INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH THIRUVANANTHAPURAM

An autonomous institution under the

Ministry of Human Resource Development, Government of India

THIRUVANANTHAPURAM

CURRICULUM AND SYLLABUS FOR THE FOUNDATION COURSES OF

THE BS-MS DUAL DEGREE PROGRAMME

2020-21

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Foundation Courses (Semesters 1 – 4)

Semester 1	Semester 2	Semester 3	Semester 4
Ecology and Evolution (3103)	Biomolecules (3103)	Genetics and Molecular Biology (3103)	Cell Biology and Microbiology (3103)
Atomic Structure & Chemical Bonding (3103)	Basic Concepts in Organic & Inorganic Chemistry I (3103)	Basic Concepts in Organic & Inorganic Chemistry II (3103)	General Physical Chemistry (3103)
Single Variable Calculus (3103)	Introduction to Linear Algebra (3103)	Multivariable Calculus (3103)	Introduction to Probability (3103)
Mechanics (3103)	Electromagnetism (3103)	Optics (3103)	Thermal and Statistical Physics (3103)
Biology Lab I (0031)	Biology Lab II (0031)	Biology Lab III (0031)	
Chemistry Lab I (0031)		Chemistry Lab II (0031)	Chemistry Lab III (0031)
Physics Lab I (0031)	Physics Lab II (0031)		Physics Lab III (0031)
Mathematical Tools I (2102)	Mathematical Tools II (3103)	Physical Principles in Biology (3103)	Principles of Spectroscopy (3103)
Fundamentals of Programming (0031)	Numeric Computing (0031)	Data Handling and Visualisation (0031)	Scientific Computing (0031)
Communication Skills I (1001)	Communication Skills II (1001)	Economics (1001)	Languages (1001)
[19]	[19]	[19]	[19]

School of Biology

BIO 111	Ecology and Evolution (3103)
Learning Outcomes	The course will introduce students to the basics of what life is, scales of biological organization and how interactions between an organism and its environment shape all aspects of the organism's biology. A student of the course will understand the fundamentals of biological evolution, how evolution has shaped phenotypic diversity & behavior, and why evolution is a unifying theme in biology.
Syllabus	1. Overview of Biology: What is life? Characteristics of living organisms; Importance of studying biology; Scales in biology (molecules (including DNA), organelles, cells, tissues, organs, organisms, populations, communities and ecosystems); Disciplines of biology in relation to these scales; Origins of life. [3] 2. Principles of Evolutionary Biology: History of evolutionary thinking - ideas that formed the basis of modern understanding of evolution; Genes and alleles; Fundamental concepts (variation, selection, units of selection, fitness, adaptation); Prerequisites for evolution by natural selection; Evidence for natural selection and evolution; Types of selection (directional, stabilizing, disruptive); Evolution without selection (genetic drift, gene flow); Species concepts and speciation; Phylogenetics (basic terminology, tree of life, phylogenetic reconstruction, molecular dating); Macroevolutionary patterns (mass extinction, adaptive radiation, convergent evolution, divergent evolution). [10-12] 3. Principles of Ecology: Biomes; Ecosystems (trophic levels, trophic structure, energy transformation, gross and net production, primary productivity, secondary productivity); Ecosystem types (tropical, temperate, subtropical); Population ecology (population characteristics, growth, life history strategies, population regulation, metapopulations); Community ecology (ecological succession, microhabitats, niche, structure of communities); Species interactions (predation, parasitism and mutualism).[6] 4. Behavioural ecology: Adaptive value of behaviour; Sexual selection; Mating systems; Kinship; Cooperation; Sociality (altruism, cooperation, kin selection, reciprocal altruism, etc.); Optimal foraging theory; Parental care; Social symbiosis. [10] 5. Biodiversity and conservation biology: Taxonomy and phylogenetic systematics; Diversification of life - a phylogenetic perspective; Diversification of life - a timeline; Measuring extant diversity; Threats to extant biodiversity (habitat loss and degradation, Invasive species, Pollution, Over-exploitation, Global climate change); *In-situ* and *ex-situ* conservation; Biodiversity of India; Island biogeography. [4-5]
Text and Reference Books	1. Manuel C Molles, Ecology: Concepts and Applications Mc Graw Hill 7th Edition 2014 2. Douglas J Futuyma, Evolution Oxford University Press 3rd Edition 2013 3. Barton et al., Evolution Cold Spring Harbor Laboratory Press 1st Edition 2007 4. Stephen C. Stearns and Rolf F. Hoekstra, Evolution: An Introduction Oxford University Press 1st Edition 2000 5. Nicholas J. Gotelli, A primer of Ecology Oxford University Press, 4th Edition 2008 6. Begon et al., Ecology: From Individuals to Ecosystem Wiley-Blackwell, 4th Edition 2005

BIO 121	Biomolecules (3103)
Learning Outcomes	To understand the importance of biomolecules (carbohydrates, lipids, proteins and nucleic acids) and its chemical diversity in shaping the biological structure and function. Students can appreciate how complex living systems are built from a handful of simple atoms and how their molecular interactions in the aqueous environment of the cells interior bring about unique functions to life matter which is essential to sustain diverse life forms in our planet.
Syllabus	1. **Chemical Characteristics of living matter:** Biological macromolecules and importance of carbon in life’s chemistry, role of inorganic/monoatomic ions in living organisms.[2] 2. **Water and life:** Unique physical and chemical properties of water that support life: high specific heat, high surface tension, high latent heat of vaporization, high heat of fusion, high tensile strength, transparency to light, universal solvent, density. Hydrogen bonding

in water and its importance in maintaining the shape, stability and properties of biological macromolecules. [3]

3. **Stabilizing interactions in biological macromolecules:** Importance of hydrogen bonds, ionic interactions, salt bridge, hydrophobic interactions, van der Waals forces, concept of dipole, instant and induced dipole. Importance of these noncovalent interactions in macromolecular interaction using an example of antigen-antibody interaction and higher order protein structure.[2]
4. **Principles of biophysical chemistry:** Bioenergetics and laws of thermodyanamics, reaction kinetics: differences between ΔG, ΔG^{o}, $\Delta G^{o\prime}$. Acid dissociation constants, pH, pka and relationship between. Importance of Henderson-Haselbach equation and calculation of problems associated with this equation. [4]
5. **Biological macromolecules:**
   (a) Carbohydrates: Structure and function of important mono, oligo and polysaccharides present in the kingdom of life: Cellulose, starch, glycogen, Raffinose family of Oligosaccharides, dextrins, dextrans, agar and agarose. Stereochemical relationship between aldo and keto monosaccharides, anomers, epimers. Cyclization of monosaccharides, acetal, hemiacetal, ketal and hemiketal linkages. Derivatives of carbohydrates and their importance in biological structure and function: sugar acids, sugar alcohols, deoxy sugars, sugar esters, amino sugars, glycosides. Carbohydrates in blood group determination, biochemistry of Bombay blood group to demonstrate the structural diversity of carbohydrates. Glycemic Index and Glycemic Load and its importance in metabolism. Importance of proteoglycans and glycoproteins in cell structure and function. [5]
   (b) Proteins: Structure and importance of proteinogenic amino acids: Physical and chemical properties of amino acids : Nonionic and zwitter ion forms of amino acids: pH,pKa and titration curve characteristic of amino acids, concept of dihedral angles phi and psi, importance of these dihedral angles in protein structure and function, Ramachandran plot and its importance in protein structure determination: Hierarchy of protein structures: Primary, secondary, tertiary and quaternary structure of proteins. Important secondary structures alpha helix, beta sheets, turns and loops, protein domain and motifs, supersecondary structures and its importance in determining protein function. [8]
   (c) Lipids: Classification of Lipids: Introduction to fatty acids and its nomenclature. Simple and complex lipids: Types, structure and importance of phospholipids, glycolipids, sphingolipids, glycerophospholipids with examples in biological structure and function. Introduction to sterols and sterol-based derivatives in life matter. [3]
   (d) Nucleic acids: Introduction to nucleic acid bases and nucleotides. Structure and function of DNA and RNA, physicochemical properties of these informational macromolecules. Ambiguous codes of nucleotide bases and amino acids. Central dogma of life: introduction of transcription, translation and protein synthesis. Concept of gene and its regulatory elements in bringing out gene function. Conceptual understanding of Polymerase Chain reaction learning about primer design, concept of sense, antisense, template and non-template strands. [7]
6. **Biological catalysis:** Functioning of enzymes, classification of enzymes, Michael Menten reaction kinetics to understand the enzyme function, Line-Weaver burke plot, competitive and non-competitive inhibition of enzyme kinetics [3]
7. **Introduction to metabolic pathways:** Principles of energy release from fuels, importance of ATP and NADH in energy transduction during glycolysis, Krebs cycle and oxidative phosphorylation. [2]

Text and Reference Books

1. Rodney F Boyer, Concepts in Biochemistry. John Wiley & Sons; 3rd Ed (2 December 2005).
2. Thomas Miilar, Biochemistry Explained: A Practical Guide to Learning Biochemistry CRC Press; 1 edition (30 May 2002)
3. Lubert Stryer et al., Biochemistry.W. H. Freeman; 6th Edition edition (14 July 2006) 4. David L Nelson, and Michael M Cox et al., Lehninger principles of biochemistry WH Freeman; 7th ed. 2017 edition (1 January 2017)

BIO 211	Genetics and Molecular Biology (3103)
Learning Outcomes	This course will introduce basic concepts of genetic inheritance and genetic interactions. It also introduces the primary concepts of gene, gene expression, genome organization and replication and use of model organisms.
Syllabus	1. Introduction to genetics [1] 2. Mendelian genetics: Mendel's law and examples, Monohybrid and di- hybrid cross,recessive and dominant mutation, concept of allele [3] 3. Non-Mendelian genetics: incomplete dominance, semi-dominance, and introduction to epigenetics, Cytoplasmic inheritance, infection heredity [6] 4. Genetic interactions: approach towards generating a network (epista- sis, redundancy,synthetic lethality, lethal interactions) [4] 5. Model organisms and studies on molecular and genetic interactions [4] 6. Basics of Expression genetics, transcription, translation [6] 7. Genome composition and organization, Cot analysis [3] 8. Chromosome structure and function [3] 9. Mitosis and Meiosis [3] 10. DNA replication, Mutations [3]
Text and Reference Books	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)

BIO221	Introduction to Cell Biology and Microbiology (3103)
Learning Outcomes	Students will understand the structures and functions of prokaryotic and eukaryotic cells as whole entities and in terms of their subcellular process and communications. Students will understand the biology of bacteria, viruses and other pathogens related with infectious diseases in humans.
Syllabus	1. Structure of prokaryotic and eukaryotic cells Introduction of cell biology, classification of living organisms, Prokaryotic cells, eukaryotic cells. [3] 2. Membrane structure and function. Structure and Composition of the Cell Membrane, Membrane Proteins, Transport across the Cell Membrane [4]. 3. 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 [6]. 4. Cell division and cell cycle Cell division and its significance, Mitosis, Meiosis, Cell cycle regulation [4]. 5. Principles of signal transduction and role of secondary messengers [basic level] Characterization of signaling components: signaling molecules, receptors, second messengers, effectors, signaling complexes [3]. 6. Basic classification and characterization of membrane receptors. G protein-coupled Receptors, Receptor Tyrosine Kinases [3] 7. Hormones and their receptors Human Endocrine system, types of hormone receptors, insulin, thyroid hormone, steroid hormones [3] 8. History of Microbiology - discovery of microbes and important milestones, microbial diversity - evolution & taxonomy, microbial nutrition - growth requirements, culture media and growth kinetics - cell cycle, growth curve [3]. 9. Viruses and prions: Introduction - development of virology, general characteristics - virus structure, reproduction, cultivation, taxonomy, viruses of bacteria and archaea [4]. 10. Microbial physiology: structure of microbes - prokaryotic cell structure & function, autotrophic and heterotrophic metabolisms - , growth and its control factors -

BIO221	Introduction to Cell Biology and Microbiology (3103)
	culturing and measurement of microbial growth, physical & chemical methods of microbe control [3]
Text and Reference Books	1. Gerald Karp, Cell Biology, WILEY (Feb. 4th, 2013) 2. Wayne M. Becker et al., World of the Cell; Benjamin Cummings; 7th edition (February 19, 2008) 3. Bruce Alberts et al., Essential Cell Biology; Richard Goldsby and Thomas J, &F/Garland, 4th Edition, (2014) 4. Alberts, Bruce.; Molecular Biology of the Cell, Garland Science; 5th edition (2 January 2008) 5. Kindt, Kuby, Immunology, W. H. Freeman; 6th edition (9 October 2006) 6. Willey, Joanne M; Sherwood, Linda; Woolverton, Christopher J; Prescott Harley Klein's Microbiology, McGraw-Hill, 7th Edition, 2008

SoB Laboratory Courses:

BIO112	Biology Laboratory I
Learning Outcomes	To provide a basic hands-on learning of Biological experimental methods.
Syllabus	1. Hypothesis testing and sampling - [12] -How to formulating a hypothesis? -Understanding Type I and Type II errors -What is a sample? Why is sampling required? How to sample? -Classroom exercises in hypotheses testing and sampling 2. Life under a microscope – [12] - Plant and animal cells under a microscope - Structure and function of plant tissues 3. Analysis of light reaction of photosynthesis by DCPIP method – [3] 4. Analysis of microbial world - [9] - Isolation of microorganisms - Gram staining - Plaque assay

BIO122	Biology Laboratory II
Learning Outcomes	To provide a basic hands-on learning of Biological experimental methods.
Syllabus	1. Biological solutions preparation and quantification of biomolecules (proteins, lipids, carbohydrates, DNA) – [12] 2. Genomic DNA isolation- [6] 3. PCR – [9] 4. Enzyme assays – [9]

BIO 212	Biology Laboratory III
Learning Outcomes	To provide a basic hands-on learning of Biological experimental methods.
Syllabus	1. Mutation frequencies, fluctuation tests – [6] 2. Analyze data from crosses: theoretical problem solving – [9] 3. Plasmid DNA isolation – [9] 4. SDS-PAGE – [6] 5. Mitosis –[3] 6. Meiosis –[3]

School of Chemistry

CHY 111	Atomic Structure and Chemical Bonding (3103)
Learning Outcomes	• To introduce quantum theory with the aim of understanding the structure of atoms • To describe various aspects of molecular symmetry and theories of bonding
Syllabus	Atomic Structure: • Thomson's and Rutherford's models of atoms, spectral emissions from atoms, Bohr's model of atom, quantization of angular momentum, discrete energy level structure, concept of quantum numbers, and Franck-Hertz experiment [4] • Photo-electric effect, dual nature of light and matter, de-Broglie's relation, blackbody radiation, electron diffraction by crystals, double slit experiments with light and matter, Stern-Gerlach experiment, and concepts of spin and orbital angular momenta [4] • Classical wave equation, Schrödinger equation, operators, postulates of quantum mechanics, solutions of Schrödinger equation for a free particle, particle-in-a-box, applications of particle-in-a-box solutions for describing electronic levels and spectra in conjugated molecules [8] • Schrödinger equation for the hydrogen atom, qualitative description of solutions, concepts of orbitals and quantum numbers, qualitative description of many-electron systems, effective nuclear charge, and orbital approximation [4] Chemical Bonding: • Molecular symmetry, symmetry elements, symmetry operations, point groups and character tables [6] • Valence bond and molecular orbital descriptions of bonding, linear combination of atomic orbitals (LCAO) approach, hybridization, bonding in $(H_2)^+$ and H_2 [4] • Bonding in homonuclear diatomic molecules of second period, bond orders, bond lengths and bond strengths, bonding in heteronuclear diatomic molecules, concepts of g and u symmetries of molecular orbitals, polarity and electronegativity, and photoelectron spectroscopy [6]
Text & Reference Books	1. D. A. McQuarrie, Quantum Chemistry, Viva Student Edition, Viva (2011). 2. P. Atkins, J. de Paula and J. Keeler, Atkins' Physical Chemistry, 11th Ed.,OUP (2018). 3. J. Barrett, Structure and Bonding, Wiley-Royal Society of Chemistry (2002). 4. T. Engel and P. Reid, Physical Chemistry, 3rd Ed., Pearson (2013). 5. R. J. Silbey, R. A. Alberty and M. G. Bawendi, Physical Chemistry, 4th Ed., Wiley Student Edition (2006).

CHY 121	Basic Concepts in Organic and Inorganic Chemistry I (3103)
Learning Outcomes	• This course introduces basic concepts in organic and inorganic chemistry with the aim to provide a structured understanding of chemistry.
Syllabus	Elements and periodicity: Classification of elements; concepts of atomic, ionic, and covalent radii; oxidation state, ionization energy, electronegativity, electron affinity, polarizability, inert pair effect, and lanthanoid contraction. [3] Structure and bonding: Crystal lattices and unit cell; crystal packing and defects; structures of NaCl, CsCl, and Wurtzite; lattice enthalpy, Born-Haber cycle; structures of elemental B, C, Si, P, and S; Bonding in boron halides, PF_5, SF_6, interhalogens, and xenon flourides; Bent's rule, Berry pseudorotation; molecular orbital diagrams of selected triatomic molecules: HF_2^-, BeH_2, and CO_2. [9] Oxidation and reduction: Reduction potential; electrochemical series; redox reactions; balancing of redox equations; factors affecting redox stability; Frost diagrams for redox reactions; Ellingham diagram and extraction of elements. [4] Acids and bases: Arrhenius concept, solvent systems (in H_2O, NH_3, SO_2, and HF), Brønsted concept, Lux-Flood concept, and Lewis concept; HSAB principle, superacids, relative strengths of acids; acid-base neutralisation curves and indicators. [4] Aromaticity: Aromaticity, antiaromaticity, and homoaromaticity; aromatic ring currents; examples of nonbenzenoid aromatic and antiaromatic compounds. [3] Acidity, basicity, pKa, steric inhibition of resonance, ortho effect, nucleophilicity, and electrophilicity dealing with organic molecules. [3] Stereochemistry: Baeyer's strain theory, Pitzer strain (torsional strain) and conformational analysis (up to decalin), geometrical isomerism (E/Z), optical isomerism, projections, CIP rules (R/S nomenclature of acyclic and cyclic molecules); nomenclature – threo and erythro, syn and anti, endo and exo, and meso and d/l; Chirality – axial and planar chirality and helicity; topicity - homotopic, enantiotopic and diastereotopic atoms, groups and faces (including Pro-R, Pro-S, and Re/Si stereodescriptors); chirotopicity and stereogenicity. [9] • Reactive Intermediates: Structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes, and nitrenes. [5]
Text & Reference Books	1. P. Atkins, T. Overton, J. Rourke, F. Armstrong, and M. Hagerman, Shriver and Atkins' Inorganic Chemistry, 5ed, W. H. Freeman and Company New York, 2009. 2. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3ed, Pearson, 2008. 3. J. E. House, Inorganic Chemistry, 3ed, Academic Press, 2019. 4. J. E. Huheey, E. A. Keiter, and R. L. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4 ed, Pearson Education, 2006. 5. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 2ed., Oxford University Press, 2012. 6. J. McMurry, Organic Chemistry, 9ed., Cengage Learning, 2015. 7. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, 7ed., Addison-Wesley, 2003. 8. D. Nasipuri, Stereochemistry of Organic Compounds-Principle and Applications, 4 Revised ed., New Academic Science, 2012.

CHY 211	Basic Concepts in Organic and Inorganic Chemistry II (3103)
Learning Outcomes	This course is a continuation of CHY 121 and deals with the basic concepts in organic and inorganic chemistry with the aim to provide a structured understanding of chemistry.
Syllabus	Nucleophilic Substitution at Saturated Carbons: S_N1, S_N2, S_Ni and S_N2' with emphasis on stereochemical considerations, substrate structure, leaving group, nucleophiles and role of solvents. [3] Elimination Reactions: Types (E1, E2 and E1cB), stereochemical considerations, and role of solvents; Saytzeff/Hofmann elimination, Bredt's rule; elimination vs substitution. [3] Electrophilic Aromatic Substitution: Mechanism, orientation, and reactivity of benzene and substituted benzene derivatives (substituent effects); mechanistic aspects of special cases such as nitration of aniline, alkylation of benzene, sulfonation. [3] Nucleophilic Aromatic Substitution. [1] Reduction and Oxidation: Mechanism and selectivity in reduction of carbonyl compounds using $NaBH_4$, $LiAlH_4$ (including esters, amides and nitriles), and oxidation of alcohols using Jones, Collins, PCC, and PDC reagents. [4] Synthesis of Drug Molecules: Naproxen, Ibuprofen, Aspirin and L-DOPA; examples love drugs and molecules of death. [3] Synthesis and Applications of Organic Materials: Polymers (biodegradable polymers, conducting polymers, etc.); smart materials, OLEDs, intelligent gels, dyes, etc. [3] Coordination Compounds: Geometries and isomerism of coordination compounds; crystal field theory, spectrochemical series, weak field and strong field ligands, spinel and inverse spinel structures; Jahn-Teller effect; thermodynamic stability and kinetic lability of coordination complexes; chelate and macrocyclic effect; optical activity of coordination complexes. [9] Metals in Biology: Introduction to types of metalloenzymes with various metals (Mg, Mo, Mn, Fe, Co, Ni, Cu, and Zn); O_2-transporting and storage proteins (hemocyanin, myoglobin, hemoglobin, and hemerythrin); bio-medical application of cis-platin. [5] Catalysis: Concepts and applications of catalysis in homogeneous and heterogenous processes such as Haber-Bosch process, Fischer-Tropsch process, Wilkinson hydrogenation, Wacker oxidation, Monsanto process, hydroformylation, and Ziegler-Natta polymerization. [3] Lanthanoids and Actinoids: Properties and reactivity trends; nuclear reactions of thorium and uranium; synthesis of trans-uranium elements; applications of radioisotopes. [3]
Text & Reference Books	1. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 2ed., Oxford University Press, 2012. 2. J. McMurry, Organic Chemistry, 9ed., Cengage Learning, 2015. 3. O. Snow, Love Drugs, Thoth Press, 2005. 4. R. H. Waring, G. B. Steventon and S. C. Mitchell Molecules of Death, Imperial College Press, 2007. 5. D. E. Newton, Chemistry of New Materials, Facts on File, 2007. 6. P. Atkins, T. Overton, J. Rourke, F. Armstrong, and M. Hagerman, Shriver and Atkins' Inorganic Chemistry, 5ed, W. H. Freeman and Company New York, 2009. 7. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3ed, Pearson, 2008. 8. J. E. House, Inorganic Chemistry, 3ed, Academic Press, 2019. 9. J. E. Huheey, E. A. Keiter, and R. L. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4ed, Pearson Education, 2006. 10. W. Kaim and B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, 2ed, Wiley, 2013.

CHY 221	General Physical Chemistry (3103)
Learning Outcomes	To introduce the formalisms for the microscopic description of states of matter, leading to an understanding of the fundamental intermolecular interactions governing them To provide an appreciation for the application of the ideas from thermodynamics for the description of solution state properties
Syllabus	• Gaseous State: Revision of gas laws, ideal gas equation of state, kinetic theory of gases, interpretation of gas pressure, Maxwell-Boltzmann distribution for velocities, speeds and energies of gas particles, average, most probable and root-mean-squared speeds, collision rate, collision flux, effusion, collision number, mean free path, transport properties, diffusion, Fick's laws, Einstein relation, thermal conductivity, viscosity, real gases, deviations from ideality, compressibility factor, van der Waals and virial equations of state, Boyle temperature, liquefaction of gases, critical constants, and law of corresponding states [10] • Intermolecular Interactions: Hard sphere potential, Lennard-Jones potential, ion-ion, ion-dipole, ion-induced dipole, dipole-dipole, dipole-induced dipole and induced dipole-induced dipole interactions, orientational averaging effects, Keesom interactions, Debye interactions, London interactions, hydrogen bonding, aromatic interactions, manifestation of intermolecular interactions in governing boiling points, states of matter, and heats of vaporization [8] • Review of Concepts in Thermodynamics: Concepts of temperature, enthalpy, entropy, Gibbs and Helmholtz energies, laws of thermodynamics, state and path functions, standard states, thermochemistry and Maxwell relations [1] • Physical Transformations of Pure Substances: Molar Gibbs energy, temperature and pressure dependence, Clausius-Clapeyron equation, phase equilibria of pure substances, application of Clausius-Clapeyron equation to solid-liquid, liquid-vapor and solid-vapor equilibria, phase rule, phase diagrams of one-component and two-component systems [4] • Thermodynamics of Mixtures: Partial molar quantities, partial molar Gibbs energy and chemical potential, thermodynamics of mixing, chemical potential of liquids, ideal dilute solutions, Henry's and Raoult's laws and their applications, fugacity and activity, liquid mixtures, excess functions and regular solutions [4] • Colligative Properties: Elevation of boiling point, depression of freezing point, lowering of vapour pressure, osmosis, and solubility [1] • Phase Equilibria of Binary Systems: Vapor pressure diagrams, temperature-composition diagrams, liquid-liquid phase diagrams, liquid-solid phase diagrams, azeotropic mixtures, fractional distillation and steam distillation [2] • Chemical Equilibria: Responses to temperature and pressure, Le Chatelier's principle, and van't Hoff equation [1] • Electrochemistry: Properties of ions in solutions, ionic mobility and conductivity, Debye-Hückel theory, standard electrode potential, Nernst equation, electrochemical cells, redox reactions, electromotive force and free energy [2] • Chemical Kinetics: Chemical reactions of various orders, integration of rate equations, elementary reactions, opposing reactions, consecutive reactions, parallel reactions, steady state approximation, enzyme catalysis, and Arrhenius equation [3]
Text & Reference Books	1. P. Atkins, J. de Paula and J. Keeler, Atkins' Physical Chemistry, 11th Ed., Oxford University Press (2018). 2. T. Engel and P. Reid, Physical Chemistry, 3rd Ed., Pearson (2013). 3. R. J. Silbey, R. A. Alberty and M. G. Bawendi, Physical Chemistry, 4th Ed., Wiley Student Edition (2006). 4. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Student Edition, Viva (2019).

SoC Laboratory Courses:

CHY 112	Chemistry Laboratory I (0031)
Learning Outcomes	This laboratory course provides opportunities for hands-on laboratory experiences related to qualitative and quantitative analyses.
Syllabus	Experiment 1 – Gravimetric Analysis: (a) Estimation of chloride anion in a water sample; (b) Estimation of nickel in a given sample as $Ni(DMGH)_2$. Experiment 2 – Colors of transition metal complexes: (a) Preparation and UV-vis analysis of coordination complexes of Co(II), Co(III), Ni(II), and Cu(II) with a series of ligands such as H_2O, NH_3, ethylenediamine, tartrate, SCN^-, Cl^-. Experiment 3 – Preparation and analysis of $[Zn(NH_3)_4][BF_4]$: (a) Synthesis of $[NH_4][BF_4]$; (b) Synthesis of $[Zn(NH_3)_4][BF_4]$; (c) Analysis of the NH_3 content in $[Zn(NH_3)_4][BF_4]$. Experiment 4 – Titrimetric Estimations Based on Acidimetry and Alkalimetry: (a) Standardisation of NaOH solution using N/20 oxalic acid solution; (b) Estimation of acetic acid concentration in commercial vinegar using standard NaOH solution as titrant; (c) Standardisation of HCl solution using N/20 oxalic acid solution, (d) Estimation of alkali content in commercial antacid tablet. Experiment 5 – Redox-Titrimetric Estimations Based on Permanganometry: (a) Standardisation of potassium permanganate using sodium oxalate; (b) Preparation of $K_3[Fe(C_2O_4)_3]\cdot 3H_2O$; (c) Estimation of the oxalate content of Potassium trisoxalatoferrate(III) trihydrate, (d) Photochemical reactions of Potassium tris-oxalatoferrate(III) trihydrate. Experiment 6 – Redox-Titrimetric Estimations Based on Dichromatometry: (a) Preparation of N/20 potassium dichromate solution; (b) Estimation of iron and chromium in a mixture using a standard N/20 potassium dichromate solution as titrant. Experiment 7 – Estimations Based on Iodimetry and Iodometry: (a) Preparation and standardisation of sodium thiosulfate solution; (b) Preparation of $Cu(NH_3)_4SO_4$ and estimation of copper(II) using standard thiosulfate solution as titrant; (c) Solubility product of $Ca(IO_3)_2$. Experiment 8 – Complexometric Estimations Based on EDTA: Quantitative estimation of calcium and magnesium in milk by EDTA complexometry - (a) Standardisation of EDTA solution using a standard zinc acetate solution; (b) Estimation of % amount of calcium and magnesium in a milk sample.
Text & Reference Books	1. G. H. Jeffery, J. Bassett, R. C. Denny, Vogel's Quantitative Chemical Analysis, 5ed, ELBS and Longmans Green & Co Ltd, 1971. 2. A. J. Elias, General Chemistry Experiments, 3ed, Universities Press (India) Pvt Ltd, 2002. 3. J. Derek Woollins, Inorganic Experiments, 3ed, Wiley, 2010.
CHY 212	**Chemistry Laboratory II (0031)**
Objectives	To learn the principles and applications of separation, isolation, and analytical techniques in organic chemistry.

Syllabus	Basic Lab Techniques [6] a) Thin layer chromatography (TLC) and calculation of Rf values. b) Column Chromatography: separation of organic mixture. c) Purification of organic compounds by crystallization. d) Filtration techniques. e) Determination of melting and boiling points. Experiment No 1: Separation and quantification [6] a) Separation of napthol, aspirin, and napthalene b) Determination of purity by melting points and TLC. Experiment No 2: Isolation of Natural Products [6] a) Extraction of eugenol from cloves by steam distillation b) Extraction of caffeine from tea leafs. Experiment No 3: Organic preparations [6] a) Preparation of paracetamol b) Preparation of aspirin Experiment No 4: conversion of nitrobenzene to aniline and its estimation [6] a) Qualitative test for nitrobenzene b) Reduction of nitro compound c) Qualitative test for aniline d) Estimation of aniline Experiment No 5: Phenol and its derivatives [6] a) Qualitative test for phenol b) Nitration of phenol c) synthesis of 7-hydroxy-4-methylcoumarin Experiment No 6: Cannizarro Reaction [6] a) Qualitative tests for benzaldehyde b) Preparation of benzyl alcohol and benzoic acid from benzaldehyde c) Qualitative tests for benzyl alcohol d) Qualitative tests for benzoic acid Experiment No 7: Claisen- Schmidt Reaction [3] a) Preparation of dibenzalacetone (1,5-diphenylpenta-1,4-diene-3-one) b) Qualitative test for bibenzalacetone Experiment No 8: Beckmann Rearrangement [6] a) Preparation of benzophenone oxime b) Conversion of benzophenone oxime to benzanilide c) Qualitative analysis of benzanilide Experiment No 9: Preparation of ester and its estimation [6] a) Preparation methyl benzoate b) Qualitative test for ethyl benzoate c) Estimation of ester
Text & Reference Books	1. Vogel's Text book of Practical Organic Chemistry - Revised by Brian S. Furniss, Antony J. Hannaford, Peter W. G. Smith, and Austin R. Tatchell, - 5 ed., John Wiley & Sons, 1991.

CHY 222	Chemistry Laboratory III (0031)
Objectives	Chemistry Laboratory III offers opportunities to familiarize the principles of physical chemistry through hands-on approaches. This laboratory is designed to have experiments related to the physical chemistry concepts taught in the theory course CHY221.
Syllabus	**1.** Viscosity: a. Determination of Viscosity of Pure Liquids b. Effect of Salt on Viscosity of Liquids 2. Surface Tension: a. Determination of the Surface Tension of a Liquid by Drop Number Method b. Determination of Parachor Values **3.** Chemical Kinetics a. Determination of the Rate Constant of the Hydrolysis of Ester by Sodium Hydroxide at Different Temperature b. Activation Energy **4.** Refractometry: a. Determination of Molar Refractions of Pure Liquids c. Determination of Molar Refraction of Solids d. Solvent-Solvent Interaction in Binary Solvent System **5.** Conductivity Measurements: a. Determination of the Degree of Ionization of Weak Electrolytes. e. Titration of a Strong Acid and Weak Acid Against a Strong Base. f. Titration of a Mixture of Acids Against a Strong Base. g. Titration of a Mixture of Weak Acids Against a Strong Base. **6.** Potentiometry: a. Determination of Single Electrode Potentials (Cu and Zn). h. Verification of Nernst Equation i. Oxidation-Reduction Titration. **7.** Distribution Law a. Distribution Coefficient of Iodine Between an Organic Solvent and Water. b. Determination of the Equilibrium Constant of the Reaction KI + I2 KI3 8. Phase Diagrams-1: Phenol Water System: a. Determine the Mutual Solubility Curve of Phenol and Water and Hence the Consolute Point. b. Determine the Critical Solution Temperature of Phenol and Water in Presence of (i) Sodium Chloride (ii) Naphthalene and (iii) Succinic acid. **9.** Phase Diagrams-2: Three Component System: a. Construction of the Triangular Phase Diagram of Acetic Acid, Chloroform and Water b. Construction of the Tie Line c. Determination of the Composition of the Given Mixture **10.** Solid Liquid Equilibrium: a. Determination of Molal Depression Constant of Naphthalene d. Determination of Molecular Weight of Solute
Reference	1. M. Halpern and G. C. McBane, Experimental Physical Chemistry: A Laboratory Text Book, 3^{rd} Edition, W. H. Freeman, 2006 2. D. P. Shoemaker, G. W. Garland and J. W. Nibler, Experiments in Physical Chemistry, 5^{th} Edition, McGraw Hill, London.

School of Mathematics

MAT 111	Single Variable Calculus (3103)
Learning outcomes	Under the BS-MS program, a few students join without mathematics background in their 10+2 standard. This course, in one hand, provides the necessary back ground in basic calculus to such students, on the other, it also exposes all the students to an abstract approach to calculus, which is necessary for more advanced courses on analysis.
Syllabus	Properties of real numbers, the least upper bound and greatest lower bound properties (4 hours) Limits of Sequences: Convergence and limit laws, limsup and liminf of sequences, some standard limits, Subsequences. (7 hours) Series: absolute and conditional convergence of an infinite series, tests of convergence, examples. (5 hours) Continuous functions on the real line: Formal definition, continuity and discontinuity of a function at a point; left and right continuity, examples of continuous and discontinuous functions, intermediate value theorem, extreme value theorem, monotonic functions, uniform continuity, limits at infinity.(8 hrs) Differentiation of functions: Definition and basic properties, local maxima, local minima, and derivatives, monotone functions and derivatives, inverse functions and derivatives, Rolle's theorem, mean value theorem, Taylor's theorem. (8 hrs) Riemann Integration: Partitions, upper and lower Riemann integrals, basic properties of the Riemann integral, Riemann integrability of continuous functions, monotone functions, and discontinuous functions, non-Riemann integrable functions, the fundamental theorems of calculus (8 hrs)
Texts and References	1. T. M. Apostol, Calculus, vol 1, 2nd ed., Wiley, 2007. 2. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 4th ed., Wiley, 2011. 3. S. Lang, A first course in Calculus, 5th ed., Springer India, 2006. 4. M. Spivak, Calculus, Publish or Perish, 2008. 5. W. Rudin, Principles of Mathematical Analysis, 3rd ed., McGraw Hill India, 1953.

MAT 121	Introduction to Linear Algebra (3103)
Learning outcomes	The basic linear algebra is foundation for every future mathematics course. The objective is to introduce the Linear algebra in a mathematically abstract form and relate it to the matrix algebra.
Syllabus	• Matrices: Systems of linear equations, Row echelon form, Elementary matrices, The determinant of a matrix, Properties of determinants. (6 hours) • Vector spaces: Definition and examples, Subspaces, Linear independence, Basis and dimension, Change of basis, Row space and column space (9 hours) • Linear maps: Definition and examples, Matrix representations of linear maps, Similarity, Rank-nullity Theorem. (7.5 hours) • Inner product spaces: The scalar product in R^n, Inner product spaces, Orthonormal sets, The Gram-Schmidt orthogonalisation process. (7.5 hours) • Eigenvalues and eigenvectors, Diagonalisable matrices, Cayley- Hamilton Theorem. (6 hours) • Hermitian Matrices. (4 hours)
Texts and References	1. S. Axler, Linear Algebra Done right, Springer; 3rd ed. 2015 edition. 2. S. H. Friedberg, A. J. Insel, L.E. Spence, Linear Algebra, Pearson Education India; 4 edition.

	3. L. N. Childs, A Concrete Introduction to Higher Algebra, Springer, 2009 4. S. Kumaresan, Linear Algebra : A Geometric Approach, Phi Learning, 2009. 5. Hoffman and R. Kunze, Linear Algebra, 2nd edition, Pearson Education, New Delhi, 2006 6. P. Halmos, Finite Dimensional Vector Spaces, Van Nostrand, Princeton, N.J, 1958

MAT 211	Multivariable Calculus (3103)
Learning outcomes	This course is an extension to MAT 111. Limit, continuity, differentiation and integration in R^n are explained in a more problem solving manner, although abstract mathematical concepts are slowly introduced. The course also introduces some very basic topological properties of R^n.
Syllabus	• Differential calculus: Limits and continuity of functions of several variables; Differentiability, Partial derivatives, total derivative, composite functions, chain rule, partial derivatives of higher order, change of variables; inverse and implicit function theorems (without proof), unconstrained maxima and minima, Lagrange multipliers; Leibniz's formula, Taylor's formula, mean value theorems. (20 hours) • Integral Calculus: Double integrals on rectangular regions, conditions of integrability, properties of integrable functions, repeated or iterated integrals, double integrals over finite regions, changing the order of integration; Fubini-Tonelli Theorem (without proof); triple integrals over any bounded domain, evaluation of multiple integral by change of variables; surface area, volume of a region, theorems of Green, Gauss, and Stokes (without proof). (20 hours)
Texts and References	1. T. M. Apostol, Calculus, vol. 2, 2nd ed., Wiley (India), 2007. 2. S. Lang, Calculus of several variables, 3rd ed., Springer 1987. 3. V. Zorich, Mathematical Analysis I, Springer 2004. 4. V. Zorich, Mathematical Analysis II, Springer 2004. 5. Moskowitz, F Paliogiannis, Funtions of several Real Variables, World Scientific Publishing 2011.

MAT 221	Introduction to Probability (3103)
Learning outcomes	The aim of this problem oriented course is to give the students a broader perspective how the combinatorial probability and statistical methods can be used in all areas of sciences.
Syllabus	• Basic probability: Set operations, counting, finite sample spaces, axioms of mathematical probability, conditional probability, independence of events, Bayes' Rule, Bernoulli trials, Poisson trials, multinomial law, infinite sequence of Bernoulli trials.(10 hours) • Random variables and probability distributions: Binomial distribution, geometric distribution, Poisson distribution, normal distribution, exponential distribution, Gamma distribution, Beta distribution; Cumulative and marginal distribution functions; Transformation of random variables in one and two dimensions.(15 hours) • Mathematical expectations: Expectations for univariate and bivariate distributions, moments, variance, standard deviation, higher order moments, covariance, correlation, moment generating functions, characteristic functions. Central limit theorem, law of large numbers.(15 hours)
Texts and References	1. R. V. Hogg, J. McKean and A. T. Craig, Introduction to Mathematical Statistics, Pearson, 7th ed., 2012 2. S. Ross, Introduction to Probability and Statistics for Engineers and Scientists, 3rd ed., Elsevier, 2004. 3. C. M. Grinstead and J. L. Snell, Introduction to Probability, 2nd ed., American Mathematical Society, 1997. 4. S. Ross, A first course in Probability ,8th edition, Prentice Hall, 2009. 5. K. L. Chung, Elementary Probability Theory, 4th edition, Springer, 2003.

	6. P. G. Hoel, S.C. Port and C.J. Stone, Introduction to Probability Theory, 1st edition, Houghton Mifflin, 1972.

School of Physics

Lecture Courses:

PHY 111	Mechanics (3103)
Learning Outcomes	• Understand and express the fundamental principles of mechanics • Undertake mathematical formulation of physical problems • Solve equations of motion (EOM) with suitable initial and boundary conditions • Comprehend relativistic concepts of space and time, reference frames.
Syllabus	• Newton's Laws [4]: Critical analysis of the Newton's laws, Concept of homogeneity and isotropy of space-time, symmetry, Concept of inertial, non-inertial reference frames, fictitious forces, Introduction to Galilean Relativity. • Motion in one dimension [8]: Analytical solutions of EOMs, Conservation of momentum, Work energy theorem, Use of potential energy graphs to understand motion. Motion under gravity (rocket motion, block-pulley systems); Simple harmonic oscillator and damped oscillator. • Motion in higher dimensions [3]: Position vector and its derivatives. EOM in Cartesian and Polar Coordinates; • Force as the gradient of potential energy; Conservation of angular momentum for a point particle; Projectile motion, Motion under central force, The Kepler problem [7] • Rigid bodies [4]:Centre of mass; Rotational inertia, Momentum and Energy, • Conservation laws, Moment of inertia-Examples with simple symmetric bodies. [5] • Torque and work energy theorem. [3] • Non-inertial frames [6]:Rotating reference frames and pseudo-forces • Special Theory of Relativity: Measuring space-time in Galilean relativity; Michelson-Morley experiment, Postulates of special relativity, Lorentz transformation-Relativity of Simultaneity, Length contraction, Time dilation; Minkowski space-time diagram, Examples: Twin paradox, Doppler Effect. [8 hrs]
Text & Reference Books	1. D. Kleppner and R. Kolenkow, An introduction to Mechanics, McGraw-Hill Science/ Engineering/ Math, 1973. REFERENCES 1. Serway and Jewett, Physics for Scientists and Engineers, Brooks/Cole Publishers 2004. 2. C. Knight, W. D. Ruderman, M. A. Helmholz, C. A. Moyer and B. J. Kittel, Berkeley Physics Course: Vol. I – Mechanics, McGraw-Hill, 1965. 3. R. Shankar, Fundamentals of Physics, Yale Press.

PHY 121	Electromagnetism (3103)
Learning Outcomes	• Understand and express the fundamental laws and principles of Electricity and Magnetism. • Describe concepts and phenomena of electromagnetic fields, and their mathematical formulation in free space and matter. • Calculate physical quantities associated with electromagnetism.
Syllabus	• Electrostatics : *Electric field:* Coulomb's law, Divergence and Curl of electrostatic fields, Gauss's law in differential and integral form and simple application [3] *Electric Potential:* Electrostatic potential, Poisson's equation and Laplace equation, Potential due to a localized charge distribution, Electrostatic Boundary conditions [3] *Work and energy in electrostatics:* Work done to move a charge, Electrostatic energy for point charge as well as continuous charge distribution, Simple examples [2] *Conductors:* Basic Properties, Surface charges induced on a conductor, Force on a conductor. *Capacitors:* Definition of capacitance, Calculation of capacitance for parallel plates, concentric spherical shells, coaxial cylindrical tubes.[2] • Special Techniques to solve the potential due to a given charge configurations: Solution by the method of separation of variables in Cartesian, spherical polar and cylindrical coordinates; Examples involving solution of boundary value problems such as a conducting sphere in uniform electric field; Potential due to an arbitrary charge distribution; Solving the potential for point charge configuration in a system of grounded conducting planes using method of images. [8]

PHY 121	Electromagnetism (3103)
	• Multipole Expansion; Electrical field and potential due to a point dipole; Dipole in an electric field [2] • Electric field in matter [4]: Dielectrics, Polarization, Field of a polarized object, Electric displacement vector (D); Gauss's theorem in dielectric media; Boundary value problem with linear dielectrics; • Electrostatic field energy; Computation of capacitance in simple cases (parallel plates); spherical and cylindrical capacitors containing dielectrics – uniform and non-uniform. [4] • Magnetostatics: Biot - Savart and Ampere's laws; Ampere's law in differential form; Magnetic vector potential, Magnetostatic boundary conditions [4] Multipole expansion of the vector potential; Determination of magnetic fields for simple cases. Energy in a magnetic field[4] • Magnetic field in matter [6]: Field of a Magnetized object; Auxiliary Field H, Ampere's law in Magnetized materials; Magnetic Susceptibility and Permeability. • Electrodynamics [6]: Current electricity: Electromotive force. Ohm's law; Motional emf; Electromagnetic induction; Faraday's law; Self-inductance and mutual inductance; Impedance; LCR circuit; Maxwell's equations; Equation of continuity; Poynting's theorem;
Text & Reference Books	TEXTBOOKS/REFERENCES 1. D. J. Griffths, Introduction to Electrodynamics, Prentice-Hall India, 2007. Additional References 2. E. M. Purcell, Berkeley Physics course: Vol 2. Electricity and Magnetism, McGraw Hill. 3. Serway and Jewett, Physics for Scientists and Engineers, Brooks/Cole Publishers, 2004.

PHY 211	Optics (3103)
Learning Outcomes	• Analyse optical systems using lens equations and matrix formalism • Evaluate the effect of different aberrations on image formation • Write expression for a travelling wave using wave properties such as wavelength, polarization and phase velocity • Distinguish between polarization states and polarization conversion • Analyse interference patterns and interferometers using the concept and conditions for interference. • Analyse effect of aperture on wave propagation, diffraction and applications
Syllabus	• Geometrical Optics [3] Fermat's Principle, Laws of reflection and refraction from Fermat's principle, • Refraction at a Single Spherical Surface, The thin lens, Thin lens equation,[3] • Matrix method in paraxial optics, Thin lens combinations, Aberrations, Prisms, Optical Systems.[3] • Wave Optics [4]: Wave Motion, One dimensional waves, Harmonic Waves, Phase Velocity, Group Velocity of a wave packet, • Three-dimensional wave equation, Spherical waves, and cylindrical waves.[3] • Polarisation: The nature of polarized light, Polarizers, Malus law, Dichroism, Birefringence, Scattering and Polarization, Polarization by reflection, Brewster angle, Retarders; full-wave plate, half-wave plate, quarter-wave plate, Circular Polarizers, Polarization of Polychromatic light [6] • Maxwell's equation, wave equation, Poynting Vector, Fresnel reflection coefficient, Total internal reflection, Optical fibre, single mode fibre, multimode fibre, evanescent wave. [5] • Interference [3]: The superposition principle, phasors and the addition of waves, Condition for interference, Coherence, • Two beam interference by division of wave-front; Fresnel' Biprism, [2] • Interference by division of amplitude; interference by a plane parallel film, Newton's rings, Michelson interferometer, multiple beam interferometry; Fabry-Perot interferometer. [5] • Diffraction: Fresnel diffraction: Fresnel Half-period zones, The zone-plate, Diffraction by a straight edge, The Fresnel propagation [6]

PHY 211	Optics (3103)
	• Fraunhofer approximation, Fraunhofer diffraction and Fourier optics: Single slit diffraction, Diffraction by a circular aperture, Two-slit Fraunhofer diffraction, N-slit Fraunhofer diffraction, The diffraction grating, Oblique incidence, X-ray diffraction.[5]
Text & Reference Books	1. Ajoy Ghatak, Optics, Tata Mcgraw-Hill, 2009. REFERENCES 1. Eugune Hecht and A. R. Ganesan, Optics, AddisonWesley Longman, 2002. 2. Francis A. Jenkins and Harvey E. White, Fundamentals of Optics, McGraw- Hill Higher Education, 4th Ed. 3. Frank S. Crawford,Waves: Berkeley Physics Course Vol. 3, Tata Mgraw Hill, 2008.

PHY 221	Thermal & Statistical Physics (3103)
Learning Outcomes	• Apply concepts and laws of thermodynamics to describe physical processes and systems. • Analyze the energy changes of physical/chemical systems using first law of thermodynamics. • Apply concepts in probability and distribution functions to different physical systems and connect single particle quantum behaviour that of macroscopic thermodynamic systems. • Evaluate intensive and extensive variables using statistical formulations for an ideal gas.
Syllabus	• Macroscopic and microscopic description of state; Thermal equilibrium and the Zeroth law; Concept of temperature; Temperature scales. [3] • Thermodynamic equilibrium; Thermodynamic variables; Equation of state; Relevant theorems in partial differential calculus; [3] • Thermodynamics of simple systems (hydrostatic system, stretched wire, surfaces, electrochemical cell, dielectric slab, paramagnetic rod); Intensive and extensive variables. [5] • Work, Heat and Internal energy; Thermodynamic Processes (reversible, irreversible, quasi-static, adiabatic, isothermal, etc); Work done in various processes; [4] • First law of thermodynamics, Specific heat capacity; Heat conduction and conductivity; Blackbody radiation; Kirchhoff's law; Stefan-Boltzmann law. [4] • The Second Law of thermodynamics; Gasoline Engine; Carnot cycle and Kelvin temperature scale, [4] • Clausius' theorem, Entropy change for simple processes; Physical interpretation of Entropy; Applications of Entropy principle. [4] • Thermodynamic functions (Enthalpy, Helmholtz free energy, Gibbs free energy, etc.);[4] • Conditions of equilibrium; Maxwell's relations, Chemical potential. [3] • Equilibrium between two phases; General equilibrium conditions; The Clausius-Clapeyron equation and phase diagrams;[3] • Stability conditions: Le-Chatelier's principle; Third law of thermodynamics. [3] • Concept of ensembles and Statistical postulates; Examples of probability distributions; Maxwell's distribution (Mean and variance); Canonical partition function of an ideal mono-atomic gas; [4] • Evaluate pressure, internal energy, and entropy of ideal gas; Equipartition of energy; Distribution of speeds (average speed, average square of speed) [4]
Text & Reference Books	1. M. W. Zemanski and R. H. Dittman, Heat and Thermodynamics, McGraw- Hill, 1997. REFERENCES 1 F. Reif, Statistical Physics: Berkeley Physics Course Vol. 5, Tata McGraw-Hill, 2011. 2. Daniel V. Schroeder, An introduction to thermal Physics, Addison- Wesley, 2000. 3. S. J. Blundell and K. M. Blundell, Concepts in Thermal Physics, Oxford, 2006.

Laboratory Courses:

PHY112	Experiments in Mechanics [0031]
Learning Outcomes	• Apply laws of mechanics to describe real life systems • Handle apparatus and Assemble simple experimental setup • Record measurements and Perform data analysis • Calculate physical parameters from experimental results and their deviation from theoretical predictions and Error Analysis
Syllabus	1. Simple pendulum & variable g pendulum 2. Conservation of energy 3. Conservation of momentum & ballistic pendulum 4. Centripetal force 5. Symmetric compound bar pendulum 6. Projectile motion 7. Melde's string 8. Newton's laws of Motion 9. Moment bar 10. Sonometer
Text & Reference Books	Laboratory Notes and Reference Material

PHY122	Experiments in Optics, Electricity and Magnetism [0031]
Learning Outcomes	• Experimentally verify theoretical concepts in electromagnetism and optics • Handle apparatus and Assemble simple experimental setup • Record measurements and Perform data analysis • Calculate physical parameters from experimental results and their deviation from theoretical predictions and Error Analysis • Appreciate safety protocols and measures taken
Syllabus	1. Magnetic field along the axis of a circular coil 2. Deflection magnetometer 3. Spot galvanometer- high resistance by leakage 4. Spectrometer: refractive index of prism and i-d curve 5. Spectrometer-Grating 6. Newton's rings 7. Diffraction at slits-single and double 8. Liquid lens 9. Reflection grating 10. Malu's law
Text & Reference Books	Laboratory Notes and Reference Material

PHY222	Experiments in Heat and Thermodynamics [0031]
Learning Outcomes	• Experimentally verify laws of Thermodynamics and Determine thermal properties of matter. • Handle apparatus and Assemble simple experimental setup • Record measurements and Perform data analysis • Calculate physical parameters from experimental results and their deviation from theoretical predictions and Error Analysis
Syllabus	1. Specific latent of steam 2. Thermal conductivity of rubber 3. Specific heat capacity of solid-method of mixtures 4. Joule's calorimeter-specific heat capacity of liquid 5. Thermal conductivity - Lee's disc method 6. Potentiometer and thermo emf 7. Latent heat of fusion of ice 8. P V Diagram 9. Stefan's Law 10. Newton's law of cooling
Text & Reference Books	Laboratory Notes and Reference Material

Interdisciplinary Courses:

IDC 111	Mathematical Tools I (2102)
Learning Outcomes	• Perform analysis of functions of several variables • Use concepts of vector calculus in physical problems • Perform operations with complex numbers
Syllabus	• Functions of several variables - partial differentiation. Cartesian, Spherical and Cylindrical coordinate systems: introduction and equivalence. Parametric representation of an equation. Introduction to Taylor's series with examples. [6] • Vector Calculus: Review of vector algebra: addition, subtraction and product of two vectors - polar and axial vectors with examples; triple and quadruple product. Concept of Scalar and Vector fields. Differentiation of a vector w.r.t. a scalar unit tangent vector and unit normal vector. Directional derivatives - gradient, divergence, curl and Laplacian operations and their meaning. Concept of line, surface and volume integrals. Statement of Gauss' and Stokes' theorems with physical examples. Gradient, divergence and curl in spherical polar and cylindrical coordinate systems. [15] • Complex numbers and functions: Arithmetic operation, conjugates, modulus, polar form, powers and roots; Derivatives. [4]
Text & Reference Books	1. E. Kreyszig, Advanced Engineering Mathematics, 8th Edition Wiley India Pvt Ltd, 2006. 2. Murray R. Spiegel, Schaum's Outlines Vector Analysis, Tata Mcgraw Hill 2009. 3. Murray R. Spiegel, Seymour Lipschutz, John Schiller, Dennis Spellman, Schaum's Outlines Complex Variables. Tata McGraw Hill Education; 2 edition, 2017

IDC 121	Mathematical Tools II (3103)
Learning outcomes	The aim of the second part of the interdisciplinary maths methods course is to making the students aware of various mathematical tools which are applied to other branches of sciences and engineering. This is a complete problem oriented course with lots of applications drawn from various fields.
Syllabus	• Solving techniques for first and second order linear ODEs: constant and variable coefficients [10] • Power series method, Legendre, Hermite, Bessel, Lauguerre, Chebyshev polynomials. [10] • Laplace transforms and application to ODEs.(6 hours) • BVPs and Green's functions.(7 hours) • Linear 2x2 systems of ODEs.(4 hours) • Application to other fields.(3 hours)
Texts and References	1. E. Kreyszig, Advanced Engineering Mathematics, 8th Edition Wiley India Pvt Ltd, 2006. 2. C. Edwards and D. Penny, Elementary Differential Equations with Boundary Value Problems, 5th Edition Prentice Hall 2007. 3. R. Bronson and G. Costa, Schaum's Outlines Differential Equations, 3rd Edition Mcgraw-hill 2009. 4. William E. Boyce, and Richard C. DiPrima, Elementary Differential Equations 9th Edition, Wiley, 2008.

IDC 211	Physical Principles in Biology (3103)
Learning Outcomes	Biological living organisms reach organizational complexity that far more exceeds the complexity of any inanimate objects or matter from which they are made of. The objective of the course is to introduce the students to the spatial (size) and temporal (time) scales that span the living organisms in order to understand the physical principles behind their complexity. The course will introduce students to the physical principles of biomolecules, their interactions/recognition, their census in time and scale, the techniques used to probe the physical properties that govern the functions of biomolecules and the linearity, non-linearity and stochasticity in biological systems.
Syllabus	1. Physical biochemistry of the cell: Chemical forces translation and rotation, diffusion, directed movements, biomolecules as machines, work, power and energy, thermal, chemical and mechanical switching of biomolecules, Responses to light and environmental cues [8-9] 2. Physical principles of molecular structure: organization of biomolecules, molecular census in size and time, macromolecular assemblies, sizing up HIV, channels, transporters and motors [19] 3. Molecular recognition: principles of specificity in biological recognition, hormone-receptor interaction, antigen-antibody interaction, transient interactions, importance of transient interaction in biology.[5-6] 4. Linearity and non-linearity in biological systems : Definitions and example of linear and non-linear systems. Representing linear and nonlinear functions and applications. Stochasticity in Biological systems. [3-4]
Text & Reference Books	1. John Kuriyan, The Molecules of Life: Physical and Chemical Principles. 2. Rob Phillips et al., Physical Biology of the Cell. Garland Science. 3. Peter Atkins and Julio de Paula, Physical Chemistry for the Life Sciences. 4. Watson J.D. and Crick F.H.C. A Structure for Deoxyribose Nucleic Acid (1953), Nature, 171, 737-738. 5. Michael J. Rust. Orderly wheels of the cyanobacterial clock (2012), PNAS, 09, 16760–16761 (Review). 6. Erwin Schrödinger. The Physical Aspect of the Living Cell (1944). Science book written for the lay reader by a physicist. 7. Kaern M, Elston TC, Blake WJ, Collins JJ (2005), Stochasticity in gene expression: from theories to phenotypes, Nat Rev Genet., 6:451-464. (Review).

IDC 221	Principles of Spectroscopy (3103)
Learning Outcomes	To describe the fundamental principles governing various spectroscopic techniques and the relevant applications
Syllabus	• Fundamental Aspects of Spectroscopy: Electromagnetic radiation, absorption, emission, scattering, Einstein A and B coefficients, signal to noise ratio, resolving power, lasers, spectral lineshapes, Fourier transform spectroscopies, and pump-probe techniques [6] • Atomic Spectroscopy: Spectra of hydrogenic systems, coupling of orbital and spin angular momenta in many-electron systems, term symbols, fine and hyperfine structure, Zeeman and Stark effects [8] • Rotational Spectroscopy: Rigid rotor model for diatomics, rotational angular momentum, rotational energy levels, rotational constant, selection rules, microwave spectra of representative diatomics, structure determination, and isotope effects [5] • Infrared Spectroscopy: Harmonic oscillator model for diatomics, energy levels, selection rules, anharmonic effects, dissociation energies, and Morse oscillator [5]

IDC 221	Principles of Spectroscopy (3103)
	• Raman Spectroscopy: Light scattering, Raman effect, classical model of scattering, polarizability, Stokes and anti-Stokes lines, selection rules, mutual exclusion principle, structure determination using IR and Raman spectroscopies [2] • Electronic Spectroscopy of Molecules: Jablonski diagram, absorption, emission, Frank-Condon principle, Stokes shift, 0-0 band, fluorescence, phosphorescence, and quantum yields [4] • Photoelectron Spectroscopies: X-ray photoelectron spectroscopy, ultraviolet photoelectron spectroscopy, and Auger processes [2] • Spin Resonance Spectroscopies: Nuclear and electron spins, effect of applied external fields, nuclear magnetic resonance spectroscopy, electron spin resonance spectroscopy, illustrative examples and applications [3] • Mössbauer Spectroscopy: Principle and illustrative examples [1]
Text & Reference Books	1. T. Engel, Quantum Chemistry and Spectroscopy, 3rd Ed., Pearson (2006). 2. J. M. Hollas, Modern Spectroscopy, 4th Ed., Wiley (2004). 3. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Ed., Tata McGraw-Hill (2017). 4. P. Atkins, J. de Paula and J. Keeler, Atkins' Physical Chemistry, 11th Ed., Oxford University Press (2018). 5. T. Engel and P. Reid, Physical Chemistry, 3rd Ed., Pearson (2013). 6. I. N. Levine, Physical Chemistry, 6th Ed., Tata McGraw-Hill (2011).

IDC 112	Fundamentals of Programming (0031)
Learning Outcomes	1. Write structured programs for accomplishing specific tasks in programming languages like C, C++ and Python. 2. Develop object-oriented programs and design computational methods for scientific and data applications. 3. Choose appropriate algorithms, libraries and Datatypes. 4. Understand the role of computation in solving problems. 5. Test and debug programs
Syllabus	• Introduction to computer architectures and components • Programming Languages, Editors and Compilers. • Variables and types, operators and comparisons, compound types: strings and lists, control flow, loops, functions • Simple Programs - Sorting - Searching
Text & Reference Books	1. Byron S Gottfried, Programming with C, Schaums Outlines, 2nd Ed, Tata McGraw-Hill, 2006. 2. John R. Hubbard, Programming with C++, Schaums Outlines, 2nd Ed, Tata McGraw-Hill, 2002. 3. R.G. Dromey, How to Solve it by Computer, Pearson Education, Fourth Reprint, 2007 4. Bjarne Stroustrup, The C++ Programming Language, Fourth Edition, Addison-Wesley 2013. 5. Guttag, John. Introduction to Computation and Programming Using Python: With Application to Understanding Data Second Edition. MIT Press, 2016. ISBN: 9780262529624. 6. H. P. Langtangen, A Primer on Scientific Programming with Python, Springer, 2016

IDC 122	Numeric Computing (0031)
Learning Outcomes	1. Write structured programs for accomplishing specific tasks in programming languages like C, C++ and Python. 2. Develop object-oriented programs and design computational methods for scientific and data applications. 3. Choose appropriate algorithms, libraries and Datatypes. 4. Understand the role of computation in solving problems. 5. Test and debug programs
Syllabus	• Arrays: Arrays and Matrices, Multidimensional arrays, array and matrix operations, indexing, slicing, reshaping and resizing. • Pointers - Arrays - Functions • Computing eigenvalues and eigenvectors, norm and determinant, solving linear system of equations, computing gradient.
Text & Reference Books	1. Byron S Gottfried, Programming with C, Schaums Outlines, 2nd Ed, Tata McGraw-Hill, 2006. 2. John R. Hubbard, Programming with C++, Schaums Outlines, 2nd Ed, Tata McGraw-Hill, 2002. 3. R.G. Dromey, How to Solve it by Computer, Pearson Education, Fourth Reprint, 2007 4. Bjarne Stroustrup, The C++ Programming Language, Fourth Edition, Addison-Wesley 2013. 5. Guttag, John. Introduction to Computation and Programming Using Python: With Application to Understanding Data Second Edition. MIT Press, 2016. ISBN: 9780262529624. 6. H. P. Langtangen, A Primer on Scientific Programming with Python, Springer, 2016

IDC 212	Data Analysis and Visualisation (0031)
Learning Outcomes	1. Write structured programs for accomplishing specific tasks in programming languages like C, C++ and Python. 2. Develop object-oriented programs and design computational methods for scientific and data applications. 3. Choose appropriate algorithms, libraries and Datatypes. 4. Understand the role of computation in solving problems. 5. Test and debug programs
Syllabus	• Introduction to data structures, classes, templates • Object oriented Programming • Understanding Program Efficiency • File input/output, Loading and storing data, data files. • Plotting and visualisation of scientific data,
Text & Reference Books	1. Byron S Gottfried, Programming with C, Schaums Outlines, 2nd Ed, Tata McGraw-Hill, 2006. 2. John R. Hubbard, Programming with C++, Schaums Outlines, 2nd Ed, Tata McGraw-Hill, 2002. 3. R.G. Dromey, How to Solve it by Computer, Pearson Education, Fourth Reprint, 2007 4. Bjarne Stroustrup, The C++ Programming Language, Fourth Edition, Addison-Wesley 2013. 5. Guttag, John. Introduction to Computation and Programming Using Python: With Application to Understanding Data Second Edition. MIT Press, 2016. ISBN: 9780262529624. 6. H. P. Langtangen, A Primer on Scientific Programming with Python, Springer, 2016

IDC 212	Scientific Computing (0031)
Learning Outcomes	1. Write structured programs for accomplishing specific tasks in programming languages like C, C++ and Python. 2. Develop object-oriented programs and design computational methods for scientific and data applications. 3. Choose appropriate algorithms, libraries and Datatypes. 4. Understand the role of computation in solving problems. 5. Test and debug programs

IDC 212	Scientific Computing (0031)
Syllabus	• Special Functions, interpolation, optimisation and fit, random numbers, numerical integration, fast Fourier transforms, signal processing and image manipulations. • Numerical solution of differential equations • Applications to problems in natural sciences
Text & Reference Books	1. Byron S Gottfried, Programming with C, Schaums Outlines, 2nd Ed, Tata McGraw-Hill, 2006. 2. John R. Hubbard, Programming with C++, Schaums Outlines, 2nd Ed, Tata McGraw-Hill, 2002. 3. R.G. Dromey, How to Solve it by Computer, Pearson Education, Fourth Reprint, 2007 4. Bjarne Stroustrup, The C++ Programming Language, Fourth Edition, Addison-Wesley 2013. 5. Guttag, John. Introduction to Computation and Programming Using Python: With Application to Understanding Data Second Edition. MIT Press, 2016. ISBN: 9780262529624. 6. H. P. Langtangen, A Primer on Scientific Programming with Python, Springer, 2016