**IPS Academy, Institute of Engineering & Science**
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Scheme & Syllabus Based on AICTE Flexible Curricula **(B. Tech)**
**Chemical Engineering Department**
**Semester III (II Year)**

| S. No. | Course Code | Course Title | Hrs./ week | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | PCC-CH301 | Chemical Engineering Thermodynamics-I | 3 | 1 | 0 | 4 |
| 2 | PCC-CH302 | Fluid Mechanics | 3 | 1 | 2 | 4 |
| 3 | PCC-CH303 | Chemical Process Calculation | 3 | 1 | 0 | 4 |
| 4 | PCC-CH304 | Fluid Particle Mechanics | 3 | 1 | 2 | 4 |
| 5 | HSMC-CH301 | Industrial Psychology & Human Resource Management | 3 | 0 | 0 | 3 |
| 6 | ESC-CH301 | Computer Programming | 0 | 0 | 4 | 2 |
| 7 | MC-CH301 | Energy & Environmental Engineering | 2 | 0 | 0 | 0 |
| **Total** | | | **17** | **04** | **08** | **21** |
| **Total Academic Engagement and Credits** | | | **29** | | | **21** |

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**Chemical Engineering Department**

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|---|---|---|---|---|
| **PCC-CH301** | **III** | **Chemical Engineering Thermodynamics-I** | **3L: 1T: 0P (04hrs)** | **Credits:04** |

**Course objective-**The objective of this course is to understand the theory and applications of classical thermodynamics, thermodynamic properties, equations of state, methods used to describe, compression and expansion of fluids.

**Course content-**

**MODULE 1: (06 hrs)**
Basic concepts of work & heat system, properties and state of systems; first law of thermodynamics; application, batch flow processes; steady & unsteady state flow.

**MODULE 2: (12 hrs)**
Critical properties corresponding state compressibility, PVT behavior of pure fluids viral equation, cubic equation, generalized correlation & eccentric factor, behavior of liquid, second law of T.D, & its application. Adiabatic reactions, Equilibrium in homogeneous and heterogeneous reactions.

**MODULE 3: (08 hrs)**
Carnot cycle, Carnot theorem, thermodynamics temperature scales, concept of entropy, calculation of entropy for various systems, entropy for real system.

**MODULE 4: (05 hrs)**
Effect of pressure on specific heat, Joule Thompson effect, third law of thermodynamics & its applications.

**MODULE 5: (08 hrs)**
Compression & Expansion of fluids; single stage, multiple stage requirements & efficiency along with effect & engineering along with effects clearance, compression of real gas.

**Course outcome-**
1: Ability to understand basic concepts of thermodynamics and first law.
2: Capability to estimate PVT behaviors and critical properties of fluids.
3: To provide knowledge & application of second law of thermodynamics.
4: To provide knowledge & application of third law of thermodynamics.
5: To analyze effect of pressure on specific heat, compression & expansion of fluids.

**Text/Reference Book-**


1. K.V Narayanan (2010). A Textbook of Chemical Engineering Thermodynamics. (1st Edition). PHI learning private limited, New Delhi
2. J. M. Smith, H.C. Ness, M. Abbott (2009). Introduction to Chemical Engineering Thermodynamics. (7th Edition). McGraw Hill Education.
3. Daubert, T. E. (Thomas E.), 1937- Chemical Engineering Thermodynamics. (1st Edition McGraw-Hill) New York.
4. Stanley I. Sandler, Thermodynamics, 5th Edition, John Wiley & Sons 2017.

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|---|---|---|---|---|
| **PCC-CH302** | **III** | **Fluid Mechanics** | **3L: 1T: 2P (06hrs)** | **Credits:04** |

**Prerequisite(s):** Engineering Mechanics

**Course objective-**The objective of this course is to understand basic concepts of fluid flow and its application to chemical process industries including pipe flow and fluid machinery.

**Course content-**

**MODULE 1: (09 hrs)**
Properties and classification of fluids; fluid statics: pressure at a point, pressure variation in static fluid absolute and gauge pressure, manometers, dimensional analysis and dynamic similitude dimensional homogeneity, use of Buckingham pi-theorem, calculation of dimensionless numbers.

**MODULE 2: (08 hrs)**
Fluid flow phenomena, introduction to non-Newtonian fluid; introduction to compressible flow. velocity field; stream function; rotational and Irrotational flow, integral and differentialanalysisforfluidmotion,streamtubes,continuityequation,boundarylayertheory, flow in boundary layer, flow past immersed bodies, packed bed, fluidized bed.

**MODULE 3: (08 hrs)**
Navier-Stokes equation, Euler's equation of motion along with a streamline and derivation of Bernoulli's equation, application of Bernoulli's equation, energy correction factor, linear momentum equation for steady flow, momentum correction factor.

**MODULE 4: (07 hrs)**
Introduction to laminar and turbulent flow, concept of Reynolds number and friction factor; friction factor for rough and smooth pipe, losses of head due to friction in pipes and fittings.

**MODULE 5: (08 hrs)**
Fluid Measurements and Machines, velocity measurement (Pitot tube, Prandtl tube, current meters etc.) flow measurement (orifices, nozzles, mouth pieces, orifice meter, nozzle meter, venturi-meter, weirs and notches). Pumps, Blower, power & head requirement for pumps, energy losses in piping system, valves and fittings.

**Course Outcomes:**

After completion of this course, the students are able to:

1: Basic concept of fluid static, viscosity, pressure & vapor pressure and dimensional analysis

2: Different types of flow, streamlines & continuity equation

3: Euler's equation of motion, Bernoulli's equation, linear momentum equation, momentum correction factor.

4: Laminar & turbulent flow, concept of Reynolds number & friction factor.

5: Fluid Measurements and velocity measurement, working of pump, fan blowers and valves and fittings.

**Text/Reference Book-**

1. McCabe W.L., Smith J.C. and Harriott P. (2017) Unit Operations of Chemical Engineering", 7th Ed., McGraw Hill.
2. Nevers N.D. (2005) Fluid Mechanics for Chemical Engineers, 3rd Ed., McGraw Hill Education.
3. Darby R. (2001) Chemical Engineering Fluid Mechanics, 2nd Ed., Marcel Dekker Inc. New York.
4. Denn. M. (1979) Process Fluid Mechanics, Prentice Hall.

**List of experiments-**

1. Determine the local point pressure with the help of pitot tube.
2. Calculate the terminal velocity of a spherical body in water.
3. Calibration of venturi meter.
4. Determination of $C_C$, $C_V$,$C_D$ of orifices.
5. Calibration of orifice meter.
6. Calibration of nozzle meter and mouth piece.
7. Reynolds experiment for demonstration of stream lines & turbulent flow.
8. Calculate the metacentric height.
9. Measure the friction factor of a pipe.
10. Study the characteristics of a centrifugal pump.
11. Verification of impulse momentum principle.

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|---|---|---|---|---|
| **PCC-CH303** | **III** | **Chemical Process Calculation** | **3L:1T:0P (04hrs)** | **Credits:04** |

**Course objective-**The objective of this course to understand and apply the basics of calculations related to material and energy flow in the processes. In addition to make practical approach to solve industrial related material energy balance problems.

**Course content-**

**MODULE 1: (9 hrs)**

Mathematical and Engineering calculation- Units, different unit systems, conversion of unit from one system to other, dimensions, dimensional analysis, dimensional group, fundamental of mole concept, composition of solid, liquid and gases, Basic Stoichiometric Calculations.

**MODULE 2: (10 hrs)**

Ideal Gases & Vapor pressure- Introduction of ideal gas, behavior of ideal gases, real gas, Vander Waal equation, compressibility factor method to solve cubic equation, vapor pressure, Raoult's Law, Humidity, relative humidity, humid heat, humid volume, dew point, humidity chart and its use.

**MODULE 3: (12 hrs)**

Material balance without chemical reaction - Fundamental of conservation of mass, Introduction of component balance, solving material balance without simultaneous equation for different unit operations, solving material balance at steady state and unsteady state, recycle, by pass and purge calculations.

**MODULE 4: (10 hrs)**

Material balance with chemical reaction- Introduction of component balance, solving material balance with chemical reactions, recycles, by pass and purge calculation with chemical reactions, combustion calculations.

**MODULE 5: (9 hrs)**

Energy balance – Laws of thermo chemistry Heat capacity, calculation of enthalpy changes, Energy Balance for unit operations, calculation of standard heat of reaction, heats of formation, combustion, solution, mixing etc., effect of pressure and temperature on heat of reaction, energy balance with chemical reaction.

**Course Outcomes:**

After completion of this course, the students are able to:

1: Unit conversion, concept of stoichiometry, mole and composition.
2: Behavior of liquids as well as gases and concept of humidity.
3: Material balance across equipment's used in process industries.
4: Material balance for chemical reactions involves in chemical process industries.

5: Energy balance including and excluding chemical reaction.

**Text/Reference Book-**

1. Hougen O.A.; Watson K.M.; Ragatz R.A. Chemical Process Principles Part I, CBS pub. 2004.
2. Himmelblau D.M. Basic Principles and Calculations in Chemical Engineering, PHI. 2012
3. Bhatt B.I.; Vora S.M.; Stoichiometry, 4th Edition McGraw Hill Education. 2004
4. Narayanan, K.V.; Lakshmikutty B. Stoichiometry and Process Calculations, PHI. 2016.

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|---|---|---|---|---|
| **PCC-CH304** | **III** | **Fluid Particle Mechanics** | **3L:1T:2P (06hrs)** | **Credits:04** |

**Prerequisite(s):** Engineering Mechanics

**Course objective-**The objective of this course is to understand basic principles of various mechanical operations, construction and working of the equipment's.

**Course content-**

**MODULE 1: (08 hrs)**

Solids, Characteristics of Solid particles, Particle size, Average particle size, Specific surface area of mixture, Screen analysis, Standard screens, Standard screens, Capacity and effectiveness of screen, Ideal and actual screens, Screening Equipment–Grizzly screens, Gyrating screens, Trommels, Shaking screens, Oscillating screens.

**MODULE 2: (08 hrs)**

Size reduction, Mechanism of Size reduction, Crushing Efficiency, Energy and power requirement, Rittinger's, Law, Kick's and Bond's Law, Work index, Size reduction equipments-crushers, grinders, ultrafine grinders and cutting machines.

**MODULE 3: (08 hrs)**

Mixing- Mixing of liquids with liquids, liquids with solids and solids with solids, power requirements. Mixing equipment-Kneaders, dispersers and masticators, Banbury Mixer, Muller Mixer, Pug mills, Ribbon Blenders, Tumbling Mixers.

**MODULE 4: (12 hrs)**

Classification of solid particles, Magnetic Separation, Electrostatic Separator, Floatation, Sedimentation, Thickeners, Cyclone Separator, Filtration, Filter Media, Filter Aid, Equipments for filtration-Pressure filters, Leaf filters, Continuous rotary filters.

**MODULE 5: (10 hrs)**

Transportation, handling and fluidization: Selection of conveying devices for solids: Conveyers-Belt conveyors, Screw conveyor, Chain and Flight conveyors, Bucket Elevators, Pneumatic conveyors, storage bins & silos. Fluidization: Particulate & aggregative fluidization characteristic of fluidized bed, pressure drop through a fluidized bed.

**Course Outcomes:**

After completion of this course, the students are able to:
1: Evaluate size, surface and population of particles, & screen analysis of solids.
2: Principle of size reduction, crushing, grinding, pulverizing and ultra-fining.
3: Mixing equipment and calculate power requirements
4: Principle of separation techniques for system involving solids, liquids and gases, sedimentation and filtration.
5: Transportation of materials, particulate and aggregative fluidization, pressure drop through fluidized bed.

**Text/Reference Book-**

1. Perry RH & Don WG; (2008) Perry's Chemical Engineering Hand Book (8th Edition); New York Chicago; Mc Graw Hill.
2. Banchero & Badger; (1998) Introduction to Chemical Engineering (6th Reprint); the University of California, Mc Graw Hill.
3. McCabe W.L., Smith J.C. and Harriott P. (2017) Unit Operations of Chemical Engineering", 7th Ed., McGraw Hill.
4. Narayan CM & Bhattacharya BC; (2014); Mechanical Operations for Chemical Engineers (3rd Edition); Khanna Publishers, New Delhi.

**List of experiments-**

1. Analyze the given sample by differential, cumulative methods using standard screen.
2. Determination of size and surface area of irregular particles using a measuring gauge.
3. Calculate the crushing efficiency and to determine the Rittinger's and Bond's constant of the given solid in a jaw crusher.
4. Determine the efficiency of a ball mill for grinding a material of known.
5. Calculate the power consumption of the hammer mill.
6. Find out the specific cake resistance for the given slurry by leaf filter.
7. Calculate the efficiency of a given cyclone separator.
8. Evaluate the efficiency of fluidized characteristic bed.
9. Perform the analysis of the dorr type of thickener.
10. Study the plate & frame filter press.

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|---|---|---|---|---|
| **HSMC-CH301** | **III** | **Industrial Psychology and Human Recourse Management** | **3L:0T:0P(03hrs)** | **Credits:03** |

**Course objective-**This course equips students with human resource management skills to be able to function effectively in their professional career.

**Course content-**

**MODULE 1: (10 hrs)**
Introduction and overview of the course, changes/challenges in HRM, management theories, research methodology andstatistical tools, management of change

**MODULE 2: (10 hrs)**
Organizational culture & climate, knowledge productivity, new leadership motivation theories

**MODULE 3: (10 hrs)**
Talent management, training & development, performance management

**MODULE 4: (10 hrs)**
Selection and recruitment, compensation, unions, entrepreneurship

**Course Outcomes:**
After completion of this course, the students are able to:
1: Knowledge about HR challenges and their management. Ability to know about research methodology and statistical tools towards improvement to HRM skill.
2: Learn about the important segment of organizations including organizational culture & climate, productivity and leadership motivation for the improvement in HRM.
3: Knowledge about the management of talent, training anddevelopment and performance along with their implementation for organizational improvement.
4: Knowledge about selection and recruitment process. Ability to handle problem related to compensation and union challenges.

**Text/Reference Book-**


1. Argyris, C. (1957). Personality and Organization: the Conflict between System and the Individual (1st edition). New York, Harper & Row.
2. Locke, E. A. (1999). The Essence of Leadership (1st edition), Lahman, Mariland, Lexington Books.
3. Robbins, S. P., Judge, T. A., N. Vohra (2016). Organizational Behavior (16th edition), London, Pearson.
4. Bach, S. (2005). Managing Human Resources (4th edition), Oxford, Blackwell publishing
5. Claydon, T., &Beardwell J. (2010) Human Resource Management: A Contemporary Approach (6th edition), Edinburgh, UK, Harlow: Financial Times Prentice Hall

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|---|---|---|---|---|
| **ESC-CH301** | **III** | **Computer Programming (Programming in Python)** | **0L:0T:4P (04 hrs)** | **Credits:02** |

**Course Objective:**

The course is designed to provide Basic knowledge of Python. Python programming is intended for software engineers, system analysts, program managers and user support personnel who wish to learn the Python programming language. Learning Outcomes: Problem solving and programming capability.

**Course Outcomes:**

After completion of this course, the students are able to:

1. Install Python and have knowledge of syntax ofPython.
2. Describe the Numbers, Math functions, Strings, List, Tuples and Dictionaries inPython.
3. Express different Decision Making statements andFunctions.
4. Develop code in Python using functions, loopsetc.
5. Design GUI Applications in Python and evaluate different databaseoperations.

**MODULE I:** **(08 hrs)**

Introduction, History,Features, Python –EnvironmentSetupLocal Environment Setup, Getting Python, Installation of Python, Use of IDE

**MODULE II:** **(08 hrs)**

Python –Basic SyntaxPythonIdentifiers, Reserved Words, Lines & Indentation, Multiline Statements, Quotation in Python, Comments & other useful constructs, Python –Variables Assigning Values to Variables, Multiple Assignment, Standard Data Types

**MODULE III:** **(08 hrs)**

Python –Variables, Assigning Values to Variables, Multiple Assignment, Standard Data Types; Python Numbers, Python Strings, Python Lists, Python Tuples, Dictionary, DataType Conversion

**MODULE IV:** **(08 hrs)**

Python –Basic Operators, Types of Operators, Arithmetic Operators, Comparison Operators, Assignment Operators, Bitwise Operators, Logical Operators, Operator Precedence, Python – Decision Making & Loops, Flowchart, If statement Syntax

**MODULE V:** **(08 hrs)**

Python-Functions, Syntax for defining a function, Calling a Function, Function Arguments, Anonymous Functions Python-Applications & Further Extensions.

**Recommended Books:**

1. Python Crash Course: A Hands-On, Project-Based Introduction to Programming, by Eric

Matthes, No StarchPress.
2. LearnPythonthe HardWay'byZedA.Shaw (3rdEdition),AddisonWesley.
3. Head-First Python, by Paul Barry,O'Reilly.
4. 'Python Programming' by John Zelle, Franklin, Beedle& AssociatesInc;

**List of Experiments:**

1. To write a Python program to find GCD of two numbers.
2. To write a Python Program to find the square root of a number by Newton's Method.
3. To write a Python program to find the exponentiation of a number.
4. To write a Python Program to find the maximum from a list of numbers.
5. To write a Python Program to perform Linear Search
6. To write a Python Program to perform binary search.
7. To write a Python Program to perform selection sort.
8. To write a Python Program to perform insertion sort.
9. To write a Python Program to perform Merge sort.
10. To write a Python program to find first n prime numbers.
11. To write a Python program to multiply matrices.
12. To write a Python program for command line arguments.
13. To write a Python program to find the most frequent words in a text read from a file.
14. To write a Python program to simulate elliptical orbits in Pygame.
15. To write a Python program to bouncing ball in Pygame.

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|---|---|---|---|---|
| **MC-CH301** | **III** | **Energy & Environmental Engineering** | **2L:0T:0P (02 hrs)** | **Credit:00** |

**Course objective-**To provide an introduction to energy resources and an emphasis on alternative energy sources and their application. To study the interrelationship between the living organism and environment. To understand the transformation and degradation of organic pollutants in the environment

**Course content-**

**MODULE 1: (06 hrs)**

Energy:Introduction, conventional and non-conventional energy resources - coal, oil, gas, solar energy, wind energy,geothermal energy, Hydropower, Bio-energy, Nuclear energy. Energy survey in India. Current and futureenergy requirements in India and across the world including associated environmental problems.

**MODULE 2: (08 hrs)**

Ecosystem and Biodiversity: Introductionof an ecosystem,Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystems (ponds, rivers, oceans),Biodiversity at global, national and local levels. Threats to biodiversity,Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic andoption values; Endangered and endemic species of India. Conservation of biodiversity: In-Situ and Ex-Situ.

**MODULE 3: (08 hrs)**

Air pollution and Water Pollution:Definition, Cause, effects and control measures of Air pollution;Mobile and stationary sources of air pollutants,effective stack height concept, CO, $CO_2$, $H_2S$, $SO_x$, $NO_x$ emissions, and its control. Definition, Classification, Cause, effects and control measures of water pollution, Measurement of levels of pollution such as DO, BOD, COD.

**MODULE 4: (06 hrs)**

E-Waste:Definition, Classification, Cause, effects and control measures of e-waste, global trade issues of e-waste, Recycling method of e-waste & its benefit.

**MODULE 5: (08 hrs)**

Environment Impact & Protection ActEnvironment: Protection Act; Air (Prevention and Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act; Issues involved in enforcement of environmental legislation; Public awareness. Environmental Impact Assessment. Measuring environmental impacts and policies for the regulation of environmental impacts.

**Course Outcomes:**

After completion of this course, the students are able to:
1: Ability to understand basic concepts conventional and non-conventional energy resources.
2: Ability to understand Ecosystem& Biodiversity.
3: To provide knowledgeabout Air pollution & Water Pollution.
4: To provide knowledge & reuse of E-Waste.

5: Ability to understand basic concepts of Environment Impact & Protection Act.

**Text/Reference Book-**

1. H. Peavy, D. Rowe & G. Tchobanoglous. Environmental Engineering, McGraw Hill Education. 2017.
2. A. K. De, Environmental Chemistry, 1st Edition New Age Publisher Int. Pvt. Ltd. 2016.
3. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publ. House, Mumbai.
4. C.R. Brunner, Hazardous Waste Incineration, McGraw Hill Inc. 1993.
5. R.K. Trivedi, Handbook of Environmental Laws, Rules Guidelines, Compliances and Standards', Vol I and II, B.S. Publications, 2010.

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**Chemical Engineering Department**
**Semester IV (II Year)**

| S. No. | Course Code | Course Title | Hrs./ week | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | BSC-CH401 | Numerical Methods, Probability & Transform Calculus | 3 | 1 | 0 | 4 |
| 2 | PCC-CH401 | Chemical Engineering Thermodynamics-II | 3 | 1 | 0 | 4 |
| 3 | PCC-CH402 | Heat Transfer | 3 | 1 | 2 | 4 |
| 4 | PCC-CH403 | Mass Transfer-I | 3 | 1 | 2 | 4 |
| 5 | PCC-CH404 | Fuel Technology | 3 | 1 | 2 | 4 |
| 6 | PCC-CH405 | Computer Applications in Chemical Engineering | 0 | 0 | 2 | 1 |
| 7 | MC-CH401 | Constitution of India | 2 | 0 | 0 | 0 |
| **Total** | | | **17** | **05** | **08** | **21** |
| **Total Academic Engagement and Credits** | | | **30** | | | **21** |

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|---|---|---|---|
| **BSC-CM401** | **Numerical Methods, Probability and Transform Calculus** | **3L:1T:0P (04 hrs)** | **Credits:04** |

**Prerequisite(s):** Calculus and Linear Algebra, Differential Equations and Vector Calculus

**Course Objectives:** The objective of this course is to serve the potential engineers with techniques of numerical mathematics, Transform calculus and their applications. It aims to equip the students to deal with advanced level of mathematics and applications that would be essential for their disciplines.

**Module-1: Numerical Methods** **(09 hrs)**
Solution of algebraic and transcendental equations: Newton-Raphson method, Secant and Regula-Falsi method, Finite differences, Interpolation using Newton's forward and backward difference formulae, Newton's divided difference, Numerical differentiation, Numerical integration: Trapezoidal rule and Simpson's $1/3^{rd}$ and $3/8^{th}$ rules.

**Module-2: Functions of Complex Variables** **(10 hrs)**
Complex numbers, Polar form of complex numbers, Triangle inequality, Limits, Continuity and differentiability of functions of a single complex variable, Analytic functions, Cauchy-Riemann equations, Cauchy's integral theorem, Integral formula and derivatives of analytic functions, Taylor's and Laurent series, Evaluation of real integrals by Cauchy residue theorem.

**Module-3: Probability and Statistics** **(09 hrs)**
Mean, Median, Mode and Standard deviation, Random variables, Definition of probability and sampling, Conditional probability, Binomial, Poisson and Normal distribution, Linear regression analysis.

**Module-4: Laplace Transform** **(09 hrs)**

Laplace transform, Properties of Laplace transform, Laplace transform of periodic functions, Finding inverse Laplace transform by different methods, Convolution theorem, Evaluation of integrals by Laplace transforms, Solution of ODEs by Laplace transform method, Solution of simultaneous ODEs by Laplace transformation.

**Module-5: Fourier Transformation** **(08 hrs)**
Definition and Properties of Fourier transformation, Convolution of Fourier transformation, Fourier transformation on function spaces, Solution of ordinary and partial differential equation by Fourier transformation.

**Course Outcomes:**
After completion of this course, the students are able to:
1: To describe and apply Numerical methods in practical problems appearing in Chemical engineering.
2: To explain and solve mathematical problems regarding functions of complex variables.
3: To understand and use the concept of probability and statistics in engineering problems.

4: To interpret and apply the concept of Laplace transform in different problems of Chemical engineering.

5: To identify and use Fourier transform in different engineering problems.

**Textbooks/References:**

1. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 10th Edition, 2018.

2. S. R. K. Iyenger, R. K. Jain, Numerical Methods, New Age International Publisher, 1st edition, 2020.

3. M. Spiegel, S. Lipschutz, J. Schiller, Complex Variables, McGraw Hill Education, 2nd Edition, 2009.

4. R. W. Hamming, Numerical Methods for Scientist and Engineers, Dover Publications,2nd edition, New York, 2016.

5. P. Kandasamy, K. Thilagavathy, K. Gunavathi, Numerical Methods, S. Chand & Company, 2nd edition, 2012.

6. B. V. Ramanna, Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 2017.

7. S. Ross, A First Course in Probability, Pearson Education India, 9th Edition, 2019.

8. E. J. Watson, Laplace Transform and Applications, Publisher: Van Nostrand Reinhold, 1980.

9. P. G. Hoel, S. C. Port, C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003.

10. R. J. Beerwends, Fourier and Laplace transform, Cambridge University Press, 2003.

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|---|---|---|---|---|
| **PCC-CH402** | **IV** | **Chemical Engineering Thermodynamics-II** | **3L:1T:0P (04 hrs)** | **Credit:04** |

**Prerequisite(s):** Chemical Engineering Thermodynamics-I

**Course objective-**The objective of this course to understand the theory and applications of Solution thermodynamics, thermodynamic properties of pure fluid, and various cycles like vapor compression cycle etc.

**Course content-**

**MODULE 1: (10 hrs)**

Thermodynamic properties of pure fluid**,** Helmholtz free energy, Gibbs free energy Relationship among thermodynamic properties, Maxwell's relationship, Clausius equation Clausius-Clapeyron equation, Gibbs-Helmholtz equation, Joule-Thomson coefficient.

**MODULE 2: (12 hrs)**

Thermodynamic properties of homogeneous mixtures; property relationship for systems of variable compositions, partial molar properties, fugacity & fugacity-coefficient in ideal-solution, concept of fugacity departure, Activity.

**MODULE 3: (10 hrs)**

Chemical potential & its physical significance, effect of pressure & temperature on heat of reaction, concept of free energy Vant-Hoffs equation, Gibbs-Duhem relationship of free energy with equilibrium constant, chemical reaction equilibria & its applications.

**MODULE 4: (08 hrs)**

Change of mixing activity, heat effects in mixing, activity effect in gaseous mixture, Excess properties, Residual properties.

**MODULE 5: (06 hrs)**

Refrigeration, ideal reversed Carnot cycle, vapor compression refrigeration, component of vapor compression plant (compressor, condenser, expansion device, and evaporator) properties of refrigerant

**Course Outcomes:**

After completion of this course, the students are able to:

1: Understand thermodynamic properties of pure fluid.

2: Ability to apply the concept of partial molar properties and its importance in heterogeneous solutions.

3: Capable to apply the concept of chemical potential and its significance in equilibrium.

4: Ability to understand the concept of heat effect in mixing and activity effect.

5: Ability to understand the concept of refrigeration and its application.

**Text/Reference Book-**

1. K.V Narayanan (2010). A Textbook of Chemical Engineering Thermodynamics. (1st Edition). PHI learning private limited, New Delhi
2. J. M. Smith, H.C. Ness, M. Abbott (2009). Introduction to Chemical Engineering Thermodynamics. (7th Edition). McGraw Hill Education.
3. Daubert, T. E. (Thomas E.), 1937- Chemical Engineering Thermodynamics. (1st Edition McGraw-Hill) New York.
4. Stanley I. Sandler, Thermodynamics, 5th Edition, John Wiley & Sons 2017.

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|---|---|---|---|---|
| **PCC-CH403** | **IV** | **Heat Transfer** | **3L:1T:2P (06 hrs)** | **Credits:04** |

**Prerequisite(s):** Chemical Process Calculation

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

**Course content-**

**MODULE 1: (07 hrs)**
Conduction- Modes of heat transfer one dimensional and two-dimensional, heat rate equations, Theory of insulation, critical radius calculations, types of insulation material, conduction through slab, cylinder and sphere.

**MODULE 2: (08 hrs)**
Convective heat transfer- Heat transfer in boundary layer and in films, natural and forced convection, co/counter/cross current contacting for heat transfer, individual and overall heat transfer coefficient, fouling factor.

**MODULE 3: (06 hrs)**
Radioactive heat transfer- Black body radiation, concept of shape factor, methods of determination of shape factor, radiation exchange in enclosure with black surfaces.

**MODULE 4: (10 hrs)**
Heat transfer under phase change conditions-boiling and condensation of pure components, heat flux temperature diagram for boiling and condensation under vertical and horizontal surfaces, nucleate & pool boiling, effect of surface condition on condensation, correlation for heat transfer under condensation. Evaporation- Type of evaporators and their applications single and multiple effect evaporators, design and operation of forward– backward and mixed feed operations, effect of boiling point elevation and hydrostatic head,vapor recompression.

**MODULE 5: (09 hrs)**
Heat Exchange equipment- Introduction to general design of double pipe,shell and tube heat exchangers, condensers, extended surface equipment's. Heat exchanger equation– coil to fluid, jacket to fluid.

**Course Outcomes:**
After completion of this course, the students are able to:
1: Understand modes of heat transfer, heat rate equation, theory of insulation.
2: Solve convective heat transfer problems, individual and overall heat transfer coefficient, fouling factor.
3: Solve radiative heat transfer problems.
4: Understand heat transfer under phase change conditions, boiling & condensation and to design forward and backward evaporators.
5:Design of double pipe shell and tube exchanger, condensers, extended surface equipment

**Text/Reference Book-**

1. McCabe W.L., Smith J.C. and Harriott P. (2017) Unit Operations of Chemical Engineering", 7th Ed., McGraw Hill.
2. Holman J.P.9th Ed, 2001, Heat Transfer, New York, McGraw Hill.
3. Incropera F.P. and Dewitt D.P. Fundamentals of Heat and Mass Transfer. Wiley; 5th Edition John Wiley. 2001

**List of experiments-**To ascertain the…

1. Thermal conductivity of metal rod.
2. Equivalent thermal conductivity of composite wall.
3. Heat transfer coefficient in force convection.
4. Heat transfer coefficient in Natural convection.
5. Heat transfer coefficient with the help of Stefan Boltzmann Apparatus.
6. Emissivity of the test plate by emissivity measurement apparatus.
7. Heat transfer coefficient in double pipe heat exchanger.
8. Heat transfer characteristics of a shell and tube heat exchanger (heating/cooling) of water.
9. Heat transfer coefficient in parallel and counter flow heat exchanger.
10. Rate of evaporation using an open pan evaporator.
11. Rate of condensation of pure water vapor and to determine the heat transfer coefficient.
12. Demonstrate the film-wise drop-wise condensation and determination of the heat transfer coefficient.
13. Study the single effect evaporator and find out the heat transfer coefficient.

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| **PCC-CH404** | **IV** | **Mass Transfer-I** | **3L:1T:2P (06 hrs)** | **Credits:04** |

**Prerequisite(s):** Chemical Process Calculation

**Course Objective:**The Objective of these subject diffusion phenomena, fundamentals of mass transfer and techniques involved in mass transfer operations of distillation and absorption.

**Course content-**

**Module 1:** **(09 hrs)**

Introduction: Mass transfer operation, Classification of mass transfer operations, choice of separation methods.Molecular diffusion: Fick's law of diffusion, steady state diffusion, multicomponent diffusion, measurement and prediction of diffusion coefficients, molecular diffusion in gases, liquid and solids, Knudsen diffusion, surface diffusion, eddy diffusion. Local and overall mass transfer coefficients.

**Module 2:** **(09 hrs)**

Fundamentals of Mass Transfer: Interphase mass transfer, two phase flow, local overall mass transfer coefficients and their inter relationships, analogies in mass, heat and momentum transfer. Mass transfer theories: film theory, penetration theory and surface renewal, material balance for co current and counter current processes, column internals: types of trays/ plates and packing, concept of ideal stage and stage efficient.

**Module 3:** **(08 hrs)**

Vapor liquid equilibrium, boiling point diagram, relative volatility, flash and differential distillation for two component mixture, steam distillation, azeotropic distillation, extractive distillation

**Module 4** **(10 hrs)**

Continuous and Differential contact Distillation: Rectification, reflux ratio, calculation, optimum reflux ratio, open steam, partial condenser, multiple feed and multiple product calculations, enthalpy concentration diagram, Panchon-Savarit method for calculation of number of theoretical plates, Fensky and Underwood equation for minimum numbers of plate calculation, batch distillation.

**Module 5:** **(09 hrs)**

Absorption: Absorption and stripping of dilute mixtures: Fundamentals of absorption, equilibrium curves, choice of solvent, co-current and counter current contacting fluids, Minimum solvent flow rate, estimation of number of ideal stages – graphical and analytical methods, significance of absorption factor, design of packed column, calculation of NTU and HTU, Concept of HETP.

**Course Outcomes:**

After completion of this course, the students are able to:

1: Understand the knowledge of mass transfer by applying principles of diffusion, mass transfer coefficients

2: Estimate the mass transfer coefficients and their inter relationship. Understanding different theories of mass transfer analogies and inter-phase mass transfer.

3: Understand the vapor liquid equilibrium and different type of distillation.

4: Evaluate the number of theoretical stages by different methods.

5: To determine NTU, HTU, HETP and height of packed bed used for absorption.

**Text/Reference Book-**

1. McCabe W.L., Smith J.C. and Harriott P. (2017) Unit Operations of Chemical Engineering", 7th Ed., McGraw Hill.
2. Coulson J. Richardson M., (2013) Chemical Engineering ($5^{th}$ Edition) Vol 2; Oxford:Butterworth Heinmann.
3. Treybal R.E., (1981) Mass Transfer Operation ($3^{rd}$ Edition), New York: Mc. Graw Hill
4. Sherwood, T.K., Pigford R.L. and Wilke, C.R.,(1975) Mass Transfer;New York: Mc. Graw Hill.
5. Dutta. B.K., (2007) Principles of Mass Transfer and Separation Processes ($1^{st}$ Edition), Delhi:PHI Learning.

**List of Experiment-**Determination of….

1. Diffusion coefficient, or diffusivity, of given liquid in air.
2. Mass transfer coefficient in gas liquid system by evaporation.
3. Study the rates and phenomena of diffusion into gases flowing through the pipe.
4. Study different types of plates and packing.
5. Study the rates and phenomena of diffusion into gases flowing through the pipe and also to verify the Sherwood & Gilliland correlations.
6. Vapor-liquid equilibrium and boiling point diagram for a binary liquid mixture.
7. Validate Rayleigh equation for differential distillation of binary system.
8. Rate of distillation by steam distillation.
9. Studies on packed tower distillation unit.
10. Studies on the sieve plate distillation unit.
11. Studies on bubble cap distillation column.
12. Mass transfer coefficient for absorption of $CO_2$ in NaOH solution in packed column.packed column.

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| **PCC-CH405** | **IV** | **Fuel Technology** | **3L:1T:2P (06 hrs)** | **Credits:04** |

**Prerequisite(s):** Applied Chemistry

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

**Course content-**

**MODULE 1: (08 hrs)**

Solid Fuels & Coal Carbonization:Coal & lignite reserves in India, classifications of coal, washing of coal, analysis of coal, proximate and ultimate analysis. Mechanism of low temperature carbonization and high temperature carbonization, byproduct recovery from coke oven, properties of coke coal, grinding, pulverization, briquetting of solid fuels.

**MODULE 2: (08 hrs)**

Liquid Fuels:Origin of petroleum production, distillation, thermal & catalytic cracking, coking, reforming, isomerizations, crude oil classification, reserves of hydrocarbon in India, introduction to petroleum refining and processing.

**MODULE 3: (08 hrs)**

Petroleum Products Properties and Its Utilization:Petroleum product and their utilization, diesel, petrol, blending of petrol for octane number boosting, AVL (aviation liquid fuel), kerosene, fuel & furnace oil, testing of petroleum product: flash point, pore point, fire point, octane number, cetane number, viscosity and viscosity index, API.

**MODULE 4: (08 hrs)**

Gaseous fuels:Natural gas, synthesis gas, producer gas, water gas, coal gas, LPG, CNG and hydrogen as a fuel, composition properties and uses.

**MODULE 5: (08 hrs)**

Renewable Energy Sources and Fuel cell:Types of solar cell and fabrication, wind energy, principles of tidal energy. Principle and working of fuel cell, various types, construction and its application

**Course Outcomes:**

After completion of this course, the students are able to:
1: Recall coal reserves in India & explain washing of coal & Discuss coal classification
2: Interpret mechanism of low and high temp carbonization
3: Illustrate the knowledge of petroleum processing like cracking, reforming, distillation and isomerization

4: Estimate properties of petroleum product and understand composition and properties of gaseous fuel
5: Discuss principle, working & construction of fuel cell and support renewable energy sources

**Text/Reference Book-**

1. Sarkar S; Fuel and Combustion; Orient Long men Ltd.
2. Gupta OP; Fuel and Combustion; Khanna Publication.
3. Gary; Refining of Petroleum Technology.
4. D.P. Kothari, K. C. Signal, R. Rajan, Renewable Energy Sources and Emerging technology, PHI Learning pvt. Ltd.
5. G.D. Roy, Non-Conventional Energy Source, Khanna Publisher.
6. J. Twidel, T Weir, Renewable Energy Sources, Taylor and Francis.

**List of experiments-**

1. Proximate analysis of the given coal sample.
2. Determine the viscosity of the given oil sample by Redwood Viscometer. No. 1 and No. 2
3. Calculate the viscosity of a given oil sample by Saybolt viscometer.
4. Estimate the viscosity of a given coal tar with the help of tar viscometer.
5. Evaluate the flash and fire points of the given oil sample by Penskey Martin'sapparatus.
6. Find the flash and fire points of the given oil sample by Abel's apparatus.
7. Determine the flash and fire points of the given oil sample by Cleveland apparatus.
8. Investigate the carbon residue of the given oil by Conradson method.
9. Calculatethe cloud and pour point of given oil sample by cloud and pour point apparatus.
10. Find the composition of given gas by Orsat apparatus.
11. Study the method of determination of calorific value by Bomb-Calorimeter.

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| **PCC-CH406** | **IV** | **Computer Application in Chemical Engineering** | **0L:0T:2P (02 hrs)** | **Credits:01** |

**Course objective:** The objective of the course to understand the application Microsoft (MS) excel to solve chemical engineering numerical

**List of experiments-**

1. Introduction to MS excel and discuss basic operations
2. Explain the diverse function in MS excel
3. Unit conversions of chemical process.
4. Ability to solve material balance solution using MS excel
5. Discuss energy balance solution using MS excel.

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| **MC-4** | **IV** | **Constitution of India** | **2L:0T:0P (02 hrs)** | **Credits:00** |

**Course Objective:** The objective of this course is to familiarize the students with the feature of the Indian constitution, laws, democracy etc.

**Course content-**

**MODULE 1: (08 hrs)**

Historical background: Formation and working of constituent assembly, formation and working of drafting committee, commencement of Indian constitution, Dr. Ambedkar's ideas of reservation in constitution.

**MODULE 2: (08 hrs)**

Important feature of the constitution: Preamble, fundamental rights, directive principles of state policy, fundamental duties, centerstate relation.

**MODULE 3: (08 hrs)**

Parliamentary democracy: Loksabha, Rajyasabha, central exclusive president, prime minister, and central ministry, Vidhansabha, Vidhanparishad and state executive (Governor, Chief minister, Minister of state).

**MODULE 4: (08 hrs)**

Special provisions in Indian constitution: finance commission contingency fund, consolidated fund, public service commissions, election commission, safeguards for SC, ST and backward classes, provisions for emergency and constitutional amendments, Indian judiciary supreme court and high court.

**Course Outcomes:**

After completion of this course, the students are able to:

1: Commencement of Indian Constitution
2: Features of Indian constitution
3: Working and functions of Parliamentary house
4: Provisions in Indian Constitution

**Text/Reference Book-**


1. Austin, G. (1999), The Indian Constitution, Oxford, Oxford University Press
2. Pylee, M. V. (2016), India's Constitution (16 Edition), New, Delhi, S. Chand Publication
3. Kumar, R. (2011), Ambedkar and Constitution (1st Edition), New Delhi, Commonwealth Publication Pvt. Ltd.


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