# Chemical and Biochemical Engineering

| Semester III | | | | | | |
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| **S.No** | **Course Code** | **Course Name** | **L** | **T** | **P** | **C** |
| 1 | CL 201 | Introduction to Transport Phenomena | 3 | 0 | 0 | 6 |
| 2 | CL 204 | Introduction to Chemical Engineering Thermodynamics | 3 | 0 | 0 | 6 |
| 3 | ME 203 | Fluid Mechanics | 2 | 1 | 0 | 6 |
| 4 | ME 222 | Mechanics of Materials | 2 | 1 | 0 | 6 |
| 5 | EE 221 | Introduction to Probability | 3 | 0 | 0 | 3 |
| 6 | EE 227 | Data Analysis | 3 | 0 | 0 | 3 |
| 7 | BB 301 | Basics of Cell Biology and Genetics | 3 | 0 | 0 | 6 |
| 8 | CL 211 | Chemical Engineering lab -1 (Thermodynamics and fluid mechanics) | 0 | 0 | 3 | 3 |
| | | Total Credits | | | | 39 |

# Chemical and Biochemical Engineering

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| **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.<br>Unidirectional flows: Pipe flow, Variable viscosity falling film, Couette viscometer, Rotating Sphere.<br>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 |

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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".<br>2. Stanley I. Sandler "Chemical, Biochemical, and Engineering Thermodynamics 4th Edition".<br>3. J.M. Smith, H.C. Van Ness, M.M. Abott, M.T. Swihart “Introduction to Chemical Engineering Thermodynamics 8th Edition" |

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| 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)<br><br>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)<br><br>Elementary Fluid Dynamics: Statics, stagnation pressure, Bernoulli Equation assumptions(4hr)<br><br>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)<br><br>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)<br><br>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)<br><br>Viscous flow: Stress relationships, NS Equations, Simple solutions for viscous flows(4hr)<br><br>Dimensional analysis Buckingham's II-theorem, Dimensionless groups & their importance (3hr)<br><br>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)<br><br>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<br>**2.** F.M.White Fluid Mechanics, Seventh Edition, Tata McGraw Hill Education,2011.<br>**3.** Kundu,Pijush K., and Ira M.Cohen.Fluid Mechanic, Elsevier,2001 |

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| 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.<br>**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.<br>**Module 3**: Bending: Euler – Bernoulli model: normal and shear stresses, deflections for symmetric bending. Statically indeterminate problems, Elastic strain energy under flexure.<br>**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.<br>**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:**<br>1. S.H Crandall, N.C Dahl and S.J Lardner, An Introduction to Mechanics of Solids, Tata McGraw Hill, Third Edition, 2012.<br>2. E.P. Popov, Engineering Mechanics of Solids, Prentice Hall of India, 2nd edition, 2012.<br><br>**REFERENCES:**<br>1. J. M. Gere and Goodno, Mechanics of Materials, 7th ed, Cengage Learning India, 2012.<br>2. J.P Den Hartog, Strength of Materials, Dover, 1949.<br>3. J.M Gere and S.P Timoshenko, Mechanics of Materials, CBS Publishers, 1986<br>4. R. C. Hibbeler, Mechanics of Materials, Pearson, 10th edition, 2016 .<br>5. S.P Timoshenko and D.H Young, Elements of strength of Materials, 5th ed, Affiliated East West Press, 1976.<br>6. F. P. Beer, E. R. Johnston Jr., John T. DeWolf , D. F. Mazurek, Mechanics of Materials, McGraw- Hill Education; 7th edition, 2014<br>7. M. Salvadori and R. Heller, Structure in Architecture, Prentice Hall Inc, 1963.<br>8. S.P Timoshenko, History of Strength of Materials, Dover, 1983.<br>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 $\sigma$-algebra, independence of events, and conditional probability, sequence of events, and Borel-Cantell Lemma.<br><br>**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.<br><br>**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.<br><br>**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.<br>**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.<br>2. **Sheldon Ross**, ``A first course in probability," Pearson Education India, 2002.<br>3. **Bruce Hayek**, ``An Exploration of Random Processes for Engineers," Lecture notes, 2012.<br>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) |

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| **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.<br><br>Papoulis and Pillai, "Probability, Random Variables and Stochastic processes," 4th Edition, Tata McGraw Hill, 1991.<br><br>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<br>2. Mendelian genetics: Mendel's law and examples, Monohybrid and di- hybrid cross, recessive, and dominant mutation, concept of allele<br>3. Non-Mendelian genetics: incomplete dominance, semi- dominance, and introduction to epigenetics, Cytoplasmic inheritance, infection heredity.<br>4. Genetic interactions: approach towards generating a network (epistasis, redundancy, synthetic lethality, lethal interactions)<br>5. Model organisms and studies on molecular and genetic interactions.<br>6. Structure of prokaryotic and eukaryotic cells<br>7. Introduction of cell biology, classification of living organisms, Prokaryotic cells, eukaryotic cells.<br>8. Membrane structure and function.<br>9. Structure and Composition of the Cell Membrane, Membrane Proteins, Transport across the Cell Membrane<br>10. Structural organization and function of intracellular organelles<br><br>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<br>2. Watson et. al., Molecular Biology of the Gene, Pearson, 7th Edition 2013<br>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)<br>4. Gerald Karp, Cell Biology, WILEY (Feb. 4th, 2013)<br>5. Bruce Alberts et al., Essential Cell Biology; Richard Goldsby and Thomas J, &F/Garland, 4th Edition, (2014).<br>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** | -- |