Semester IV						
Sr No	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
1	ME 220	Heat Transfer	2	1	0	6
2	ME 222	Mechanics of Materials	2	1	0	6
3	CL 202	Reaction engineering	3	0	0	6
4	MA 407	Introduction to Numerical Linear Algebra	3	1	0	4
5	MA 103	Differential Equations -I	3	1	0	4
6	BB 404	Biophysics	3	0	0	3
7	CH 201	Organic chemistry	3	0	0	3
8	CL 203	Mass transfer	3	0	0	6
		Total Credits				38

1	**Title of the course (L-T-P-C)**	**Heat Transfer (2-1-0-6)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	• **Introduction:** Typical heat transfer situations, Modes of heat transfer, Introduction to laws, some heat transfer parameters • **Conduction:** Fourier's law and thermal conductivity, Differential equation of heat conduction, boundary conditions and initial conditions, Simple one-dimensional steady state situations – plane wall, cylinder, sphere (simple and complex situations), concept of thermal resistance, concept of U, critical radius. variable thermal conductivity (exercise), Special one-dimensional steady state situations: heat generation, pin fins, other fin configurations (exercise), Two-dimensional steady state situations, Transient conduction, Lumped capacitance model, One dimensional transient problems: analytical solutions, 1D Heisler charts, Product solutions, Numerical methods in conduction, Steady state 1D and 2D problems, 1D transient problems: Explicit and implicit • **Radiation:** Basic ideas, spectrum, basic definitions, Laws of radiation, black body radiation, Planck's law, Stefan Boltzmann law, Wien's Displacement law, Lambert cosine law, Radiation exchange between black surfaces, shape factor, Radiation exchange between Gray surfaces – Radiosity-Irradiation method, Parallel plates, Enclosures (non-participating gas), Gas radiation Forced Convection: Concepts of fluid mechanics, Differential equation of heat convection, Laminar flow heat transfer in circular pipe: constant heat flux and constant wall temperature, thermal entrance region, Turbulent flow heat transfer in circular pipe, pipes of other cross sections, Heat transfer in laminar flow and turbulent flow over a flat plate, Reynolds analogy, Flow across a cylinder and sphere, flow across banks of tubes, impinging jets • **Natural Convection:** Introduction, governing equations, Vertical plate Pohlhausen solution, horizontal cylinder, horizontal plate, enclosed spaces Heat Exchangers: Types of heat exchangers, LMTD approach – parallel, counter-flow, multi-pass and cross flow heat exchanger, NTU approach: parallel, counter- flow, shell and tube, cross flow heat exchanger Condensation and Boiling: Dimensionless parameters, boiling modes, correlations, forced convection boiling, laminar film condensation on a vertical plate, turbulent film condensation • **Mass Transfer:** Analogy between heat and mass transfer, mass diffusion, Fick's law of diffusion, boundary conditions, steady mass diffusion through a wall, transient mass diffusion, mass convection, limitations of heat and mass transfer analogy.
4	**Texts/References**	**1.** In crop era FP and Dewitt DP, Fundamentals of Heat and Mass Transfer, 5th e, John Wiley & Sons, 2010. **2.** Cengel YA, Heat and Mass Transfer - A Practical Approach, Third edition, McGraw-Hill, 2010. **3.** Holman JP, Heat Transfer, McGraw-Hill, 1997.

1	**Title of the course (L-T-P-C)**	**Mechanics of Materials (2-1-0-6)**
2	**Pre-requisite courses(s)**	**Nill**
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 Numerics, 1st ed, Elsevier India, 2006.

1	**Title of the course (L-T-P-C)**	**Introduction to Computational Chemistry (3-0-0-3)**
2	**Pre-requisite courses(s)**	**Fundamental concepts and applications of chemistry (CH101)**
3	**Course content**	Interpolation and Curve Fitting, Roots of Equations, Matrix Methods, Differential Equations, Numerical Integration, Integral Transforms, Ab initio methods, Density functional methods, Software's for quantum mechanical calculations, Different forms of inputs for Ab initio calculations, Computation of single point energies, Geometry optimization, Electron densities and electrostatic potentials, Analysis of output for Gaussian programmes, Molecular frequencies, Modelling in solutions
4	**Texts/References**	**1.** R. Levine, Quantum Chemistry, Prentice Hall India (Ltd.), 1995. **2.** A. Szabo and N. S. Ostlund, Modern Quantum Chemistry, McGraw- Hill, 1989. J. **3.** GAMESS Program, Gaussian-11 Program

1	**Title of the course (L-T-P-C)**	**Reaction engineering (3-0-0-6)**
2	**Pre-requisite courses(s)**	**Nill**
3	**Course content**	Kinetics Reaction rate, order, rate constant; Batch reactors Design + basics; Kinetic constants from batch reactor data; Ideal flow reactors Mass and Energy balances; Isothermal, adiabatic and non-isothermal operation; Catalysts, Catalytic rates, Reaction mechanisms; Internal/External transport in catalysts; non-catalytic solid-gas reactions; Reactor design for ideal flow reactors; Yield and Selectivity; Concept of RTD; Segregation and Maximum Mixedness models
4	**Texts/References**	**1.** H.S.Fogler, Elements of Chemical Reaction Engineering, 2nd ed., Prentice Hall, New Jersey, 1992. **2.** O.Levenspiel, Chemical Reaction Engineering, 2nd ed., Wiley Eastern,1992 **3.** J.M.Smith, Chemical Engineering Kinetics, 3rd ed., McGraw Hill, 1980.

1	**Title of the course (L-T-P-C)**	**Introduction to Numerical Linear Algebra (3-1-0-4)**
2	**Pre-requisite courses(s)**	Calculus, MA 101 & Linear Algebra, MA 106
3	**Course content**	Floating point number system, Big O notation Matrix and vector norms, ill conditioned problems Solution of a system of linear equations, Gauss elimination, LU factorization, Cholesky method, Classical iterative methods: Jacobi and Gauss-Seidel Eigenvalue problems, Power method, QR method, Gershgorin theorem. Exposure to MATLAB
4	**Texts/References**	S. D. Conte and Carl de Boor, Elementary Numerical Analysis- An Algorithmic Approach (3rd Edition), McGraw-Hill, 1980

1	**Title of the course (L-T-P-C)**	**Differential Equations -I (3-1-0-4)**
2	**Pre-requisite courses(s)**	**Nill**
3	**Course content**	Exact equations, integrating factors and Bernoulli equations. Orthogonal trajectories. Lipschitz condition, Picard's theorem, examples on non-uniqueness. Linear differential equations generalities. Linear dependence and Wronskians. Dimensionality of space of solutions, Abel-Liouville formula. Linear ODE's with constant coefficients, the characteristic equations. Cauchy-Euler equations. Method of undetermined coefficients. Method of variation of parameters. Laplace transform generalities. Shifting theorems. Convolution theorem.
4	**Texts/References**	**1.** E. Kreyszig, Advanced engineering mathematics (10th Edition), John Wiley (1999) **2.** W. E. Boyce and R. DiPrima, Elementary Differential Equations (8th Edition), John Wiley (2005)

1	**Title of the course (L-T-P-C)**	**Biophysics** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	

3	**Course content**	• Diffusion and Brownian motion and biological applications.
		• Electrostatic interactions
		• Chemical potential and Chemical reactions
		• Self-assembly, micelles, cell membranes
		• Helix coil transition
		• Stretching of macromolecules
		• Protein folding
		• Unzipping of DNA
		• Machines in membranes
		    ○ Electro-osmotic effects
		    ○ Ion pumping
		• Nerve Impulses
		    ○ Action Potentials
		    ○ Ion Channels
		• Physical Techniques and related biology
		    ○ X-ray diffraction, light and neutron scattering
		    ○ Nuclear magnetic Resonance
		    ○ Fluorescence
		    ○ DNA Microarrays
		    ○ Manipulation of bio-molecules using optical tweezers.
		    ○ Tomography
		    ○ Patch clamps

4	**Texts/References**	1. Physical biology of the cell, second edition by rob phillips, jane kondev, julie theriot, and hernan garcia (garland science, 2012). 2. Biological Physics: energy, information, life student edition by philip nelson. (chiliagon science)

1	**Title of the course (L-T-P-C)**	**Organic chemistry (3-0-0-3)**
2	**Pre-requisite courses(s)**	Fundamental concepts and applications of chemistry (CH101)
3	**Course content**	**Reactive Intermediates**: An overview of the chemistry of carbenes, nitrenes, radicals, carbocations, carbanions and benzynes. Introduction to substitution, elimination, addition, oxidation, reduction, rearrangement types of reactions **Epoxidation named reactions**: Jacobsen and Sharpless. **Olefination named reactions**: Wittig, Julia, Wharton, Peterson, Tebbe. **Cross-Coupling named reactions**: Buchwald-Hartwig, Negishi, Sonogashira, Suzuki, Wurtz, Ullmann, McMurry, Heck, Stille. **Pericyclic reactions**: Diels-alder cycloaddition, Ene reaction, Cope rearrangement, Claisen rearrangement (Johnson, Ireland and Eschenmoser). **Organic chemistry in industry**: Pharmaceuticals, dye, and agrochemicals
4	**Texts/References**	1. Jerry March and Michael Smith, "Advanced Organic Chemistry", 7th Ed., Wiley, 2015. 2. F. A. Carey and R. J. Sundberg, "Advanced Organic Chemistry, Part A and B", 5th Ed., Springer, 2008. 3. J. Clayden, N. Greeves, and S. Warren, "Organic Chemistry", 2nd Ed., Oxford University Press, 2014. 4 W. Carruthers and I. Coldham, "Modern Methods of Organic Synthesis", 4th Ed., Cambridge University Press, 2015. 5. Laszlo Kurti and Barbara Czako, "Strategic applications of named reactions in organic synthesis", 1st Ed., Elsevier, 2005. 6. R. B. Grossman, "Art of writing reasonable organic reaction mechanisms", 2nd Ed., Springer, 2010. 7. P. Bruice, "Organic Chemistry" 7th Ed., Pearson, 2013. 8. Penny Chaloner, "Organic chemistry: A mechanistic approach, CRC Press; 1st edition, 2014

1	**Title of the course (L-T-P-C)**	**Mass transfer (3-0-0-6)**
2	**Pre-requisite courses(s)**	**Nill**
3	**Course content**	Principles of Mass transfer: Constitutive laws of diffusion; unsteady state diffusion; Convective mass transfer. Interphase mass transfer and mass transfer coefficients; Mass transfer theories/models; Equilibrium stages and transfer units: number and height of transfer units; stage efficiency. Gas absorption: plate and packed column design. Distillation: batch distillation, continuous fractionation, other types of distillation (e.g., azeotropic), solvent extraction, drying, cooling towers.
4	**Texts/References**	1. R.E.Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, New Delhi, 1983. 2. E.D. Cussler, Di usion - Mass Transfer in Fluid Systems, Cambridge University Press, Cambridge 1984. 3. A. S. Foust, Principles of Unit Operations, 2nd Edition, Wiley, New York, 1980. 4. C.J. Geankoplis, Transport Processes and Unit Operations, 3rd Edition, Prentice Hall, India, 1993.