

**INDIAN INSTITUTE OF SCIENCE EDUCATION
AND RESEARCH
THIRUVANANTHAPURAM**



COURSE CATALOGUE

BS-MS / i² SCIENCES



2026 - 27

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About the Booklet

IISER Thiruvananthapuram offers the following undergraduate, graduate and post-graduate level programs. Each has its own course structure and requirements for completion. The Schools offer an array of courses that students may opt to pursue. This catalogue enlists all the courses offered by various schools at IISER Thiruvananthapuram in a particular academic year.

1. BS MS Dual Degree program in Basic Sciences and i2 Sciences
2. Master of Sciences program
3. Integrated Ph.D program
4. Ph. D program

Primarily there are two types of courses:

- Core Courses
- Elective Courses (within the department and Across the institute)

The booklet lists the courses starting with the Foundation Courses (Semesters 1 - 2) and Pre-Major Courses (Semester 3) which are all CORE courses. Later School/Discipline wise list of courses is provided along with detailed syllabi. Curriculum tables for each program relevant to each School are provided to offer glimpses of requisite CORE and Elective courses for each program.

Each course carries a unique Course Code and Course Name. The Course Code may be understood as follows:

- The CORE courses of the BSMS program are numbered in the format: XYZ LSC (LTPC)
- The CORE courses of the MSc program are numbered in the format: MSQ LSC (LTPC)
- ELECTIVE courses are numbered in the format: XYZ LSCD (LTPC)
- CORE/ELECTIVE MODULES carrying less than 3 credits are numbered as MSQ/XYZ LSC m (LTPC)/ MSQ/XYZ LSCD m (LTPC) or MSQ/XYZ LSC mn (LTPC)/ MSQ/XYZ LSCD m (LTPC)

XYZ	:	Subject code for CORE and Elective courses
MSQ	:	Prefix MS followed by Programme code (B-Biology, C-Chemistry, M-Mathematics, P-Physics)
L	:	Number denoting Level of the course (1, 2, 3, 4, 5, 6, 7)
SC (SCD)	:	Numbers unique to a Course
m (mn)	:	Module position – Applicable only to 1 and 2 credit modules a : Module spans 1 st one-third of the semester (13 lectures) b : Module spans 2 nd one-third of the semester (13 lectures) c : Module spans 3 rd one-third of the semester (13 lectures) ab : Module spans 1 st two-thirds of the semester (26 lectures) bc : Module spans 2 nd two-thirds of the semester (26 lectures)
L	:	Number of Lecture hours per week
T	:	Number of Tutorial hours per week
P	:	Number Practical (laboratory) hours week
C	:	Number of Credits

Subject Codes (XYZ)

BIO: Biological Sciences

MAT: Mathematical Sciences

IDC: Interdisciplinary Studies

DSC: Data Sciences

EES: Earth, Environmental and Sustainability Sciences

I2M: ~~Mathematical~~ Studies

CHY: Chemical Sciences

PHY: Physical Sciences

HUM: Humanities

I2B: ~~Biological~~ Sciences

I2C: ~~Chemical~~ Sciences

I2P: ~~Physical~~ Sciences

FOUNDATION & PRE-MAJOR COURSES

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

i^2 Sciences (SEM: 1 - 3)



Foundation & Pre-Major Courses

	Semester 1	Semester 2	Semester 3	Semester 4	
Theory courses	BIO 111 [2103] Principles of Life I: Biomolecules, Genetics and Evolution	BIO 121 [2103] Principles of Life II: Biophysics, Cell and Molecular Biology	Subject A - 1	Major Courses	
	CHY 111 [2103] Basic Organic & Inorganic Chemistry I	CHY 121: [3104] Basic Physical Chemistry I			
	MAT 111 [2103] Introduction to Algebra	MAT 121 [3104] Single Variable Calculus	Subject A - 2		
	PHY 111 [2103] Mechanics I	PHY 121 [3104] Electromagnetism	Subject B - 1		
			Subject B - 2		
			Subject C - 1		
Laboratory courses	BIO 112 [0031] Biology Lab I	BIO 122 [0031] Biology Lab II			
	CHY 112 [0031] Chemistry Lab I	CHY 122 [0031] Chemistry Lab II	Subject C - 1		
	PHY 112 [0031] Physics Lab I	PHY 122 [0031] Physics Laboratory II	Subject C - 2		
Skill Enhancement Courses (SEC)	IDC 111 [3104] Mathematical Tools I	IDC 121 [2103] Mathematical Tools II	IDC 212 [0031] Introduction to C++ Programming	IDC 222 [0031] Introduction to Numerical Computing using C/C++	
	IDC 112 [0031] Introduction to Python programming	IDC 122 [0031] Foundations of Artificial Intelligence			
Ability Enhancement Courses (AEC)	HUM 111 [1001] Communication Skills I	HUM 121 [1001] Communication Skills II	HUM 211 [1001] Introduction to Economics	HUM 221 [1001] Introduction to Sociology	
Total Credits	21	23	23	20/21	

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
ESS 211 [3104] Fundamental of Earth System Sciences	MAT 201 [3104] Multivariable Calculus	PHY 211 [3104] Thermal & Statistical Physics
ESS 212 [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]	
Prerequisite	None
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]

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

BIO 112: Biology Lab I [0 0 3 1]	
Prerequisite	None
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 [6] - Plant and animal cells under a microscope - Isolation of microorganisms

BIO 112: Biology Lab I [0 0 3 1]	
	• Biological solutions preparation and quantification of biomolecules (proteins, lipids, carbohydrates, DNA) [9] • Mutation frequencies and fluctuation tests [6] • Analyse data from crosses: Theoretical problem solving [6] • Sampling and hypothesis testing [9]

BIO 121: Principles of Life II: Biophysics, Cell and Molecular Biology [2 1 0 3]	
Prerequisite	None
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] • 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]

BIO 121: Principles of Life II: Biophysics, Cell and Molecular Biology [2 1 0 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]	
Prerequisite	None
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]

BIO 122: Biology Lab II [0 0 3 1]	
	• Meiosis [3]

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

BIO 211: Principles of Life III: Organismal Biology [3 1 0 4]	
	• 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, WileyBlackwell 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 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 10. 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

BIO 212: Principles of Life IV: Microbiology [3 0 0 3]	
	• 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	1. Willey, Joanne M; Sherwood, Linda; Woolverton, Christopher J; Prescott Harley Klein's Microbiology, McGraw-Hill, 7th Edition, 2008 Reference Books: 2. Bacterial Physiology: A Molecular Approach / edited by Walid El-Sharoud, Springerlink 3. 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]	
Prerequisites	NA
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 homonuclear diatomic molecules – H_2, N_2, O_2 and F_2, concept of bond order, bond length and bond strength, bonding in heteronuclear diatomic molecules – CO, NO, HCl, and ICl, concepts of σ and π symmetries of molecular orbitals. Bonding in triatomic molecules – HF_2^-, BeH_2, O_3, and CO_2. [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, pK_a, 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.

CHY 111: Basic Organic and Inorganic Chemistry [2 1 0 3]	
	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]	
Prerequisites	NA
Learning Outcomes	This laboratory course provides opportunities for hands-on laboratory experiences related to qualitative and quantitative analyses.
Syllabus	Basic Lab Techniques [3] a) Thin layer chromatography (TLC) and calculation of R_f 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,

CHY 112: Chemistry Lab I [0 0 3 1]	
	(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 $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$ and estimation of copper(II) using standard thiosulfate solution as titrant; (c) Solubility product of $\text{Ca}(\text{IO}_3)_2$. 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]	
Prerequisites	NA
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.

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

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

CHY 122: Chemistry Lab II [0 0 3 1]	
	b) Determination of the Equilibrium Constant of the Reaction $\text{KI} + \text{I}_2 \rightarrow \text{KI}_3$ 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 the 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] - 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

CHY 211: Atomic Structure and Chemical Bonding [3 1 0 4]	
	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 $(\text{H}_2)^+$ and H_2 [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 111 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: S_N1, S_N2, S_{Ni} and S_{N2}' 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. syneliminations. [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); O_2-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 transuranium 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.

CHY 212: Basic Organic and Inorganic Chemistry II [3 0 0 3]

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| | <ol style="list-style-type: none">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. |
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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? Rules 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;

DSC 211: Introduction to Artificial Intelligence I [3 0 0 3]

	• 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, MultiDimensional Scaling, Principal Coordinate analysis, Isometric Map, Stochastic 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.

DSC 211: Introduction to Artificial Intelligence I [3 0 0 3]	
	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]	
Prerequisites	NA
Learning Outcomes	On completion of this course, students should be able to • Explain and apply fundamental concepts of graph theory, linear algebra, and metric spaces relevant to data science. • Analyze and evaluate mathematical structures such as graphs, inner product spaces, and spectral methods for modeling and solving data-driven problems. • Construct and interpret mathematical models using graph-theoretic and linear algebraic techniques in data science contexts.
Syllabus	Module 1: Discrete Mathematics (20) Module 1.1: Revision: Set theory and functions (2) Module 1.2: Basic Graph Theory: Elements of graph theory, Euler graph, Hamiltonian path, trees, tree traversals, spanning trees (7) Module 1.3: Intermediate concepts in graph theory: Brief coverage of coloring problem, Concepts of cliques and independent sets, Concept of planarity, Concept of flows and cuts, Graph adjacency matrix (7) Module 1.4: Spectral Graph Theory: Matrix representations of graphs, Eigenvalues and eigenvectors of graphs, Graph partitioning and clustering (4) Module 2: Inner Product and Metric Space (20) Module 2.1: Introduction to Inner Product: The scalar product in R^n, Inner products and norms (3) Module 2.2: Orthonormality and Operators on Inner Product Spaces: Orthonormal basis and lists, the Gram–Schmidt procedure, Linear functionals on inner product spaces, Self-adjoint and normal operators (6)

DSC 212: Mathematical Foundations for Data Science [3 1 0 4]	
	Module 2.3: Proof of Standard Inequalities using Inner products (1) Module 2.4: Metric Space Basics: Concept of distance, Basics of metric space, Examples of nontrivial metrics and non-metrics, Concept of open and closed sets (3) Module 2.5: Convergence in Metric Space: Sequences and convergence concept in metric space, Completeness (5) Module 2.6: Banach Space and Hilbert Space: Definitions and examples. (2)
Text & Reference Books	1. Sheldon Axler, Linear Algebra Done Right, Springer, https://doi.org/10.1007/978-3-031-41026-0 2. Bondy and Murty, Graph Theory, Springer 2008, https://doi.org/10.1007/978-1-84628-970-5 3. West, D.B. (2001) Introduction to Graph Theory. 2nd Edition, Prentice-Hall, Inc., Upper Saddle River. 4. S. Kumaresan, Topology of Metric Spaces, Alpha Science International Ltd. 2005

Earth, Environmental & Sustainability Sciences Courses

EES 211 Fundamentals of Earth System Sciences [3 1 0 4]	
Prerequisite	Nil
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 [3] • 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]

EES 211 Fundamentals of Earth System Sciences [3 1 0 4]	
	- The Earth's atmosphere: The Atmosphere: vertical structure, density, pressure, thermal structure and composition. [3] Activity-2 [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 [3] - Atmospheric Dynamics: Forces acting on the Earth Atmosphere, Coriolis force and centrifugal forces, hydrostatic equilibrium [1] - Global cycles: Hydrological Cycle and groundwater. [3] - Climate Change: Global CO₂ concentration and Keeling curve, Greenhouse effect, Radiative forcing of 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. [3] - 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. [3]
Text and Reference Books	- Ahrens, C.D., 2001. <i>Essentials of meteorology: an invitation to the atmosphere</i> (p. 544). Australia: Brooks/Cole/Thomson Learning. - Lutgens, F.K., Tarbuck, E.J. and Tasa, D.G., 2000. <i>Essentials of geology</i> (Vol. 480). Upper Saddle River, NJ: Prentice Hall. - Laura Leser, <i>Introduction to Earth Science</i>: - Thomas, D.N. and Bowers, D., 2012. <i>Introducing oceanography</i>. Dunedin Academic Press Ltd. - Bonan, G. (2015). <i>Ecological climatology: concepts and applications</i>. Cambridge University Press.

EES 212 Introduction to Environmental and Sustainability Sciences [3 0 0 3]	
Prerequisite	Nil
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

EES 212 Introduction to Environmental and Sustainability Sciences [3 0 0 3]

	• 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, Ecosystem activity: Producers, Consumers, Decomposers; 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, Keeling plot, Suess effect, Bjerrum plot, Ocean acidification [4] • Nutrient cycles: Nitrogen cycle, forms of nitrogen in the environment, N_2 fixation, diazotrophs, nitrification, denitrification, nitrogen assimilation processes, Haber–Bosch process, Phosphorus cycle, eutrophication, harmful algal blooms, agricultural practices, [2] • 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 [4] • Biodiversity: Conservation and utilization of biodiversity, biomes, landscapes, and ecosystems, problems, and issues in biodiversity and forestry, green revolution [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, Case studies of environmental pollution episodes and successful interventions, Carbon footprint and carbon credits. [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, Composting methods [4]

EES 212 Introduction to Environmental and Sustainability Sciences [3 0 0 3]

	- Environment policy & legislation: Environmental policy and its relevance in the Indian and global contexts, environmental protection act and Biodiversity act. [4] - Sustainability and sustainable development goals; systems thinking [6] - Applications of 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. Thomas, D. N., & Bowers, D. G. (2021). Introducing Oceanography. Liverpool University Press. 2. Reichle, D. E. (2020). The Global Carbon Cycle and Climate Change Elsevier. 3. Kirchman, D. L. (2012). Processes in Microbial Ecology. Oxford University Press. 4. Schindler, D. W., & Vallentyne, J. R. (2008). The Algal Bowl: Overfertilization of the World's Freshwaters and Estuaries. University of Alberta Press. 5. Theis, T., & Tomkin, J. (Eds.). (2015). Sustainability: A Comprehensive Foundation. OpenStax CNX. 6. Wright, R. T., & Boorse, D. F. (2017). Environmental Science: Toward a Sustainable Future (13th ed.). Pearson.

Mathematics Courses

MAT 111: Introduction to Algebra [2 1 0 3]	
Prerequisite	Nil
Learning Outcomes	Understanding basic concepts of groups via various examples and basic concepts of linear Algebra via matrices and their properties.
Syllabus	• Introduction to groups, examples - symmetric groups, cyclic groups, dihedral groups; subgroups [6] • 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] • Vectors in $\mathbb{R}^2$ and $\mathbb{R}^3$, $\mathbb{R}^n$ as a vector space, Subspaces [2] • Linear dependence and linear independence of vectors, Basis and dimension [2] • Linear Transformations, Matrix as a linear operator, Kernel and Range space of a matrix [4] • Rank-Nullity theorem, Change of basis matrix [3]
Text & Reference Books	1. G. Strang, Linear Algebra and Its Applications, 4th Edition, Brooks/Cole, 2006 2. S. Kumaresan, Linear Algebra: A Geometric Approach, PHI Learning, 2009. 3. J. A. Gallian, Contemporary Abstract Algebra, Cengage India Pvt. Ltd, 2019.

MAT 121: Single Variable Calculus [3 1 0 4]	
Prerequisite	Nil
Learning Outcomes	The aim of this course is to introduce students to the calculus of function of a single variable. Key concepts of differential and integral calculus are introduced along with applications.

MAT 121: Single Variable Calculus [3 1 0 4]	
Syllabus	- Quantifiers and various methods of proofs [3] - Real sequences and subsequences, Limit of a sequence, Monotone sequences and bounded sequences, Divergence of a sequence [6] - Series, Tests of convergence: Comparison test, Root test, Ratio test. Examples of some standard convergent and divergent series, Absolute convergence, Conditional convergence [6] - Real-valued functions: Examples of standard functions, periodic functions, boundedness of 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, algebra of continuous functions [5] - Differentiation: Tangents and slopes, rate of change and derivative, Differentiability and Continuity, Rules of differentiation [4] - Mean value theorem, Rolle's theorem and applications. Taylor's theorem and Taylor's series, Maclaurin Series [5] - 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	- T M Apostol, Calculus, Volume I, 2nd. Edition, Wiley, India, 2007 - James Stewart, Calculus: Early Transcendentals, Eighth Edition, Cengage Learning, 2014 - Ross L. Finney and George B Thomas, Calculus and Analytic Geometry, 9th Edition, Addison Wesley Publishing Company.

MAT 201: Multivariable Calculus [3 1 0 4]	
Prerequisites	MAT 121: Single Variable Calculus
Learning Outcomes	Students will develop an understanding in multivariable calculus learning topics such as limits and continuity of functions, partial derivatives, directional derivatives, and integration in two and three variables.

MAT 201: Multivariable Calculus [3 1 0 4]	
Syllabus	• 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] • Introduction to Riemann Integration in one variable - partition, refinement, lower and upper Riemann sums, Riemann integration; Examples [4]] • Double triple integrals, line and surface integrals Changing the order of integration, Fubini-Tonelli theorem. (statement) [9] • Statements and Applications of Green, Gauss and Stoke's theorem [6]
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.

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 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]

MAT 202: Introduction to Probability [3 0 0 3]	
	• 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]	
Prerequisite	None
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. Helmholtz, C. A. Moyer and B. J. Kittel, Berkeley Physics Course, Vol1, Mechanics, McGraw Hill 2017

PHY 111: Mechanics [2 1 0 3]	
	4. R. Shankar, Fundamentals of Physics, Yale Press 2019

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

PHY 121: Electromagnetism [3 1 0 4]	
Prerequisite	Nil
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,

PHY 121: Electromagnetism [3 1 0 4]

	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] • 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. Griffiths, Introduction to Electrodynamics, Prentice-Hall India, 2007. Additional References 2.E. M. Purcell, Berkeley Physics course: Vol 2. Electricity and Magnetism, McGraw Hill.

PHY 121: Electromagnetism [3 1 0 4]	
	3. Serway and Jewett, Physics for Scientists and Engineers, Brooks/Cole Publishers, 2004.

PHY 122: Physics Lab II [0 0 3 1]	
Prerequisite	Nil
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 (3) 2. Deflection magnetometer (3) 3. Spot galvanometer- high resistance by leakage (3) 4. Viscosity of a liquid – Oscillating disc method (3) 5. Young's Modulus: Cornu's method (3) 6. Young's Modulus: Optic Lever Method (3) 7. Surface Tension Capillary Method (3) 8. Joules Calorimeter- Specific Heat Capacity of a Liquid (3) 9. Latent heat of fusion of ice (3) 10. Newton's Law of Cooling (3)
Text & Reference Books	Laboratory Notes and Reference Material

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

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

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

PHY 212: Optics [3 0 0 3]	
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
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, - Retardors; 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]

PHY 212: Optics [3 0 0 3]	
	• 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. 2. Eugene Hecht and A. R. Ganesan, Optics, AddisonWesley Longman, 2002. 3. Francis A. Jenkins and Harvey E. White, Fundamentals of Optics, McGraw- Hill Higher Education, 4th ed. 4. Frank S. Crawford, Waves: Berkeley Physics Course Vol. 3, Tata Mgraw Hill, 2008.

Skill Enhancement Courses (SEC)

IDC 111: Mathematical Tools I [3 1 0 4]	
Prerequisite	Nil
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, AddisonWesley Publishing Company Inc, 9Ed.

IDC 112: Introduction to Python Programming [0 0 3 1]	
Prerequisite	Nil
Learning Outcomes	• Write, execute, debug, and document simple Python programs. • Apply programming constructs such as variables, operators, conditional statements, loops, and functions to solve computational problems. • Use Python data structures (lists, tuples, dictionaries, and sets) for data manipulation. • Read from and write to files, and perform basic data analysis and visualization using Python libraries. • Use the 'NumPy' library to solve simple scientific problems.
Syllabus	• Introduction to Linux OS and Linux Command Line Interface. [3] • Getting started with Python: What is Python? Why Python? How to get started with Python. Official Python website, download and installation instructions. The "Hello World" program in Python. Different ways of running a Python script. Jupyter Notebook. Using print(), comments, basic arithmetic operations, input, and output formatting. [3] • Variables, Data Types, and Operators: Concept of variables, objects, and references. Python's basic data types: Integers, Floats, Booleans, type conversion, arithmetic, comparison, and logical operators. [3] • Python control structure, loops, and iterative programming: if, if-else, nested if, and elif statements. Example programs for a grading system, a leap year, quadraticroots, menu-driven calculator. Python for loop, while loop, range(), nested loops, break, continue. Programs on factorial, Fibonacci, prime numbers, multiplication tables, and pattern printing. [6] • Functions and Modular Programming: User-defined functions, parameters, return values, scope of variables, importing modules, math module. Programs involving reusable functions. Exception handling. [3] • Strings and String Processing: String operations, slicing, searching, formatting, methods, palindrome checking, frequency counting, and simple text processing. [3] • Sequence data types: Lists, Tuples, Sets, Dictionaries. Creating lists, indexing, slicing, list methods, nested lists, tuples, and list comprehension. Programs involving sorting and searching.

IDC 112: Introduction to Python Programming [0 0 3 1]	
	Dictionary creation, key-value operations, iteration, sets, and set operations. Applications such as word frequency counting and student record management. [3] • File Handling and Exception Handling: Reading/writing text files, CSV files, try-except blocks, handling common errors, logging simple outputs. [3] • Introduction to NumPy: 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. [3] • Data plotting and visualization with Matplotlib: Using Matplotlib for plotting line graphs, bar charts, scatter plots, and histograms using sample datasets. Manipulating and customizing plot styles, color, axes range, labels, legends, annotation etc. [6]
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://matplotlib.org/

IDC 121: Mathematical Tools II [2 1 0 3]	
Prerequisite	Nil
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.

IDC 121: Mathematical Tools II [2 1 0 3]	
	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: Foundations of Artificial Intelligence [0 0 3 1]	
Prerequisite	IDC 112: Introduction to Python Programming
Learning Outcomes	- Understand the fundamental concepts, terminology, history, and applications of Artificial Intelligence. - Explain the principles of data-driven learning, machine learning, neural networks, and deep learning for solving computational problems. - Apply Python programming and AI libraries to preprocess data, build, train, test, and evaluate basic AI models. - Implement simple machine learning and neural network solutions for classification and regression tasks.
Syllabus	- Experiencing Artificial Intelligence: AI applications in everyday life, what AI can and cannot do, and different categories of AI applications. How do AI systems learn? What is AI ethics? Why is it important? Core Principles of ethical AI. Lab Activities: Identify AI systems encountered in daily life for tasks such as Route planning, Spam detection, Recommendation, Face recognition, Language translation, Conversational AI etc. Interact with a conversational AI such as ChatGPT, for example, to learn Newton's laws of motion, generate a Python program to print Fibonacci numbers, write a poem, etc. Use an AI to generate images. Prompt engineering to generate the most realistic image. Demonstration of AI hallucination with a difficult question. Demonstration of bias in AI responses. [3] - Foundations of Artificial Intelligence: What is AI? Different definitions of AI from history. Human Intelligence vs Artificial Intelligence. A brief history of AI. Why is AI advancing now? AI vs Machine Learning vs Deep Learning. Major branches of AI with

IDC 122: Foundations of Artificial Intelligence [0 0 3 1]

example applications, e.g., for machine learning (ML), natural language processing (NLP), computer vision, robotics, search processing, expert systems, etc. AI Strengths and Limitations. Lab Activities: Simple Python programs to demonstrate “representation of knowledge and decision making” by AI. [6]

- Intelligent Agents and Problem Solving: What is an Intelligent Agent? PEAS Framework and examples. Types of environments that are easier for AI. Types of Intelligent Agents, such as: simple reflex agent, model-based reflex agent, goal-based agent, utility-based agent, learning agent.

Lab Activities: Simple Python programs to create toy models of various intelligent agents. [6]

- Data in AI. What is data? Why does data matter? Types of data. Structured vs unstructured data. Dataset. Features and Labels. Data Quality.

Lab Activities: Simple Python programs demonstrating features and labels of example data. [3]

- Introduction to Machine Learning. Traditional programming vs Machine Learning.

Definition of machine learning (ML). ML workflow. Examples. Why Machine Learning? Types of Machine Learning, e.g., supervised, unsupervised, and reinforcement learning. Training Models and Evaluating Performance: training, testing, and validation data sets. Overfitting and underfitting. Evaluation Metrics: accuracy, precision, and recall.

- Lab Activities: Simple Python programs working with CSV data files. Use the scikit-learn Python package to work with a few well known ML models. Iris Flower

- Classification: to load the well-known Iris dataset, split data into training and testing sets, train a simple Decision Tree classifier, predict the species of a few flowers, and compute and interpret the accuracy. House Price Prediction: Remove missing values, visualize house prices, Train Linear Regression, predict price for a new house, and compute Mean Absolute Error (MAE). [9]

- Neural Networks: Why do we need Neural Networks? Biological inspiration, Artificial neurons, Perceptron, Activation Function. Example Python program implementing a single neuron. Neural networks: neural layers, forward propagation, training, epoch, loss function. Simple Python programs illustrating training.

Lab Activities: Handwritten Digit Recognition using MLP: Use the Python Keras package to implement a “handwritten digit

IDC 122: Foundations of Artificial Intelligence [0 0 3 1]	
	recognition” program using a fully connected Neural Network (MLP), illustrating the main workflow steps, e.g. loading data (MNIST), exploring the data, preprocessing the data, building the Neural Network, compiling and training the model, evaluating the model, making and visualizing predictions, and analyzing errors. [9].
Text & Reference Books	1. Stuart Russell & Peter Norvig, “Artificial Intelligence: A Modern Approach” (4th Edition, 2021) 2. Ethem Alpaydin, “Introduction to Machine Learning” (4th Edition) 3. Laurence Moroney, “AI and Machine Learning for Coders” 4. Aurélien Géron, “Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow” (3rd Edition)

IDC 212: Introduction to C++ Programming [0 0 3 1]	
Learning Outcomes	• Understand the basic concepts of programming using a compiled language. • Learn procedural programming, algorithms, variables, data types, and control structures of the C++ language. • Develop C++ programs using expressions, decision-making, loops, functions, and arrays to solve computational problems. • Learn standard programming tools for compiling, debugging, testing, and documenting C++ programs.
Syllabus	• Introduction to C++: Mechanics of creating, compiling, and executing a C++ program. The ‘Hello World’ program in C++. Program structure, simple statements, and the formatting style of source code. Example programs: Simple arithmetic calculator, area and perimeter calculations, unit conversions, etc. [3] • Data-types, Operators and Expressions: Basic data types in C++, arithmetic operators, relational operators, logical operators, assignment operators, increment/decrement operators, type conversions. Expressions in C++. Example programs: Temperature converter, Simple interest calculator, BMI calculator, Swap numbers. [6] • C++ control structure, loops, and iterative programming: if statement, if-else, nested if, else-if ladder, switch statement. for-loop, while-loop, do-while loop, nested loops, break, and continue.

IDC 212: Introduction to C++ Programming [0 0 3 1]	
	Example programs: Largest of three numbers, Grade calculator, Leap year checker, Multiplication tables, Prime number check, Factorial, Fibonacci sequence, Patternprinting [6] • Functions: Function declaration, Function definition, Function calling, Function arguments, Return values, Scope of variables, Function overloading. Example programs: Modular calculator, GCD and LCM calculator, Prime checking function, and Recursive factorial. [6] • Arrays and Strings: One-dimensional arrays, Two-dimensional arrays, Character arrays. Introduction to string class. • Example programs: Find maximum/minimum, Average of marks, Sorting elements in a number array. Dot product and matrix products of vectors and matrices. String manipulations. [6] • Pointers: Memory concept, Pointer declaration, Pointer arithmetic, Connection to arrays, Passing function arguments by reference. Example programs: Swapping values using pointers, Array traversal using pointers, Using pointers to create dynamic arrays. [3] • Structures and File Handling: Structure data type. Arrays of structures. File objects, Reading from text files, Writing to files. Example programs: Library record management using structures. Save and read library records from files. [6]
Text & Reference Books	1. Stephen Prata, C++ Primer plus (6th Ed), Addison-Wesley 2. Yashavant Kanetkar, Let us C++, BPB Publications 3. Programming: Principles and Practice Using C++, Bjarne Stroustrup

IDC 222: Introduction Numerical computing using C++ [0 0 3 1]	
Prerequisite	• IDC 212: Introduction to C++ Programming
Learning Outcomes	• Understand sources of systematic errors in numerical computations. • Usage of C++ standard library data structures useful for numerical computation. • Learn methods of numerical solutions to typical mathematical problems.

IDC 222: Introduction Numerical computing using C++ [0 0 3 1]	
	• Develop ideas to design computer algorithms to solve numerical problems. • Implement numerical algorithms in the C++ programming language.
Syllabus	• Binary numbers: Why binary numbers? Binary Arithmetic. Integer Representation, Integer Overflow, Representation of Floating-Point Numbers, Floating-Point Precision, Machine precision, Rounding errors. Example programs: Find the maximum and minimum values of built-in integer types using <code>std::numeric_limits</code>. Demonstrate integer overflow. Compare the precision of float and double by summing decimal fractions. Print the memory size of common C++ data types using <code>sizeof</code>. [3] • C++ Class and Standard Library Containers: Introduction to C++ Class. Structure of a Class, Constructors, Public & Private members, creating objects of a Class. Usage of containers such as, <code>std::vector</code>, <code>std::map</code>, <code>std::set</code>. Example programs: Create a “Complex” class to emulate complex numbers in Mathematics. Store the marks of students in a <code>std::vector</code>, find the maximum and minimum marks. compute average marks, sort the marks. Use <code>std::vector</code> to represent mathematical vectors, find dot product, cross product. Use <code>std::map</code> to represent a Polynomial. Use <code>std::map</code> to store a sparse vector. Use <code>std::map</code> to store experimental data measured at different times. Use <code>std::set</code> to find unique numbers in a list. Use <code>std::set</code> to find the union of two data sets. [6] • Numerical Differentiation & Integration: Finite difference formulas for numerical differentiation, Errors. Numerical integration, Trapezoid rule, Simpson’s rule, composite Newton-Cotes formulas. Example programs: Implementation of the algorithms using C++. [9] • Solving Equations: Finding the root of an equation of a single variable. Bisection method, Newton’s method, secant method. Example programs: Implementation of the algorithms using C++. [9] • System of Equations: Gaussian Elimination, LU factorization, Jacobi method.

IDC 222: Introduction Numerical computing using C++ [0 0 3 1]	
	Example programs: Implementation of the algorithms using C++. [9].
Text & Reference Books	1. Timothy Sauer, Numerical Analysis, Pearson 2. Stephen Prata, C++ Primer plus (6th Ed), Addison-Wesley 3. Yashavant Kanetkar, Let us C++, BPB Publications

Ability Enhancement Courses (AEC)

HUM 111: Communication Skills I [1 0 0 1]	
Prerequisites	NA
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]	
Prerequisites	NA
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]
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 o What is Economics? Scarcity, choice and economic systems [1] ○ Market: Consumption o 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]

HUM 211: Introduction to Economics [1 0 0 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 211: Introduction to Philosophy [1 0 0 1]	
Prerequisites	NA
Learning Outcomes	• Gain familiarity with the history of knowledge development in both Eastern and Western traditions. • To comprehend the interplay between sciences and humanities, emphasizing their productive reciprocal relationship. • To have conceptual comprehension of the relationship between distinct cultures and the underlying philosophical beliefs held by diverse cultures with their critical and reflective evaluation.
Syllabus	• Absorption, Reflection, Criticality (1) • Philosophy as mother of all fields (1) • Contemplation and thinking (1) • Introduction to Western Philosophy (1) • Introduction to Eastern Philosophy (1) • Contemporary Natural Philosophy (1) • Sankhya and Yoga Tradition (1)

HUM 211: Introduction to Philosophy [1 0 0 1]	
	• Eastern Practices (1) • Cross cultural studies and Experimental Philosophy (1) • Cultural beliefs and Social Cognition (1) • Summary of Philosophy and its utility for Sciences (1) • Limits of Philosophy, and Limits of Sciences(1)
Text & Reference Books	• Gaarder, J. (2010). Sophie's World. United Kingdom: Orion.Hesse, • H. (2016). Siddhartha. India: Jaico Publishing House. • Russell, B. (2004). History of Western Philosophy (Routledge Classics). United Kingdom: Routledge. • Chatterjee, S., Datta, D. M. (2016). An Introduction to Indian Philosophy. Motilal Banarsidass Publishers Private Limited. • Russell, B. (2001) The Problems of Philosophy (2nd ed.). Oxford University Press. • Radhakrishnan, S. (2008). Indian Philosophy. India: Oxford University Press. • Philosophy, University of Arizona. (n.d.). Some Suggestions for How to Approach Reading Philosophical Article or Book. Connie Rosati, Philosophy, University of Arizona. philosophy.arizona.edu.

HUM 221: Introduction to Sociology [1 0 0 1]	
Prerequisites	NA
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] o Politics and social order o Education and mass media o Sociology of body and health o Nation and Globalization

HUM 221: Introduction to Sociology [1 0 0 1]	
	• 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.

HUM 312: Foundations of Critical Thinking [3 0 0 3]	
Prerequisites	NA
Learning Outcomes	• To understand and identify various meanings, perspectives, and relationships embedded in critical thinking in both implicit and explicit discourses • To comprehend and apply various dimensions, methods, types and forms of critical thinking on various textual, scientific and social discourses. • Cognize the limits to the process of critical thinking and will gain the ability these limits in applications • Grasp nature of contemplative traditions and practices with emphasis on methods to uncover the limits to process critical thinking
Syllabus	• Critical Thinking from Ancient to Contemporary What is Critical Thinking? History of Critical Thinking • Effect of Culture on Thinking Folk stories and Heuristic, Heuristic vs Thinking: Cognitive Resources Culture and Cognition: WEIRD, Eastern and Western Cognition: Analytical and Holistic, Experimental Philosophy: Geography of Philosophy for Indian Wisdom and Western Wisdom • Effect of Language on Thinking Syntax and Semantics, Coding Multiple Valence and Semantics in Singular Syntax Sapir-Whorf Hypothesis, Monolingualism, Bilingualism and Multilingualism, Verbal and non- verbal Semantics, The dual semantic structure of Krishna Gita in Kashmiri Shaivism

HUM 312: Foundations of Critical Thinking [3 0 0 3]

	• Effect of Perspective on Thinking Self: Embodied, Embedded, Enactive, Extended, Situated other: Perspective-taking, Self and other, Role-playing and Theory of Mind, Cognitive and Affective (TT & ST) • Methods of Thinking Critical Thinking Methods: Concrete, Abstract, Analogical, Analytical, Convergent, Divergent, Synthetic, Computational, Creative, Meta, and Contemplative • Types of Thinking Correlational; and Causation; Statistical, Contextual and Non-contextual: Temporal and Non-temporal. • Forms of Thinking Symbolic Thinking, Auditory Thinking, Visual Thinking, Tactile thinking, Olfactory Thinking, Proprioceptive Thinking, Synaesthesiac Thinking • Reasoning and Biases Reasoning: Inductive, Deductive and Abductive, Logical Fallacies and Cognitive Biases, Scientific Thinking, Reductionism, Empiricism, and Instrumentation • Critical thinking in Action Intutions and Thought Experiments, Art of Argumenation, Art of Critical Reading and Writing • Confinement of Thinking Philosophy of the limits of thought, Limits of Perspective taking Nagarjuna and the limits of thought, Cognitive Bottlenecks. • Going Beyond Thinking: The Indian Way Dharana, Dhayana and Samadhi, Thinking as a consequence of dharana, Thinking as an activity of Dhayana, Non- thinking as Samadhi, Concept of aparavidya (Lower knowledge through thinking) and paravidya(higher knowledge through non-thinking)
Text & Reference Books	1. Cohen, M. (2024). Critical Thinking Skills for Dummies. United Kingdom: Wiley. 2. Kahneman, D. (2011). Thinking, Fast and Slow. United Kingdom: Penguin Books Limited. 3. Moore, B. N., Parker, R. (2008). Critical Thinking. United Kingdom: McGraw-Hill Education. 4. Halpern, D. F., Dunn, D. S. (2022). Thought and Knowledge: An Introduction to Critical Thinking. United Kingdom: Taylor & Francis.

HUM 422X: Introduction to Cognitive Sciences [3 0 0 3]	
Prerequisites	NA
Learning Outcomes	• Gain insight into the current debates and critical issues in the field of cognitive science. • Comprehend the fundamental concepts of cognitive science and their connection to the problem of the mind. • Discover the ways in which empirical research in the cognitive sciences has influenced theoretical debates and thought in society. • Develop understanding about core empirical research in the cognitive sciences, including consciousness, intelligence, perception, memory, and attention.
Syllabus	• Philosophy of Mind (3) • Descartes's legacy Varieties of materialism: Behaviourism and psycho-physical identity Functionalism and the Representational Theory of Mind • Psychology of Mind (2) • Behaviourism Cognitivism • Foundations of Cognition (2) • Three levels of Abstraction: Computational, Algorithmic, and Hardware • Non-normative Cognition (1) • Dementia, DID, Dead belief, Alien hand syndrome, Psychedelics, Meditation experiences • Problem of Consciousness-Mind-Body (1) • Mechanical Philosophy, and Causation, Phenomenal and Access Consciousness • Theories of Mind (2) • Computational representational theory of mind, 4E Cognition • Theories of Consciousness (2) • Global Workspace Theory, Information Integration Theory, Attention Schema Theory • Indian theories of cognition and Consciousness (2) • Sankhya-Yoga and Charvaka • Human Cognition (18) • Cognitive Psychology, Cognitive Neuroscience, Intelligence, Attention, Perception, Short Term Memory and Working Memory, Long Term Memory, Conceptual Knowledge, Visual Imagery, Types of Self, Judgment, Decision and Reasoning

HUM 422X: Introduction to Cognitive Sciences [3 0 0 3]	
	• Cognitive Artificial Intelligence (2) • Multiple-realizability, Computational processing and Cyber organisms • Neurolaw and Society (2) • Rehabilitation, Justice, Free Will and Pre-policing • Cognition Optimization (3) • Psychedelics, Psychotropics and Meditation • Practical Session
Text & Reference Books	1. Kurzweil, R. (2005). The Singularity Is Near: When Humans Transcend Biology. United States: Penguin Publishing Group. 2. Thagard, P. (2005). Mind, Second Edition: Introduction to Cognitive Science. India: A Bradford Book. 3. Goldstein, E. B. (2004). Cognitive Psychology: Connecting Mind, Research and Everyday Experience. 4. Clark, A. (2000). Mindware: An Introduction to the Philosophy of Cognitive Science. 5. Chalmers, D. J. (2021). Philosophy of Mind: Classical and Contemporary Readings.

Preparatory Courses

HUM 101: Primer for Communication Skills [1 0 0 1]	
Prerequisites	Nil
Learning Outcomes	• Better guide their own communication skills and encourage themselves towards improving communication skills. • Gain writing skills and understanding of the language in terms of structure of sentences, grammar, and use of words. • Improve comprehension skills • Enhance confidence and sustain conversations with the peer group.
Syllabus	• Introduction to language; why should we speak and how can we speak better in an error-free manner using correct grammar (2 lectures) • To speak, listening is imperative. What are listening skills and how can it be used to aid communication and understanding? (2 lectures) • Fundamentals of reading and how should reading be so as to make communication sharper and focused. (2 lectures) • How to structure a sentence, follow basic rules, draft a neat document, and make it as error-free as possible. (2 lectures) • Practical sessions (2 lectures, suggestion to make available 2 more lectures)
Assignment	Students could be encouraged to launch a community radio or a Youtube channel where they will post interesting topics they find on campus with regard to campus life, research work, poetry sessions, interviews, etc., that can help them put to use their speaking, writing, reading, and listening skills.
Text & Reference Books	1. NCERT books on language skills: Interactions, Activity books on Listening and Speaking 2. Grammar and Language Skills–Basics NCERT 3. The Communication Book, by Mikael Krogerus and Roman Tschappeler 4. Quick and easy way to effective speaking, Dale Carnegie 5. Essential Language Skills, Macmillian Education 6. British Council's Learn English Modules 7. Book on essays and for comprehension (to be selected as per the choice of the students)

MAT 101: Primer for Mathematics [1 0 0 1]	
Prerequisites	Nil
Learning Outcomes	This course is aimed towards the students, who didn't have mathematics in their higher secondary (10+2), to prepare them for better understanding of the foundational mathematics courses at IISER TVM offered during the first year of study. Specific topics from 10+2 level mathematics will be taught in this course.
Syllabus	Algebra [8 lectures]: Set, example of sets, finite and infinite sets, empty sets, subsets, set of reals, rationals, natural numbers, set operations and Venn diagrams. Relations and functions, domain, codomain, range, example of standard functions (modulus, exponential, logarithmic, trigonometric), injective, surjective and bijective functions, inverse of a function, composition of functions Complex numbers, algebra of complex numbers, modulus and argument of complex numbers Matrices, row, column and square matrices, diagonal matrices, equality of matrices, operations involving matrices, notion of inverse of a matrix Determinants, expansion rules for determinants • Geometry [2 lectures]: Basic coordinate geometry, plotting of functions, equation of lines in different forms Distance formula, equation of a circle • Calculus [10 lectures]: Sequence and series, formula for arithmetic and geometric progression Limits, calculating limits for different functions, L'Hospital rule Notion of continuity, examples Derivatives, rules of derivatives, calculating derivatives of different functions, composition rule, derivative as tangent to a curve Integrals, calculating integrals of standard functions, rules of integrals, definite integrals and area under a curve
Text & Reference Books	NCERT Mathematics - XI and XII