Semester I

CH103	**Chemistry**	**L-T-P-CR-CH: 3-0-1-4-5**

Course Objectives

CO1. To explain the basic principles of Physical, Inorganic and Organic Chemistry

CO2. To explain the basic principles of different spectroscopic techniques and demonstrate their practical applications

CO3. To demonstrate the role of chemistry in everyday life using some simple examples in theory classes as well as with hands-on experiments

Learning Outcomes

Upon the completion of the course, the students will be able to:

LO1. Solve problems of chemistry with the knowledge of fundamental principles.

LO2. Connect the basic chemistry knowledge with the daily experiences.

LO3. Utilize the knowledge of chemistry in their future studies.

SYLLABUS

Theory:

Unit 1: Atomic and molecular structure (11 lectures)

Schrödinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Molecular orbitals of diatomic molecules and plots of the multicentre orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomics. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

Unit 2: Spectroscopic techniques and applications (6 lectures)

Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules. Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterization techniques. Diffraction and scattering.

Unit 3: Intermolecular forces and potential energy surfaces (4 lectures)

Ionic, dipolar and van der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H_3, H_2F and HCN and trajectories on these surfaces.

Unit 4: Use of free energy in chemical equilibria (5 lectures)

Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Water chemistry. Corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.

Unit 5: Nuclear Chemistry (4 lectures)

Isotopes, isotones, isobars, α, β and γ rays, nuclear transformations, fission and fusion, cosmic rays, binding energy, packing fraction, radioactive hazards, nuclear power plants.

Unit 6: Stereochemistry (4 lectures)

Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds

Unit 7: Organic reactions and synthesis of a drug molecule (4 lectures)

Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

Practical:

Experiment 1: Standardization of sodium thiosulphate solution with standard potassium dichromate solution and application for estimation of copper in a solution.

Experiment 2: Determination of the dissociation constant of a weak acid using pH meter.

Experiment 3: Determination of the strength of a strong acid by conductometric titration with a strong base.

Experiment 4: Determination of the strength of a weak acid by conductometric titration with a strong base.

Experiment 5: Determination of the total hardness of water by complexometric titration.

Experiment 6: Preparation of Mohr's salt.

Experiment 7: Determination of the wavelength of maximum absorption ($\lambda_{\max}$)of a colored solution using spectrocolorimeter.

Experiment 8: Preparation of buffer solution and determination of pH.

Total **(46 lectures)**

Books:

1. University Chemistry; B. H. Mahan and Rollie J. Myers; Pearson Publication, Fourth Edition. 2017.

2. Chemistry: Principles and Applications; M. J. Sienko and R. A. Plane

3. Fundamentals of Molecular Spectroscopy; C. N. Banwell; Tata McGraw-Hill Education, Fourth Edition 2001.

4. Physical Chemistry; P. W. Atkins, Julio De Paula; Oxford University Press, Ninth Edition, 2009.

5. Organic Chemistry: Structure and Function; K. P. C. Volhardt and N. E. Schore; W.H. Freeman and Company, 7th Edition, 2014. http://bcs.whfreeman.com/vollhardtschore5e/default.asp

6. Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan

MS104	**Mathematics I**	**L-T-P-CR-CH : 3-1-0-4-4**

Course Objectives

CO1. To explain the basics of real analysis for further application in integration theory.

CO2. To elaborate the basics of vector algebra for applications using Green, Gauss and Stokes theorem.

CO3. To demonstrate the concepts of improper integrals and their convergence, Beta-Gamma functions as a special case.

CO4. To explain the theory of differential equations which will be useful every now and then while solving engineering problems.

CO5. To prepare the students for the remaining semester as this is prerequisite to the following semester courses.

CO6. To impart competence to the students for solving problems of the standards pertaining to standards of the various national level competitive examinations like GATE, UPSC, PSUs etc.

Learning Outcomes

Upon the completion of the course, the students will be able to:

LO1. Analyze the concepts of real analysis and its use in Power series, Taylor's series, series for exponential, trigonometric and logarithm functions which will appear in several multidisciplinary problems.

LO2. Evaluate multivariable calculus and its use involving limit, continuity and differentiability of functions of several variables, applied in various engineering problems.

LO3. Identify applications of Green, Gauss and Stokes theorems to evaluate line, surface and volume integrals in an easier way.

LO4. Determine some advance knowledge of integration such as improper integrals which will help the use of Beta-Gamma functions in several engineering problems.

LO5. Recall the theory of Ordinary Differential Equations, which is an inseparable tool for any engineering discipline.

SYLLABUS

Unit 1: Sequence and series (8 lectures)

Sequence and series of real numbers, tests for convergence. Power series, Taylor's series, series for exponential, trigonometric and logarithm functions.

Unit 2: Calculus (6 lectures)

Continuity and differentiability of single variable, Rolle’s theorem, Cauchy’s mean value theorem, Taylor’s and Maclaurin theorems with remainders, Indeterminate forms, L'Hospital's rule.

Unit 3: Multivariable calculus (8 lectures)

Limit, continuity and differentiability of functions of several variables, partial derivatives, directional derivatives, total derivative. Euler’s theorem on homogeneous functions. Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers.

Unit 4: Multiple integrals (10 lectures)

Gradient, Curl, Divergence, Laplacian, line integral, multiple integral, change of order of integration and change of variables, surface integral, theorems of Green. Gauss and Stokes theorems, orthogonal curvilinear coordinates. Simple applications involving cubes, sphere and rectangular parallelepipeds.

Unit 5: Improper integrals (5 lectures)

Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Unit 6: Ordinary differential equations (8 lectures)

First order differential equations – exact, linear and Bernoulli’s form, second order differential equations with constant coefficients, Euler equations. Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equations.

Total (45 lectures)

Textbooks

1. Advanced Engineering Mathematics, H. K. Dass, S. Chand, 22nd edition, 2018.
2. Higher Engineering Mathematics: B. V. Ramana. McGraw Hill, 6th edition, 2010.
3. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Alpha Science, 5th edition, 2016.
4. Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers, 44th edition, 2017.

Reference Books

1. Ordinary and Partial Differential Equations, M. D. Raisinghania, S. Chand, 20th edition, 2020.
2. Introduction to Real Analysis, R. G. Bartle and D. R. Sherbert, John Wiley & Sons, Inc., 4th edition, 2011,
3. Mathematical Analysis, S. C. Malik and S. Arora, New Age International Private Limited, 4th edition, 2017.

PH103	Physics-I	L-T-P-CR-CH: 2-0-1-3-4

Course Objectives

CO1. To demonstrate the components of velocity and acceleration in different coordinate systems.

CO2. To display the use of Newton's laws of motion to explain ideas on uniformly rotating frame, centripetal acceleration, Coriolis force and its applications.

CO3. To provide an elaborate look at classical and modern optics and to develop a firm fundamental understanding of interference and diffraction.

CO4. To familiarize the students with Maxwell's laws governing electrodynamics, concepts of electromagnetic waves, solution of electromagnetic plane wave equations and polarization.

CO5. To explain the application of principles of mechanics, optics and electromagnetics in solving engineering problems.

Learning Outcomes

Upon the completion of the course, the students will be able to:

LO1. Solve numerical problems of mechanics by application of Newton's laws of motion.

LO2. Analyze the application of Newton's laws of motion in non-inertial frames of reference.

LO3.Recall the wave nature of light and interpret the intensity variation of light due to interference and diffraction.

LO4. Describe experimental arrangements for observing interference and diffraction pattern.

LO5. Formulate and solve engineering problems on electromagnetics and electromagnetic plane wave equations.

SYLLABUS

Unit 1: Mechanics (10 lectures)

Curvilinear coordinate systems; Concepts of potential energy, conservative and non-conservative forces; Angular momentum and orbital motion; Non-inertial frames of reference; Rotating coordinate system, Centripetal and Coriolis accelerations

Unit 2: Optics (9 lectures)

Fermat's principle of stationary time and its applications, Light as an electromagnetic wave and Fresnel equations, reflectance and transmittance, Brewster's angle, total internal reflection. Young's double slit experiment, Newton's rings, Michelson interferometer, Farunhofer diffraction from a single slit and a circular aperture, Diffraction gratings and their resolving power.

Unit 3: Electromagnetic Theory (9 lectures)

Basics of electrostatics and magnetostatics; Displacement current, Maxwell's equations: Continuity equation for current densities; Maxwell's equation in vacuum; Energy in an electromagnetic field; Flow of energy and Poynting vector with examples. The wave equation; Plane electromagnetic waves in vacuum, their transverse nature and polarization.

<u>Practical:</u>

Experiment 1: Determine the value of surface tension of pure water with the help of capillary action. (Jurine's law).

Experiment 2: Determine the wavelength of He- light by observing the diffraction pattern produced with a plane transmission grating.

Experiment 3: Verify Hooke's law of elasticity and hence determine the value of Young's modulus of elasticity of the material of a given rod by the method of flexure.

Experiment 4: To determine the moment of a bar magnet and horizontal component of earth's magnetic field by Magnetometers.

Experiment 5: Determine the Planck's constant by solar cell.

Experiment 6: Prove the existence of atomic energy levels and determine the first excitation potential (eV) of Argon atom using Frank Hertz Experimental set-up.

Experiment 7: Determine the Planck's constant using different wavelength of light using Planck Constant Kit.

Total (28 lectures)

Text Books:

1. Engineering Mechanics. M. K. Harbola, Cengage Learning India Pvt. Ltd., 2nd Edition, 2012.
2. Optics. E. Hecht and A. R. Ganesan, Pearson Education, 5th Edition, 2019.
3. Introduction to Electrodynamics. D. J. Griffiths, Cambridge University Press, 4th Edition, 2017.

Reference Books:

1. Physics for Degree Students B.Sc. First Year. C. L. Arora and P. S. Hemne, S. Chand Publishing, 2nd Edition, 2010.
2. A Textbook of Engineering Physics. M. N. Avadhanulu, P. G. Kshirsagar and TVS A. Murthy, S. Chand Publishing, 11th Edition, 2018.
3. Engineering Physics. G. Aruldhas, Prentice Hall India Learning Private Limited, 1st Edition, 2010.
4. Physics for Engineering Applications. S. Puri, Narosa Publishing House, 1st Edition, 2010.
5. An Introduction to Mechanics (Sie). D. Kleppner and R. Kolenkow, McGraw Hill Education, 1st Edition, 2017.
6. University Physics with Modern Physics, H. D. Young and R. A. Freedman, Pearson Education, 14th Edition, 2017.

Semester II

MS105	**Mathematics II**	**L-T-P-CR-CH : 3-1-0-4-4**

Course Objectives

CO1. To explain the basics of linear algebra including matrix theory, system of linear equations, eigenvalues and eigenvectors.

CO2. To elaborate the basic concepts of complex algebra and analysis for applications in engineering subjects.

CO3. To demonstrate the basics of numerical methods for different kind of interpolations; finding roots of algebraic and transcendental equations etc.

CO4. To demonstrate the basics of numerical differentiation and integrations and their applications

CO5. To display the theories of Laplace, Fourier transformations and their applications in differential equations.

CO6. To impart competence to the students for solving problems of the standards pertaining to standards of the various national level competitive examinations like GATE, UPSC, PSUs etc.

Learning Outcomes

Upon the completion of the course, the students will be able to:

LO1. Create the required mathematical foundation. He/she will be confident enough to solve various mathematical problems arising in their engineering problems and apply as per their requirement.

LO2. Identify the use of matrix theory to solve the system of linear equations and apply in various engineering problems.

LO3. Recall the concepts of eigenvalues and eigenvectors in future engineering applications.

LO4. Apply the knowledge of complex analysis for analyzing engineering problems and develop solution techniques for complex problems

LO5. Measure the techniques of integral equations to solve physical and other engineering problems

SYLLABUS

Unit 1: Linear algebra (12 lectures)

Rank of a matrix, determinants, Cramer's Rule. Linear systems of equations, Direct methods: Gauss elimination, Gauss-Jordan elimination and LU factorization.
Vector spaces – Linear dependence of vectors, basis, linear transformations, range and kernel of a linear map, rank and nullity, rank-nullity theorem. Matrix associated with a linear map. Eigenvalues and eigenvectors, Cayley-Hamilton Theorem.

Unit 2: Complex analysis (6 lectures)

Limit, continuity, differentiability and analyticity of functions Cauchy-Riemann equations, elementary analytic functions (exponential, trigonometric, logarithm) and their properties.

Unit 3: Complex integration (8 lectures)

Line integrals, contour integral, Cauchy's integral theorem, Cauchy's integral formula, Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof). Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof).

Unit 4: Numerical methods-I (7 lectures)

Finite differences, relation between operators, Interpolation using Newton's forward and backward difference formulae. Interpolation with unequal intervals: Newton's divided difference and Lagrange's formulae. Solution of polynomial and transcendental equations – Bisection method, Newton-Raphson Method, Secant method and Regula-Falsi method.

Unit 5: Numerical methods-II (6 lectures)

Taylor's series, Numerical Differentiation, Numerical integration: Trapezoidal rule and Simpson's rules. Numerical solution of ordinary differential equations using Euler and modified Euler's methods. Runge-Kutta methods.

Unit 6: Integral transform (6 lectures)

Laplace Transform, Properties of Laplace Transform, Laplace transform of periodic functions. Finding inverse Laplace transform by different methods, convolution theorem. Evaluation of integrals by Laplace transform, solving ODEs and PDEs by Laplace Transform method.
Fourier series, Fourier transforms. methods, inverses and their applications.

Total (45 lectures)

Text Books:

1. Advanced Engineering Mathematics, H. K. Dass, S. Chand, 22^{nd} edition, 2018.
2. Higher Engineering Mathematics: B. V. Ramana. McGraw Hill, 6^{th} edition, 2010.
3. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Alpha Science, 5^{th} edition, 2016.
4. Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers, 44^{th} edition, 2017.

Reference Books:

1. Numerical Methods, S. R. K. Iyengar and R. K. Jain, New Age International Private Limited, 3rd Edition, 2012
2. Schaum's Outline of Linear Algebra, S. Lipschutz and M. Lipson, McGraw Hill Education 6^{th} Edition, 2017.
3. Complex Variable: Schaum's Outlines Series, M. Spiegel, S. Lipschutz, J. Schiller, D. Spellman, McGraw Hill Education, 2^{nd} edition, 2017.

PH104	**Physics II**	**L-T-P-CR-CH: 2-0-0-2-2**

Course Objectives

CO1. To introduce and elaborate the fundamental physical principles of basic quantum mechanics, waves, solid-state physics, and their engineering applications.

CO2. To elaborate technologically relevant solved problems on quantum mechanics, waves and solid-state physics, highlighting the significance of underlying basic physical principles.

CO3. To demonstrate an interdisciplinary perspective to the students by showing how a few physical laws are at the core of various apparently different engineering problems.

CO4. To explain basic principles of quantum mechanics which is later used to understand solid state devices.

CO5. To demonstrate - how the electronic band theory evolved and why quantum mechanics is essential for understanding modern electronic devices.

CO6. To elaborate the most general aspects of waves and oscillations which are ubiquitous in engineering and technological problems.

Learning Outcomes

Upon the completion of this course, the student will be able to:

LO1. Apply the most basic principles of quantum mechanics, waves and solid-state physics and solid-state devices.

LO2. Solve one dimensional quantum mechanical problems and have the ability to see how quantum mechanics is at the heart of solid-state devices.

LO3. Determine why some materials are metals, some are insulators, and some are semiconductors, based on their electronic band structure.

LO4. Analyze problems of carrier generation and transport phenomena in intrinsic and extrinsic semiconductors – which is essential to understand all electronic devices.

LO5. Solve engineering problems dealing with simple, damped or forced harmonic oscillation and perform Fourier analysis of wave phenomenon.

SYLLABUS

Unit 4: Quantum Mechanics (11 lectures)

Wave nature of particles and the Schrodinger equation; Born interpretation, probability current, Expectation values, Free-particle wave function and wave-packets, Uncertainty principle; Application of Schrodinger equation: particle in a box.

Unit 5: Waves and oscillations (7 lectures)

Simple harmonic motion, damped and forced simple harmonic oscillator, quality factor, Applications in mechanical and electrical systems, power absorbed by oscillator; superposition of waves and Fourier method, wave groups and group velocity;

Unit 6: Solid state, semiconductor physics and Lasers (11 lectures)

Free electron theory of metals, Fermi level, density of states, Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction, LED, photodetector, Solar cells, Laser-device structure, materials, working principle and characteristics.

Total **(29 lectures)**

Text Books:

1. Quantum Physics. R. Eisberg and R. Resnick, John Wiley and Sons, 2nd Edition, 1985.
2. Semiconductor Optoelectronics: Physics and Technology. J. Singh, McGraw-Hill Inc., New York, 1995.
3. Introduction to solid state physics. C. Kittel, Wiley, 8th Edition, 2012.
4. Oscillations and waves in physics, I. G. Main, Cambridge University Press, 3rd Edition, 1995.

Reference Books:

1. Fundamentals of Physics. D. Halliday, R. Resnick and J. Walker, Wiley India (Delhi), 6th Edition, 2010.
2. Introduction to Quantum Mechanics. D. J. Griffiths, Cambridge India, 2nd Edition, 2016.
3. The physics of vibrations and waves. H. J. Pain, John Wiley and Sons, 6th Edition, 2005.
4. Principles of Lasers. O. Svelto, Springer, 5th Edition, 2010.
5. Online course: “Semiconductor Optoelectronics” by M R Shenoy on NPTEL
6. Online course: "Optoelectronic Materials and Devices" by Monica Katiyar and Deepak Gupta on NPTEL
7. All relevant courses available on NPTEL

Semester III

MS205	**Mathematics III**	**L-T-P-CR-CH : 3-0-0-3-3**

Course Objectives

CO1. To explain the basic concepts of probability, statistics and partial differential equation.

CO2. To elaborate the concepts of random variables, probability distributions and their various uses.

CO3. To demonstrate moments, correlation, regression and advance theory of applied statistics.

CO4. To explain different orders of linear and non-linear partial differential equations and their solving procedures.

CO5. To demonstrate the basics of curve fitting and its various applications.

Learning Outcomes

Upon the completion of the course, the students will be able to:

LO1. Apply the knowledge of binomial, poisson and normal distribution for engineering application.

LO2. Recall different problems related to moments, skewness, kurtosis and correlation, regression

LO3. Measure various physical models through discreet and continuous distributions.

LO4. Identify the use of different test of significance to various engineering problems.

LO5. Analyse the techniques of partial differential equations to solve physical and other problems involving functions of several variables

LO6. Determine heat and sound equations, fluid flow, elasticity, electrostatics, electrodynamics, etc., problems using partial differential equation techniques.

SYLLABUS

Unit 1: Basic Probability (10 lectures)

Probability spaces, conditional probability, Discrete random variables, Independent random variables, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, infinite sequences of Bernoulli trials, Probability distributions: Binomial, Poisson - evaluation of statistical parameters for these distributions, Poisson approximation to the binomial distribution.

Unit 2: Continuous Probability Distributions (5 lectures)

Continuous random variables and their properties, distribution functions and densities, normal, exponential, and gamma densities.

Unit 3: Applied Statistics (11 lectures)

Moments, Skewness, Kurtosis, Chebyshev's Inequality, Correlation and regression, method of least squares. Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations.

Unit 4: Curve fitting (4 lectures)

Curve fitting - fitting of straight lines, second degree parabolas and more general curves. Splines fitting.

Unit 5: Partial differential equations (15 lectures)

Definition of Partial Differential Equations, First order partial differential equations, solutions of first order linear and non-linear PDEs. Solution to homogenous and non-homogenous linear partial differential equations second and higher order by complimentary function and particular integral method. Second-order linear equations and their classification. Method of separation of variables.

Total: (45 lectures)

Text Books

1. Advanced Engineering Mathematics, H. K. Dass, S. Chand, 22nd edition, 2018.
2. Higher Engineering Mathematics: B. V. Ramana. McGraw Hill, 6th edition, 2010.
3. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Alpha Science, 5th edition, 2016.
4. Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers, 44th edition, 2017.

Reference Books

1. Ordinary and Partial Differential Equations, M.D. Raisinghania, S. Chand, 20th edition, 2020.
2. Fundamentals of Mathematical Statistics, S.C. Gupta and V.K. Kapoor, S. Chand, 10th edition, 2017.