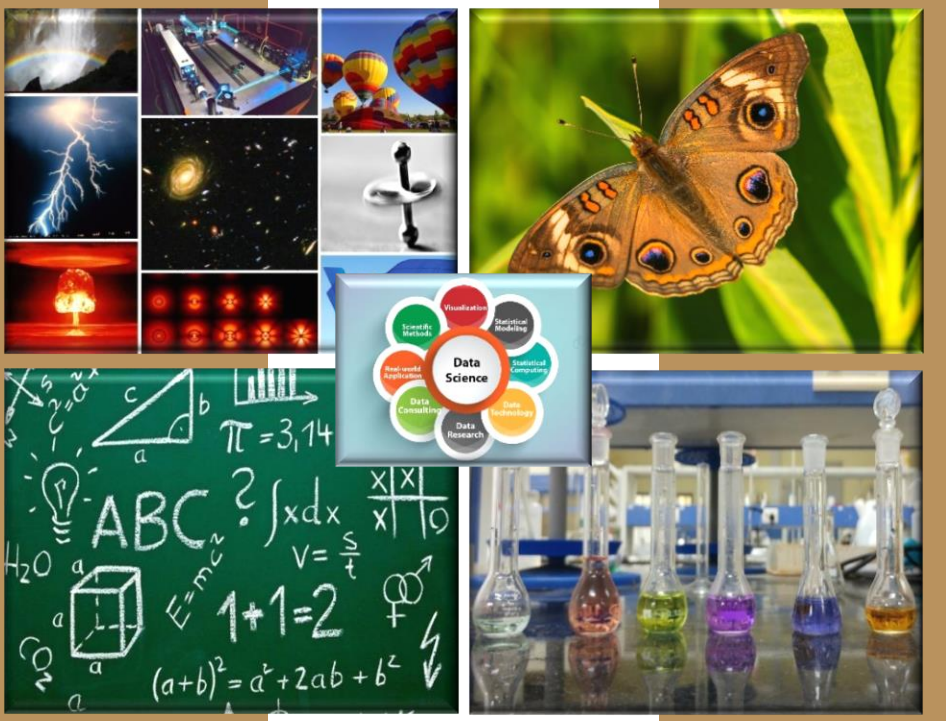
FOUNDATION & PRE-MAJOR COURSES

CURRICULUM FOR BS-MS (SEM: 1 - 3)

i^2 Sciences (SEM: 1 - 3)



Foundation & Pre-Major Courses

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Courses offered in Semester 3	Combination of 3 subjects (A B C) with 2 courses in each subject from those listed below.	
BIO 211 [3104] Principles of Life III: Organismal biology	CHY 211 [3104] Atomic Structure and Chemical Bonding	DSC 211 [3003] Introduction to Artificial Intelligence
BIO 212 [3003] Principles of Life IV: Microbiology	CHY 212 [3003] Basic Organic and Inorganic Chemistry II	DSC 212 [3104] Mathematical Foundations to Data Science
EESS 201 [3104] Introduction to earth and climate sciences	MAT 201 [3104] Calculus and Matrices II	PHY 211 [3104] Thermal & Statistical Physics
EESS 202 [3003] Introduction to environmental and sustainability sciences	MAT 202 [3003] Introduction to Probability	PHY 212 [3003] Optics

Allowed combinations of Subjects A B & C

Subject A	Subject B	Subject C	Combination
BIO	CHY	EES	**BCE**
BIO	CHY	MAT	**BCM**
BIO	DSC	MAT	**BDM**
BIO	EES	MAT	**BEM**
BIO	MAT	PHY	**BMP**
CHY	DSC	MAT	**CDM**
CHY	EES	MAT	**CEM**
CHY	MAT	PHY	**CMP**
DSC	MAT	PHY	**DMP**
EES	MAT	PHY	**EMP**

Biology Courses

BIO 111: Principles of Life I: Biomolecules, Genetics and Evolution [2 1 0 3]	
Learning Outcomes	The course will introduce students to the framework of biological systems. On completion of the course, students will ▪ gain an understanding of the basics of what life is, scales of biological organization, the chemical basis of life, and inheritance of traits. ▪ understand the fundamentals of biological evolution, how evolution has shaped phenotypic diversity & behaviour and how evolution is a unifying theme in biology.
Syllabus	Overview of Biology: • What is life? Importance of studying biology; Scales in biology; Disciplines of biology; Origins of life. [4] Biomolecules: • Chemical composition of life - elements and the importance of water [1] • Carbohydrates - mono-, oligo- and polysaccharides, their presence in biological systems. Isomers, enantiomers, epimers, cyclization. Derivatives of carbohydrates and their importance. [2] • Introduction to proteins - amino acids, classes (based on chemical nature and essential nature). [2] • Lipids - fatty acids structure and nomenclature. Types • (phospholipids, glycolipids, sphingolipids) and their importance. [2] • Nucleic acids - Introduction to nucleic acid bases and nucleotides. Structure and function of DNA and RNA, physicochemical properties of these informational macromolecules. [3] • Patterns and uniqueness of biomolecules: chemical nature, physical dimensions, the importance of understanding why biomolecules are specified for their respective functions. [1] Genetics: • Introduction to genetics-concept of gene and allele [2] • Mendelian genetics - Mendel's law and examples, Monohybrid and di-hybrid cross, recessive and dominant mutation [3] • Non-Mendelian genetics - incomplete dominance, semidominance, and introduction to epigenetics [3] • Genetic interactions (epistasis and synthetic lethality) [1] Evolutionary Biology • Basics of evolution - History of evolutionary thinking; 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) [9] • Species concepts and speciation [3] • Phylogenetics - Basics of phylogenetics; Understanding evolutionary history through phylogenies [3] • Human behaviour - an evolutionary perspective. [1]
Text & Reference Books	1. Nelson and Cox, Lehninger Principles of Biochemistry. WH Freeman 7th Edition. 2. Voet, Voet and Pratt, Biochemistry, Wiley, 4th Edition.

BIO 111: Principles of Life I: Biomolecules, Genetics and Evolution [2 1 0 3]	
	3. Anthony J. F. Griffiths et al., An Introduction to Genetic Analysis, W. H. Freeman, 7th ed., 2000. 4. Snustad and Simmons, Principles of Genetics 7th Edition. 5. Douglas J. Futuyma and Mark Kirkpatrick. Evolution. Oxford University Press 4th Edition 6. Barton et al., Evolution Cold Spring Harbor Laboratory Press 1st Edition 2007 7. Stephen C. Stearns and Rolf F. Hoekstra. Evolution: An Introduction Oxford University Press 2nd Edition

BIO 112: Biology Lab I [0 0 3 1]	
Learning Outcomes	This course teaches the students to apply scientific methods and provides basic training for sampling, experimental design, making scientific observations, record keeping and hypothesis testing. After this course, a student should be able to practically understand the structure of a cell, chemical nature of biomolecules and principles of flow of genetic information.
Syllabus	Life under a microscope: • Plant and animal cells under a microscope [6] • Isolation of microorganisms [9] • Biological solutions preparation and quantification of biomolecules (proteins, lipids, carbohydrates, DNA) [6] • Mutation frequencies, fluctuation tests [6] • Analyse data from crosses: theoretical problem solving • Sampling, hypothesis testing [9]

BIO 121: Principles of Life II: Biophysics, Cell and Molecular Biology [2 1 0 3]	
Learning Outcomes	On completion of this course, students will be able to understand the biophysical, cellular and molecular basis of life. The course lays the foundation for advanced biology courses by encompassing the basic and essential topics.
Syllabus	Biophysics: • Stabilizing interactions in biological macromolecules - hydrogen bonds, ionic interactions, salt bridges, hydrophobic interactions, van der Waals forces. [2] • Principles of biophysical chemistry - bioenergetics and laws of thermodynamics, reaction kinetics. [4] • Protein Structure and Function – physicochemical properties of amino acids. Basics of Ramachandran plot. Primary, secondary, tertiary and quaternary structure. [8] Cell Biology: • Structure of prokaryotic and eukaryotic cells. [2] • Cell membrane - structure and composition of the cell Membrane, membrane Proteins, transport across the cell membrane. [3] • Structure and function of intracellular organelles – cytoplasm, cytoskeletal elements, mitochondria, ribosomes, endoplasmic reticulum, lysosomes, Golgi complex, peroxisomes, vacuoles. [4]

BIO 121: Principles of Life II: Biophysics, Cell and Molecular Biology [2 1 0 3]	
	• Cell division and cell cycle - mitosis, meiosis, cell cycle regulation. [4] Molecular Biology: • Central dogma of molecular biology – replication, transcription and translation. [5] • Concept of gene regulation – operon concept, positive and negative regulation. [3] • DNA repair and mutagenesis – major DNA repair pathways, mutation assays. [3] • Genome composition and organization – AT & GC content, chromatin organization. [3] • Methods in molecular biology - PCR and cloning [1]
Text & Reference Books	1. Watson et. al., Molecular Biology of the Gene, Pearson, 7th Edition 2013 2. Jocelyn E. Krebs et al., Lewin's Gene Jones & Bartlett Learning; 11th edition (December 31, 2012) 3. Gerald Karp, Cell Biology, WILEY (Feb. 4th, 2013) 4. Wayne M. Becker et al., World of the Cell; Benjamin Cummings; 7th edition (February 19, 2008) 5. David L. Nelson, and Michael M. Cox et al., Lehninger principles of biochemistry, W. H. Freeman, 7th ed., 2017. 6. Bruce Alberts et al., Essential Cell Biology; Richard Goldsby and Thomas J, &F/Garland, 4th Edition, (2014) 7. Alberts, Bruce.; Molecular Biology of the Cell, Garland Science; 5th edition (2 January 2008). 8. Branden C and Tooze J, Introduction to protein structure, Garland Science

BIO 122: Biology Lab II [0 0 3 1]	
Learning Outcomes	▪ This course will provide basic hands-on learning of biological experimental methods involving various biomolecules. ▪ After this course, the students should be able to practically understand the fundamental processes and stages of cell division, linking it with distribution of genetic material in somatic and germ cells.
Syllabus	• Determination of pKa and pI of amino acids/proteins [3] • Enzyme assays [3] • Genomic DNA isolation [6] • PCR [6] • Plasmid DNA isolation [6] • SDS-PAGE [6] • Mitosis [3] • Meiosis [3]

BIO 211: Principles of Life III: Organismal biology [3 1 0 4]	
Prerequisites	NA

BIO 211: Principles of Life III: Organismal biology [3 1 0 4]	
Learning Outcomes	On completion of this course, students should be able to ▪ appreciate the importance of interactions between organisms and their environment ▪ understand what factors control populations of organisms ▪ understand the importance of biodiversity and its conservation ▪ understand the evolutionary basis of animal behaviour ▪ appreciate the importance of studying plants and its unique life cycle ▪ understand the growth, development, and physiology of plants ▪ learn how the gained knowledge of plant biology facilitates improvements in agriculture
Syllabus	Ecology • Diversity of Life (both plants and animals). [4] • Populations, Communities and Ecosystems [3] • Life history strategies [3] Animal Biology [5] • Eco-physiology • Comparative, environmental and evolutionary physiology • Problems of scale and size • Physiological effects of temperature • Coping with the aquatic, terrestrial, and extreme environments Behaviour [5] • Proximate and Ultimate explanations in Biology • Darwinian selection and the study of behaviour • Discovering the causes, development and control of behaviour • Evolution of key behaviours for Survival, Feeding, Reproduction, and Parental care Plant Biology • Why study plants? Unique aspects of the plant life cycle. [2] • Plant- water relations: Water potential and its components. [1] • Transpiration, root pressure, guttation, xylem-phloem interactions, and water transport in the soil-plant-air continuum. [1] • Photosynthesis: Light-dependent and independent phases, electron transport. [2] • C3, C4, and CAM pathways of Co2 fixation. [2] • Plant growth and development, floral development and reproductive physiology. [5] • Phytohormones: Auxin, cytokinin, gibberellic acid, brassinosteroids, ethylene, abscisic acid, salicylic acid, and jasmonic acid: its roles in plant development. [3] • Plant breeding and genetic improvements in agriculture. [4]
Text & Reference Books	1. John Alcock. Animal Behaviour: an evolutionary approach.Sinauer Associates, 2009. 2. Patrick J. Butler, J. Anne Brown, D. George Stephenson, and John R. Speakman, Animal Physiology: An environmental perspective. Oxford University Press. 3. Willmer Pat, and Stone G, Environmental Physiology of Animals. Wiley-Blackwell, 2009 4. Davies NB, Krebs JR, and West SA, An Introduction to Behavioural Ecology, 4th Edition, Wiley-Blackwell 5. Plant Biology by Alison Smith, George Coupland, Liam Dolan, Nicholas Harberd, Jonathan Jones, Cathie Martin, Robert Sablowski, and Abigail Amey, Garland Science, Taylor and Francis group

BIO 211: Principles of Life III: Organismal biology [3 1 0 4]	
	6. BIOS Instant Notes in Plant Biology, A.J. Lack & D.E. Evans, BIOS Scientific Publishers Limited, 2001 7. Teaching Tools in Plant Biology, published by "The Plant Cell" Oxford Academic Publishers. 8. Genetics, Agriculture, and Biotechnology by Walter Suza and Donald Lee Iowa State University Digital Press Ames, Iowa 9. Plant breeding- Classical to Modern by PM. Priyadarshan Springer publications 11. Other individual review articles and updated research advances will be cited during the lecture.

BIO 212: Principles of Life IV: Microbiology [3 0 0 3]	
Prerequisites	NA
Learning Outcomes	On completion of this course, Students should be able to ▪ Understand the basics of Microbiology and structures and functions of prokaryotic cells as whole entities and in terms of their subcellular process ▪ Understand the biology of bacteria, viruses and other pathogens related to infectious diseases in humans.
Syllabus	• History of Microbiology: Discovery of microbes, important milestones, microbial diversity. [4] • Prokaryotic cell structure and function: Prokaryotic cell membrane, cell wall nucleoid and plasmids. [6] • Microbial physiology: microbial nutrition: growth requirements, culture media, growth kinetics, growth curve, autotrophic and heterotrophic metabolisms, microbial growth control: physical and chemical methods. [6] • Microbial pathogenesis: microbial diseases, types, mode of infection with examples of human pathogens, antimicrobial agents and their mode of action. [9] • Applied microbiology: biodegradation, bioremediation, fermentation, recombinant protein production. [6] • Viruses and prions: Introduction - development of virology, general characteristics - virus structure, reproduction, cultivation and pathogenesis. [9]
Text & Reference Books	Text Books: 1. Willey, Joanne M; Sherwood, Linda; Woolverton, Christopher J; Prescott Harley Klein's Microbiology, McGraw-Hill, 7th Edition, 2008 Reference Books: 1. Bacterial Physiology: A Molecular Approach / edited by Walid El-Sharoud, Springerlink 2. Irving, Will, Ala'Aldeen, Dlawer, Boswell Tim; Medical Microbiology, New York : Taylor and Francis Group, 2005.

Chemistry Courses

CHY 111: Basic Organic and Inorganic Chemistry [2 1 0 3]	
Learning Outcomes	This course introduces basic concepts in organic and inorganic chemistry with the aim to provide a structured understanding of chemistry.
Syllabus	• Chemical Bonding: Molecular orbital theory, bonding in homo-diatomic molecules – H2, N2, O2 and F2, concept of bond order, bond length and bond strength, bonding in heteronuclear diatomic molecules – CO, NO, HCl, and ICl, concepts of g and u symmetries of molecular orbitals. Bonding in triatomic molecules – HF2–, BeH2, O3, and CO2. [7] • Acids and bases: Brønsted concept, Lewis concept; Non-aqueous solvents, HSAB principle, super acids, relative strengths of acids. [3] • Oxidation and reduction: Reduction potential; electrochemical series; redox reactions; balancing of redox equations; factors affecting redox stability; Frost diagrams for redox reactions. [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 [2] • Stereochemistry: Baeyer's strain theory, Pitzer 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 - Pro-R, Pro-S, and Re/Si stereodescriptors; chirotopicity and stereogenicity. [9]
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 112: Chemistry Lab I [0 0 3 1]	
Learning Outcomes	This laboratory course provides opportunities for hands-on laboratory experiences related to qualitative and quantitative analyses.

CHY 112: Chemistry Lab I [0 0 3 1]	
Syllabus	Basic Lab Techniques [3] 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 [3] a) Separation of naphthol, aspirin, and naphthalene b) Determination of purity by melting points and TLC. Experiment No 2: Isolation of Natural Products [3] a) Extraction of eugenol from cloves by steam distillation Experiment No 3: conversion of nitrobenzene to aniline and its estimation [3] a) Qualitative test for nitrobenzene b) Reduction of nitro compound c) Qualitative test for aniline d) Estimation of aniline Experiment 4: Titrimetric Estimations Based on Acid-Base Chemistry: [3] (a) Standardisation of HCl solution using standard NaOH solution, (b) Estimation of alkali content in commercial antacid tablet. Experiment 5: Redox-Titrimetric Estimations Based on Permanganometry: [6] (a) Standardisation of potassium permanganate using sodium oxalate; (b) Preparation of Potassium trisoxalatoferrate(III) trihydrate (c) Estimation of the oxalate content of Potassium trisoxalatoferrate(III) trihydrate. Experiment 6: Estimations Based on Iodimetry and Iodometry: [3] (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 7: Complexometric Estimations Based on EDTA: Quantitative estimation of calcium and magnesium in milk by EDTA complexometry. [3] (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. 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. 2. G. H. Jeffery, J. Bassett, R. C. Denny, Vogel's Quantitative Chemical Analysis, 5ed, ELBS and Longmans Green & Co Ltd, 1971. 3. A. J. Elias, General Chemistry Experiments, 3ed, Universities Press (India) Pvt Ltd, 2002. 4. J. Derek Woollins, Inorganic Experiments, 3ed, Wiley, 2010.

CHY 121: Physical Chemistry [3 1 0 4]	
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.

CHY 121: Physical Chemistry [3 1 0 4]	
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, 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] Thermodynamics: Concepts of temperature, enthalpy, entropy, Gibbs and Helmholtz energies, laws of thermodynamics, state and path functions, standard states, thermochemistry and Maxwell relations [5] Physical Transformations of Pure Substances: 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 [7] 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. Colligative Properties: Elevation of boiling point, depression of freezing point, lowering of vapour pressure, osmosis, and solubility [10] 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 [6]
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).

CHY 122: Chemistry Lab II [0 0 3 1]	
Learning Outcomes	Chemistry Laboratory II 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 CHY121.

CHY 122: Chemistry Lab II [0 0 3 1]	
Syllabus	1. Viscosity: [3] a) Determination of Viscosity of Pure Liquids b) Effect of Salt on Viscosity of Liquids 2. Chemical Kinetics: [3] a) Determination of the Rate Constant of the Hydrolysis of Ester by Sodium Hydroxide at different Temperature b) Activation Energy 3. Refractometry: [3] a) Determination of Molar Refractions of Pure Liquids b) Determination of Molar Refraction of Solids c) Solvent-Solvent Interaction in Binary Solvent System 4. Conductivity Measurements: [3] a) Determination of the Degree of Ionization of Weak Electrolytes. b) Titration of a Strong Acid and Weak Acid Against a Strong Base. 5. Potentiometry: [3] a) Determination of Single Electrode Potentials (Cu and Zn). b) Verification of Nernst Equation and Oxidation-Reduction Titration. 6. Distribution Law: [3] a) Distribution Coefficient of Iodine Between an Organic Solvent and Water. b) Determination of the Equilibrium Constant of the Reaction KI + I2 → KI3 7. Phase Diagrams: [3] 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/Naphthalene/Succinic acid. 8. Solid Liquid Equilibrium: [3] a) Determination of Molal Depression Constant of Naphthalene b) Determination of Molecular Weight of Solute
Text & Reference Books	1. M. Halpern and G. C. McBane, Experimental Physical Chemistry: A Laboratory Text Book, 3rd Edition, W. H. Freeman, 2006 2. D. P. Shoemaker, G. W. Garland and J. W. Nibler, Experiments in Physical Chemistry, 5th Edition, McGraw Hill, London.

CHY 211: Atomic Structure and Chemical Bonding [3 1 0 4]	
Prerequisites	NA
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, and concept of quantum numbers [4]

CHY 211: Atomic Structure and Chemical Bonding [3 1 0 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 [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: • Valence bond and molecular orbital descriptions of bonding, linear combination of atomic orbitals (LCAO) approach, hybridization, bonding in (H2)+ and H2 [6] • Bonding in homonuclear diatomic molecules of second period, bond orders, bond lengths and bond strengths, bonding in heteronuclear diatomic molecules, and concepts of g and u symmetries of molecular orbitals [4] • Photoelectron spectroscopy: Principle and application to simple spectra of diatomic molecules. [4] • HMO theory, π conjugation, delocalization energy. Application of HMO theory to simple conjugated systems and aromaticity. [4]
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 212: Basic Organic and Inorganic Chemistry II [3 0 0 3]	
Prerequisites	NA
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.

CHY 212: Basic Organic and Inorganic Chemistry II [3 0 0 3]	
Syllabus	• Nucleophilic Substitution at Saturated Carbons: SN1, SN2, SNi and SN2' with emphasis on stereochemical considerations, substrate structure, leaving group, nucleophiles and role of solvents; Neighbouring group participation. [7] • Elimination Reactions: Types (E1, E2 and E1cB), stereochemical considerations, and role of solvents; Saytzeff/Hofmann elimination, Bredt's rule; elimination vs substitution. syn-eliminations. [6] • 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. [4] • Nucleophilic Aromatic Substitution. [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); O2-transporting and storage proteins; biomedical application of cis-platin. [5] • Homogeneous and Heterogeneous Catalysis: Basic concepts and applications in Haber-Bosch process, Fischer-Tropsch process, and Ziegler-Natta polymerization. [4] • Lanthanoids and Actinoids: Properties and reactivity trends; nuclear reactions of thorium and uranium; synthesis of trans-uranium elements; applications of radioisotopes. [2]
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.

Data Sciences Courses

DSC 211: Introduction to Artificial Intelligence I [3 0 0 3]	
Prerequisite	NA
Learning Outcomes	On completion of this course, students should be able to ▪ Gain detailed knowledge on expert systems ▪ Obtain a broad overview of the field ▪ Identify the scope of Machine Learning in the broader field of Artificial Intelligence ▪ Implement advanced dimensionality reduction and clustering approaches on tabular datasets
Syllabus	• Introduction to knowledge-based intelligent systems: A brief history of AI, broad applications of AI; Goal of developing intelligent machines; Turing Test [1] • Rule-based expert systems: Goal of expert systems; What is knowledge? Riles as knowledge representation technique; Structure and Characteristics of an expert systems and participants in its development; Forward and Backward chaining; Advantages and Disadvantages; Practical examples of expert systems [2] • Uncertainty management in expert systems: What is uncertainty and how it can be modelled in an expert system? Revision of basic Probability Theory until Bayes Theorem; Bayesian reasoning; Bias of the Bayesian method; Certainty factors theory and evidential reasoning; Comparison of Bayesian reasoning and certainty factors; Case study [3] • Fuzzy expert systems: Introduction to fuzzy thinking? Fuzzy sets; Linguistic variables and hedges; Operations of fuzzy; Fuzzy rules; Fuzzy inference; Building a fuzzy expert system; Real-life application of fuzzy expert system [3] • Frame-based expert systems: Introduction to a frame; Frames as a knowledge representation technique; Inheritance in frame-based systems; Methods and demons; Interaction of frames and rules; Real-life application of fuzzy expert system [2] • Hybrid intelligent systems, Knowledge Engineering and Data Mining: Fuzzy evolutionary systems, applicability of expert systems, case studies, when to use what type of Expert system (3) • Evolutionary computation: Can evolution be intelligent? Components of modelling natural evolution; Genetic algorithms; Why genetic algorithms work; Evolution strategies; Genetic programming with demonstration [4] • Brief introduction to machine learning: Purpose of machine learning models; Beginner-level introduction to supervised-unsupervised approaches and classification-regression approaches; linear and logistic regression; Loss functions; Insights on convexity of loss functions, using gradient descent to learn parameters for a linear and logistic regression with a coding component. [6] • Detailed exploration of clustering algorithms: Fundamental clustering algorithms k-Means, fuzzy C-Means, DBSCAN, OPTICS, Agglomerative clustering; Brief revision of the concepts of Eigenvectors and Eigenvalues; Advanced clustering algorithms and related concepts such as Spectral Clustering; Self-Organizing Maps, CURE clustering, Particle Swarm Optimization, modularity in graphs; Performance measures for clustering such as Silhouette Score, Dunn Index, Davies-Bouldin index; Parameter learning and elbow method; Coding component to demonstrate the algorithms. [8] • Detailed exploration of dimensionality reduction: Principal component Analysis, Multi-Dimensional Scaling, Principal Co-ordinate analysis, Isometric Map, Stochastic

DSC 211: Introduction to Artificial Intelligence I [3 0 0 3]	
	Neighborhood Embedding, t-Stochastic Neighborhood Embedding, Uniform Manifold Approximation and Projection; Coding component to demonstrate the algorithms [8]
Text & Reference Books	1. Michael Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems, Addison-Wesley, ISBN 0 321 20466 2 2. Xu, D., Tian, Y. A Comprehensive Survey of Clustering Algorithms. Ann. Data. Sci. 2, 165–193 (2015). https://doi.org/10.1007/s40745-015-0040-1 3. Zhang, C., Huang, W., Niu, T. et al. Review of Clustering Technology and Its Application in Coordinating Vehicle Subsystems. Automot. Innov. 6, 89–115 (2023). https://doi.org/10.1007/s42154-022-00205-0 4. Newman, Mark E. J. “Modularity and community structure in networks.” Proceedings of the National Academy of Sciences of the United States of America 103 23 (2006): 8577-82 5. Maaten, Laurens van der and Geoffrey E. Hinton. “Visualizing Data using t-SNE.” Journal of Machine Learning Research 9 (2008): 2579-2605. 6. McInnes, Leland and John Healy. “UMAP: Uniform Manifold Approximation and Projection for Dimension Reduction.” ArXiv abs/1802.03426 (2018) 7. Zha, Hongyuan and Zhenyue Zhang. “Isometric Embedding and Continuum ISOMAP.” International Conference on Machine Learning (2003). 8. Hout, Michael C. et al. “Multidimensional scaling.” Wiley interdisciplinary reviews. Cognitive science 4 1 (2013): 93-103.

DSC 212: Mathematical Foundations for Data Science [3 1 0 4]	
Prerequisite	NA
Learning Outcomes	On completion of this course, Students should be able to ▪ Acquire knowledge of basic mathematics that is necessary to understand advanced Data Science Courses ▪ Acquire knowledge on how and where mathematics is connected to Data Science
Syllabus	• Module 1: Linear Algebra [22] • Vector spaces: Definition and examples, Subspaces, Linear independence, Basis and dimension, Change of basis, Row space, and column space [6] • Linear maps: Definition and examples, Matrix representations of linear maps, Similarity, Rank-nullity Theorem [8] • Inner product spaces: The scalar product in R^n, Inner product spaces, Orthonormal sets, The Gram-Schmidt orthogonalization process [8] • Module 2: Discrete Mathematics [18] • Revision: Set theory and functions [4] • Basic graph theory: Elements of graph theory, Euler graph, Hamiltonian path, trees, tree traversals, spanning trees [7] • Intermediate concepts in graph theory: Brief coverage of coloring problem, Concepts of Cliques and Independent sets, Concept of planarity, Concept of Flows and Cut, Graph adjacency matrix [7]

DSC 212: Mathematical Foundations for Data Science [3 1 0 4]	
Text & Reference Books	1. S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice Hall India Learning Private Limited, 2000 2. Sheldon Axler, Linear Algebra Done Right, Springer, https://doi.org/10.1007/978-3-031-41026-0 3. Bondy and Murty, Graph Theory, Springer 2008, https://doi.org/10.1007/978-1-84628-970-5 4. West, D.B. (2001) Introduction to Graph Theory. 2nd Edition, Prentice-Hall, Inc., Upper Saddle River, 82-83

Earth Environmental & Sustainability Sciences Courses

EESS 201: Introduction to earth and climate sciences [3 1 0 4]	
Prerequisites	NA
Learning Outcomes	On completion of this course, students should be able to ▪ Understand Earth's Climate components ▪ Describe the layers of Earth, Atmosphere, Ocean ▪ Interpret and express radiative balance and vertical structure of atmosphere ▪ Conceptualize feedback in the climate system. ▪ Understand the Earth systems and geological events
Syllabus	• Solar System and the Planet Earth: Origin of the Earth's atmosphere, Sun, Earth and the atmosphere, Sun-Earth relationship, seasons-solstices and equinoxes. [2] • Components of Climate system: Lithosphere, Cryosphere, Biosphere, Hydrosphere, Atmosphere. [1] • Structure of the Earth: Layers, Lithosphere, Asthenosphere, Crust, Mantle, Core, Composition and structure of oceanic and continental crust. [2] • Plate Tectonics, volcanoes and mountain building: Convergent boundaries, Subduction, Divergent boundaries, Mid ocean ridges, Magma, movement within the Earth, Earth's magnetic field, volcanism and plate tectonics, Continental drift, Earthquakes; mountain building. [3] • Minerals: Composition, crystal structure, physical properties, classification and identification [1] • Rocks: Igneous Rocks, Sedimentary Rocks, Metamorphic Rocks, Composition, texture, classification, identification, formation, agents of change, Weathering, soil mineralogy, soil erosion. [1] • Activity-1 • Geological time: Relative ages and the principles of stratigraphy, Construction of the relative geologic time scale, Radioactivity and the absolute time scale, Numerical dating, stable isotope techniques, carbon dating. [3] • The Ocean: Structure of Ocean, Oceanic lithosphere, Continental margins, Ocean circulation, thermohaline circulation, waves, eddies, currents and tides, emergent and submergent coast, light, density, salinity, and temperature in the ocean. [3] • The Earth's atmosphere: The Atmosphere: vertical structure, density, pressure, thermal structure and composition. [3] • Activity-2 • Atmospheric Radiation: Heat transfer in the atmosphere - conduction, convection, radiation, laws of blackbody radiation, radiative equilibrium temperature, radiation balance, energy budget [3] • Activity-3 • Atmospheric Dynamics: Forces acting on the Earth Atmosphere, Coriolis force and centrifugal forces, hydrostatic equilibrium [3] • Global cycles: Hydrological Cycle and groundwater. [1]

EESS 201: Introduction to earth and climate sciences [3 1 0 4]	
	• Climate Change: Global CO2 concentration and Keeling curve, Greenhouse effect, Radiative forcing global warming and climate change, Ozone hole, Montreal Protocol, Brief summary of Intergovernmental Panel on Climate Change (IPCC) reports, The Human Impacts on the Climate system. [5] • The Earth System: Coupled Ocean-Atmosphere-Land processes in the Earth's Climate System modeling, El Nino Southern Oscillation (ENSO), Indian Summer Monsoon, Indian-Ocean Dipole. [5]
Text and Reference Books	1. Essentials of meteorology, Donald Ahrens 2. Meteorology Today: An introduction to Weather, Climate and the Environment, C. Donald Ahrens, Robert Henson 3. First course in atmospheric Science, Lutgen and Tarbuk 4. Essentials of Geology Lutgen and Tarbuk 5. Introduction to Earth Science: Laura Leser 6. Introducing Oceanography: Thomas and Bowers 7. Bonan, G. (2015). Ecological climatology: concepts and applications. Cambridge University Press.

EESS 202: Introduction to environmental and sustainability sciences [3 0 0 3]	
Prerequisites	NA
Learning Outcomes	On completion of this course, students should be able to ▪ Understand the importance of the environment and ecosystems ▪ Describe the biogeochemical cycling in the environment ▪ Identify the causes and aftermaths of environmental pollution ▪ Understand sustainability, waste management, and environmental policy ▪ Describe the application of GIS in environmental studies
Syllabus	• Earth's environment: Definition, scope, and importance of environment and ecosystems, components of Earth's environment, hydrosphere, lithosphere, atmosphere, and biosphere [3] • Hydrosphere: Ocean, terrestrial aquatic systems, the composition of freshwater and seawater, nutrients, and the biology of aquatic systems. [3] • Carbon in the environment: Carbon cycle, photosynthesis, terrestrial and marine primary production, phytoplankton, inorganic and organic carbon, reservoirs, flux and net change, carbon sequestration, solubility, and biological pump. [3] • Nitrogen in the environment: Nitrogen cycle, forms of nitrogen in the environment, N2 fixation, diazotrophs, nitrification, denitrification, nitrogen assimilation processes. [3] • Biodiversity: Conservation and utilization of biodiversity, biomes, landscapes, and ecosystems, problems, and issues in biodiversity and forestry. [3] • Environmental pollution: Causes, effects, and preventive measures of water, soil, noise, and air pollution, Fossil fuel and biomass burning, air quality, health impacts, greenhouse effect, smoke, fog, and acid rain. [3]

EESS 202: Introduction to environmental and sustainability sciences [3 0 0 3]	
	• Environmental pollution: Keeling plot, Suess effect, Bjerrum plot, Ocean acidification, Aquatic pollution, Haber–Bosch process, green revolution, Phosphorus eutrophication, harmful algal blooms, agricultural practices, and environmental footprints. [3] • Waste management: Toxic chemical waste, acute and chronic toxicity, persistent organic pollutants in the environment, microplastics, Waste management: Solid, hazardous and e-waste management, waste treatment and segregation, 3Rs of the waste management program [3] • Environment policy: Environmental policy and its relevance in the Indian and global contexts. [3] • Sustainability and sustainable development: Ecosystem activity: Producers, Consumers, Decomposers; Case studies of environmental pollution episodes and successful interventions; Composting methods, Carbon footprint and carbon credits; life cycle assessment. [6] • Energy and water: management and conversion: Renewable and non-renewable energy sources, Fossil fuels and biofuels, Clean and green energy, Water resource conservation, rainwater harvesting methods, water treatment, water purification methods, Water footprint of consumer products. [3] • Geoinformatics and remote sensing in environmental sciences: Geographic Information System (GIS), Satellite remote sensing, Applications of GIS and remote sensing in environmental sciences. [3]
Text and Reference Books	1. Introducing oceanography; David N. Thomas and David G. Bowers 2. The Global Carbon Cycle and Climate Change; David E. Reichle (2020), ISBN: 978-0-12-820244-9 3. Processes in microbial ecology; David L. Kirchman (2012), ISBN 978–0–19–958693–6 (Hbk.), 978–0–19–958692–9 (Pbk.) 4. The algal bowl; David W. Schindler & John R. Vallentine 5. Sustainability: A Comprehensive Foundation, Edited by Tom Theis and Jonathan Tomkin (https://cnx.org/contents/F0Hv_Zza@45.1:HdWd2hN5@2/Foreword) 6. Textbook Of Remote Sensing And Geographical Information Systems, 4th Edition by M. Anji Reddy.

Mathematics Courses

MAT 111: Introduction to Proofs [2 1 0 3]	
Learning Outcomes	Understanding basic concepts of mathematical logic, Using sets for solving problems and using the properties of set operations, Working with relations and functions and investigating their properties, Using induction to prove simple statements, Introducing concepts from elementary groups.
Syllabus	• Propositional logic, Predicates and quantifiers, Proofs and methods of proofs [6] • Sets, Set operations, Functions, Relations and their properties, Representing relations, Equivalence relations, Countable and uncountable sets, Product of sets (finite and infinite), Real numbers, Subsets of R, intervals, bounded and unbounded subsets [10] • Mathematical induction, Strong induction and well-ordering, Recursive Induction and structural induction [4] • Set of bijections from a set to itself, Symmetric groups and examples, Cayley's theorem, order of elements of a symmetric group [7]
Text & Reference Books	1. Ajith Kumar, B K Sharma and S Kumaresan. A Foundation Course in Mathematics, Narosa, 2018. 2. Kenneth Rosen. Discrete Mathematics and Its Applications, Seventh Edition, McGraw Hill Education, 2017 3. Donald Knuth, Oren Patashnik, and Ronald Graham. Concrete Mathematics, AddisonWesley Professional, 1994

MAT 121: Matrices and Calculus [3 1 0 4]	
Learning Outcomes	The aim of this course is to introduce students to the calculus of functions of a single variable and matrices. Key concepts of differential and integral calculus and linear systems of equations are introduced along with applications.
Syllabus	• Vectors in R^2 and R^3, R^n as a vector space, Subspaces [2] • System of linear equations, Row reduced echelon forms, Rank of a matrix. [2] • Consistent and inconsistent systems, Solution(s) (or its lack, thereof) of linear systems. [2] • Determinant of a matrix and its properties. [2] • Eigenvalues and eigenvectors of a matrix, Cayley-Hamilton theorem. [2] • Real sequences and subsequences, Limit of a sequence (intuitive definition and verification through examples), Monotone sequences and bounded sequences [3] • Series and limits of series, Absolute convergence, Conditional convergence. [2] • Tests of convergence: Comparison test, Root test, Ratio test. Examples of some standard convergent and divergent series [4] • Real-valued functions: Examples of standard functions, periodic functions, inverse functions, composition of functions. [2] • Continuous functions, Limits, Boundedness of continuous functions in closed and bounded intervals, Intermediate value theorem and its applications. [3] • Differentiation: Tangents and slopes, rate of change and derivative, Differentiability and Continuity, Rules of differentiation. [4]

MAT 121: Matrices and Calculus [3 1 0 4]	
	• Mean value theorem, Rolle's theorem and applications. Taylor's theorem and Taylor's series, Maclaurin Series [4] • Applications of differentiation in curve sketching: critical points, finding the extremum values using derivatives, second derivative test, monotone functions [4] • Anti-derivatives, Fundamental theorems 1 and 2 of calculus [4]
Text & Reference Books	1. T M Apostol, Calculus, Volume I, 2nd. Edition, Wiley, India, 2007 2. R. Bartle and D. Sherbert, Introduction to Real Analysis, Fourth Edition, Wiley India 3. G. Strang, Linear Algebra and Its Applications, 4th Edition, Brooks/Cole, 2006 4. James Stewart, Calculus: Early Transcendentals, Eighth Edition, Cengage Learning, 2014 5. Ross L. Finney and George B Thomas, Calculus and Analytic Geometry, 9th Edition, Addison Wesley Publishing Company.

MAT 201: Calculus and Matrices II [3 1 0 4]	
Prerequisites	MAT101
Learning Outcomes	▪ Understanding the basic concepts of matrix theory, including matrix operations, kernel and range spaces, basis and dimension, and the rank-nullity theorem. ▪ Students will develop proficiency in multivariable calculus, mastering topics such as limits and continuity of functions, partial derivatives, directional derivatives, and integration in two variables.
Syllabus	• Matrix as a linear operator.Kernel and Range space of a matrix.Linear dependence and linear independence of vectors, Basis and dimension,Rank-Nullity theorem.Change of basis of vector spaces. [12] • Limits and continuity of functions of several variables, Directional derivatives, Partial derivatives and total derivatives. [8] • Partial derivatives of higher order, Composition of functions and change of variable. [5] • Maxima and minima, Lagrange multipliers.Mean value theorems in several variables. [6] • Double integrals on rectangular regions,Repeated or iterated integrals, Double integrals over bounded domains,Changing the order of integration, Fubini-Tonelli theorem. [9]
Text & Reference Books	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. Kenneth Hoffman and Ray Kunze, Linear Algebra, Second Edition, Prentice Hall Inc, 1971. 6. G. Strang, Linear Algebra and Its Applications, 4th Edition, Brooks/Cole, 2006 7. S. Kumaresan, Linear Algebra: A Geometric Approach, PHI Learning, 2009. 8. S. Axler, Linear Algebra Done right, 3rd ed., Springer 2015

MAT 202: Introduction to Probability [3 0 0 3]	
Prerequisites	NA
Learning Outcomes	This is a first course on basics of probability theory beginning with combinatorial probability. The outcome is to make students familiar with more on problem solving and give them a broader perspective on how l probability can be used in various areas of science.

Syllabus	• Basic probability: Set operations, counting, finite sample spaces, axioms of mathematical probability [3]
	• Conditional probability, independence of events, Bayes' Rule, Bernoulli trials, Poisson trials, infinite sequence of Bernoulli trials [7]
	• Random variables and probability distributions:
	  ○ Binomial distribution, geometric distribution [2]
	  ○ Poisson distribution, normal distribution [3]
	  ○ Exponential distribution, Gamma Distribution, Beta distribution; [2]
	• Bivariate and multivariate probability distributions, marginal and conditional probability distributions, independent random variables, i.i.d. sequence of random variables [6]
	• Transformation of random variables in one and two dimensions [3]
	• Mathematical expectations: Expectations for univariate and bivariate distributions [2]
	• moments, variance, standard deviation [2]
	• higher order moments, covariance correlation, moment generating functions, characteristic functions [4]
	• Law of large numbers, Central limit theorem [6]

Text & Reference Books	1. R. V. Hogg, J. McKean and A. T. Craig, Introduction to Mathematical Statistics, 7th ed., Pearson, 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 ed., Prentice Hall, 2009. 5. D. D. Wackerly, W. Mendenhall III and R. L. Scheaffer, Mathematical Statistics with Applications, 7th Edition, Brooks/COle Engage Learning, 2008. 6. P. G. Hoel, S.C. Port and C.J. Stone, Introduction to Probability Theory, 1st ed., Houghton Mifflin, 1972

Physics Courses

PHY 111: Mechanics [2 1 0 3]	
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
Syllabus	Newton's Laws [2]: • Critical analysis of the Newton's laws • Concept of homogeneity and isotropy of space-time - symmetry. • Concept of inertial and non-inertial reference frames, fictitious forces, Galilean transformation. Motion in One dimension [4]: • Forces and Equations of Motion, • Conservation of Momentum, Work Energy theorem, • Analytical solutions of EOMs, • Motion under gravity, Simple harmonic oscillator and damped oscillator. Motion in higher dimensions [4]: • Position vector and its derivatives, • EOM in Cartesian and Polar Coordinates Angular Momentum and Fixed Axis Rotation [8] • Angular momentum, Torque, • Work–Energy Theorem and Rotational Motion, • Motion under central force, Centre of mass, Kepler's laws. Rigid Body Motion [6] • Angular Momentum, Moment of Inertia - simple symmetric bodies. • EOM of rotating bodies. Introduction to Special Theory of Relativity [2]
Text & Reference Books	1. D. Kleppner and R. Kolenkow, An introduction to Mechanics, McGraw-Hill Science/ Engineering/ Math, second reprint 2008 2. Serway and Jewett, Physics for Scientists and Engineers, 7th edn, Brooks/Cole Publishers 2008. 3. C. Knight, W. D. Ruderman, M. A. Helmholz, C. A. Moyer and B. J. Kittel, Berkeley Physics Course, Vol1, Mechanics, McGraw Hill 2017 4. R. Shankar, Fundamentals of Physics, Yale Press 2019

PHY 112: Physics Lab I [0 0 3 1]	
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

PHY 112: Physics Lab I [0 0 3 1]	
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

PHY 121: Electromagnetism [3 1 0 4]	
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. Electric Potential: Electrostatic potential, Poisson's equation and Laplace equation, Potential due to a localized charge distribution, Electrostatic Boundary conditions [4] • 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 configuration. Solution by the method of separation of variables in Cartesian; 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. [6] • Multipole Expansion; Electrical field and potential due to a point dipole [2] • Electric field in matter: Dielectrics, Polarization, Field of a polarized object, Electric displacement vector (D); Gauss's theorem in dielectric media; Boundary value problem with linear dielectrics; [6] • Electrostatic field energy; Computation of capacitance in simple cases (parallel plates); spherical and cylindrical capacitors containing dielectrics – uniform and non-uniform. [6] • 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, Magnetic field in matter [4]

PHY 121: Electromagnetism [3 1 0 4]	
	• Electrodynamics: Current electricity: Electromotive force. Ohm's law; Motional emf; Electromagnetic induction; Faraday's law; Self-inductance and mutual inductance; Maxwell's equations. [4]
Text & Reference Books	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 122: Physics Lab II - Experiments in Optics, Electricity and Magnetism [0 0 3 1]	
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

PHY 211: Thermal & Statistical Physics [3 1 0 4]	
Prerequisites	NA
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

PHY 211: Thermal & Statistical Physics [3 1 0 4]	
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] • 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 212: Optics [3 0 0 3]	
Prerequisites	NA
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.

PHY 212: Optics [3 0 0 3]	
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 ClausiusClapeyron 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 monoatomic 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: 2. F. Reif, Statistical Physics: Berkeley Physics Course Vol. 5, Tata McGraw-Hill, 2011. 3. Daniel V. Schroeder, An introduction to thermal Physics, Addison- Wesley, 2000. 4. S. J. Blundell and K. M. Blundell, Concepts in Thermal Physics, Oxford, 2006.

Skill Enhancement Courses (SEC)

IDC 111: Mathematical Tools I [3 1 0 4]	
Learning Outcomes	▪ Perform analysis of functions of single variable ▪ Perform analysis of functions of several variables ▪ Use concepts of vector calculus in physical problems ▪ Use complex numbers to describe physical systems or parameters
Syllabus	• Introduction to Limit and Continuity with examples [3] • Introduction to Differentiation. Introduction to Taylor's series with examples [3] • Functions of several variables - partial differentiation [3] • Cartesian, Spherical and Cylindrical coordinate systems: introduction and equivalence. Parametric representation of an equation [4] Vector Calculus: • Review of vector algebra: addition, subtraction and product of two vectors - polar and axial vectors with examples; triple and quadruple product. [4] • Concept of Scalar and Vector fields. Differentiation of a vector w.r.t. a scalar unit tangent vector and unit normal vector. [4] • Directional derivatives - gradient, divergence, curl and Laplacian operations and their meaning. [6] • 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. [9] • Complex numbers and functions: Arithmetic operation, conjugates, modulus, polar form [3]
Text & Reference Books	1. Frank Ayres, Elliott Mendelson, Schaum's Outlines Series Theory and Problems of Differential and Integral Calculus, Tata McGraw Hill, 3Ed 2. Murray R. Spiegel, Schaum's Outlines Vector Analysis, Tata Mcgraw Hill, 2Ed 3. Murray R. Spiegel, Seymour Lipschutz, John Schiller, Dennis Spellman, Schaum's Outlines Complex Variables, Tata McGraw Hill Education; 2Ed 4. George B. Thomas, Ross L. Finney, Maurice D. Weir, Calculus and Analytic Geometry, Addison-Wesley Publishing Company Inc, 9Ed.

IDC 112: Introduction to programming in C/C++ [0 0 3 1]	
Learning Outcomes	▪ Gain the basic skills in working with a Linux computer. ▪ Gain familiarity with the tools and techniques of creating a computer program. ▪ Gain familiarity with the basic C/C++ language features. ▪ Write a complete structured program in C/C++ to perform specific tasks. ▪ Develop ideas to design computer algorithms to solve simple problems.
Syllabus	• Introduction to computer architecture and components. • Introduction Linux OS and Linux Command Line Interface • Mechanics of creating, compiling, running a C/C++ program. The 'Hello World' program in C/C++. Program structure, simple statements, formatting style of source code.

IDC 112: Introduction to programming in C/C++ [0 0 3 1]	
	• Variables and keywords, Built-in data types, numeric literals or various data types, automatic type conversions, arithmetic operators, expressions. • Strings, arrays, dynamic arrays, concept of automatic, static and dynamic storage. • Loops and relational expressions. • Branching statements and logical operators. • Pointers and its relation to arrays. References. • Functions, function prototypes, different ways of passing arguments to functions, array arguments • File input/output. • Examples: Basic to intermediate level exercises utilizing the concepts in all the lab sessions.
Text & Reference Books	1. Stephen Prata, C++ Primer plus (6th Ed), Addison-Wesley 2. Stephen Prata, C Primer plus (6th Ed), Addison-Wesley 3. Kernighan and Ritchie, C Programming language, Prentice Hall

IDC 121: Mathematical Tools II [2 1 0 3]	
Learning Outcomes	The aim of the second part of the interdisciplinary mathematical methods course is to make the students aware of various tools to solve differential equations with applications in other branches of sciences and engineering. This is a problem-oriented course with lots of applications.
Syllabus	• Solving techniques for first and second order linear ODEs: constant and variable coefficients [12] • Power series method; Legendre and Hermite polynomials. [5] • Laplace transforms and application to ODEs. [5] • Fourier transforms [5]
Text & Reference Books	1. William E. Boyce, and Richard C. DiPrima, Elementary Differential Equations 9th ed., Wiley, 2008. 2. E. Kreyszig, Advanced Engineering Mathematics, 8th ed. Wiley India Pvt Ltd, 2006. 3. C. Edwards and D. Penny, Elementary Differential Equations with Boundary Value Problems, 5th ed. Prentice Hall 2007. 4. R. Bronson and G. Costa, Schaum's Outlines Differential Equations, 3rd ed. Mcgraw-hill 2009. 5. Dennis G. Zill, Warren S Wright, Differential Equations with Boundary value problems,Edition 8, Cengage Learning 2012.

IDC 122: Numerical computing using C/C++ [0 0 3 1]	
Learning Outcomes	▪ Understand sources of systematic errors in numerical computations. ▪ Learn about methods of numerical solutions to simple mathematical problems. ▪ Ability to implement a numerical algorithm in C/C++ programming language. ▪ Learn how to represent simple physical/mathematical objects using Classes in C++.

IDC 122: Numerical computing using C/C++ [0 0 3 1]	
Syllabus	• Binary numbers, computer representation of real numbers, machine precision, rounding errors. • Numerical differentiation, finite difference formulas, rounding errors • Numerical integration, Trapezoid rule, Simpson's rule, composite Newton-Cotes formulas. • Finding the root of an equation of a single variable. Bisection method, Newton's method, secant method. • Least squares, fitting a model to data. • Introduction to Class in C++: Basic notions of procedural and object-oriented programming, the concept of a Class, how to define and implement a Class, Class data members, Class methods, Private & Public member, Creating and using Class objects. • Examples: Create and use a 'Vector' class to mimic physical vectors in 3D space. Create and use a 'Complex' class to mimic mathematical complex numbers. • Example science problems.
Text & Reference Books	1. Timothy Sauer, Numerical Analysis, Pearson 2. Stephen Prata, C++ Primer plus (6th Ed), Addison-Wesley 3. Siddhartha Rao, C++ in One Hour a Day, SAMS

IDC 212: Programming in Python [0 0 3 1]	
Learning Outcomes	▪ Understand the nature of Python language, how it differs from C/C++. ▪ Learn about the fundamental data types in Python. ▪ Learn to write a complete Python program performing simple manipulations on various data types. ▪ Get introduced to various Python modules. ▪ Get introduced to scientific oriented programming using 'NumPy'.
Syllabus	• Introduction: What is Python? Why Python? Why is it called an interpreted language? Differences with C/C++. • Official Python website, download and installation instructions. • The "Hello World" program in Python. Different ways of running a Python • script. • Concept of variables, objects, and references. Python's built-in data types: Numbers, Strings, Lists, Tuples, Sets, Dictionaries. Concept of Sequence data • type. • More on numeric types: Integers, Floats, Complex number, Decimal, Fraction, Boolean. Random numbers of different distributions. • Python control structures: if-else statements. Looping statements: for, while loops. List comprehension. Python Functions. Exception handling. • File handling, Formatting of output texts. • Introduction to 'NumPy': What is NumPy, Why use NumPy? Why is it faster? NumPy 'ndarray': axes, shape, size, dtype. NumPy array creation, printing. Basic operations, universal functions. Array indexing, slicing, iterating. Array shape manipulation. Array Copies and Views.

IDC 212: Programming in Python [0 0 3 1]	
	• Linear algebra with 'NumPy'. Use NumPy arrays to create vectors and matrices. Matrix-vector, matrix-matrix multiplications. Use NumPy built-in functions to find matrix norm, determinant, inverse, decompositions, eigenvalues and eigenfunctions. • Example science problems
Text & Reference Books	1. Mark Summerfield, Programming in Python 3, Addison-Wesley 2. Mark Lutz, Learning Python, O'Reilly 3. https://www.python.org/ 4. https://numpy.org/ 5. https://scipy.org/

IDC 222: Scientific Computing and Data Visualization [0 0 3 1]	
Learning Outcomes	▪ Learn different types of data structures represented by various C++ standard template library (STL) containers. ▪ Learn how to use the C++ STL containers to handle and process numerical data. ▪ Learn how to use SciPy to handle special mathematical functions, perform some of the routine numerical tasks with functions. ▪ Learn how to produce various graphics for visualization of numerical data using Python matplotlib. ▪ Learn how to apply numerical computing and data visualization techniques for specific scientific problems.
Syllabus	• Introduction to C++ standard template library (STL): Container Classes, Iterators, STL algorithms. • Data structures in STL containers: Usage of STL 'Vector', 'Array', 'Deque', 'List', 'Set', 'Multiset', 'Map', 'Multimap'. • Introduction to SciPy. Use SciPy to compute Special functions, do numerical integrations, find the root of a function, optimize a function. • String manipulation using Python. • Data plotting and visualization with Matplotlib. Anatomy of a matplotlib Figure. Figure, Axes, Artist, Color, Styles, Labels, Annotation. • Matplotlib Pyplot: Point plot, Line plot of 2D data, customizations. Histogram, Surface plot of 3D data, Contour plot. Plotting numpy arrays as images. • Introduction Seaborn: Statistical data visualization. • Application to specific scientific problems.
Text & Reference Books	1. Stephen Prata, C++ Primer plus (6th Ed), Addison-Wesley 2. Mark Summerfield, Programming in Python 3, Addison-Wesley 3. https://matplotlib.org/ 4. https://numpy.org/ 5. https://scipy.org/

Ability Enhancement Courses (AEC)

HUM 111: Communication Skills I [1 0 0 1]	
Learning Outcomes	▪ Understand the origin, nature and functions of language, its structural universals, its use in varied contexts in science and society, and its evolution into a marker of personal, social, and cultural identity. ▪ Comprehend the nature and role of communication including media. ▪ Expand writing skills through controlled and guided activities. ▪ Identify common errors in writing and rectify them. ▪ Develop coherence, cohesion and competence in communication.
Syllabus	• Need for a Universal Language [1] • Relevance of communication from the perspective of Science, Scientists and Society [1] • Communication as a tool to promote Art, Literature and Music [1] • Communication modules: how does it work and structure based on basic theories [1] • Developments in communication: emergence of social media, AI, and the issue of rights [1] • Varied kinds of communication: Verbal, Non-Verbal, Visual [1] • Different aspects of Verbal Communication a) Reading: its psychology and practice [1] b) Writing: the different perspectives of it from the angle of media and research [1] c) Listening and its psychological and social impacts and outcomes [1] • Functional Grammar [4]
Text & Reference Books	1. NCERT Vocational training modules on Communication 2. Remedial English Grammar for Foreign Students by F.T. Wood 3. Boy from the Hills by Ruskin Bond 4. Communication Studies: The Essential Resource (Essentials), Andrew Beck, Peter Bennett, Peter Wall

HUM 121: Communication Skills II [1 0 0 1]	
Learning Outcomes	▪ Comprehend the nature and role of communication including media ▪ Expand writing skills through controlled and guided activities ▪ Identify common errors in writing and rectify them ▪ Develop coherence, cohesion and competence in communication
Syllabus	• Communication as a social science rather than a tool for interaction [2] • Interdisciplinary nature of communication: theories pertaining to sociology and psychology - Relevance to science communication [2] • Understanding media and putting it to good use [2] • Subaltern voices: Communication's role in exploring gender, ecology, rights, science. [2] • Functional grammar e.g. tenses and construction of sentences etc., common errors, deeper understanding of tenses, concepts like dangling modifiers, etc. [5]

HUM 121: Communication Skills II [1 0 0 1]	
Text & Reference Books	1. Introduction to Communication Studies (Studies in Culture and Communication) 2. Remedial English Grammar by F.T. Woods 3. NCERT Vocational training modules on Communication 4. Communication Studies: The Essential Resource (Essentials) by Andrew Beck, Peter Bennett, Peter Wall

HUM 211: Introduction to Economics [1 0 0 1]	
Prerequisites	NA
Learning Outcomes	To familiarize the students with basic economic concepts and introduce them to the tools to analyze and evaluate public policies, poverty and welfare questions, and other applied topics.

Syllabus	• Introduction
	  ○ What is Economics? Scarcity, choice and economic systems [1]
	• Market: Consumption
	  ○ Supply and demand; [1]
	  ○ Market equilibrium and the price mechanism. [1]
	  ○ Shifts in the demand and supply curve and the impact on market equilibrium. [1]
	  ○ Examples and Applications
	• Market in Action
	  ○ Elasticity of demand [1]
	  ○ Consumer choice; Consumer theory with indifference curves [1]
	  ○ Examples and Applications [1]
	• Market: Production
	  ○ Production and cost; how firms make decisions: profit maximization [1]
	• Market Structure
	  ○ Perfect competition& Monopoly (representation of Market) [1]
	• Market Failure
	  ○ Micro economics and Public Policy: Externalities and Public Good; Poverty, Inequality and Welfare State [2]
	• Macro Economics
	  ○ Introducing macroeconomics: The Big picture [1]

Text & Reference Books	1. Mankiw, N. Gregory, Principles of Economics, 6th ed., South-Western College Publishers, 2012. 2. Paul A Samuelson & William Nordhaus, Microeconomics, McGraw Hill Education, New York, 2013.

HUM 221: Introduction to Sociology [1 0 0 1]	
Prerequisites	NA

HUM 221: Introduction to Sociology [1 0 0 1]	
Learning Outcomes	To improve the ability to cogently discuss and analyze social issues, institutions, relations and practices. To Identify the main methods of collecting data in sociological research and determine which is most appropriate for specific kinds of research questions.

Syllabus	• Introduction: what is sociology? Micro and macro sociology [1]
	• Basic sociological Questions and concepts [1]
	• Sociological Perspectives and methods [2]
	• Social stratification and Class [2]
	• Social deviance/Crime [2]
	• Key elements of sociology [3]
	  ○ Politics and social order
	  ○ Education and mass media
	  ○ Sociology of body and health
	  ○ Nation and Globalization
	• Social Problems [1]
	• Sociology in India and South Asia [1]

Text & Reference Books	1. Giddens, Anthony and Sutton Philip (2017) Sociology, 8th Edition, Wiley India Private Limited, New Delhi. 2. Beteille Andre (2002) Sociology: Essays on Approach and Method, Oxford India, New Delhi 3. T K Oommen (2007) Knowledge and Society: Situating Sociology and Social Anthropology, Oxford University Press, New Delhi.