Chemical and Biochemical Engineering

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	CL204T	Fluid Mechanics and Mechanical Operations	3	0	0	6
4	CH205T	Heat Transfer for Chemical Engineers	3	0	0	6
5	CH203T	Introduction to Chemical Engineering Thermodynamics	3	0	0	6
6	ME201T	Engineering Mechanics	2	1	0	6
7	BB401T	Basics of Cell Biology and Genetics	3	0	0	6
		Total Credits				**39**

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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)**	**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.

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)

1	**Title of the course** (L-T-P-C)	**Fluid Mechanics and Mechanical Operations** **2-1-0-6**
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)	**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)	**Engineering Mechanics (2-1-0-6)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	**Module 1:** Introduction to Engineering Mechanics covering, Force Systems Basic concepts, Particle equilibrium in 2-D & 3-D; Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Components in Space – Resultant- Moment of Forces and its Application; Couples and Resultant of Force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium of Coplanar Systems and Spatial Systems; Static Indeterminacy **Module 2:** Friction covering, Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, screw jack & differential screw jack; **Module 3:** Basic Structural Analysis covering, Equilibrium in three dimensions; Method of Sections; Method of Joints; How to determine if a member is in tension or compression; Simple Trusses; Zero force members; Beams & types of beams; Frames & Machines; **Module 4:** Centroid and Centre of Gravity covering, Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia of circular plate, Cylinder, Cone, Sphere, Hook; **Module 5:** Virtual Work and Energy Method- Virtual displacements, principle of virtual work for particle and ideal system of rigid bodies, degrees of freedom. Active force diagram, systems with friction, mechanical efficiency. Conservative forces and potential energy (elastic and gravitational), energy equation for equilibrium. Applications of energy method for equilibrium. Stability of equilibrium. **Module 6**: Particles dynamics- Kinematics of Particles: Rectilinear motion, Plane curvilinear motion - rectangular coordinates, normal and tangential coordinates, polar coordinates, Space curvilinear - cylindrical, spherical (coordinates), Relative and Constrained motion. Kinetics of Particles: Force, mass and acceleration – rectilinear and curvilinear motion, work and energy, impulse and momentum – linear and angular; Impact – Direct and Oblique. Kinetics of System of Particles: Generalized Newton's Second Law, Work-Energy, Impulse-Momentum, Conservation of Energy and Momentum **Module 7:** Introduction to Rigid body dynamics Kinematics of Planar Rigid Bodies: Equations for rotation of a rigid body about a fixed axis, General plane motion, Instantaneous Center of Rotation in Plane Motion Plane Motion of a Particle Relative to a Rotating Frame. Coriolis Acceleration Kinetics of Planar Rigid Bodies: Equations of Motion for a Rigid Body, Angular Momentum of a Rigid Body in Plane Motion, Plane Motion of a Rigid Body and D'Alembert's Principle, Systems of Rigid Bodies, Constrained Plane Motion; Energy and Work of Forces Acting on a Rigid Body, Kinetic Energy of a Rigid Body in Plane Motion, Systems of Rigid Bodies, Conservation of Energy, Plane Motion of a Rigid Body - Impulse and Momentum, Systems of Rigid Bodies, Conservation of Angular Momentum. **Module 8**: Mechanical Vibrations covering, Basic terminology, free and forced

		vibrations, resonance and its effects; Degree of freedom; Derivation for frequency and amplitude of free vibrations without damping and single degree of freedom system, simple problems, types of pendulum, use of simple, compound and torsion pendulums
4	**Texts/References**	**Textbooks:** 1. J. L. Meriam and L. G. Kraige, Engineering Mechanics, Vol I – Statics, Vol II – Dynamics, 6th Ed, John Wiley, 2008. 2. F. P. Beer and E. R. Johnston, Vector Mechanics for Engineers, Vol I - Statics, Vol II – Dynamics, 9th Ed, Tata McGraw Hill, 2011. 3. R. C. Hibbler, Engineering Mechanics: Principles of Statics and Dynamics, Pearson Press, 2006. **References:** 1. S. P. Timoshenko and D. H. Young, Engineering Mechanics. Fourth Edition. McGraw-Hill, New York, 1956. 2. I. H. Shames, Engineering Mechanics: Statics and dynamics, 4th Ed, PHI, 2002. 3. Robert W. Soutas-Little; Daniel J. Inman; Daniel Balint, Engineering Mechanics: Dynamics – Computational Edition, 1st Ed., Cengage Learning, 2007 4. Robert W. Soutas-Little; Daniel J. Inman; Daniel Balint, Engineering Mechanics: Statics-Computational Edition, 1st Ed., ,Cengage Learning, 2007