III Semester:

S. No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.	22CHT202	Computer Aided Numerical Methods	PC	Theory	4	2	2	0
2.	22CHT204	Fluid Mechanics	PC	Theory	4	3	1	0
3.	22CHT205	Mechanical Operations	PC	Theory	4	3	1	0
4.	22CHT201	Chemical Engineering Thermodynamics-II	PC	Theory	4	3	1	0
5.	22CHT203	Conventional &Alternate Energy Resources	PC	Theory	3	3	0	0
6.	22MST241	Fundamentals of Materials Science and Engineering[#]	PL/EAS	Theory	3	3	0	0
7.	22CHP206	Fluid Mechanics Lab	PC	Lab	1	0	0	2
8.	22CHP207	Mechanical Operations Lab	PC	Lab	1	0	0	2
Total					**24**	**17**	**5**	**4**

[#]To be taught by the Material Research Centre

SEMESTER – III

1. Subject Code: 22CHT202 Course Title: Computer Aided Numerical Methods

2. Contact Hours: L:2 T:2 P:0

3. Credits: 4 Semester: III

4. Pre-requisite: Nil

5. Course objective:To learn the different numerical techniques for solving algebraic, ordinary differential, partial differential equations and curve fitting of experimental data.

6. Course outcome:Upon completion of this course, the students will be able to:

i. Apply numerical techniques for solving linear and nonlinear problems, including polynomials, single equation problems, and systems of linear and nonlinear equations
ii. Use the regression techniques for linear and nonlinear parameter estimation
iii. Able to apply the different techniques of numerical differentiation and integration
iv. Use the numerical techniques for solving all the different types of ordinary and partial differential equations

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Linear Algebraic Equations:** Introduction, Gauss-Elimination, Gauss-Siedel and LU Decomposition methods, Thomas' algorithm.	8
2.	**Nonlinear Algebraic Equations:** Single variable and multivariable successive substitution method, single variable and multivariable Newton-Raphsontechnique,Polynomial root finding methods.	6
3.	**Function Approximation:** Least squares curve fit, Newton's interpolation formulae, Lagrangian interpolation, Pade approximation, Cubic spline approximation.Numerical differentiation& Integration.	8
4.	**Ordinary Differential Equations - Initial Value Problems:** Explicit Adams Bashforth technique, Implicit Adams-Moulton technique, Predictor-corrector technique, Runge-Kutta methods, Stability of algorithms. **Ordinary Differential Equations - Boundary Value Problems:** Finite difference technique, Orthogonal Collocation (OC), Shooting Techniques.	10
5.	**Partial Differential Equations:** Partial Differential Equations (PDE) – Classification of PDE, Finite difference technique (Method of lines), Case Studies. Use of spreadsheets.	6

8. Books:

(A) Text **Books:**

S.No.	**Authors / Name of Book / Publisher**	**Year of Publication**
1	Sastry, S. S., Introductory Methods of Numerical Analysis, 5th Ed., PHI, New Delhi.	2012
2	Gupta, S. K., Numerical Methods for Engineers, 4th Ed. New Age International Ltd., New Delhi.	2019

(B) Reference **Books:**

S.No.	**Authors / Name of Book / Publisher**	**Year of Publication**
1	Constantinides, A., and Mostoufi, N., Numerical Methods for Chemical Engineers with MATLAB Applications, Prentice Hall.	1999
2	Hanna, O.T. and Sandall, O. C., Computational Methods in Chemical Engineering,Prentice-Hall.	1995
3	Davis, M. E., Numerical Methods & Modeling for Chemical Engineers,JohnWiley.	1984
4.	Finlayson Bruce A., Introduction to Chemical Engineering Computing, Wiley.	2012

1. Subject Code: 22CHT204 Course Title: Fluid Mechanics

2. Contact Hours: L:3 T: 1 P: 0

3. Credits: 4 Semester: III

4. Pre-requisite: Nil

5. Course Objective:

To understand the basic principles of fluid mechanics and acquiring the ability to analyze fluid flow problems with the application of the momentum and energy equations. The studentare also to be made familiar with understanding of pipe flows as well as fluid machinery.

6. Course Outcomes: Upon completion of this course, the students will be able to:

i. To understand types of flows, various laws related to fluid flow and concept of fluid friction and its determination

ii. To understand principles and working of various fluid moving devices.

iii. To illustrate the principles of fluid flow on some real systems such as piping, porous beds, fluidized beds, metering devices and fluid machinery.

iv. To understand and apply the concept of Boundary layer

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Introduction:** Overview**,** Properties of fluids, Pressure measurement, Types of flows, Method of describing fluid motion	3
2.	**Fluid Flow Equations:** Continuity equation for compressible and incompressible fluids. Bernoulli's equation, Euler's equation, introduction to Navier-Stokes equation.	12
3.	**Flow Measuring Devices:** Venturimeter, Orificemeter, Rotameter, Pitot tube, etc.	4
4.	**Flow of Incompressible Fluids:** Relationship between shear stress and pressure gradient, laminar and turbulent flow, Hagen-Poiseuille equation, friction loss in flow, velocity profile and boundary layer calculations for turbulent flow	8
5.	**Flow through Packed and Fluidized Beds**	4
6.	**Transportation of Fluids**: Valves, pipe fittings and their standards, equivalent length of pipe fittings, Pumps (positive displacement and centrifugal), compressors fans and blowers	9

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1.	Streeter, V. L. and Wylie, "Fluid Mechanics," 8th Ed., McGraw-Hill, New York.	1985
2.	McCabe, W.L., Smith, J.C., and Harriott, P., "Unit Operations of Chemical Engineering", 7th Ed., McGraw Hill.	2017

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1.	Gupta, S. K., "Momentum Transfer Operations," 2nd Ed. Tata McGraw-Hill.	1982
2.	Coulson, J. M. and Richardson, J. F., "Chemical Engineering," Vol. 1, Asian books, New Delhi.	2017

1. Subject Code: 22CHT205 Course Title: Mechanical Operations

2. Contact Hours: L:3 T:1 P:0

3. Credits: 4 Semester: III

4. Pre-requisite: NIL

5. Course Objective: To understand basic principles of various mechanical operations, construction, and working of the equipment

6. Course Outcomes:Upon completion of this course, the students will be able to:

i. Understand fluid particle systems and equipment

ii. Select suitable size reduction equipment, solid-solid separation method, conveying systemand analyze mixing processes

iii. Understand the fluid flow and design of filtration and sedimentation processes

7. Details of Course:

Unit No.	Contents	Contact Hours
1	**Size Reduction:** Principles of crushing and grinding, Determination of mean particle size and size distribution, Laws of crushing and grinding, Energy required for size reduction, crushing and grinding equipment, closed and open circuit grinding.	10
2	**Screen Analysis and Size Separation:** Types of screens, mesh number and size distribution, different types of screening, effectiveness of screen, Particle size analysis, separation efficiency and screening equipment.	8
3	**Solid-Liquid-Gas Separation:** Theory of Filtration, Filtration equipment, equations for compressible and incompressible cakes, Constant volume and Constant Pressure Filtration, Press Filter, Rotary drum and vacuum filter. Fiber and fabric filters, sedimentation, classifiers and thickeners, Centrifuges- Principles and applications, Cyclone separators and electrostatic precipitator- Principles and applications.	10
4	**Fluidization:** Fluidization of solids and its applications, Hydraulic and Pneumatic transport of solids.	6
5	**Mixing:** Mixing of liquids and solids, Power requirement in mixing. **Storage and Handling of Materials:** Hoppers and bins, Mechanical and pneumatic conveying systems.	6

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	McCabe, W.L., Smith, J.C., and Harriott, P., "Unit Operations of Chemical Engineering", 7th Ed., McGraw Hill.	2017
2	Brown, G. G., "Unit Operations," CBS Publishers & Distributors, New Delhi.	2005
3	Coulson, J. H. and Richardson, J. F., Backhurst, J. R., and Harker, J.H., "Coulson & Richardson's Chemical Engineering," Vol. 2, 4th Ed., Asian Books Private Ltd., New Delhi.	1998

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Perry, R. H. and Green, D.W., "Perry's Chemical Engineers' Handbook," 9th Ed., McGraw-Hill.	2018
2	Foust, A.S., et al., "Principles of Unit Operations", 2nd Ed., John Wiley, Singapore.	1980
3	Chattopadhyay, P. "Unit Operations of Chemical Engineering", Vol. I., Khanna Publishers, Delhi.	1998
4	Anup Swain, Hemlata Patra, G K Roy, "Mechanical Operations", McGraw Hill Education	2017

1. Subject Code: 22CHT201 Course Title: Chemical Engineering Thermodynamics-II

2. Contact Hours: L:3 T:1 P:0

3. Credits: 4 Semester: III

4. Pre-requisite: Chemical Engineering Thermodynamics-I

5. Course Objective: To learn and apply the principles of phase equilibrium and chemical equilibrium to analyze the problems.

6. Course Outcomes: Upon completion of this course, the students will be able to:

i. Understand the concepts of multi-component systems
ii. To apply phase equilibria using various thermodynamic models
iii. To grasp the calculation of chemical reaction equilibria

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Multi-component Systems:** Chemical potential, ideal-gas mixture, ideal solution, Raoult's Law. Partial properties, fugacity and fugacity coefficient, generalized correlations for the fugacity coefficient, excess Gibbs' energy, activity coefficient.	10
2.	**Phase Equilibria at Low to Moderate Pressures:** Phase rule, phase behavior for vapor liquid systems, Margules equation, Van Laar equation, Wilson equation, NRTL equation, UNIQUAC, UNIFAC. Dew point, bubble point and flash calculations.	10
3.	**Solution Thermodynamics:** Ideal solution, fundamental residual-property relation, fundamental excess-property relation. Evaluation of partial properties. Heat effects of mixing processes. Partially miscible systems.	10
4.	**Chemical Reaction Equilibria:** Reaction coordinate, equilibrium criteria to chemical reactions, standard Gibbs' energy change and the equilibrium constant. Effect of temperature on the equilibrium constant, evaluation of equilibrium constants. Relations between equilibrium constants and compositions: gas-phase reactions, liquid-phase reactions, heterogeneous reaction mixtures. Calculation of equilibrium compositions for single-phase reactions. Multi-reaction equilibria.	10

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Smith, J. M., Van Ness, H. C. and Abbott, M. M., "Introduction to Chemical Engineering Thermodynamics", 7th Ed., McGraw-Hill.	2009
2	Rao, Y. V. C., "Chemical Engineering Thermodynamics," University Press.	1997

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Sandler, S.I., "Chemical and Engineering Thermodynamics", 3rd Ed., John-Wiley & Sons.	1998

1**. Subject Code: 22CHT203 Course Title: Conventional and Alternate Energy Resources**

2. Contact Hours: L: 3 T: 0 P: 0

3. Credits: 3 Semester: VII

4. Pre-requisite: Nil.

5. Objective: To study various types of conventional and non-conventional energy resources including solid, liquid and gaseous fuels.

6. Course Outcomes: Upon completion of this course, the students will be able to:

i. Work in energy-related fields by providing an overview of the challenges related to energy production

ii. Understand environmental and economic issues related to energy production

iii. Carry out a comparative analysis of different types of coal, including their treatment, liquefaction and gasification

iv. Compare the liquid and gaseous fuels sourced from petroleum including their characterization

v. Analyse the potential of alternate energy sources and their scope and limitations

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Energy Scenario:** Energy resources spectrum, Classification of various energy sources, Renewable and non-renewable energy sources, Present and future energy demands, Energy crisis, Pattern of energy consumption, Efficiency of energy resources	2
2.	**Solid Fuels:** Coal: Origin, formation, Properties, proximate and ultimate analyses, heating value, classification, washing and carbonization, Treatment of coal gas, Recovery of chemicals from coal tar, Coal gasification, Liquid fuel synthesis from coal, Carbonization of coal, Briquetting of fines, electricity generation from coal.	8
3.	**Liquid and Gaseous Fuels:**Petroleum origin and processing, various types of fuels, Properties and handling. Natural and liquefied petroleum gases, CNG, Gas hydrates, Gasification of liquid fuels, Hydrogen as a fuel, fuel cell	8
4.	**Biomass Energy**: Biomass types, characterization, pyrolysis, gasification, biochemical conversion routes, biogas, fuel alcohol, biodiesel.	8
5.	**Alternate Energy Sources**: Wind power, Geothermal energy,Tidal energy, Nuclear power **Solar Energy:** Solar insolation, flat plate and focusing collectors, solar space heating and cooling, solar pond, solar cells and storage.	14

8. **Books:**

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Gupta, O.P., Elements of Fuel, Furnaces and Refractories, Khanna Publishers.	1996
2	Brame J.S.S. and King J.G., Edward Arnold "Fuel Solid, Liquid and Gases" Edward Arnold.	1967
3	Rai, G.D., Non-Conventional Energy Sources, Khanna Publishers.	2001

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Twiddle, J. Weir, T. "Renewable Energy Resources," Cambridge University Press.	1986
2	Sorenson, B, "Renewable Energy", 3rd Ed., Elsevier Science.	2004
3	Sukhatme S.P, Solar Energy - Principles of Thermal Collection and Storage, Tata McGraw- Hill.	1996

1. Subject Code: 22MST241

Course Title: Fundamentals of Materials Science and Engineering
(To be taught by Material Research Centre)

2. Contact Hours: L: 3 T: 0 P: 0

3. Credits: 3 Semester: III

4. Pre-requisite: Nil

5. Course Objective:

The objective of this course is to provide basic understanding of the structure, properties and applications of materials to the undergraduate students. The course will also introduce the students to phases and enable them to understand the phenomenon pf phase transformations in materials.

6. Course Outcome:Upon completion of this course, the students will be able to:

i. Classify various classes of materials and explain their structures and imperfections.
ii. Construct the phase diagrams of some systems and interpret the phase transformations
iii. Explain the types and applications of ceramics and polymers
iv. Understand and appreciate the distinctive properties of materials.
v.

7. Details of Course:

Unit No.	Course content	Contact Hours
1.	**Introduction:**Why study materials science and engineering? Review of basic types of interatomic bonds, Classification of materials, Processing/structure/properties/ performance correlations.	3
2.	**Structure and Imperfections**:Lattices, Unit cells, Miller indices of directions and planes for cubic and hexagonal systems, Close packing in solids, Common metallic structures, Voids in close-packed structures, Common ceramics structures – NaCl, CsCl, Diamond Cubic, Zinc Blende, Wurtzite, Rutile, Fluorite, Fullerenes, Spinel, Perovskite, etc., Polycrystalline materials, X-Ray diffraction for determination of crystal structures, Solid state diffusion – Ficks laws of diffusion, Diffusion mechanisms, Temperature dependence of diffusivity, Defects in crystals - Point defects, Dislocations, Grain boundaries and Surfaces	10
3.	**Phase Diagrams and Phase Transformations:** Phase rule, Solid solutions, Hume-Rothery rules, Intermediate phases and compounds, Unary and binary phase diagrams, Isomorphous and eutectic systems, Lever rule, Typical phase diagrams: Fe-C, Cu-Ni, Cu-Zn etc. Classification of phase transformations, Liquid to solid transformation, Homogeneous and heterogeneous Nucleation, Nucleation growth and	8

	overall transformations, Kinetic considerations in solid state transformations, Microstructure evolution during solidification in isomorphous system.	
4.	**Ceramics and polymers:** Types and applications of Glasses, Glass-Ceramics, Clay products, Abrasives, Cements**.** Introduction to polymers, Types of polymerizations, Molecular weight, shape, structure and configuration, Thermoplastic and Thermosetting polymers. Glass transition, melting and glass transition temperature, factors affecting melting and glass transition temperatures. Plastics, elastomers, fibres, Advanced polymeric materials, Some applications of polymers	7
5.	**Properties of Materials** **Mechanical Properties**: Stress-strain response of metallic, ceramic and polymer materials, yield strength, tensile strength and modulus of elasticity, toughness, plastic deformation, fatigue, creep and fracture; **Electronic Properties**: Free electron theory, Fermi energy, density of states, elements of band theory, semiconductors, Hall effect, dielectric behaviour, piezo, ferro, pyroelectric materials; **Magnetic Properties:** Origin of magnetism in metallic and ceramic materials, paramagnetism, diamagnetism, ferro and ferrimagnetism; **Thermal Properties:** Specific heat, thermal conductivity and thermal expansion, thermoelectricity. **Optical Properties:** Refractive index, absorption and transmission of electromagnetic radiation in solids, electrooptic and magneto-optic materials, spontaneous and stimulated emission, gas and solid state lasers.	11

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1.	V. Raghavan, "Materials Science and Engineering- A First Course", 5th Edition, PHI Learning Pvt. Ltd., New Delhi	2004
2.	W. D. Callister, Jr. and D. G. Rethwisch, "Materials Science and Engineering- An Introduction", 10th edition, John Wiley and Sons, Inc.	2018

1. Subject Code: 22CHP206 **Course Title: Fluid Mechanics Lab**

2. Contact Hours: L: 0 T: 0 P: 2

3. Credits: 1 Semester: III

4. Pre-requisite: Studying/completed Fluid Mechanics course

5. Course Objective:

To provide hands on practice in estimating friction losses in pipe line flow, estimating equivalent length for fittings, understanding of pressure drop and flow in packed and fluidized bed. To impart training to use various flow measuring devices for making engineering judgments.

6. Course Outcome: Upon completion of this course, the students will be able to:

vi. Estimate the friction and measure the frictional losses in fluid flow.
vii. Experiment with flow measurement devices like venture meter and orifice meter.
viii. Predict the coefficient of discharge for flow through pipes
ix. Understand Bernoulli's theorem and its applications
x. Predict pressure drop in packed and fluidized bed.

7. Details of Course:

Experiment No.	Objectives	Contact Hours
1.	Determination of head losses in the pipe fitting and valves at various flow rates by determining the loss coefficient for pipe fittings and valves.	3
2.	Experimental verification of Bernoulli's equation and graphically justifying the observations on total energy vs. distance line.	3
3.	Measurement of flow discharge through Venturimeter and Orificemeter by determiningthe coefficient of discharge.	3
4.	Determining the friction factor and friction losses in circular and non-circular pipes.	3
5.	Studying the flow through a fluidized bed and determining the pressure drop and minimum fluidization velocity.	3
6.	Studying the characteristics of a packed bed and determining the pressure drop.	3
7.	Studying the Reynolds Apparatus to identify the nature of fluid flow.	3
8.	Determining the friction factor and losses due to pipes.	3
9.	Centrifugal Pump Test Rig	3
10.	Reciprocating Pump Test Rig	3

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1.	Streeter, V. L. and Wylie, "Fluid Mechanics,"8th Ed., McGraw-Hill, New York.	1985
2.	McCabe, W.L., Smith, J.C., and Harriott, P., "Unit Operations of Chemical Engineering", 7th Ed., McGraw Hill.	2017

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1.	Gupta, S. K., "Momentum Transfer Operations," 2nd Ed. Tata McGraw-Hill.	1982
2.	Coulson, J. M. and Richardson, J. F., "Chemical Engineering," Vol. 1, Asian books, New Delhi.	1998

1. Subject Code: 22CHP207 Course Title: Mechanical Operations Lab

2. Contact Hours: L: 0 T: 0 P: 2

3. Credits: 1 Semester: III

4. Pre-requisite: Studying/completed Mechanical Operations course

5. Course Objective:

To understand the importance of various mechanical operations used in process industry. To apply principles of basic sciences and chemical engineering for designing various size reduction, size separation and conveying equipment.

6. Course Outcome: Upon completion of this course, the students will be able to:

i. To apply the principles of various fluid particle mechanics unit operations through experimentation

ii. To demonstrate the ability to understand the various equipment used in chemical and allied process industry

7. Details of Course:

Experiment No.	Objective	Contact Hours
1.	Determining the efficiency of the Jaw crusher for crushing a material of known weight of feed.	3
2.	Calculating the efficiency of a ball mill for grinding a material of known work index by using variable speed ball mill. Determination of critical speed of ball mill	3
3.	Studying the motion of solid particle moving through a liquid to determine its drag coefficient and to obtain the relation between drag coefficient vs. particle Reynolds number.	3
4.	Studying the operation of Elutriator and to determine the water velocity at varying condition.	3
5.	Separation of different particle sizes using screen analysis and estimating the efficiency of the screen used.	3
6.	Studying the Power number vs. Reynolds number for the given set of impellers in agitated vessels.	3
7.	Understanding working principle of continuous type thickener and to determine the concentration of product obtained at the different heights of sampling points.	3
8.	Understanding the performance of a vacuum rotary drum filter by determining the specific cake resistance for given slurry of $CaCO_3$.	3
9.	Understanding the operation of cyclone separator and determining is collection efficiency.	3
10.	Understanding of the operation of Plate and Frame Filter Press by calculating the medium resistance and the specific cake resistance.	3

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	McCabe, W.L., Smith, J.C., and Harriott, P., "Unit Operations of Chemical Engineering", 7th Ed., McGraw Hill.	2017
2	Brown, G. G., et al, "Unit Operations," CBS Publishers & Distributors, New Delhi.	1995
3	Coulson, J. H. and Richardson, J. F., Backhurst, J. R., and Harker, J.H., "Coulson & Richardson's Chemical Engineering," Vol. 2, 4th Ed., Asian Books Private Ltd., New Delhi.	1998

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Perry, R. H. and Green, D.W., "Perry's Chemical Engineers' Handbook," 9th Ed., McGraw-Hill.	2018
2	Foust, A.S., et al., "Principles of Unit Operations", 2nd Ed., John Wiley, Singapore.	1980
3	Chattopadhyay, P. "Unit Operations of Chemical Engineering", Vol. I., Khanna Publishers, Delhi.	1998