Semester III						
S.No	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
1	EE205T	Introduction to Probability	3	0	0	3
2	EE207T	Data Analysis	3	0	0	3
3	CL205T	Heat Transfer for Chemical Engineers	3	0	0	6
4	CL203T	Introduction to Chemical Engineering Thermodynamics	3	0	0	6
5	CL204T	Fluid Mechanics and Mechanical Operations	3	0	0	6
6	ME210T	Mechanics of Materials	2	1	0	6
7	BB401T	Basics of Cell Biology and Genetics	3	0	0	6
		Total Credits				39

1	**Title of the course** (L-T-P-C)	**Introduction to Probability** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	Basic calculus
3	**Course content**	**Introduction**: Motivation for studying the course, revision of basic math required, connection between probability and length on subsets of the real line, probability-formal definition, events and σ-algebra, independence of events, and conditional probability, sequence of events, and *Borel-Cantell* Lemma. **Random Variables**: Definition of random variables, and types of random variables, CDF, PDF and its properties, random vectors and independence, brief introduction to transformation of random variables, introduction to Gaussian random vectors. **Mathematical Expectations**: Importance of averages through examples, definition of expectation, moments and conditional expectation, use of MGF, PGF and characteristic functions, variance and k-th moment, MMSE estimation. **Inequalities and Notions of convergence**: Markov, Chebychev, Chernoff and Mcdiarmid inequalities, convergence in probability, mean, and almost sure, law of large numbers and central limit theorem. **A short introduction to Random Process:** Example and formal definition, stationarity, autocorrelation, and cross correlation function, definition of ergodicity.
4	**Texts/References**	**1. Robert B. Ash**, ``Basic Probability Theory," Reprint of the John Wiley & Sons, Inc., New York, 1970 edition. **2. Sheldon Ross**, ``A first course in probability," Pearson Education India, 2002. **3. Bruce Hayek**, ``An Exploration of Random Processes for Engineers," Lecture notes, 2012. **4.** D.P. Bertsekas and J. Tsitisklis, “Introduction to Probability” MIT Lecture notes, 2000 (*link*: https://www.vfu.bg/en/e-Learning/Math-- Bertsekas_Tsitsiklis_Introduction_to_probability.pdf)

1	**Title of the course** (L-T-P-C)	**Heat Transfer for Chemical Engineers** **3-0-0-6**
2	**Pre-requisite courses(s)**	--
3	**Course content**	**Introduction:** Overview of heat transfer and its significance, difference between thermodynamics and heat transfer, basic modes of heat transfer **Conduction:,** Fourier's law, thermal conductivity, steady-state heat conduction through a plane, composite wall, cylinder, sphere, heat generation inside solids, unsteady-state heat conduction, types of thermal insulation, critical thickness and optimum thickness of insulation, extended surfaces, fin performance evaluation, effectiveness of fins. **Convection:** Free and forced convection inside and outside the tubes as well as over the plates, individual and overall heat transfer coefficients. Heat transfer in laminar flow and turbulent flow, dimensional analysis, dimensionless numbers in heat transfer, heat transfer correlations for natural convection. Condensation and Boiling, Condensation over flat plates, condensation inside and outside the tubes in horizontal, vertical, and inclined positions, film condensation, and dropwise condensing. Estimation of the film coefficient of heat transfer for condensing vapors, turbulence in condensing film. Heat Transfer to boiling liquids, pool boiling, and forced convection boiling, boiling curve and its characteristics. **Radiation:** Radiation heat transfer, laws of radiation, concepts of black body, gray body, greenhouse effect, emissive power, heat flux by radiation, view factors, radiation shield, luminous and non-luminous gases, heat exchangers, and heat transfer fluids. **Application in Various Unit Processes and Operations**: Chemical and bioreactors, shell and tube heat exchangers, LMTD and NTU approaches, condensers, furnaces, boilers, distillation columns, multi- effect evaporators, solar thermal systems etc, strategy for thermal management and optimization, pinch analysis and design of heat exchanger network
4	**Texts/References**	**1.** Dutta B.K., Heat Transfer Principles and Applications, 2 nd Edition, 2023, PHI Learning Pvt..Ltd, New Delhi, ISBN-10: 81963789122. **2.** J. P. Holman, Souvik Bhattacharyya, Heat Transfer, 10th Edition, 2017, McGraw-Hill Education, ISBN-10: 9780071069670 **3.** Donald Kern, Process Heat Transfer, Indian Edition, 2017, McGraw Hill Education, ISBN- 10:0074632175 **4.** Frank P. Incropera, David P. DeWitt, Fundamentals of Heat and Mass Transfer, ohn Wiley & Sons; 5th edition (20 August 2001), ISBN-10 0471386502.

1	**Title of the course (L-T-P-C)**	**Introduction to Transport Phenomena (3-0-0-6)**
2	**Pre-requisite courses(s)**	**Nill**
3	**Course content**	Introduction: Vectors/Tensors, Viscosity, Shell balance: Falling film, Circular tube. Equations of Change for isothermal systems: Continuity, Motion, Energy, Substantial derivatives. Unidirectional flows: Pipe flow, Variable viscosity falling film, Couette viscometer, Rotating Sphere. Unsteady flows: Startup Plate flow, Parallel plates, Oscillating plate; Thermal conductivity and mechanism of energy transport; Shell energy balances and temperature distributions in solids and laminar flow; The equations of change for non-isothermal systems; Diffusivity and the mechanisms of mass transport; Concentration distributions in solids and laminar flow; Equations of change for multicomponent systems; Introduction to the concept of heat and mass transfer-coefficients.
4	**Texts/References**	R.B.Bird, W.E. Stewart and E.N. Lightfoot, Transport Phenomena, 2nd ed., Wiley, 2006

1	**Title of the course** (L-T-P-C)	**Introduction to Chemical Engineering Thermodynamics (3-0-0-6)**
2	**Pre-requisite courses(s)**	Nil
3	**Course content**	Thermodynamics introduction and basic definitions; Importance of PVT relation and equation of state; First law of thermodynamics, applications and limitations; Second law of thermodynamics and its applications; Irreversibility and availability; Thermodynamic potentials & property relations; Thermodynamic property estimation for ideal gas, real gas, and multicomponent mixtures; Solution thermodynamics: ideal and real solutions and the concept of excess properties; Phase equilibrium including vapor-liquid, liquid-liquid, and solid-liquid equilibrium; Chemical reaction equilibrium
4	**Texts/References**	1. Y V C Rao; "Chemical Engineering Thermodynamics". 2. Stanley I. Sandler "Chemical, Biochemical, and Engineering Thermodynamics 4th Edition". 3. J.M. Smith, H.C. Van Ness, M.M. Abott, M.T. Swihart "Introduction to Chemical Engineering Thermodynamics 8th Edition"

1	**Title of the course** (L-T-P-C)	**Fluid Mechanics and Mechanical Operations** **3-0-0-6**
2	**Pre-requisite courses(s)**	--
3	**Course content**	Introduction of fluid mechanics, Fluid statics, surface tension, Newtonian and non-Newtonian fluids, transport properties, shell balances including differential form of Bernoulli equation and energy balance, equation of continuity, equation of motion, equation of mechanical energy, Macroscopic friction factors, dimensional analysis and similitude, Internal incompressible viscous flow in pipes and channels , fully developed laminar, Elementary boundary layer theory, multiple pipe flow systems and turbulent flow. Flow past immersed bodies including packed and fluidized beds, turbulent flow: fluctuating velocity, universal velocity profile and pressure drop. Transportation and metering of fluids, pump types, pump characteristics curves, Net Positive Suction Head (NPSH), Pump Priming and Cavitation, blowers and compressors, direct flow measurement (pitot tube, rotameter, orifice meter etc., indirect methods and commercial flow meters; Mixing and Agitation, power consumption, impeller types and flow patterns, mixing times. Particle size and shape, particle size distribution, size reduction and classification of solid particles; free and hindered settling; centrifuge and cyclones; thickening and classification, filtration, agitation and mixing; conveying of solids.
4	**Texts/References**	**1.** F.M. White, Fluid Mechanics, 8th Edition, Tata McGraw Hill Education, 2016. **2.** Fox, R. W., McDonald, A. T., & Mitchell, J. W., Fox and McDonald's Introduction to Fluid Mechanics, 10th Edition, Wiley, 2020. **3.** McCabe, W. L., Smith, J. C., & Harriott, P., Unit Operations of Chemical Engineering, 7th Edition, McGraw-Hill, 2004. **4.** Çengel, Y. A., & Cimbala, J. M., Fluid Mechanics: Fundamentals and Applications, 5th Edition, McGraw-Hill, 2024. **5.** Richardson, J. F., Harker, J. H., & Backhurst, J. R., Coulson and Richardson's Chemical Engineering: Volume 2 – Particle Technology and Separation Processes, 5th Edition, Butterworth-Heinemann, 2002.

1	**Title of the course (L-T-P-C)**	**Fluid Mechanics (2-1-0-6)**
2	**Pre-requisite courses(s)**	**Nill**
3	**Course content**	Introduction: Scope, definition of fluid as continuum, fluid properties. (2hr) Fluid Statics: Pressure at a point, basic equation for pressure field, pressure variation (fluid at rest): standard atmosphere, Measurement of pressure manometer, Hydrostatics force on a plane and curve surface, Buoyancy, flotation and stability, pressure variation in a fluid with rigid body motion linear motion, rigid body rotation(4hr) Elementary Fluid Dynamics: Statics, stagnation pressure, Bernoulli Equation assumptions(4hr) Fluid Kinematics The velocity filed: Eulerian and Largrangian flow descriptions, steady and deformation, Acceleration field: material derivative, unsteady and convective effects. Control volume and system representation: Reynolds' Transport Theorem, physical interpretation, steady, unsteady effects, moving control volume, potential function(6Hr) Integral approach Conservation of mass derivation of continuity, fixed, non-deforming control volume, moving non-deforming control volume, deforming control volume. Conservation of momentum: linear momentum and moment of momentum equation and their application., comparison of energy equation with Bernoulli's equation(6hr) Differential approach: linear motion and angular motion with deformation, Conservation of mass: differential form of continuity equation, stream function, Conservation of linear momentum, Inviscid flows, Irrotational flow(6hr) Viscous flow: Stress relationships, NS Equations, Simple solutions for viscous flows(4hr) Dimensional analysis Buckingham's II-theorem, Dimensionless groups & their importance (3hr) Viscous Flow in Pipes: General characteristics of pipe flow, fully developed laminar and turbulent flow, turbulent shear stress, turbulent velocity profile, Pipe Flow rate measurement. (4hr) Boundary layer: Boundary layer characteristics boundary layer structure and thickness on a plate, Blasius boundary layer, momentum integral boundary layer equation-for-a-flat-plate(4hr).
4	**Texts/References**	**1.** Yunus A. Cengel, John M. Cimbala, Fluid Mechanics, Tata McGraw Hill Education,2011 **2.** F.M.White Fluid Mechanics, Seventh Edition, Tata McGraw Hill Education,2011. **3.** Kundu,Pijush K., and Ira M.Cohen.Fluid Mechanic, Elsevier,2001

1	**Title of the course** (L-T-P-C)	**Mechanics of Materials** **(2-1-0-6)**
2	**Pre-requisite courses(s)**	Nil
3	**Course content**	**Module 1:** Basics: Fundamentals of mechanics of deformable solids. Concepts of stress and strain and their relationships. Axially loaded members - Normal stress and strain, Simple (direct) shear stress and strain, Hooke's law, Stresses on inclined planes under axial loading, thermal stresses and strains, statically indeterminate problems. Elastic strain energy under axial loads. **Module 2:** Torsion: torsion of circular cross-section shafts (Solid and hollow sections): Deformation field, Torsion formulae for stresses and angular deflection, Elastic strain energy under torsion, Closely-wound helical springs – stresses and deflections. **Module 3**: Bending: Euler – Bernoulli model: normal and shear stresses, deflections for symmetric bending. Statically indeterminate problems, Elastic strain energy under flexure. **Module 4:** Combined stresses: State of stress and strain at a point , transformation laws , Mohr's circle diagram for stress and principal stresses, thin walled structures : thin cylinders and spheres. Theories of failure: Maximum Normal-Stress theory, Maximum shear-stress theory and Maximum Distortional-energy theory. **Module 5:** Energy methods – Castigliano's theorem and its applications, fictitious-load method. Stability of structures – Buckling of idealized and elastic columns
4	**Texts/References**	**TEXTBOOKS:** 1. S.H Crandall, N.C Dahl and S.J Lardner, An Introduction to Mechanics of Solids, Tata McGraw Hill, Third Edition, 2012. 2. E.P. Popov, Engineering Mechanics of Solids, Prentice Hall of India, 2nd edition, 2012. **REFERENCES:** 1. J. M. Gere and Goodno, Mechanics of Materials, 7th ed, Cengage Learning India, 2012. 2. J.P Den Hartog, Strength of Materials, Dover, 1949. 3. J.M Gere and S.P Timoshenko, Mechanics of Materials, CBS Publishers, 1986 4. R. C. Hibbeler, Mechanics of Materials, Pearson, 10th edition, 2016 . 5. S.P Timoshenko and D.H Young, Elements of strength of Materials, 5th ed, Affiliated East West Press, 1976. 6. F. P. Beer, E. R. Johnston Jr., John T. DeWolf , D. F. Mazurek, Mechanics of Materials, McGraw- Hill Education; 7th edition, 2014 7. M. Salvadori and R. Heller, Structure in Architecture, Prentice Hall Inc, 1963. 8. S.P Timoshenko, History of Strength of Materials, Dover, 1983. 9. M. H. Sadd, Elasticity: Theory, Applications, and Numeric, 1st ed, Elsevier India, 2006.

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1	**Title of the course (L-T-P-C)**	**Introduction to Probability (3-0-0-3)**
2	**Pre-requisite courses(s)**	**Basic calculus**
3	**Course content**	**Introduction**: Motivation for studying the course, revision of basic math required, connection between probability and length on subsets of the real line, probability-formal definition, events and σ-algebra, independence of events, and conditional probability, sequence of events, and Borel-Cantell Lemma. **Random Variables**: Definition of random variables, and types of random variables, CDF, PDF and its properties, random vectors and independence, brief introduction to transformation of random variables, introduction to Gaussian random vectors. **Mathematical Expectations**: Importance of averages through examples, definition of expectation, moments and conditional expectation, use of MGF, PGF and characteristic functions, variance and k-th moment, MMSE estimation. **Inequalities and Notions of convergence**: Markov, Chebychev, Chernoff and Mcdiarmid inequalities, convergence in probability, mean, and almost sure, law of large numbers and central limit theorem. **A short introduction to Random Process:** Example and formal definition, stationarity, autocorrelation, and cross correlation function, definition of ergodicity.
4	**Texts/References**	1. **Robert B. Ash**, ``Basic Probability Theory," Reprint of the John Wiley & Sons, Inc., New York, 1970 edition. 2. **Sheldon Ross**, ``A first course in probability," Pearson Education India, 2002. 3. **Bruce Hayek**, ``An Exploration of Random Processes for Engineers," Lecture notes, 2012. 4. D. P. Bertsekas and J. Tsitisklis, "Introduction to Probability" MIT Lecture notes, 2000 (*link*:https://www.vfu.bg/en/e-Learning/Math--Bertsekas_Tsitsiklis_Introduction_to_probability.pdf)

1	**Title of the course (L-T-P-C)**	**Data Analysis (3-0-0-3)**
2	**Pre-requisite courses(s)**	**Introduction to Probability**
3	**Course content**	The role of statistics. Graphical and numerical methods for describing and summarizing data. Sampling variability and sampling distributions, Estimation using a single sample, Hypothesis testing using a single sample, Comparing two populations or treatments, Simple linear regression and correlation, and Case studies.
4	**Texts/References**	Sheldon M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists," Elsevier, New Delhi, 3rd edition (Indian), 1987. Papoulis and Pillai, "Probability, Random Variables and Stochastic processes," 4th Edition, Tata McGraw Hill, 1991. William Feller , "An Introduction to Probability Theory and Its Applications," Vol. 1, 3rd edition, John Wiley International, 1968.

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1	**Title of the course (L-T-P-C)**	**Basics of Cell Biology and Genetics (3-0-0-6)**
2	**Pre-requisite courses(s)**	None
3	**Course content**	**1.** Quantity Introduction to genetics **2.** Mendelian genetics: Mendel's law and examples, Monohybrid and di- hybrid cross, recessive, and dominant mutation, concept of allele **3.** Non-Mendelian genetics: incomplete dominance, semi- dominance, and introduction to epigenetics, Cytoplasmic inheritance, infection heredity. **4.** Genetic interactions: approach towards generating a network (epistasis, redundancy, synthetic lethality, lethal interactions) **5.** Model organisms and studies on molecular and genetic interactions. **6.** Structure of prokaryotic and eukaryotic cells **7.** Introduction of cell biology, classification of living organisms, Prokaryotic cells, eukaryotic cells. **8.** Membrane structure and function. **9.** Structure and Composition of the Cell Membrane, Membrane Proteins, Transport across the Cell Membrane **10.** Structural organization and function of intracellular organelles Structure and function of cytoplasm, Cytoskeletal elements and architecture, Structure and Function of mitochondria, Ribosomes, Endoplasmic reticulum, Rough endoplasmic reticulum and protein secretion, Lysosomes, The Golgi Complex, Peroxisomes, Vacuoles, plant cell organelles, Cell locomotion.
4	**Texts/References**	**1.** Anthony JF Griffiths et al., An Introduction to Genetic Analysis W.H. Freeman and Co 7th Edition 2000 **2.** Watson et. al., Molecular Biology of the Gene, Pearson, 7th Edition 2013 **3.** Jocelyn E. Krebs et al., Lewin's Gene Jones & Bartlett Learning; 11 edition (December 31, 2012) 4. Richard Kowles, Solving Problems in Genetics Springer; 2001 edition (June 21, 2001) **4.** Gerald Karp, Cell Biology, WILEY (Feb. 4th, 2013) **5.** Bruce Alberts et al., Essential Cell Biology; Richard Goldsby and Thomas J, &F/Garland, 4th Edition, (2014). **6.** Alberts, Bruce.; Molecular Biology of the Cell, Garland Science; 5th edition (2 January 2008)

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1	**Title of the course (L-T-P-C)**	**Chemical Engineering lab -1 (Thermodynamics and fluid mechanics) (0-0-3-3)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	**Thermodynamics:** Determination of partial molar enthalpies, vapour pressures, infinite dilution activity coefficient, vapour-liquid equilibrium, adiabatic calorimetry. **Fluid mechanics:** Flow visualization, Flow rate, velocity and pressure measurements, calibration of flowmeters, flow-through pipes and piping elements including Bernouli's principle, Impact of fluid-jets on substrates.
4	**Texts/References**	--