INDIAN INSTITUTE OF PETROLEUM AND ENERGY
2nd Floor, Main Building, A.U. College of Engineering (A),
Andhra University, Visakhapatnam-530 003.

B.TECH SECOND YEAR SYLLABUS CHEMICAL ENGINEERING 2021 Batch

3rd SEMESTER

Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Transform Calculus & Probability	3	1	0	3	
2	Numerical Methods	2	0	2	3	
3	Fluid Mechanics & Multiphase Flow	3	1	0	4	
4	Chemical Process Calculations	3	1	0	4	
5	Object Oriented Programming	2	0	3	4	
6	Innovations Lab	0	0	3	2	
7	Workshop	0	0	3	2	
8	EAA III	0	0	2	P/F	
	Total	**13**	**3**	**13**	**22**	

4th SEMESTER

Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Statistical Techniques	3	0	0	3	
2	Chemical Engineering Thermodynamics	3	1	0	4	
3	Heat Transfer	3	1	0	4	
4	Chemical Process Technology	3	0	0	3	
5	Chemical Reaction Engineering-I	3	0	0	3	
6	Fluid Flow Lab and Design	0	0	3	2	
7	Fuel Lab	0	0	3	2	
8	EAA IV	0	0	3	P/F	
	Total	**15**	**2**	**9**	**21**	

3rd SEMESTER

Course Type	Course Code	Name of Course	L	T	P	Credit
	BS 20001	Transform Calculus & Probability	3	1	0	3

Course Objective

1. To make the students understand the basic concepts of Laplace and Fourier transforms, Fourier series and the applications of these transform techniques in solving initial and boundary value problems.
2. To introduce the fundamentals of probability theory and study different kinds of distributions and their properties such as mean, variance and moments, etc.
3. To explore topics like functions of random variables, jointly distributed random variables and independent random variables.

Learning Outcomes

At the end of the course, the student will be able to:

1. Solve initial and boundary value problems by using Laplace and Fourier transform techniques.
2. Understand the approximation of a function in terms of Sine and Cosine functions.
3. Learn all three types of definitions of a probability measure.
4. Know the variety of distributions and their PMFs and PDFs
5. Find the probabilities of a variety of random variables taking the values on the subsets of the set of Real numbers.
6. Able to check whether the given sequence of random variables is independent or not.

Unit No.	Topics to be Covered	Learning Outcome
1	Laplace Transform: Definition of Laplace transform, linearity property, conditions for existence of Laplace transform, first and second shifting properties, Laplace transform of derivatives and integrals, unit step function, Dirac-delta function and error function, differentiation and integration of transforms, convolution theorem, inversion, periodic functions, evaluation of integrals by Laplace transforms, solution of initial and boundary value problems.	The student will be able to, solve initial and boundary value problems by using Laplace transform techniques.

2	Fourier Series: Orthogonal and Orthonormal functions, periodic functions, representation of a function in terms of orthonormal functions, Fourier series representation of a function and its convergent properties, half range series, sine and cosine series, complex form of a Fourier series, Fourier integral representation of a function, Parseval's identity.	The student will be able to, understand the approximation of a function in terms of Sine and Cosine functions.
3	Fourier Transform: Fourier transform, Fourier sine and cosine transforms, linearity, scaling, frequency shifting and time shifting properties, self-reciprocity of Fourier transform, convolution theorem, Applications to boundary value problems.	The student will be able to, solve initial and boundary value problems by using Fourier transform techniques.
4	Probability: Sample space, events, classical, relative frequency and axiomatic definitions of probability, addition rule, conditional probability, multiplication rule, independence, total probability, Bayes' theorem. Random variables: Discrete, continuous and mixed random variables, cumulative distribution, probability mass and probability density functions, Bernoulli, Binomial, Geometric, Poisson, Uniform, Exponential, Normal and Gamma distributions. Functions of random variables, expectation, variance, moments, jointly distributed random variables and joint cumulative probability distribution functions, jointly continuous random variables, independent random variables, covariance, sum of random variables.	The student will learn all three types of definitions of a probability measure and applications of Bayes' theorem. The student will learn the variety of distributions and their PMFs and PDFs. The student will be able to check whether the given sequence of random variables is independent or not.

Text Books:

1. R. K.Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa publisher.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley publisher.
3. Sheldon Ross, A first course in probability, Pearson publisher.

References:

1. W. Feller, An introduction to Probability theory and its applications.
2. Peter V, O'Neil, Advanced Engineering Mathematics, 6th edition.

Course Type	Course Code	Name of Course	L	T	P	Credit
	BS 20007	Numerical Methods	2	0	2	3

Course Objective

1. This course is to introduce the basic concepts of numerical methods for a variety of problems such as algebraic equations, linear systems of equations, approximation, ordinary and partial differential equations.

Learning Outcomes

At the end of the course, the student will be able to:

1. Understand the numerical error and applicability of a particular method.
2. Find roots of a polynomial or a nonlinear equation, and interpolate a function.
3. Analyse the variety of direct and iterative methods for solving systems of linear equations.
4. Identify different methods to find the approximate integration by quadrature rules.
5. Solve ordinary and partial differential equations by finite difference methods.

Unit No.	Topics to be Covered	Learning Outcome
1.	Numerical errors, Error propagation, Taylor's series. convergence, order, and stability. Finding roots of equations: Bisection, Regula-falsi, Newton-Raphson, secant methods and their convergence. Basic concepts of iteration and solutions.	The student will be able to, understand the numerical error and applicability of a particular method to find roots of a polynomial or a nonlinear equation.
2.	Interpolation by polynomials: Lagrange and Newton divided differences methods, error of the interpolating polynomial, piecewise linear and cubic spline interpolation. Numerical differentiation and integration of functions, Rectangle, Trapezoidal and Simpson's rules, Composite rules, error formulae, Gaussian quadrature rules.	The student will be able to, identify different methods to interpolate and to approximate the integration by quadrature rules.
3.	Matrices, vectors, Norms, ill-conditioning, System of Linear Equations, Gaussian elimination, Gauss-Jordan method, LU and Cholesky decomposition, Iterative methods: Gauss-Seidel and Gauss-Jacobi, Eigenvalue problems: power method, QR method, Gershgorin's theorem. Linear and nonlinear Least Squares, Newton-Raphson Method in two variables.	The student will be able to, analyze the variety of direct and iterative methods for solving systems of linear equations.

4.	Numerical Solution of ODE: Taylor's, Euler's, Modified-Euler, Runge-Kutta methods. Numerical Solutions of PDE: Heat, Wave and Laplace equations.	The student will be able to, solve ordinary and partial differential equations by finite difference methods.

Text Books:

1. S. D. Conte and Carl de Boor, Elementary Numerical Analysis- An Algorithmic Approach (3rd Edition), McGraw-Hill, 1980.
2. K. Atkinson, An Introduction to Numerical Analysis (2nd Edition), John-Wiley & Sons, 1989.
3. E. Kreyszig, Advanced Engineering Mathematics (8th Edition), John Wiley (1999).

References:

1. S.S. Sastry, Introductory Methods of Numerical Analysis - Prentice Hall of India.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	BS 20002	Fluid Mechanics & Multiphase Flow	3	1	0	4

Course Objective

To understand the basic concept of fluid flow and its application to chemical process industries including pipe flow and fluid machinery.

Learning Outcomes

At the completion of this course, every student should be able to:

1. Explain the basic concepts in fluid mechanics; describe the physics and formulate mathematical descriptions of viscous flows.
2. Identify the fundamental concepts in boundary layer theory, and turbulence.
3. Formulate physical model and mathematic model to solve typical fluids problems of engineering importance.

Unit No.	Topics to be Covered	Learning Outcome
Section A:		
1.	Definition of Fluid, Lagrangian and Eulerian methods of description; Velocity Field: Streamline and stream function, Vorticity, Stress Field; Rheology: Newtonian/non-Newtonian Fluids.	Students will be introduced to various fluids and their properties.

2.	Viscous/Inviscid, Laminar/Turbulent, Compressible/ Incompressible, Internal/External, Rotational/Irrotational.	Students will acquaint with various flow field.
3.	**Fluid Statics:** Pressure variation in static fluids, manometer, capillary hydrostatics.	Students will have a strong foundation on static fluid.
4.	Macroscopic mass and momentum balance using integral control volume method, Euler & Bernoulli equations, Internal Incompressible Viscous Flow. Fully developed laminar flow in pipes, Couette and annular flows; Hagen Poiseulle Equation.	Students will be able to apply Euler and Bernouli equation to compute pressure drop, friction losses in flow systems of different configurations.
5.	Eddy viscosity, Universal velocity profile; Skin and Form Friction, friction factor and friction factor versus Reynolds number relation, Calculation of Head Losses in pipes and fittings, Converging and diverging nozzles, Solution of single and multi-path pipe flow systems.	Students will be familiar with head losses in pipes, fittings, converging and diverging nozzles.
6.	Flow around immersed bodies, Drag and Lift, Drag coefficient.	Basic understanding and applications of external incompressible flow.
7.	Valves, Pumps, Compressors, Flow meters (Head/Area): Venturi, Orifice, Rotameter.	Students will be introduced to various flow measuring instruments and pumps.
Section B:		
8.	Introduction to Hydrodynamics of Gas-liquid flow: Homogeneous flow model, Separated flow model, Bubble formation and dynamics, Mass bubbling and liquid entrainment.	Students will understand hydrodynamics of gas-liquid and liquid-liquid two-phase flow system.

Text Books:

1. Introduction to Fluid Mechanics by R. W. Fox & Alan T. McDonald, Wiley; 6th edition (2003).
2. Fundamentals of Multiphase Flow by C. E. Brennen, Cambridge University Press; 1st edition (2009).

References:

1. Fluid Dynamics and Heat Transfer by James G. Knudsen and Donald L. Katz, McGraw-Hill; First Edition (1958).
2. Coulson & Richardson's Chemical Engineering: Fluid Flow, Heat Transfer & Mass Transfer, Vol.1., Butterworth-Heinemann; 6th edition (1999).

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH20001	Chemical Process Calculations	3	1	0	4

Course Objective

This course aims to introduce the material and energy balances for chemical engineers.

Learning Outcomes

At the end of the course, the student will be able to:

1. Learn the basic calculations and techniques used in chemical engineering problems.
2. Understand the basics of material and energy balances and will be able to apply them to chemical processes.
3. Understand the behaviour of liquid, gas and solids.

Unit No.	Topics to be Covered	Learning Outcome
1.	Numerical techniques for solving material & energy balance equations.	Introduction material and energy balance equations.
2.	Material balance with and without chemical reactions, Recycle, bypass, purge calculations, computer-based calculations.	Solving material balance problems on chemical process units.
3.	Vapor-liquid equilibrium: Bubble point, dew point calculations, phase envelope calculations.	Understand the properties of gas and liquids. Phase envelope diagrams.
4.	Energy balances with and without chemical reactions; fuel calculations, adiabatic flame temperature; computer-based calculations for energy balance. psychrometric calculations.	Solving energy balance problems on chemical process units.
5	Introduction to Fuels (solid, liquid and gas): Important properties and specifications.	Fuels and their properties.

Text Books:

1. Himmelblau, D. M. and Riggs, J. B. (2012). Basic Principles and Calculations in Chemical Engineering. 8th Ed., PHI, Eastern Economy Edition.
2. Felder R.M. and Rousseau R.W., (2005), Elementary Principles of Chemical Processes, 3rd Ed., John Wiley & Sons.
3. Introduction to Material and Energy Balances, G V Rekliatis, John Wiley & Sons, 1983.

References:

1. Chemical Process Principles, Part I by O. A. Hougen, K. M. Watson and R. A. Ragatz

Course Type	Course Code	Name of Course	L	T	P	Credit
	BS20004	Object Oriented Programming	2	0	3	4

Course Objective

Introduce students to:

1. The fundamentals of object-oriented concepts, OO programming, and database concepts.
2. Model real world problems with Object Oriented constructs and solve them.

Learning Outcomes

Students will be able to:

1. Analyse a given problem and model it using objects, inheritance, and other OO constructs..
2. Implement a given OO model using the Python language.

Unit No.	Topics to be Covered	Learning Outcome
1.	Fundamental concepts of object oriented programming: Introduction to the principles of object- oriented programming (classes, objects, messages, encapsulation, inheritance, polymorphism, exception handling, and object-oriented containers).	Students will understand: the need for OOP, how the OO constructs help to decompose the complex problems.
2.	Object design implementation in a programming language, e.g., C++ or java or Python. (Currently, Python is used.).	Familiarize with Python basics, built-in data structures, functions, etc. Implement object oriented concepts using Python.
3.	Object oriented database systems: Object oriented data model, query languages, storage organization and indexing techniques; object relational databases.	Familiarize with modelling data, creating Python application to interact with a database.

Text Books:

1. Grady Booch, Object Oriented Analysis and Design, Addison-Wesley.
2. Programming Python: Powerful Object-Oriented Programming (4th Edition), Author: Mark Lutz, O'Reilly.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	BS20006	Workshop	0	0	3	2

Course Objective

1. To study the basics of workshop engineering practice.
2. To identify the hand tools and instruments and acquire measuring skills.
3. To acquire practical skills by performing the experiments in different shops of workshop.

Learning Outcomes (LO)

1. The student will be able to use different manufacturing (machining, welding, foundry, sheetmetal working, etc) processes required to manufacture a product from the raw materials.
2. Learn to use different measuring, marking, cutting tools used in workshop.
3. Get to know about various safety precautions while working in workshop.

Unit No.	Topics to be Covered	Learning Outcomes
1	**Safety Precautions in workshop** **Welding Shop** 1. To study about various welding processes and the tools and equipment's use in welding shop. 2. To prepare a joint (lap/ butt/ T) using gas welding.	Students will get to know about various safety precautions while working in workshop. Students will learn about welding methodology and metal joining processing by using welding.
2	**Foundry Shop** 3. To study about tools and equipments use in foundry shop and how to make a mould. 4. To prepare an aluminium sand casting using the mould prepared by the students.	Students will get to know about mould making and foundry process.

3	**Machine Shop** 5. To study about various machine tools (lathe, milling, shaper, drilling, grinding and EDM drill) available in machine shop. 6. To study about various machining process performed on lathe machine tool in detail and to study the cutting tools used for various machining processes in lathe. 7. To perform facing, step turning, taper turning and knurling on a given work-piece material.	Students will get to know about using various machine such as Lathe, milling, grinding. In lathe machine they will perform various turning operations.
4	**To study about the carpentry, fitting and sheet-metal shop.** 8. To study about the job holding devices, machine tools. 9. To study about the measuring, marking, cutting and plain tools.	Learn to use different measuring, marking, cutting tools used in workshop.

Text books:

1. Hajra S. K. and Chaudhary, Workshop Technology I & II, Khanna Publisher.
2. Raghuvansi B. S., Workshop Technology I & II.

References:

1. Chapman W. A. J., Workshop Technology Vol. 1, 2, 3 & 4, Butterworth-Heinemann.
2. Gupta I. C., Engineering Metrology, Dhanpat Rai & Sons.
3. Beckwith Thomas G., Mechanical Measurements, Narosa Publishing House.
4. Gupta K. M., Material Science and Engineering, Umesh Publication.
5. Callister W. D., Material Science & Engineering, John Wiley & Sons.

4th SEMESTER

Course Type	Course Code	Name of Course	L	T	P	Credit
	BS 2006	Statistical techniques	3	0	0	3

Course Objective

1. The main objective of this course is to introduce statistical concepts and methods for solving engineering problems. Students will learn to organize, describe, analyze, and present data. It will develop students' ability in statistical modeling, inferring unknown parameters, and predicting future observations using existing data.

Learning Outcomes

At the end of the course, the student will be able to:

1. Understand the distributions of sample mean and sample variances.
2. Evaluate the point and interval estimations of functions of unknown parameters from the given random sample.
3. Test a hypothesis by measuring and examining a random sample of the population being analysed.
4. Predict the outcome of a response variable by using several explanatory variables.
5. Learn the associated techniques for selecting, testing and validating simple and multiple linear regression models using data. Understand the testing of hypotheses corresponding to the multiple population means.

Unit No.	Topics to be Covered	Learning Outcome
1.	**Sampling distributions:** Chi-square, t and F distributions, random sample, sample mean and sample variance, the central limit theorem, distributions of the sample mean and the sample variance for a normal population.	The student will be able to, understand the distributions of sample mean and sample variances.
2.	**Estimation:** Unbiasedness, consistency, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for properties, problems.	The student will be able to, evaluate the point and interval estimations of functions of unknown parameters from the given random sample.

3.	**Testing of Hypotheses:** Null and alternative hypotheses, the critical and acceptance regions, two types of errors, power of the test, the most powerful test and Neyman-Pearson fundamental lemma, tests for one sample and two sample problems for normal population (t, F, Z tests), tests for proportions, Chi-square goodness of fit test and its applications, problems.	The student will be able to, test a hypothesis by measuring and examining a random sample of the population being analysed.
4.	**Regression Analysis:** Simple linear regression (Description of the model, Least squares estimation, properties of the least square estimators, confidence interval and hypothesis testing for the model parameters, correlation); Multiple linear regression model (Description of the model, matrix approach of Least squares, properties of the least square estimators, confidence interval and hypothesis testing for the model parameters).	The student will be able to, predict the outcome of a response variable by using several explanatory variables. The student will learn the associated techniques for selecting, testing and validating simple and multiple linear regression models using data.
5.	**Design and Analysis of Experiments:** Analysis of variance (One-way classification of fixed effect model, comparing variances, pair wise comparison), randomized complete block design, Latin square design, random effect models, Factorial design, blocking and confounding, Nested and split plot design, Examples from chemical process.	The student will be able to, understand the testing of hypotheses corresponding to the multiple population means.

Text Books:

1. Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier.

2. D C Montgomery, Design and Analysis of Experiments, Wiley 2014.

References:

1. J. S. Milton & J. C. Arnold, Introduction to Probability and Statistics, McGraw Hill.

2. Alexander Mood, Franklin Graybill D. Boes, Introduction to the theory of Statistics, McGraw Hill.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH20002	Chemical Engineering Thermodynamics	3	1	0	4
Course Objective						

To impart knowledge on relevant concepts in thermodynamics for chemical engineers such as laws of thermodynamic and their applications, property estimation of real fluids, vapor-liquid equilibrium, fugacity, activity coefficient, and reaction equilibrium with specific focus on chemical engineering aspects.

Learning Outcomes

At the end of the course, the student will be able to

1. Understand and apply concepts of thermodynamics relevant to chemical engineers.
2. Compute heat-work and bubble point/ dew point calculations.
3. Estimate Gibbs free energy by selecting appropriate mode.

Unit No.	Topics to be Covered	Learning Outcome
1.	Estimation of properties: Real fluids and their mixtures, Algorithms for computer aided property estimation, and their applications to chemical engineering processes.	Understand the concepts of thermodynamics relevant to Chemical Engineers.
2.	Heat effects of industrial reactions: Theory and applications.	Estimate thermodynamic properties of ideal and real fluids.
3.	Multiphase processes and multi component equilibria; Chemical reaction equilibria; Thermodynamic analysis of real processes.	Compute temperature and pressure at Bubble point and Dew point.

Text Books:

1. Chemical Engineering Thermodynamics by J. M. Smith, H. C. Van Ness and M. M. Abbott, M. T. Swihart, Eighth Edition, McGraw Hill (2018).
2. Chemical Engineering Thermodynamics by Y. V. C. Rao, Second Edition, University Press (2001).

References:

1. Chemical Engineering Thermodynamics by B. G. Kyle, Third Edition, Prentice Hall (1999).
2. Engineering Thermodynamics by P. K. Nag, Sixth Edition, McGraw Hill (2017).
3. Engineering and Chemical Thermodynamics by M. D. Koretsky, Second Edition, John Wiley and Sons (2012).

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH 20003	Heat Transfer	3	1	0	4

Course Objective

The course emphasizes the underlying concepts of the conduction, convection and radiation modes of heat transfer and enumerates the laws, governing equations relating to the rates of heat transfer, based on derivation from fundamentals.

Learning Outcomes

After completion of the course, the students will have a strong foundation on conduction, convection and radiation modes of heat transfer. Students will be able to apply the basic principles, the laws, and the pertinent equations to practical scenarios.

Unit No.	Topics to be Covered	Learning Outcome
1.	Mechanisms of heat flow - conduction, convection, and radiation.	Students will be introduced to different heat transfer mechanisms.
2.	Steady and unsteady state one, two and three dimensional conduction equations in different geometries.	Students will be able to solve real time conduction and problems.
3.	Dimensional analysis, forced and natural convection.	Students will be able to solve real time convection problems.
4.	Stefan Boltzman law, Kirchoff's Law, and their applications, black body, gray body, exchange of radiant heat between gray bodies. Furnaces, flame temperature, optimum thickness of insulation.	Basic understanding of radiation heat transfer. Students will be able to solve real time radiation problems.
5.	Classification and design, metallic and non-metallic heat exchangers. Evaporators: Types and design features. Design of natural and forced circulation reboilers optimization of heat exchanger design; heat exchanger performance evaluation. Process design and performance evaluation of Double Pipe, Shell and Tube, Plate, Spiral Heat Exchangers; Process design data sheets, Heat pumps.	Design of heat exchangers and evaporators.

Text Books:

1. Process Heat Transfer by D. Q. Kern, McGraw-Hill Inc.,US (1950).

2. Heat Transfer by J. P. Holman, McGraw Hill Education; 10th edition (2017).

3. Unit Operations by G. G. Brown, CBS PUBLISHERS AND DISTRIBUTORS PVT LTD (2005).

Reference Books:

1. Unit Operations of Chemical Engineering by W. L. McCabe, J. C. Smith and P. Harriott, McGraw Hill; 7th edition (2004).

2. Process Heat Transfer Principles & Applications by R.W. Serth, Academic Press, (2007).

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH20004	Chemical Process Technology	3	0	0	3

Course Objective

1. To offer students a broad background and overview of chemical industries.
2. This course provides a chance to explore chemical industries on the basics of unit process and unit operation concepts.

Learning Outcomes

At the end of the course, the student will be able to:

1. To clearly distinguish function role and importance of various processes and operation in the plant.
2. To get clear technical knowledge in selection of operating conditions such as temperature, pressure and compositions.
3. Draw the chemical industry flow sheet by using unit operation and unit processes.

Unit No.	Topics to be Covered	Learning Outcome
1.	Scope of CPT in process industries; Introduction of CPT with reference to Indian resources, industries, trade and export potentials, small-scale industries and rural development.	Background of chemical engineering.
2.	Major process symbols, preparation of process flow diagrams, and piping and instrumentation diagrams.	Application of various chemical engineering equipment and their principles in industry.

3.	Introduction to the following industries (including the special features of design and operation) : Fuel and industrial gases including natural gas; petrochemical and downstream industries (in brief); polymer industries; fertilizer industries; caustic-chlorine industries; coal based chemical industries; petroleum refining processes (in brief) and allied industries including additives; nitrogen and nitrogen derivatives industry; sulphur and sulphur derivatives industry; phosphorus and its derivatives industry; soap and detergent industry; pulp and paper industry; alcohols and allied chemicals industry; other important basic and specialty chemicals industry.	Manufacturing process of inorganic chemical products.
4.	Process Software.	Learn about the software employed in industries.

Text Books:

1. Shreve's Chemical Process Industries by G.T. Austin, Fifth edition, Tata McGraw Hill (2012).
2. Dryden's Outlines of Chemical Technology by M.G. Rao, Third edition, East West Press (2018).

References:

1. Moulijn J.K; Makkee M. and van Diepen A;"Chemical Process Technology", Second edition, Wiley (2013).
2. Riegel's Hand Book of Industrial Chemistry by James A Kent, Ninth edition, CBS publishers & distributors (1997).

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH20005	Chemical Reaction Engineering-I	3	0	0	3

Course Objective

1. The objective of the course is to study reaction kinetics and design of ideal reactors for homogeneous reactions.

Learning Outcomes

At the end of the course, the student will be able to

1. Learn how to interpret the kinetic data.
2. Design ideal reactors under isothermal and nonisothermal operations.
3. Study Residence Time Distribution and non-ideal reactor models.

Unit No.	Topics to be Covered	Learning Outcome
1.	Kinetics of homogeneous reactions; Interpretation of batch reactor data.	Understand the basics of rate equation and interpretation of batch reactor data.
2.	Isothermal reactor design- Batch, plug flow and mixed flow; Chemical reactor analysis.	Design ideal reactors under isothermal operations for single and multiple reactions.
3.	Non-isothermal reactors, steady state multiplicity; Reactor design.	Design ideal reactors under non-isothermal operations for single and multiple reactions.
4.	Non-ideal flow in reactors, Residence time distribution.	Basics of non-ideal flow, tools and models for diagnosis of real reactors.

Text Books:

1. Levenspiel O, Chemical Reaction Engineering, 3rd Edition, Wiley India (1999).
2. Fogler S H, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall India (2015).

References:

1. Davis M E and Davis R J, Fundamentals of Chemical Reaction Engineering, 1st Edition, McGraw Hill (2003).
2. Schmidt L D, The Engineering of Chemical Reactions, 2nd Edition, Oxford University Press (2005).
3. Froment G F and Bischoff K B, Chemical Reactor Analysis and Design, 2nd Edition, John Wiley & Sons (1990).

Course Type	Course Code	Name of Course	L	T	P	Credit
LAB	BS 20008	Fluid Flow Lab and Design	0	0	3	2

Course Objective

1. To impart training to use various flow measuring devices for making engineering judgments.

Learning Outcomes

1. Estimate the friction and measure the frictional losses in fluid flow.
2. Experiment with flow measurement devices like venturimeter and orifice meters.
3. Predict the coefficient of discharge for flow through pipes.

Unit No.	Topics to be Covered	Learning Outcome
1.	Bernoulli's experiment;	At the end of the course, the student will be able to perform experiment on various fluid flow equipment and machineries.
2	Flow through square and circular pipes.	
3	Nozzles; pipe fittings.	
4	Venturi meter, orifice meter and	
5	Horizontal V-notch.	
6	Packed bed.	
7	Rotameter.	
8	Pitot tube.	
9	Characteristics of centrifugal pump.	
10	Pipe flow Viscometer.	
11	**Flow in pipes, valves and fittings:** Design studies on valves, pipe fittings and piping networks.	
12	**Two phase flow.**	
13	**Design of Fluid Systems:** Mechanical design of pressure vessel, flange, reinforcement for opening, support.	

Text Books:

1. Introduction to Fluid Mechanics by R. W. Fox & Alan T. McDonald, Wiley; 6th edition (2003).
2. Fundamentals of Multiphase Flow by C. E. Brennen, Cambridge University Press; 1st edition (2009).

Course Type	Course Code	Name of Course	L	T	P	Credit
Basic	BS 20009	Fuel Laboratory	0	0	3	2

Course Objective

1. An ability to identify, analyse and characterize the fuels.

Learning Outcomes

1. To give an insight into fuel systems.
2. Understand the fuel product specifications, various test methods used to qualify different types of fuels.
3. Describe various parameters that are utilized to characterize the fuels.

Unit No.	Topics to be Covered	Learning Outcome
1.	ASTM distillation.	Determination of distillation characteristic (boiling, volatility) of petroleum products.
2.	Reid vapour pressure (RVP).	Determination of volatility of petroleum products.
3.	Gum content (existent).	Characterization of nonvolatile residue present in fuels.
4.	Smoke point.	Identification of smoking tendency of light petroleum products.
5.	Aniline point.	Characterization of degree of aromaticity of petroleum products.
6.	Flash point.	Identification of fire hazardous of fuels.
7.	Moisture content by Dean & Stark method.	Determination of % of moisture present in liquid fuels.
8.	Kinematic viscosity by Dynamic viscosity.	Identification of viscosity, film thickness of liquid lubricants and hydrocarbon fuels.
9.	Redwood viscometer.	Identification of Kinematic viscosity of a liquid fuel sample.
10.	Pour point.	Characterization of the ability fuels to flow under cold operating conditions.
11.	Conradson / Ramsbottom Carbon residue.	Characterization of % carbon residue in fuels.

12.	Rotational viscometer.	Identification of viscosity of liquid lubricants and hydrocarbon fuels.
13.	Gaseous fuels: Orsat Analysis.	Identification of oxygen, carbon monoxide and carbon dioxide content in fuels.
14.	Calorific Value by Junkers calorimeter.	Determination of heat of combustion and the calorific value of gaseous fuels.
15.	Gas chromatography.	Analysis of composition of fuels.

Text Books:

1. Theory, Measurement, and Interpretation of Well Logs", Bassiouni, SPE Textbook Series, Vol. 4, (1994).
2. Fuels & Combustion by Samir Sarkar, 3rd Edition, Universities Press.ISBN 9788173716690.

References:

1. Fuels & Combustion by SP Sharma &Chander Mohan,Tata McGraw Hill Education, ISBN 9780070966277.