skills on New Public Management, Public Grievances and Redressal Mechanisms, Accountability and Transparency in Administration and e-governance in the rural development sector.
3. Develop their competency on the role of Bureaucracy in Rural Development.

Course Outcomes

After completion of the course student will be able to:

1. Students can understand the definitions, concepts and components of Rural Development.
2. Students will know the importance, structure, significance, resources of Indian rural economy.
3. Students will have a clear idea about the area development programmes and its impact.
4. Students will be able to acquire knowledge about rural entrepreneurship.
5. Students will be able to understand about the using of different methods for human resource planning.

Course Contents

UNIT-I: (8 hours)

Rural Planning & Development: Concepts of Rural Development, Basic elements of rural Development, and Importance of Rural Development for creation of Sustainable Livelihoods, An overview of Policies and Programmes for Rural Development- Programmes in the agricultural sector, Programmes in the Social Security, Programmes in area of Social Sector.

UNIT-II: (8 hours)

Rural Development Programmes: Sriniketan experiment, Gurgaon experiment, Marthandam experiment, Baroda experiment, Firkha development scheme, Etawapilot project, Nilokheri experiment, approaches to rural community development: Tagore, Gandhi etc.

UNIT-III: (8 hours)

Panchayati Raj & Rural Administration: Administrative Structure: bureaucracy, structure of administration; Panchayati Raj Institutions Emergence and Growth of Panchayati Raj Institutions in India; People and Panchayati Raj; Financial Organizations in Panchayati Raj Institutions, Structure of rural finance, Government & Non-Government Organizations / Community Based Organizations, Concept of Self help group.

UNIT-IV: (8 hours)

Human Resource Development in Rural Sector: Need for Human Resource Development, Elements of Human Resource Development in Rural Sector Dimensions of HRD for rural development-Health, Education, Energy, Skill Development, Training, Nutritional Status access to basic amenities – Population composition.

UNIT-V: (8 hours)

Rural Industrialization and Entrepreneurship: Concept of Rural Industrialization, Gandhian approach to Rural Industrialization, Appropriate Technology for Rural Industries, Entrepreneurship and Rural Industrialization-Problems and diagnosis of Rural Entrepreneurship in India, with special reference to Women Entrepreneurship; Development of Small Entrepreneurs in India, need for and scope of entrepreneurship in Rural area.

Text Books/References:

1. Corporate Social Responsibility: An Ethical Approach - Mark S. Schwartz.

2. Katar Singh: Rural Development in India – Theory History and Policy.

3. Todaro M.P. Economic Development in III World war.

4. Arora R.C – Integrated Rural Development in India.

5. Dhandekar V.M and Rath N poverty in India.

6. A.N.Agarwal and Kundana Lal: Rural Economy of India.

7. B.K.Prasad: Rural Development-Sarup& Son’s Publications.

HSMC-2

PROJECT MANAGEMENT & ENTREPRENEURSHIP (AHT-016)

L:T:P:: 3:1:0 **Credits-3**

COURSE OBJECTIVES:

The course should enable the students to:

1 Understand the concepts of Project Management for planning to execution of projects.

2 Understand the feasibility analysis in Project Management and network analysis tools for cost and time estimation.

3 Be capable to analyze, apply and appreciate contemporary project management tools and methodologies in Indian context.

4 Understand the concepts of Entrepreneurship, role of entrepreneur in economic development, steps for establishing an enterprise.

COURSE OUTCOMES:

After completion of the course student will be able to:

1 Understand project characteristics and various stages of a project.

2 Understand the conceptual clarity about project organization and feasibility analyses – Market, Technical, Financial and Economic.

3 Analyze the learning and understand techniques for Project planning, scheduling and Execution Control.

4. Describe Entrepreneurship, Examine role of entrepreneur in economic development.

5. Describe the steps to establish an enterprise.

COURSE CONTENTS

UNIT-I: (8 hours)

Entrepreneurship: Entrepreneurship: need, scope , Entrepreneurial competencies & traits, Factors affecting entrepreneurial development, Entrepreneurial motivation (Mc Clellend's Achievement motivation theory), conceptual model of entrepreneurship , entrepreneur vs. intrapreneur; Classification of entrepreneurs; Entrepreneurial Development Programmes.

UNIT-II (8 hours)

Entrepreneurial Idea and Innovation: Introduction to Innovation, Entrepreneurial Idea Generation and Identifying Business Opportunities, Management skills for Entrepreneurs and managing for Value Creation, Creating and Sustaining Enterprising Model & Organizational Effectiveness.

UNIT-III: (8 hours)

Project Management: Project management: meaning, scope & importance, role of project manager; project life-cycle Project appraisal: Preparation of a real time project feasibility report containing Technical appraisal, Environmental appraisal, Market appraisal (including market survey for forecasting future demand and sales) and Managerial appraisal.

UNIT-IV (8 hours)

Project Financing: Project cost estimation & working capital requirements, sources of funds, capital budgeting, Risk & uncertainty in project evaluation , preparation of projected financial statements viz. Projected balance sheet, projected income statement, projected funds & cash flow statements, Preparation of detailed project report, Project finance.

UNIT-V: (8 hours)

Social Entrepreneurship: Social Sector Perspectives and Social Entrepreneurship, Social Entrepreneurship Opportunities and Successful Models, Social Innovations and Sustainability, Marketing Management for Social Ventures, Risk Management in Social Enterprises, Legal Framework for Social Ventures.Case study and presentations: Case study of successful and failed entrepreneurs. Power point presentation on current business opportunities..

Text Book:

1. Innovation and Entrepreneurship by Drucker, P.F.; Harperand Row.
2. Business, Entrepreneurship and Management: Rao, V.S.P.;Vikas
3. Entrepreneurship: Roy Rajeev.
4. TextBookofProjectManagement:Gopalkrishnan,P.andRamamoorthy,V.E.;McMill.
5. Project Management for Engineering, Business and Technology: Nicholas, J.M., and Steyn, H.;PHI.
6. Project Management: The Managerial Process: Gray, C.F., Larson, E.W. and Desai, G.V.;MGH.

Innovations and Problem Solving (AHT-018)

L:T:P: 2:1:0 **Credits-0**

COURSE OBJECTIVES:

This subject aims to inculcate critical thinking abilities and application of knowledge for problem solving. It will expose the students with various simple methods and practices that are essential to development of new systems, problem formulation and problem solving in technical and non-technical fields. This course will stimulate the work environment of the modern day engineers and technologists by familiarizing them with the state-of-the art results, design and analysis tools in various disciplines, the ability to extract relevant information to formulate and solve problems arising in practice.

COURSE OUTCOMES:

The course will enable students to,

1. Identify the market and value proposition
2. Carry out rigorous and accessible formulation to problems
3. Solutions via reducing the search space
4. Eliminating tradeoffs to reduce dimension of optimization problems
5. Execution through developing strategies for experiment, construction and monetization.
6. Simulate the work environment of the modern engineer or knowledge worker in general.

Unit – I 8 Hrs

Introduction to Critical Design Thinking

- Understanding critical thinking, creative thinking, and problem solving through examples.
- New ways to solve problems.

Unit – II 8 Hrs

Theory of Inventive Problem Solving

- Examples of inventive problem solving,
- Era of technical systems,
- Science of inventing,
- Art of inventing,
- Amazing world of tasks

Unit – III 8 Hrs

Logic and Tools for Creativity and Clarity of Thought

- TRIZ tools for creativity and solutions,
- World's known solutions,
- Fundamentals of Problem solving,
- Thinking in Time and Scale,
- Uncovering and solving contradictions,
- Fast Thinking with ideal outcome.

Unit – IV 8 Hrs

Modeling for Problem Solving

- Moving from problem to ideal final result,
- Tradeoffs and inherent contradictions,
- Invisible reserves,
- Law of increasing ideality,
- Evaluation of solutions,
- Enriching models for problem solving.

Unit – V 8 Hrs

Principles for Innovation

- General review,
- Segmentation, Separation,
- Local quality, symmetry change, merging and multifunctionality,
- Nested doll and weight compensation,
- Preliminary counteraction, preliminary action, and beforehand compensation,
- Equipotentiality, the other way around and curvature increase,
- Dynamic parts, partial or excessive actions, dimensionality change, mechanical vibration
- Periodic action, continuity of useful action, and hurrying,
- Blessing in disguise, feedback, and intermediary,
- Self service, copying, cheap disposables, and mechanical interaction substitution

Pneumatics and hydraulics, flexible shells and thin films, and porous materials,

- Optical property changes, homogeneous, and discarding and recovering,
- Parameter changes, phase transitions, and thermal expansion,
- Strong oxidants, inert atmosphere, and composite materials,
- How to select most suitable principle out of 40 ways to create good solutions

References

1. ABC-TRIZ Introduction to Creative Design Thinking with Modern TRIZ Modeling by Michael A. Orloff

2. TRIZ And Suddenly the Inventor Appeared TRIZ, the Theory of Inventive Problem Solving by GenrichAltshuller

3. TRIZ for Engineers Enabling Inventive Problem Solving by Karen Gadd

4. Simplified TRIZ New Problem Solving Applications for Engineers and Manufacturing Professionals by Rantanen K., Domb E.

DISASTER MANAGEMENT (AHT-017)

L:T:P:: 3:0:0 **Credits-3**

COURSE OBJECTIVES:

The course should enable the students to:

1. To introduce the students to various types of natural and manmade disasters.
2. To understand causes and impact of disasters.
3. To understand approaches of Disaster Management.
4. To build skills to respond to disaster.

COURSE OUTCOMES:

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

1. To provide students an exposure to disasters, their significance and types.
2. To ensure that students begin to understand the relationship between vulnerability, disasters, disaster prevention and risk reduction.
3. To understand approaches of Disaster Management.
4. To build skills to respond to disaster.

COURSE DETAILS

Unit-1 Introduction to Disasters

Concepts, and definitions (Disaster, Hazard, Vulnerability, Resilience, Risks). Disaster Types, Trends, Causes, Consequences and Control of Disasters, Geological Disasters; Hydro-Meteorological, Biological, Technological and Manmade Disasters.

Unit-2 Disasters: Classification, Causes, Impacts

(Including social, economic, political, environmental, health, psychosocial, etc.)

Differential impacts-in terms of caste, class, gender, age, location, disability. Global trends in disasters urban disasters, pandemics, complex emergencies, Climate change.

Unit-3 Approaches to Disaster Risk Reduction:

Disaster cycle- its analysis, Phases, Culture of safety, prevention, mitigation and preparedness, community based DRR, Structural- nonstructural measures, roles and responsibilities of community, Panchayati Raj

Institutions/ Urban Local Bodies (PRIs/ULBs), States, Centre, and other stake-holders.

Unit-4 Inter-relationship between Disasters & Development

Factors affecting Vulnerabilities, differential impacts, Impact of Development projects such as dams, embankments, changes in Land-use etc. Climate Change Adaptation. Relevance of indigenous knowledge, appropriate technology and local resources

Unit-5 Disaster Risk Management in India:

Hazard and Vulnerability profile of India. Components of Disaster Relief: Water, Food, Sanitation, Shelter, Health, Waste Management Institutional arrangements (Mitigation, Response and Preparedness, DM Act and Policy, Other related policies, plans, programmes and legislation)

Text/Reference Books:

1. Disaster Management Guidelines, GOI-UND Disaster Risk Program (2009-2012)
2. Damon, P. Copola, (2006) Introduction to International Disaster Management, Butterworth Heineman.
3. Gupta A.K., Niar S.S and Chatterjee S. (2013) Disaster management and Risk Reduction, Role of Environmental Knowledge, Narosa Publishing House, Delhi.
4. Murthy D.B.N. (2012) Disaster Management, Deep and Deep Publication PVT. Ltd. New Delhi.
5. Modh S. (2010) Managing Natural Disasters, Mac Millan publishers India LTD.