# Uttarakhand Technical University, Dehradun
## Scheme of Examination as per AICTE Flexible Curricula

Evaluation Scheme & Syllabus

for

B. Tech Second Year
(Chemical Engineering)

## W.E.F. Academic Session 2019-20

## B Tech II Year
## 3rd and 4th SEMESTER

## Bachelor of Technology (B. Tech.)
## [CHEMICAL ENGINEERING]

# Uttarakhand Technical University, Dehradun

**B.TECH (CHEMICAL ENGINEERING)**
**SEMESTER- III**

| S No. | Sub. code | Category | Subject | Maximum marks allotted | | | | | Total | Contact Hour per week | | | Credit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | | | Practical | | | | | | |
| | | | | End Sem. | Mid Sem. | Quiz/ Assignment | End Sem. | Lab Work & Sessional | | L | T | P | |
| 1 | BCET 301 | HSMC | Energy & Environmental Engineering | 100 | 30 | 20 | - | - | 150 | 3 | 1 | 0 | 4 |
| 2 | BMET 303 | BS | Strength of Material | 100 | 30 | 20 | - | - | 150 | 3 | 1 | 0 | 4 |
| 3 | BCHT 301 | DC | Material and Energy Balance | 100 | 30 | 20 | - | - | 150 | 3 | 1 | 0 | 4 |
| 4 | BCHT 302 | DC | Chemical Engineering Fluid Mechanics | 100 | 30 | 20 | - | - | 150 | 3 | 1 | 0 | 4 |
| 5 | BCHT 303 | DC | Heat Transfer Operations | 100 | 30 | 20 | - | - | 150 | 3 | 0 | 0 | 3 |
| 6 | BCHP 301 | DLC | Chemical Engineering Fluid Mechanics Lab | | | | 30 | 20 | 50 | 0 | 0 | 2 | 1 |
| 7 | BCHP 302 | DLC | Heat Transfer Operations Lab | | | | 30 | 20 | 50 | 0 | 0 | 2 | 1 |
| 8 | BCHP 304 | DLC | Soft Computing Lab | | | | 30 | 20 | 50 | 0 | 0 | 2 | 1 |
| 9 | BCHP 305 | DLC | Internship Assessment | | | | | 50 | 50 | 0 | 0 | 2 | 1 |
| 10 | | | 90 hrs Internship based on using various software's – Internship-II | To be completed anytime third/fourth semester. Its evaluation/credit to be added in fifth semester | | | | | | | | | |
| | | | Total | | | | | | 950 | | | | 24 |

# Uttarakhand Technical University, Dehradun

**B.TECH (CHEMICAL ENGINEERING)**
**SEMESTER- IV**

| S No. | Sub. code | Category | Subject | Maximum marks allotted | | | | | Total | Contact Hour per week | | | Credit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | | | Practical | | | | | | |
| | | | | End Sem. | Mid Sem. | Quiz/ Assignment | End Sem. | Lab Work & Sessional | | L | T | P | |
| 1 | BAST 401 | BSC | Mathematics III | 100 | 30 | 20 | - | - | 150 | 3 | 1 | 0 | 4 |
| 2 | BCHT 401 | DC | Mass Transfer Operation-I | 100 | 30 | 20 | - | - | 150 | 3 | 1 | 0 | 4 |
| 3 | BCHT 402 | DC | Mechanical Operations | 100 | 30 | 20 | - | - | 150 | 3 | 1 | 0 | 4 |
| 4 | BCHT 403 | DC | Chemical Reaction Engineering-I | 100 | 30 | 20 | - | - | 150 | 3 | 1 | 0 | 4 |
| 5 | BCHT404 | DC | Material Science | 100 | 30 | 20 | - | - | 150 | 3 | 0 | 0 | 3 |
| 6 | BCHT 405 | DC | Chemical Engineering Thermodynamics | 100 | 30 | 20 | - | - | 150 | 3 | 0 | 0 | 4 |
| 7 | BCHP 402 | DLC | Mechanical Operations Lab | | | | 30 | 20 | 50 | 0 | 0 | 2 | 1 |
| 8 | BCHP 403 | DLC | Chemical Reaction Engineering Lab | | | | 30 | 20 | 50 | 0 | 0 | 2 | 1 |
| 9 | BCSP 409 | DLC | Numerical Methods of Analysis Lab | | | | 30 | 20 | 50 | 0 | 0 | 2 | 1 |
| 10 | BCST 408 | MC | Cyber Security | Non Credit course | | | | | | | | | |
| | | | 90 hrs Internship based on using various software's – Internship-II | To be completed anytime third/fourth semester. Its evaluation/credit to be added in fifth semester | | | | | | | | | |
| | | | Total | | | | | | 1050 | | | | 26 |

**BCHT 301 - Material and Energy Balance** L:3 T:1 P:0 C:4
**Prior Learning:** Engineering Mathematics

**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:

- CO [1]Apply steady-state and unsteady state material and energy balance on a system.
- CO [2] Ability to implement material and energy balance for system with or without chemical reactions.
- CO [3] Analyze and apply all the stiochiometric and balances being applied on a system undergoing chemical process.
- CO [4] Estimation and design equipment with inlet and outlet; including recycle- bypass and purging streams for a chemical process.

**COURSE DETAILS**

| S. No | Unit | Topics in the unit |
|---|---|---|
| 1. | Introduction and Material Balance | Units and dimension in chemical engineering, units 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. |
| 2. | Material Balance with and without Chemical Reaction for Single and Multiple Units | Conservation of mass/atom, material balance for Systems without chemical reactions involving single unit and multiple units.<br>Concept of excess reactant, extent of reaction, Material balance for systems with chemical reactions involving single unit and multiple units. |
| 3. | Recycle, Bypass, and Purge their Industrial Applications | Calculations for a cyclic processes involving recycle/ purge/ bypass, material balances involving gases, vapors, liquids and solids and use of real gas relationships, material balance involving gases, vapors, liquids & solids and uses of real gas relationships, vapor-liquid equilibrium and concepts of humidity & saturation, analysis of systems with bypass, recycle and purge, analysis of processes |
| 4. | 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 &liqid – vapor), heat of reaction, heat of combustion, heat of solutions and mixing, determination of temperatures for adiabatic and nonadiabatic reactions, use of psychometric and enthalpy-concentration diagrams. |
| 5. | 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. |

**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.

**Reference link**

1. NPTEL video lectures

**BCHT 302 - Fluid Mechanics** **L:3 T:1 P:0 C:4**
**Prior Learning**: Engineering Physics

**COURSE OBJECTIVES**

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

**COURSE OUTCOME**

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

- CO [1].Identify the various basic fluid properties and different flow regimes of fluids and express in basic terms related to fluid flow phenomena.
- CO [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.
- CO [3]. Understand and apply dimensionless analysis and it's signification in chemical Engineering Problems.
- CO [4].Describe effects of roughness, restriction, head loss, friction of flow etc. on incompressible fluid.
- CO [5].Select and evaluate the performance of various fluid transport and metering devices like mixers, agitated vessels, pumps, compressors, orifice meter, venturi meter, rotameter, and pitot tube etc.

| S. No | Unit | Topics in the unit |
|---|---|---|
| 1 | 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. |
| 2 | Elementary Fluid Kinematics and analysis of flow | Lagrangian and Eulerian descriptions; Flow visualization – streamline, pathline, 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. |
| 3 | Dimensional Analysis, Similitude and Modeling | Dimensional homogeneity and analysis; Methods of finding dimensionless numbers; Selection of variables, Rayleigh and Buckingham's $\pi$ method; Common dimensionless numbers and their physical significance; Model and Prototypes; Complete and incomplete similarity. |
| 4 | 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. |

| | | |
|---|---|---|
| 5 | Flow Measurements and | Flow rate and velocity measurements – Pitot tube, orifice meter, venturimeter, rotameter, notches and weirs. |
| 6 | Fluid Handling Machinery and Agitation, Mixing | Classification; Positivedisplacement pumps and compressors, centrifugal pumps and compressors, Axial flow pumps and compressors, compressor efficiency. Characteristics of centrifugal pumps; NPSH; Selection of pumps. Agitated vessels; Blending and mixing; Suspension of solid particles; Dispersion operations; Agitator selection and scale up. |

**Text Books**


1. Rajput, R. K., "Textbook of Fluid Mechanics", S. Chand and Co., 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


**Reference link**

1. NPTEL video lectures

**BCHT 303 - Heat Transfer Operations** L:3 T:0 P:0 C:3
**Prior Learning:** Thermodynamics

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

## COURSE DETAILS

| S. No | Unit | Topics in the unit |
|---|---|---|
| 1. | 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. |
| 2. | 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.<br>Free Convection: Dimensionless parameters of Free Convection, Correlations of free convection on a vertical plate, Free Convection on a horizontal plate. |
| 3. | Condensation | Nusselt equation for horizontal and vertical condenser, Drop and film type condensation, Effect of non-condensable gases.<br>Boiling: Boiling of liquids. Nucleate and film boiling. |
| 4. | Heat Transfer by Radiation | Concept of black body, Kirchoff's Law Emissivity, absorptivity, black body and grey body radiation. View factors. |
| 5. | Heat Exchangers | 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. |

| | | |
|---|---|---|
| | | Hair pin (double pipe exchangers) 1-2 shell and tube exchangers, Finned tube exchangers, fouling factor. |
| 6. | Evaporation | Classification and application, evaporator feeding mechanism, operation of single effect evaporators. |

**Text Books**

1. Heat transfer- Principles and applications; B K Dutta, Prentice Hall India
2. Heat Transfer – J P Holman Souvik Bhattacharyya, Mc hill Education private limited

**Reference Books**

1. Holman, J. P., Heat Transfer, 10th Edition., Tata McGraw-Hill Education Private ltd.
2. Kern, D.Q., Process Heat Transfer, 1st Edition, Tata McGrawHill Education Private ltd.
3. Cengel Y.A. and Ghajar A.J., "Heat and Mass Transfer: Fundamentals and Applications", 4th Ed., McGraw Hill
4. McCabe, W.L, Smith J.C, and Harriot, P, Unit Operations in Chemical Engineering, 7th Edition, McGraw-Hill, Inc.

**Reference link**

1. NPTEL video lectures

**BCHP 302 - Chemical Engineering Fluid Mechanics Lab** L:0 T:0 P:2 C:1
**Prior Learning:** Fluid mechanics

## 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. Determination of coefficient of velocity, coefficient of resistance, coefficient ofcontraction.
6. To determine the pressure drop in a packed bed.
2. 7.Determination of discharge coff.with Reynolds Number in case of an orifice meter and a venturi meter.
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.

**BCHP 303 - Heat Transfer Operations Lab** L:0 T:0 P:2 C:1
**Prior Learning:** Heat transfer operation

**COURSE OBJECTIVES**

- To determinethe amount of heat exchange in various modes of heat transfer includingcondensation & 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 ex-changers 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 Boltzman'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.

**BCHP 304 - Soft computing Lab** L:0 T:0 P:2 C:1
**Prior Learning:** MS-EXCEL

**COURSE OBJECTIVES**

- To use different softwares 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 design a distillation column, feed height and number of trays in a column using Mccabethiele method.

## SEMESTER-IV

**BCHT 401 - Mechanical Operations** L:2 T:1 P:0 C:2

**Prior Learning:** Fluid mechanics and Math.

**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 behavior of solid particles in fluidized state.

**COURSE OUTCOME**

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

1. CO [1] Measure the particlesize.
2. CO [2] Estimate the crushing efficiency of different type'scrushers.
3. CO [3] Explain the process involved and results obtained by filtration.
4. CO [4] Explain the methods for storage and handling of solids.
5. CO [5] Design the methods involved in transport of solid in any industrial process.

**COURSE DETAILS**

| S. No. | Contents |
|---|---|
| 1. | **Particles Size Analysis:** General characteristics of solids; Different techniques of size analysis; Shape factor; Surface area determination; Estimation of particle size; Screening methods and equipment; Screen efficiency; Ideal and actual screens. |
| 2. | **Size Reduction:** Methods of size reduction; Classification of equipments; Crushers; Grinders; Disintegrators for coarse, Intermediate and fine grinding; Laws of size reduction; Energy relationships in size reduction; power requirement; Work index |
| 3. | **Particle Separation:** Gravity settling; Sedimentation; Thickening; Elutriation; Centrifugal separation; Continuous centrifuges; Industrial dust removing equipment; Cyclones; Hydro cyclones; Electrostatic - Magnetic separators; Heavy media separations; Floatation |
| 4. | **Storage and conveying of solids:** Silos; Bins; Hoppers; Transportation of solids in bulk; Conveyer selection; Types of conveyers; Belt Conveyor; Bucket conveyor; Screw conveyor; Pneumatic conveyor |
| 5. | **Flow through Porous media (Filtration):**Theory of filtration, Batch and continuous filters, Filtration equipments; Rotary drum filter; Plate and frame filter; Leaf filter; Bag filter; Filter aids. Flow through filter cake and Filter media; Compressible and incompressible filter cakes |
| 6. | **Fluidization:** Fluidization characteristics, aggregative and particulate fluidization, voidage and minimum fluidization velocity, terminal velocity of particles; pressure drop influidization. |

**Text Books**

1. Backhurst ,J.R.and HarkerJ.H. coulsonand Richardson Chemical Engineering",Vol.II",5 Ed., Butterworth- Heinemann.

2. Narayanan C.M. & Bhattacharya B.C., “Mechanical Operation for Chemical Engineers – Incorporating Computer Aided Analysis”, Khanna Publishers.

**REFERENCE BOOKS**

1. McCabeW.L.,SmithJ.C HarriottP.,“UnitOperationsof ChemicalEngineering”, 7Ed. , McGrawHill.

**Reference link**

1. NPTEL video lectures

**TCH 402 - Chemical Reaction Engineering-I** L:3 T:1 P:0 C:4
**Prior Learning:** Process calculation

**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. CO 1. Identify the reaction type and their kinetics.
2. CO 2. Design the reactor for the batch and continuous chemical process.
3. CO 3. Understand the Ideal and Non – Ideal Reactors.

**COURSE DETAILS**

| S. No | Unit | Topics in the unit |
|---|---|---|
| 1. | 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. |
| 2. | Design of Reactors | Design of continuous reactors – stirred tank and tubular flow reactor, recycle reactors - combination of reactors - size comparison of reactors. |
| 3. | 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. |
| 4. | 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. |
| 5. | Non Ideal Reactors | The residence time distribution as a factor of performance; residence time functions andrelationship between them in reactor; basic models for nonidealflow; conversion in non ideal reactors. |

**Text Books**
1. Levenspiel O, Chemical Reaction Engineering, 3rd Edition, Wiley India Pvt Ltd. 2010

**Reference Books**
1. Smith, J.M, Chemical Engineering Kinetics, 3rd Edition McGraw. 2014
2. Fogler.H.S., Elements of Chemical Reaction Engineering, 4$^{th}$Edition, Phi Learning Pvt Ltd (RS). 2009
3. Froment. G.F. &K.B.Bischoff,Chemical Reactor Analysis and Design, 3rd Edition, Wiley. 2010.
4. Butt, J.B., " Reaction Kinetics and Reactor Design" 2nd Ed., CRC Press 2000

**Reference link**
1. NPTEL video lectures

**BCHT 403 - Chemical Engg. Thermodynamics** L:3 T:1 P:0 C: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. CO [1] Explain various forms of energy related transformation as unit operation or unit process in chemical process industries.
2. CO[2] Study about different terminology used in Chemical Engineering Thermodynamics.
3. CO[3] Identify and relate the thermodynamic property of the pure substance and mixture.
4. CO[4] Explain the phase equilibrium, equilibrium conversion for homogeneous and chemical reaction systems.
5. CO[5] Know the basic principles of refrigeration and liquefaction process.

**COURSE DETAILS**

| S. No | Unit | Topics in the unit |
|---|---|---|
| 1 | 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 |
| 2 | 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. |
| 3 | 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. |
| 4 | 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. |
| 5 | Refrigeration Principles | 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. Hougen, O.A., Watson, K.M., and Ragatz, R.A., Chemical Process Principles Part II", Thermodynamics, John Wiley.

**Reference Books**

1. Smith, J.M., VanNess, H.C., & Abbot M.C, Introduction to Chemical Engineering Thermodynamics, 7th Edition, Tata Mcgraw Hill Education Private Limited.
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

**BCHP 401 - Mechanical Operations Lab** L:0 T:0 P:2 C: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 particlesize.
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 fluidizedbed
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'sconstant.
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 efficiencyof separation.
5. To find the cake and filter medium resistance of Plate and Frame Filterpress.
6. To find the filter medium resistance of a Vacuum LeafFilter.
7. To find the cake and filter medium resistance of a Rotary drumFilter.
8. To find minimum fluidization velocity of solid in liquid medium.

**BCHP 402 - Chemical Reaction Engg. Lab** L:0 T:0 P:2 C:1
**Prior Learning:** Chemical reaction engg.

**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. Analyse the reaction type and their kinetics.
2. Design the reactor for the batch and continuous chemical process.

**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 flow reactor
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 contant 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 potassium iodide with iodine.
10. Study and operation of a cascade CSTR

**BCSP 409 - Numerical Methods of Analysis Lab** L:0 T:0 P:2 C:1

**COURSE OBJECTIVES**

- To teach the student various numerical methods to analysis 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 computational methods for advantages and drawback,
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 and develop the computational method that is suitable for the underlying problem.

**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 Regula falsi 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-Kutta method.
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.
11. Simpson's 3/8-rule.9.

| BCST 408 | Cyber Security | Non- Credit Course |
|---|---|---|

**Course Objectives:**

1. Understand the basic concept of Cyber Security.
2. Understand the basic concept of Viruses.
3. Understand the basic concept of Digital Attacks.
4. Understand the basic concept of Phishing.
5. Understand the basic concept of Cyber Law.

**Course Outcomes:**

After the completion of this course the student will able to:

1. Know about various attacks and viruses in cyber systems
2. Know about how to prevent digital attacks
3. Know about how to prevent Phishing Attacks
4. Know about how to do secure transactions

**UNIT-1**

Introduction to information systems, Types of information Systems, Development of Information Systems, Introduction to information security, Need for Information security, Threats to Information Systems, Information Assurance, Cyber Security, and Security Risk Analysis.

**UNIT-2**

Application security (Database, E-mail and Internet), Data Security Considerations-Backups, Archival Storage and Disposal of Data, Security Technology-Firewall and VPNs, Intrusion Detection, Access Control.

Security Threats -Viruses, Worms, Trojan Horse, Bombs, Trapdoors, Spoofs, E-mail viruses, Macro viruses, Malicious Software, Network and Denial of Services Attack, Security Threats to E-Commerce- Electronic Payment System, e- Cash, Credit/Debit Cards. Digital Signature, public Key Cryptography.

**UNIT-3**

Developing Secure Information Systems, Application Development Security, Information Security

Governance & Risk Management, Security Architecture & Design Security Issues in Hardware, Data Storage & Downloadable Devices, Physical Security of IT Assets,

Access Control, CCTV and intrusion Detection Systems, Backup Security Measures.

**UNIT-4**

Security Policies, Why Policies should be developed, WWW policies, Email Security policies, Policy Review Process-Corporate Policies-Sample Security Policies, Publishing and Notification Requirement of the Policies.

Information Security Standards-ISO, IT Act, Copyright Act, Patent Law, IPR. Cyber Laws in India; IT Act 2000 Provisions, Intellectual Property Law: Copy Right Law, Software License, Semiconductor Law and Patent Law.

**References:**


1. Charles P. Pfleeger, Shari Lawerance Pfleeger, “Analysing Computer Security ”, Pearson Education India.
2. V.K. Pachghare, “Cryptography and information Security”, PHI Learning Private Limited, Delhi India.
3. 3.Dr. Surya Prakash Tripathi, Ritendra Goyal, Praveen kumar Shukla ,”Introduction to Information Security and Cyber Law” Willey Dreamtech Press.
4. Schou, Shoemaker, “ Information Assurance for the Enterprise”, Tata McGraw Hill. 5. CHANDER, HARISH,” Cyber Laws And It Protection ” , PHI Learning Private Limited ,Delhi ,India