Detailed Syllabus of Minor and MD C courses offered by various Departments

1. Biology

2. Chemsitry

3. Computer Science

4. Mathematics

5. Photonics

6. Physics

7. Statistics

Syllabus (Minors and MDCs)

Five-Year Integrated M.Sc. Major in Biological Sciences

Cochin University of Science and Technology (CUSAT)

w.e.f. June 2024

24-811-0101. FUNDAMENTALS OF LIFE (4C; 3L+0T+2P) (Academic Level 100)

Course description: The course covers the studies of living creatures, from the tiny and simple through to the complexities of plants and animals, ending with a basic understanding of ecology and the study of population dynamism. Different scopes of biology will also be conveyed to the students.

Course outcomes: After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Explain the biological processes common to life	Understand
C.O. 2: Compare fundamental differences in the forms and how they may differ	Analyse
C.O. 3: Comprehend and explain how present-day organisms may have arisen	Understand
C.O. 4: Interpret how different life forms, including humans, interact with each other and with the physical, chemical and biological world around them.	Analyse
C.O. 5: Use the knowledge gained through scopes of biology for higher studies and furthering careers in biology.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	-	2	-				
CO2	2	-	-	-				
CO3	3	-	-	-		2		
CO4	2	-	2	-				
CO5	2	-	-	-			1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to cell: Cell theory, Cell and its components: nucleus, mitochondria, chloroplast, Golgi apparatus, ribosomes, vacuoles; types of cells, the concept of tissues

MODULE II: Biomolecules of life: Water as a biological solvent, carbohydrate, nucleic acid, amino acids, proteins, lipids, enzymes, vitamins, and minerals.

MODULE III: Biodiversity: concept, values and types of biodiversity. Analysing and documenting biodiversity. Maintenance of ecological diversity, Biodiversity hotspots in India.

MODULE IV: Ecology and Conservation: Concepts and elements of Biotic and Abiotic environment; Interaction between biotic and abiotic environment; Ecosystem- concept and components, Community-structure and dynamics; Biome- grassland, tundra, forest, deserts, salt & freshwater ecosystem; Biodiversity and Conservation; Impact of climate change on biodiversity.

MODULE V: Principles of Developmental Biology & Evolution: Basic concepts in developmental biology regarding plants and animals, and their biological significance Introduction to evolution: History, Types, Theories, and evidence of Evolution.

Suggested Practical

1. Familiarizing with microscopes and their application.
2. Microscopic examination and identification of unicellular and multicellular life forms: Monerans: Euglena, Paramecium, Amoebae, Chlamydomonas, Chlorella, Diatoms.
3. Microscopic observation of bacteria and fungi
4. Volvox as a model of evolution- (Cellular level- single cell to the multicellular organization)

REFERENCES

1. Reece, J. B., & Campbell, N. A. (2011). Campbell Biology. Boston, Benjamin Cummings / Pearson.
2. Manuel C Molles, Ecology: Concepts and Applications McGraw Hill 7th Edition 2014
3. Douglas J Futuyma, Evolution Oxford University Press 3rd Edition 2013
4. Barton et al., Evolution Cold Spring Harbor Laboratory Press 1st Edition 2007
5. Stephen C. Stearns and Rolf F. Hoekstra, Evolution: An Introduction Oxford University Press 1st Edition 2000
6. Nicholas J. Gotelli, A primer of Ecology Oxford University Press, 4th Edition 20086. Begon et al., Ecology: From Individuals to Ecosystem Wiley-Blackwell, 4th Edition 2005
7. Instant notes on ecology by A. Mackenzie, A.S. Ball, S.R. Virdee, 2nd edition- 2020

24-811-0102 INTRODUCTION TO ANIMAL & PLANT BIOLOGY (4C; 4L+0T+0P) (Academic Level 100)

Course description: This course provides a foundation for understanding the fundamental principles of life focusing on plants and animals. Through lectures, discussions, and laboratory exercises, we will explore the diversity, structure, function, and inter-dependence of these two kingdoms within the biological world.

Course Outcomes: After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Understand the vast diversity of plants and animals	Understand
C.O. 2: Comprehend the basic structure and function of animal plant cells and reproduction	Understand
C.O. 3: Comprehend the basic structure and function of animal cells and tissues	Understand
C.O. 4: Understand the basic concepts of nutrition	Understand
C.O.5: Analyse the inter-relationships between plants and animals within ecosystems.	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2							
CO3	2							
CO4	2							
CO5	2					2		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I-Introduction: Characteristics of life, The scientific method and biological inquiry, Classification of living organisms (including major plant and animal groups)

MODULE II- Plant cell structure and function (including photosynthesis); Plant tissues, organs, and organ systems, Transport in plants (water and nutrients), Plant reproduction (sexual and asexual)

MODULE III- Animal structure and function: Animal cell structure and function, Animal tissues, organs, and organ systems (digestive, respiratory, circulatory, excretory, nervous, endocrine, reproductive), Animal movement and behaviour, Sensory reception

MODULE IV- Nutrition and Gas Exchange: Autotrophs vs. heterotrophs, Types of nutrition in plants and animals, Digestion and absorption in animals, Respiration in plants and animals

MODULE V- Interdependence and the Environment: Symbiotic relationships between plants and animals, Importance of plants and animals in ecosystems, Threats to biodiversity and conservation efforts

REFERENCES

1. Burgess, J. (1985). Introduction to Plant Cell Development. United Kingdom: Cambridge University Press.
2. Pandey, B. P. (2001). College Botany - Volume I. India: S. Chand Limited.
3. Agarwal, V. K. (2022). Zoology for Degree Students (For B.Sc. Hons. 4th Semester, As per CBCS). India: S Chand & Company Limited.
4. Campbell, P. N. (2013). The Structure and Function of Animal Cell Components: An Introductory Text. United Kingdom: Elsevier Science.
5. Yadav, P. R. (2006). Biotechnology of Animal Tissues. India: Discovery Publishing House Pvt. Limited.
6. Schulze, E., Beck, E., Müller-Hohenstein, K. (2005). Plant ecology. Germany: Springer.
7. Jain, V. K. (2000). Fundamental Of Plant Physiology. India: S. Chand Limited.
8. Animal Physiology. (2000). India: S. Chand, Limited.

24-811-0103 MYSTERIES OF BIOLOGY (3C; 3L+0T+0P) (Academic Level 100)

Course Description:
This course delves into captivating and intriguing aspects of the biological sciences, exploring fascinating phenomena, extraordinary adaptations, and curious behaviours exhibited by organisms across various taxa. Through a combination of lectures, discussions, readings, and

hands-on activities, students will develop a deeper appreciation for the wonders of the natural world and gain insight into the scientific processes that unravel its mysteries.

Course Outcomes: After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Explore the captivating topics in biology that ignite curiosity and inspire further study.	Apply
C.O. 2: Develop critical thinking skills through the analysis of complex biological phenomena.	Analyse
C.O. 3: Appreciate the diversity of life and the interconnectedness of biological systems.	Analyse
C.O. 4: Develop independent inquiry and research interest in fascinating biological topics.	Analyse
C.O. 5: Apply the knowledge gained for higher studies and furthering careering in biology and biological research.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2							2	
CO3	2							
CO4	2				1			
CO5	2						1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Module I- Introduction to Fascinations of Biology-Overview of the course objectives and structure**;** Importance of curiosity and wonder in biological sciences**;** Bioluminescence: Mechanisms and ecological significance of bioluminescence**;** Case studies of bioluminescent organisms

Module II- Extreme Environments- Adaptations of extremophiles to extreme conditions; Exploration of extreme environments on Earth and beyond; Cryptic Coloration and Mimicry: Camouflage, cryptic coloration, and mimicry in the animal kingdom; Examples of mimicry in insects, amphibians, and other organisms

Module III- Behavioural Ecology: Evolutionary drivers of animal behaviour; Case studies of complex behaviours in various species; Plant Communication: Signalling and communication mechanisms in plants; Inter-plant communication and defence strategies; **Unusual Reproductive Strategies**: Unique reproductive strategies in plants and animals; Ecological and evolutionary implications of different reproductive strategies

Module IV- Genetic Engineering and Synthetic Biology: Applications and ethical considerations of genetic engineering; Cutting-edge developments in synthetic biology **Neuroscience Mysteries**: Fascinating phenomena in neuroscience; Current research and theories addressing neuroscientific mysteries

Module V- Evolutionary Arms Race: Coevolutionary interactions between species; Evolutionary adaptations driven by competition and conflict; Biodiversity Hotspots: Importance of biodiversity hotspots for conservation; Threats to biodiversity and efforts to preserve it; **Emerging Infectious Diseases**: Impact of emerging infectious diseases on human health and ecosystems; Factors contributing to disease emergence and spread

REFERENCES

1. Campbell, P. N. (2013). The Structure and Function of Animal Cell Components: An Introductory Text. United Kingdom: Elsevier Science.
2. Yadav, P. R. (2006). Biotechnology of Animal Tissues. India: Discovery Publishing House Pvt. Limited.
3. Schulze, E., Beck, E., Müller-Hohenstein, K. (2005). Plant ecology. Germany: Springer.
4. Jain, V. K. (2000). Fundamental Of Plant Physiology. India: S. Chand Limited.
5. Animal Physiology. (2000). India: S. Chand, Limited.
6. Smith and Smith (2014) Ecology 9th edition. Pearson Education
7. Desmond S. T. Nicholl (2023) An Introduction to Genetic Engineering

SEMESTER II

24-811-0201- BIOMOLECULES (4C; 3L+0T+2P) (Academic Level 100)

Course description: The program is designed to enable a student to acquire sound knowledge of biochemistry and its practical applicability. The course will encourage the students to join the industry or to prepare them for higher studies including research. The syllabus is based on a basic and applied approach to ensure that students develop problem-solving skills, laboratory skills, chemistry communication skills, team skills as well as ethics.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Describe the significance of biomolecules	Understand
C.O. 2: Differentiate the biomolecules (proteins, lipids, nucleic acids, and carbohydrates) based on their structural basis	Analyse
C.O. 3: Quantify various biomolecules.	Analyse
C.O. 4: Employ chromatographic techniques to separate various biomolecules.	Apply
C.O. 5: Apply proper procedures and regulations in handling and disposal of chemicals.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	2	1					
CO3	2	2	2					
CO4	2	2	1	1				
CO5	2		1	1				

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: A brief history of biochemistry, Basic chemistry- Elements, Functional groups, pH, Mole concept, Bonding and chirality, non-covalent interactions, Water, interactions in aqueous systems, Molarity, normality, Ionization state of biomolecules, Laws of thermodynamics, Gibbs free energy, and maintenance of equilibrium.

MODULE II: Carbohydrates: Structure, chemical & biological properties and functions. Monosaccharides- Ribose, Glucose and fructose. Oligosaccharides -Sucrose, maltose, lactose, Polysaccharides- Glycogen, cellulose and starch. Glycoproteins, proteoglycans and glycolipids. Hetero-polysaccharides, Carbohydrates as informational molecules- the sugar code.

MODULE III: Nucleic Acids: Nucleotides, Nucleic Acid composition, a historical perspective leading up to the proposition of DNA double-helical structure; the difference in RNA and DNA structure and their importance in the evolution of DNA as the genetic material. Lipids & Fats: Storage lipids, Structural lipids in membranes, Lipoproteins. Lipids as signals, cofactors and pigment, biological functions of lipids. Vitamins and Minerals:

General accounts and biological functions.

MODULE IV: Proteins: structural and functional group properties; pH and properties of amino acids, Peptides and covalent structure of proteins; peptide bond, polypeptide, protein structure- secondary, tertiary and quaternary, protein structure & function, Enzymes as Biological Catalysts: General principles of enzyme catalysis, Activation energy and stereospecificity, classification of enzymes; Types of enzymes and their specific functions. Enzyme characterization and Michaelis–Menten kinetics, Regulation and Inhibition of enzyme.

MODULE V: Methods in Biophysical and Biochemical Analysis: Buffers, pH meter, Calorimetry, Spectrophotometry, Centrifugation techniques, Mass spectrometry, Chromatographic techniques, Electrophoretic Techniques.

Suggested practical

1. Preparation of Normal and Molar solutions
2. Preparation of Buffers (Acidic, Neutral and Alkaline Buffers)
3. Verification of Beer Lambert's law
4. Estimation of biomolecules (glucose, protein, lipids and nucleic acid).
5. Separation of biomolecules using paper and TLC
6. Electrophoretic Techniques

REFERENCES

1. Rodney F Boyer, Concepts in Biochemistry. John Wiley & Sons; 3rd Ed (2 December 2005).
2. Thomas Millar, Biochemistry Explained: A Practical Guide to Learning Biochemistry CRC Press; 1 edition (30 May 2002)
3. Lubert Stryer et al., Biochemistry, W. H. Freeman; 6th Edition (14 July 2006)
4. David L Nelson, and Michael M Cox et al., Lehninger principles of biochemistry WH Freeman; 7th ed.2017 edition (1 January 2017)
5. Lehninger. Principles of Biochemistry, Macmillan, U.K.
6. Geoffrey Zubay. Biochemistry. Macmillan Publishing company, New York
7. Sadasivam and Manickam. Biochemical Methods. New Age International Publishers. NewDelhi.
8. David T. Plummer, An Introduction to Practical Biochemistry. Tata McGraw Hill.
9. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). Lehninger principles of biochemistry. Macmillan
10. Tymoczko, J. L., Berg, J. M., &Stryer, L. (2011). Biochemistry: a short course. Macmillan.
11. Voet, D., & Voet, J. G. (2016). Fundamentals of Biochemistry. 5th Edition. Wiley & Sons.

24-811-0202- GENERAL MICROBIOLOGY (4C; 4L+0T+0P) (Academic Level 100)

Course Description:

General Microbiology is an introductory course that explores the fundamental principles of microbiology, focusing on the morphology, physiology, genetics, ecology, and pathogenesis of microorganisms. Students will examine the diversity of microorganisms, including bacteria, viruses, fungi, and protozoa, and their roles in various environments, human health, and biotechnology. Laboratory exercises will complement theoretical concepts, providing hands-on experience in microbiological techniques and experimentation.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1 Understand the basic characteristics and classification of microorganisms and to explore the structure and function of microbial cells	Understand
C.O. 2: Examine microbial growth and metabolism	Analyse
C.O. 3: Investigate the genetics and molecular biology of microorganisms.	Analyse
C.O. 4: Analyse the interactions between microorganisms and their environments and to study the role of microorganisms in human health and disease.	Apply
C.O. 5: To develop proficiency in microbiological techniques and laboratory skills.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	2	1					
CO3	2	2			1			
CO4	2	1	1	1				
CO5	2	1	2	1	1			

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I Introduction to Microbiology- Definition and scope of microbiology; Historical perspectives; Microbial diversity and classification. **Microbial Cell Structure and Function**- Prokaryotic and eukaryotic cell structure; Cell wall composition and function; Membrane structure and transport mechanisms; Microbial motility and appendages

MODULE II Microbial Growth and Metabolism-Growth requirements and factors affecting growth; Nutritional categories and metabolic pathways; Energy production and ATP synthesis; Microbial fermentation and respiration. **Microbial Genetics**- DNA structure and replication; Gene expression and regulation; Mutation and genetic variation; Horizontal gene transfer

MODULE III Microbial Ecology- Microbial interactions and symbiosis**;** Biogeochemical cycles and microbial roles**;** Microbial communities and ecosystems. **Environmental Microbiology**- Microbial adaptation to extreme environments; Bioremediation and microbial degradation; Microbial contributions to agriculture and industry

MODULE IV Microorganisms and Human Health- Host-microbe interactions**;** Infectious diseases and epidemiology; Immunology and host defence mechanisms**;** Microbial pathogenesis and virulence factors

MODULE V. **Microbiological Techniques**- Aseptic techniques and culture methods; Microscopic examination of microorganisms; Biochemical tests for microbial identification; Molecular techniques and genetic analysis

Suggested Practical

1. Sterile technique and media preparation
2. Microbial isolation and staining techniques
3. Microbial growth kinetics and quantification
4. Identification of unknown microorganisms
5. Molecular biology techniques (PCR, gel electrophoresis, etc.)

REFERENCES

1. Prescott's Microbiology, 10th Edition Authors: Joanne Willey, Linda Sherwood and Christopher J. Woolverton, 2016
2. Microbiology: An Introduction, 13th Edition Authors: Gerard J. Tortora, Berdell R. Funke and Christine L. Case, 2018
3. Microbiology Fundamentals: A Clinical Approach (3rd Edition) Marjorie Kelly Cowan, Heidi Smith, Jennifer Lusk, 2019
4. Ananthanarayan and Paniker's Textbook of Microbiology, (12th Edition) 2022

24-811-0203- BIOPHYSICAL CHEMISTRY (3C; 3L+0T+0P) (Academic Level 100)

Course Description: This course aims to provide an overview of some of the fundamentals of biophysics and biochemistry. The course will discuss advanced topics with an emphasis on structure, function relationships and techniques for probing the structure and dynamics of biological systems.

Course Outcome (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Describe the basic units in biological science	Understand
C.O.2: Discuss the laws of Thermodynamics and biomolecular interactions	Understand
C.O.3: Discuss the biomolecular kinetics and protein chemistry	Understand
C.O. 4: Differentiate the different types of microscopes and their working principles and elucidate different chromatographic techniques.	Analyse
C.O.5: Elucidate the mechanisms of various separation techniques in spectroscopy and their applications	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	2						
CO3	2	1						
CO4	2	1	1					

CO5	2	1	1					

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Introduction to Biophysical Chemistry- Definition and scope of biophysical chemistry**;** Interdisciplinary nature of the field**;** Historical development and key concepts. Introduction to measurements, SI units-standard units for measurement, Basic units, Derived units-volume; Mole concept; Hydrogen ion concentration. -pH. Determination of pH. Dissociation of weak acids (pKa), Buffers of blood plasma, red blood cells and tissue fluids.

MODULE II- Thermodynamics of Biomolecular Systems- Laws of thermodynamics and their application to biological systems; Thermodynamic properties of biomolecules; Gibbs free energy and its role in biochemical reactions. **Biomolecular Interactions-** Properties of covalent molecules- bond length, energy and bond angle. Hydrogen bond, inter-and intra-bio-molecular interactions.

MODULE III- Kinetics of Biomolecular Reactions-Rate laws and reaction mechanisms**;** Enzyme kinetics and catalysis**;** Transition state theory and reaction mechanisms. **Protein Folding and Stability**- Protein folding pathways and energy landscapes; Factors influencing protein stability; Chaperones and protein folding diseases

MODULE IV- Basics of microscopy: principle, working, types (light, electron microscopy) and application of microscopy in life science research; Separation techniques: **Chromatography**- basic principles, types and application; Centrifuge- Basic principle, types and applications.

MODULE V- Electrophoresis- Basic principle, types and applications; Biopolymers-Classification. polymerization process. **Spectroscopy**: Basic principles, Beer-Lamberts law, types and applications, X-ray crystallography and NMR spectroscopy, Radioisotopes-applications in life science

REFERENCE

1. Rodney F Boyer, Concepts in Biochemistry. John Wiley & Sons; 3rd Ed (2 December 2005)
2. Single Molecule Biology. (2009). Netherlands: Elsevier Science
3. McMurry, J. (2013). Fundamentals of General, Organic, and Biological Chemistry. United Kingdom: Pearson.
4. Springer Handbook of Microscopy. (2019). Germany: Springer International Publishing.
5. Roberson, R. W., Chandler, D. E. (2009). Bioimaging: current concepts in light and electron microscopy. United Kingdom: Jones and Bartlett Publishers.
6. Gel Electrophoresis. (1964). United States: Academy.
7. Pavia, D. L., Vyvyan, J. A., Lampman, G. M., Kriz, G. S. (2014). Introduction to Spectroscopy. United States: Cengage Learning.

SEMESTER III

24-811-0301- GENETICS AND MOLECULAR BIOLOGY (4C; 3L+0T+2P) (Academic Level 200)

Course Description: This course aims to provide an overview of genetics starting from the work of Mendel to the current understanding of various phenomena like recombination, transposition, sex determination and mutations. The course will help in building sound fundamental knowledge of the principles of genetics, to be used as a stepping stone for higher studies and research in this field. The course also aims to provide students with an introduction of the underlying molecular mechanisms of various biological processes in cells and organisms. The study primarily involves learning about the structure and synthesis of deoxyribose and ribose nucleic acids, the formation of proteins, and the regulation of gene expression. The course aims to develop a basic understanding of molecular biology techniques and their applications.

Course Outcomes: After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Describe the basic principles of inheritance with examples	Understand
C.O.2: Predict the inheritance pattern of heredity based on classical genetics and gene interaction analysis	Analyse
C.O. 3: Differentiate the basic structures of DNA and RNA Discuss the DNA replication machinery in prokaryotes and eukaryotes.	Understand
C.O. 4: Explain the mechanism of the flow of genetic information in prokaryotes and eukaryotes	Analyse
C.O.5: Discuss and apply the knowledge of gene regulation in Molecular biology studies in lab	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	1	1					
CO3	2	1	1	1	1			
CO4	2			1	1			
CO5	2	1	1	1	1			1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I-Mendelian Genetics- Mendelian principles, the concept of traits & alleles, monohybrid and dihybrid crosses, back cross and test cross and Mendel's success, Modified Mendelian ratios; Incomplete dominance, Recessive and Dominant epistasis, Complementary genes, Duplicate gene, Duplicate dominant genes and Inhibitory factor. Multiple Alleles- General accounts. ABO blood group in man. Rh factor. Quantitative characters- quantitative inheritance, polygenic inheritance, cytoplasmic inheritance.

MODULE II -Linkage and crossing over- Linkage and its importance, linkage and independent assortment. Complete and incomplete linkage. Crossing over – a general account, two-point and three-point test crosses. Determination of gene sequence. Interference and coincidence. Mapping of chromosomes (recombination mapping) and complementation

analysis. Conjugation, transduction and transformation. Sex determination- Sex chromosomes, the chromosomal basis of sex determination in Drosophila and humans. Pedigree analysis.

MODULE III- Introduction: history, development and scope of molecular biology. DNA as the genetic material, Griffith's experiment, Avery, Mac Leod and Mc Carty, experiment, Hershey & Chase's experiment. Structure of nucleic acids - Watson - Crick model of DNA, DNA replication in prokaryotes and eukaryotes. Semi-conservative method. Replication machinery and mechanism, enzymes involved in DNA replication. Arrangement of DNA in a chromosome- Nucleosome structure. Modification and repair of DNA. Different types of DNA and RNA.

MODULE IV- Gene Expression: One gene-one enzyme hypothesis, one gene-one polypeptide hypothesis, central dogma hypothesis, colinearity of genes and gene products. RNA: structure & types, Genetic code - features and wobble hypothesis. Contributions of Nirenberg and his associates, Khorana and his associates. Transcription of RNAs and post-transcriptional modifications & reverse transcription and PCR. Translation and post-translational modification of proteins

MODULE V- Gene regulation in prokaryotes; operon concept - Lac operon and Trp operon. Regulation of eukaryotic gene expression. Level of control of gene expression, transcriptional factors, regulation of RNA processing, mRNA translation, mRNA degradation & protein degradation control, epigenetics.

Suggested Practical

Genetics

1. Monohybrid cross and Dihybrid cross using Pea plant & Drosophila.
2. Gene interactions
3. Barr body staining from cheek cells
4. Preparation of human karyotype and study of chromosomal aberrations with respect to number, translocation, deletion, etc. from the pictures provided.

Molecular Biology

1. Genomic DNA isolation
2. PCR amplification of DNA (Demo)
3. Electrophoretic separation of Nucleic Acid/Proteins
4. Scoring of bands on RAPD Agarose gel
5. Use of restriction enzymes- Single and double digestion

REFERENCES

1. Alberts, B., Johnson, A., Walter, P., Lewis, J., Raff, M., & Roberts, K. (2008). Molecular cell biology. New York: Garland Science.
2. Lodish, H., Berk, A., Darnell, J. E., Kaiser, C. A., Krieger, M., Scott, M. P. & Matsudaira, P. (2008). Molecular cell biology. Macmillan.
3. Lewin, B., Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2014). Lewin's Genes XI. Jones & Bartlett Publishers.
5. Hardin, J., Bertoni, G. P., & Kleinsmith, L. J. (2017). Becker's World of the Cell. Pearson Higher Ed.
6. Baker, T. A., Watson, J. D., & Bell, S. P. (2003). Molecular biology of the gene. Benjamin-Cummings Publishing Company.

24-811-0302 ECOLOGY AND ENVIRONMENTAL SCIENCES (4C; 4L+0T+0P) (Academic Level 200)

Course description: This course explores the interconnectedness of living organisms with their environment and the challenges we face in maintaining a healthy planet. Through lectures, discussions, labs, and field trips the students will have a classic experience on the various concepts of ecology and environmental science.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Understanding the basic concepts of ecology and evolution	Understand
C.O. 2: Evaluate the basic components of the ecosystem	Analyse
C.O. 3: Understanding the concepts of population	Understand
C.O. 4: Analyse human impacts on the environment, including pollution, climate change, and habitat loss	Analyse
C.O. 5: Understanding the fundamentals of environmental policies and legislation	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2							
CO3	2							
CO4	2			2			1	
CO5	2				2		1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Introduction to Ecology and Environmental Science: The science of ecology and environmental science: history, key concepts, and interdisciplinary nature. Levels of ecological organization: populations, communities, ecosystems, biomes, the biosphere. Environmental ethics and sustainability principles.

MODULE II- Abiotic and biotic components of ecosystems, Energy flow through ecosystems: trophic levels, food webs, energy pyramids. Biogeochemical cycles: carbon, nitrogen, phosphorus, water. Ecological succession: primary and secondary succession.

MODULE III- Population characteristics: density, dispersion, growth patterns, Population regulation: density-dependent and density-independent factors. Life history strategies: r- and K-selection. Human population growth and its ecological consequences.

MODULE IV- Environmental pollution: types, sources, and impacts (air, water, soil), Climate change: causes, consequences, and mitigation strategies, Habitat loss and biodiversity decline, Impacts of Environmental pollution, Resource depletion and sustainable use practices.

MODULE V- Environmental policy and legislation, Renewable energy sources and energy conservation, Sustainable resource management practices, Individual actions and collective responsibility for environmental protection.

REFERENCES

1. Townsend, C. R., Begon, M., & Harper, J. L. (2008). *Essentials of ecology* (No. Ed. 3). Blackwell publishing.
2. Begon, M., Howarth, R. W., & Townsend, C. R. (2014). *Essentials of ecology*. John Wiley & Sons.
3. Rana, S. V. S. (2009). Essentials of Ecology and Environmental Science. India: Prentice-Hall Of India Pvt. Limited.
4. Hadjibiros, K. (2013). Ecology and Applied Environmental Science. United Kingdom: CRC Press.
5. Yadav, P. R., Mishra, S. R. (2004). Environmental Ecology. India: Discovery Publishing House.
6. Ecology, Environmental Science & Conservation. (2014). India: S. Chand Pvt. Limited.

24-811-0303- HUMAN DISEASES AND HEALTH CARE MANAGEMENT (3C; 3L+0T+0P) (Academic Level 200)

Course Description: This course will introduce the basic knowledge of various aspects of human diseases and the healthcare industry. It also aims to understand various factors that contribute to the occurrence of diseases and how those diseases may be treated by clinical professionals.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcomes	Cognitive Level
C.O. 1: Demonstrate a basic understanding of the mechanism of diseases, diagnosis and treatment	Understand
C.O. 2: Discuss the understanding of the pathophysiology	Understand
C.O. 3: Demonstrate the knowledge of various diseases affecting the organs	Understand
C.O.4: Discuss the importance of genetic disorders and their possible cures	Apply
C.O.5: Discuss the various aspects of public health policy and health care management	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	2						
CO2	2	1						
CO3	2	2			1			
CO4	2	1			1		1	
CO5					1		1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Epidemiology and Infectious Diseases. Overview of epidemiology, epidemiology tools, history of diseases, quantifying disease in a population, comparing disease rate, outbreaks of disease, epidemiological aspects of infections and chronic diseases of national importance.

MODULE II- Basics of Pathophysiology. Introduction to the basics of pathophysiology, altered cellular and tissue biology, cellular adaptation, atrophy, hypertrophy, hyperplasia, dysplasia, metaplasia, cell injury, immunological & inflammatory injury, manifestations of cellular injury, cell death: apoptosis, necrosis, and autophagy.

MODULE III- Pathophysiology of Organ Dysfunction and Disorders. Diseases of the nervous system, Diseases of the endocrine system, Diseases of the cardiovascular system, Diseases of the reproductive system and sexually transmitted diseases.

MODULE IV- Genetic Disorders: General introduction to human genetics and various genetic disorders, autosomal and X-linked disorders, gene mutation and chromosomal abnormalities, inborn errors of metabolism, pedigree analysis, introduction to cytogenetics and its applications.

MODULE V- Public Health Policy and Health care Management: Overview of public health policy, an overview of WHO and global health policies, an overview of Indian public health policies, Health Care Management Overview of public health care management in India and other countries.

REFERENCES

1. Pathophysiology of Disease: An Introduction to Clinical Medicine 8E. (2018). United Kingdom: McGraw-Hill Education.
2. Marya, R. K. (2006). Pathophysiology. India: CBS Publishers & Distributors.
3. Wright, A., Hastie, N. (2007). Genes and Common Diseases: Genetics in Modern Medicine. United Kingdom: Cambridge University Press.
4. Thompson, E. A. (1986). Pedigree Analysis in Human Genetics. United Kingdom: Johns Hopkins University Press.
5. Pal, G. P. (2009). Medical Genetics. India: A.I.T.B.S. Publishers.
6. Agarwal, V. K. (2009). Genetics. India: S. Chand Limited.
7. Introduction to Health Care Management. (2016). United States: Jones & Bartlett Learning.

24-811-0405 SCIENTIFIC WRITING AND COMMUNICATION IN BIOLOGY (3C; 3L+0T+0P) (Academic Level 200)

Course Description

This course is designed to equip students with the skills necessary to effectively communicate scientific concepts, research findings, and ideas within the field of biology. Through a combination of lectures, workshops, and practical exercises, students will learn how to write scientific papers, reports, and proposals, as well as how to deliver clear and engaging presentations. Emphasis will be placed on critical thinking, clarity, accuracy, and ethical considerations in scientific communication.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Understand the principles of scientific writing and communication.	Understand
C.O.2: Develop proficiency in writing various scientific documents, including research papers, lab reports, and grant proposals.	Analyse
C.O. 3: Learn how to organize and present scientific information in a clear, concise, and logical manner.	Analyse
C.O. 4: Enhance critical thinking skills through the evaluation and analysis of scientific literature.	Apply
C.O.5: Practice effective communication strategies for oral presentations and scientific discussions.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2						2	
CO3					2	2	2	2
CO4						2	1	
CO5						2	1	2

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Module I: Introduction to Scientific Writing and Communication- Overview of scientific communication; Importance of effective communication in biology; Understanding the target audience; Ethical considerations in scientific writing

Module II: **Writing Scientific Papers**- Structure and organization of scientific papers; Writing abstracts, introductions, methods, results, and discussions; Citation and referencing styles (e.g., APA, MLA); Peer review process and responding to reviewer comments

Module III: Lab Reports and Technical Writing- Guidelines for writing lab reports and technical documents**;** Writing clear and concise methods sections**;** Data presentation and interpretation**;** Incorporating figures, tables, and graphs

Module IV: Research Proposals and Grant Writing-Components of research proposals**;** Grant writing strategies and techniques**;** Understanding funding agencies and grant applications**;** Budgeting and resource allocation

Module V: Oral Presentations and Scientific Talks- Planning and organizing oral presentations**;** Effective delivery techniques and public speaking skills**;** Visual aids and slide design**;** Handling questions and engaging with the audience **Communication in the Digital Age-** Writing for online platforms and social media**;** Blogging, science communication, and outreach**;** Using multimedia tools for scientific communication**;** Digital ethics and online presence

Suggested readings

1. R. Barrass 1978. Scientists Must Write. John Wiley and Sons, New York.
2. C. S. Loban and M. Schefter 1992. Successful Lab Reports: A Manual for Science Students. Cambridge University Press.
3. V. E. McMillan 1988. Writing Papers in the Biological Sciences. St Martin's Press, NewYork.
4. J. A. Pechenik 1997. A Short Guide to Writing About Biology. Addison-Wesley Pub Co.
5. "Writing for Science: A Practical Handbook for Science, Engineering, and Technology Students" by Heather Silyn-Roberts
6. Scientific journals and articles
7. Online writing guides and resources
8. Writing workshops and tutorials

SEMESTER V

24-811-0506 INTRODUCTION TO CELL CULTURE TECHNIQUES (3C; 3L+0T+0P) (Academic Level 200)

Course Description: The Plant and Animal Cell Culture Techniques course provides students with a comprehensive understanding of the principles, methodologies, and applications of cell culture techniques in both plant and animal systems. Through lectures, laboratory demonstrations, and hands-on training, students will learn the fundamentals of establishing and maintaining plant and animal cell cultures, as well as techniques for genetic transformation, propagation, and characterization. Emphasis will be placed on mastering sterile technique, media preparation, and experimental design relevant to both plant and animal cell culture research.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcomes	Cognitive Level
C.O. 1: Understand the principles and importance of cell culture in plant and animal research.	Understand
C.O. 2: Gain proficiency in sterile technique and aseptic practices specific to plant and animal cell culture.	Apply
C.O. 3: Learn methods for establishing, maintaining, and characterizing plant and animal cell cultures.	Analyse
C.O. 4: Develop skills in genetic transformation techniques applicable to both plant and animal cells.	Analyse
C.O. 5: Explore advanced applications and recent advancements in plant and animal cell culture research.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2		1					
CO3		2	2	2				
CO4			2		1			
CO5				2	1	1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I. Introduction to Plant and Animal Cell Culture- Definition and historical context; Importance of cell culture in plant and animal research; Types of cells used in culture: Protoplasts, cell lines, primary cultures

MODULE II. **Laboratory Safety and Aseptic Technique**- Biosafety levels and laboratory regulations specific to plant and animal cultures; Sterile technique: Proper handling of plant tissues, animal cells, and culture media; Prevention and management of contamination in plant and animal cultures

MODULE III. Culture Media and Growth Conditions- Plant cell culture media: MS, B5, Woody Plant Medium; Animal cell culture media: DMEM, RPMI, MEM; Growth regulators and supplements for plant and animal cultures

MODULE IV. Plant Cell Culture Techniques-Isolation and culture of plant tissues and organs; Callus induction, organogenesis, and somatic embryogenesis; Regeneration of whole plants from cultured cells or tissues. **Animal Cell Culture Techniques**-Isolation and culture of animal cell lines and primary cultures; Sub-culturing and passaging animal cells; Cryopreservation and storage of animal cell cultures

MODULE V. Applications of Plant and Animal Cell Culture-Production of secondary metabolites in plant cultures; Recombinant protein expression in animal cell cultures; Disease modelling, drug screening, and biopharmaceutical production. **Ethical Considerations and Regulatory Compliance**-Ethical guidelines for plant and animal cell culture research; Compliance with regulations: Institutional policies, animal welfare; Case studies and discussion of ethical dilemmas

References

1. "Plant Tissue Culture: Techniques and Experiments" by Roberta H. Smith
2. "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications" by R. Ian Freshney
3. "Plant Cell Culture Protocols" edited by Robert J. Nicklin and John M. Carter
4. "Animal Cell Culture: Essential Methods" edited by John M. Davis and Jeanne L. Becker

SEMESTER VI

24-811-0604 BASIC SKILLS OF COMPUTATIONAL BIOLOGY (3C; 3L+0T+0P) (Academic Level 200)

Course description: This course introduces the fundamental concepts and practical skills required to utilize computational tools for analysing biological data. Through lectures, discussions, coding exercises, and tutorials, the students will explore how computational biology bridges the gap between biology and computer science. The course introduces students to the power of molecular visualization tools and their applications in various biological disciplines.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Understand the vast amount and diverse nature of biological data generated by high-throughput sequencing	Understand
C.O. 2: Develop basic programming skills using a scripting language	Apply
C.O. 3: Develop a problem-solving approach to analyse biological data using computational methods.	Understand
C.O. 4: Explore the role of computational tools in analysing biological structures	Analyse
C.O. 5: Interpret and visualize biological data using computational tools.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	2	2					
CO2	2			2	1			
CO3	2				2	2		
CO4					2	2	2	
CO5						2	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to computational biology: Big data in biology: Genomics, Transcriptomics, Proteomics, etc. Basic principles of computer science relevant to biology: Algorithms, data structures, data types, programming concepts. Overview of major bioinformatics databases and online resources.

MODULE II: Introduction to programming: Programming languages and types, Learning the basics of a scripting language like Python (syntax, data types, loops, functions). Working with biological data in Python: reading, manipulating, and visualizing data. Automating common tasks in data analysis using scripts.

MODULE III: Sequence analysis techniques: Introduction to the world of biological sequences, Sequence similarity searches and interpreting the data, Introduction to sequence alignments and standalone packages for sequence alignments. Sequence submission portals, gene ontology and annotations

MODULE IV: Structural proteomics: Protein folding problems, methods of sequence-based protein structure predictions, understanding protein function using sequence and structure analysis, Protein-protein interaction prediction tools and their applications

MODULE V: Data Visualization and Communication: Understand the importance of molecular visualization in biological research, Introduction to molecular visualization tools, Visualizing protein structure and function prediction methods, Online modelling servers and applications.

REFERENCES

- Harisha, S. (2013). Fundamentals of Bioinformatics. India: I.K. International Publishing House Pvt. Limited.
- Sequence Alignment: Methods, Models, Concepts, and Strategies. (2009). United Kingdom: University of California Press.
- Lesk, A. (2014). Introduction to Bioinformatics. United Kingdom: OUP Oxford.
- Hagen, H. (2007). Visualization in Medicine and Life Sciences. Germany: Springer Berlin Heidelberg.
- Introduction to Biological Data Analysis in Python. (2023). (n.p.): Stilianos Louca.
- Via, A., Rother, K., Tramontano, A. (2014). Managing Your Biological Data with Python. United Kingdom: Taylor & Francis.
- Bioinformatics, Fifth edition: Methods and Applications - Genomics, Proteomics and Drug Discovery. (2022). (n.p.): PHI Learning Pvt. Ltd.
- Tramontano, A. (2018). Introduction to Bioinformatics. United Kingdom: CRC Press.

24-811-0605- PLANT PHYSIOLOGY AND BIOCHEMISTRY (4C; 4L+0T+0P) (Academic Level 300)

Course description: The course aims at making students realize how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology. The course also highlights the importance of secondary metabolites and nitrogen fixation.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1: Describe the importance of physical theories for maintaining the physiology	Understand
C.O.2: Differentiate biodiversity based on morphology, anatomy, cell structure and biochemistry with plant functioning.	Analyse
C.O.3: Explain the significance and transportation of mineral nutrition with respect to plants.	Understand
C.O. 4: Apply the knowledge of plant hormones for crop improvement in plant biotechnology	Apply
C.O. 5: Discuss the process of photosynthesis and the rate-limiting steps	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8

CO1	3							
CO2	2	2						
CO3	2							
CO4	2		2	2	2			
CO5				1	2			

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Physiology: General Introduction on physiological processes, their significance and applications, Water relations of plants, physical aspects of absorption-imbibition, diffusion and osmosis. Water potential and osmotic potential, Plasmolysis and its significance, Mechanism of water absorption-active and passive absorption, root pressure, aquaporins. Pathway of water across root cells, Ascent of sap-vital and physical theories. Transpiration-cuticular, lenticular and stomatal. Mechanism-theories -starch sugar hypothesis, potassium - ion theory. Significance of transpiration, anti-transpirants, Guttation and its significance.

MODULE II-Mineral nutrition: Gross chemical analysis of the plant body, ash analysis, criteria for the essentiality of elements, macro and microelements, the role of essential elements and their deficiency symptoms. Culture methods-sand culture, hydroponics and aeroponics. Mechanism of mineral absorption (a) passive absorption-ion exchange and Donnan equilibrium (b) active absorption -carrier concept, Lundegardh hypothesis, Translocation of solutes: Pathway of movement, phloem transport, mechanism of transport-Munch hypothesis, protoplasmic streaming theory-activated diffusion hypothesis, electro-osmotic theory.

MODULE III- Plant movements: Tropic and nastic movements. Circadian rhythm and biological clock. Stress Physiology: Types of stress- water, temperature, salt, stresses caused by pests and pathogens and pollutants, Plant defense systems and mechanisms. Growth regulators-Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic acid-synthetic plant hormones-practical applications. Senescence and abscission. Photoperiodism. Vernalization, Dormancy.

MODULE IV- Photosynthesis, structure and function of the chloroplast, Fluorescence and phosphorescence, Red drop, Emersion effect; Two pigment systems; Mechanism of photosynthesis-Light reaction, Calvin cycle; comparative study of C3, C4 and CAM plants; photorespiration, Factors affecting photosynthesis-Law of limiting factor, Respiration Energy relation of respiration-RQ and its significance-Factors affecting respiration.

MODULE V-Secondary Metabolites and Nitrogen Fixation: Types, structure, functions, Biosynthesis of Secondary metabolites, economic importance. Plants and Nitrogen: The nitrogen cycle, Nitrogen metabolism: Source of nitrogen, Biological nitrogen fixation-symbiotic and asymbiotic. Nitrogen fixation by blue-green algae-rotation of crops. Genetics of N fixation - Nif genes and Leghaemoglobin. Biosynthesis of amino acids- reductive amination and transamination. GDH and GS/ GOGAT pathway.

REFERENCES

1. Dayananda B, 1999. Experiments in Plant Physiology. Narosa Publishing House, New Delhi.
2. Taiz L, Zeiger E, 2023. Plant Physiology and Development (7th Edn). Panima publishing Corporation, New Delhi.

3. Hopkins W G, Norman P A Huner, 2008. Introduction to plant physiology. John Wiley and sons. New York.
4. Jain J L, Sanjay Jain, Nitin Jain, 2005. Fundamentals of Biochemistry. S Chand, New Delhi.
5. Lehninger A L, 1975. Biochemistry. Lalyan publishers, Ludhiana.
6. Nelson D L, Cox M M, 1993. Principles of Biochemistry. MacMillan Publications.
7. Pandey S N, Sinha B K, 2006. Plant Physiology. Vikas Publishing House Pvt. Ltd.
8. Srivastava H S, 2005. Plant Physiology. Rastogi publications, Meerut.
9. Verma V, 2007. Textbook of Plant Physiology. Ane Books India, New Delhi.

24-811-0606 ECONOMIC BOTANY (4C, 4L+0T+0P) (Academic Level 300)

Course Description: This course explores the economic significance of plants, focusing on their uses, cultivation, conservation, and commercial applications. Through theoretical knowledge and practical examples, students will gain insights into the historical, cultural, and contemporary aspects of economic botany, with an emphasis on sustainable utilization and management of plant resources.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1: Understand the historical development and theoretical foundations of economic botany.	Understand
C.O.2: Identify and classify economically important plant species and their products and explore the cultural, social, and economic significance of plants in human societies.	Analyse
C.O.3: Examine the principles and practices of plant cultivation, breeding, and domestication for economic purposes and analyse the impact of human activities on plant biodiversity and conservation strategies.	Analyse
C.O. 4: Evaluate the role of plants in providing food, medicine, fibres, dyes, and other commercial products.	Apply
C.O. 5: Develop an understanding of sustainable practices in plant resource management and utilization and apply economic botany principles to real-world scenarios and case studies.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2							
CO3	2							
CO4		2	1					
CO5							1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: **Origin of Cultivated Plants**-Concept of Centres of Origin, their importance with reference to Vavilov's work examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.

MODULE II: **Cereals-** Wheat and Rice (origin, morphology, processing & uses), a brief account of millets. **Legumes-** General account, importance to man and ecosystem. **Sugars & Starches**- Morphology and processing of sugarcane, products and by-products of the sugarcane industry. Potato – morphology, propagation & uses.

MODULE III- **Spices**- Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper. **Beverages**- Tea, Coffee (morphology, processing & uses). **Oils & Fats**- General description, classification, extraction, their uses and health implications groundnut, coconut, linseed and Brassica and Coconut (Botanical name, family & uses)

MODULE IV- **Essential Oils**- General account, extraction methods, comparison with fatty oils & their uses. **Natural Rubber**- Para-rubber: tapping, processing and uses. **Drug-yielding plants**- Therapeutic and habit-forming drugs with special reference to Cinchona, Digitalis, Papaver and Cannabis.

MODULE V- **Tobacco**- Tobacco (Morphology, processing, uses and health hazards). **Timber plants**- General account with special reference to teak and pine. **Fibres** Classification based on the origin of fibres, Cotton and Jute (morphology, extraction and uses)

REFERENCES

1. Economic Botany- A comprehensive study by S L Kochhar, Fifth Edition(2016), Cambridge University Press, UK
2. A Text Book of Economic Botany by V Verma, (2009)Anne Books Pvt Ltd, New Delhi
3. Economic Botany: Principles and Practices by G.E. Wickens (2012) Kluwer Academic Publishers, New York

24-811-0607 MEDICINAL BOTANY (4C, 4L+0T+0P) (Academic Level 300)

Course Description: This course explores the medicinal properties of plants, focusing on their botanical sources, active constituents, pharmacological actions, and therapeutic applications. Through lectures, laboratory demonstrations, and fieldwork, students will gain insights into the diverse range of medicinal plants, their traditional uses, modern pharmacology, and implications for healthcare and drug discovery.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1: Understand the chemical composition and pharmacological properties of medicinal plants.	Understand
C.O.2: Explore traditional and contemporary uses of medicinal plants in healthcare systems worldwide.	Understand
C.O.3: Analyse the role of medicinal botany in drug discovery, pharmaceutical industry, and alternative medicine.	Analyse
C.O. 4: Develop practical skills in the collection, identification, processing, and preparation of medicinal plants.	Apply
C.O. 5: Appreciate the cultural, historical, and ethical dimensions of medicinal botany and herbal medicine.	Understand/Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	3							
CO3	2	2		1				
CO4			2	1	1			
CO5					2	2	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: **Introduction to Medicinal Botany**- Definition and scope of medicinal botany. Historical perspectives on medicinal plants and herbal medicine. Importance of medicinal plants in traditional and modern healthcare systems

MODULE II: **Botanical Sources of Medicinal Plants**- Classification and identification of medicinal plant families and species. Plant parts used in herbal medicine: roots, leaves, flowers, seeds, and fruits. Botanical gardens and herbaria: resources for studying medicinal plants

MODULE III: **Phytochemistry of Medicinal Plants**- Secondary metabolites in plants: alkaloids, glycosides, terpenoids, and phenolics. Chemical composition and bioactive compounds in medicinal plants. Methods of extraction, isolation, and characterization of plant constituents**. Pharmacology of Medicinal Plants-** Pharmacokinetics and pharmacodynamics of herbal remedies**.** Mechanisms of action and therapeutic effects of medicinal plants**.** Safety, toxicity, and adverse effects of herbal products

MODULE IV: **Traditional Medicine Systems**- Traditional healing practices and indigenous medicine systems. Ayurveda, Traditional Chinese Medicine (TCM), Unani, and other traditional systems. Ethnobotanical studies and documentation of traditional knowledge. **Plant Conservation and Sustainable Harvesting-** Conservation status of medicinal plants: threats and conservation strategies**.** Sustainable harvesting practices and cultivation of medicinal crops**.** Certification schemes and ethical sourcing of medicinal plants

MODULE V: **Therapeutic Applications of Medicinal Plants**. Herbal remedies for common ailments: digestive disorders, respiratory infections, skin conditions, etc. Phyto-therapy in chronic diseases: cardiovascular disorders, diabetes, cancer, etc. Herbal preparations: decoctions, infusions, tinctures, extracts, and essential oils. **Modern Applications and Research in Medicinal Botany.** Role of medicinal plants in drug discovery and development Pharmaceutical industry and herbal medicine: challenges and opportunities Clinical trials and evidence-based medicine in herbal therapeutics

REFERENCES

1. Medicinal Plants: Properties, Uses and Production (2021) D. K. Semwal
2. Medical Botany: Plants Affecting Human Health by Memory P. F. Elvin-Lewis; Walter H. Lewis.
3. A Handbook of MEDICINAL PLANTS - A Complete Source Book (2012) edited by Prajapati, Sharma, Kumar, Purohit
4. Relevant research and review articles

24-811-0608- HUMAN PHYSIOLOGY AND ENDOCRINOLOGY (4C; 4L+0T+0P) (Academic Level 300)

Course description: The students will be introduced to the principles of normal biological function in the human body. Basic human physiology will be outlined and correlated with

histological structures. The course also provides students with a basic understanding of human endocrine glands, neuro-endocrine glands and their structure, function and signalling pathways. Students will also study the influence of biological rhythm on hormone secretion.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1. Explain the principles of normal biological function in the human body.	Understand
C.O.2. Compare histological structures with their function	Analyze
C.O.3. Discuss how animals maintain an internal homeostatic state in response to changes in their external environment.	Understand
C.O. 4. Describe the endocrine system and the basic properties of hormones.	Understand
C.O. 5. Gain insight into the molecular mechanism of hormone action and its regulation.	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	3	2						
CO3	2							
CO4	2							
CO5	2							

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Nutritional physiology: Structure and digestive system: General introduction, types of nutrition, mechanical and chemical changes of food in the alimentary canal, balanced diet, nutritional disorders-PEM, vitamin and mineral deficiency, hormonal control of digestion Circulatory physiology: Structure of heart, Blood composition and functions of blood plasma and formed elements, blood groups, mechanism of blood clotting, intrinsic and extrinsic pathways, disorders of blood clotting, anticoagulants, heartbeat, conducting system and pacemaker, pulse and blood pressure, clinical significance, control of cardiac activity, common cardiovascular diseases-arteriosclerosis, atherosclerosis, myocardial infarction, electrocardiogram, angiogram, angioplasty, Lymph and lymphatic system.

MODULE II- Respiratory physiology: Structure of lungs. Gas exchange, respiratory pigments-structure of haemoglobin, transport of oxygen-Oxyhaemoglobin curve, Bohn effect, transport of CO_2-carbonic acid, carbamino haemoglobin, bicarbonate and chloride shift, carbon monoxide poisoning, bronchitis, asthma, physiological effects of smoking, fibrosis
Renal Physiology: Structure of kidney. Nephron-structure, urine formation, counter current multiplier system, the role of the kidney in osmoregulation, renal disorders-nephritis, haematuria, renal calculi, acidosis, and alkalosis-, fibrosis, Dialysis and kidney transplantation

MODULE III- Muscle Physiology: Brief account of types of muscles, fast and slow twitch muscles, red and white muscles, the ultrastructure of striated muscle fibre, muscle proteins, simple muscle twitch, summation, tetanus, tonus, ALL or None Law, fatigue, oxygen belt, rigor mortis, physiological and biochemical events in muscle contraction.

Sensory physiology: Structure of eye and ear. Physiology of vision, visual elements and pigments, photochemistry of vision. Eye defects-myopia, hyperopia, presbyopia, astigmatism, cataract. Structure of ear and mechanism of hearing, hearing impairments-deafness, labyrinthine disease. olfactory, gustatory and tactile sense organs.

MODULE IV-Nerve Physiology: Structure of brain, Neurons-structure, types of neuron. Synapse and types of synapse, nerve impulse propagation, synaptic transmission. Reflex action, refractory period, neurotransmitters, electro encephalogram. Nerve disorders- epilepsy, Alzheimer's disease, Parkinson's disease

MODULE V- Endocrinology: Definition, classification and characteristics of chemical messengers (hormones, neurohormones, neurotransmitters, cytokines, pheromones), Hormone delivery: Endocrine, paracrine and autocrine modes, Hormone feedback mechanisms, Structure and functions of: Pituitary, Thyroid, Parathyroid, Adrenal, Endocrine pancreas, Testis, Ovary, Endocrine glands in insects, Pars Intercerebralis-corpus cardiacum-corpus allatum complex, Prothoracic glands, endocrine disorders.

REFERENCES

1. Best and Taylor. (1990). Physiological basis of Medical Practice. Wilkins Co.
2. Eckert, R. and D. Randell. (1987). Animal Physiology, CBS Publishers and Distributors N. Delhi.
3. Ganong, W.F. (2003), Review of Medical Physiology, McGraw Hill, New Delhi.
4. Guyton, A.C. (1981). Textbook of Medical Physiology, W.B. Saunders Co.
5. Hoar, W.S.(1975). General and Comparative Physiology, Prentice-Hall.
6. Mac. Eleroy, W.D. (1971). Cell Physiology and Biochemistry. Prentice-Hall of India Ltd.
7. Nagabhushanan, R., Kaobarkar M.S. and Sarojini, R. (1983). A textbook of animal physiology, Oxford IBH Publishing Co., New Delhi.
8. Prosser, C.L. (1978). Comparative animal physiology. W.B. Saunders Co.
9. Rama Rao, V., First aid in accidents, Srikrishnan Brothers, Thambuchetty Street, Madras.
10. Schmidt-Nielson K. (2002). Animal Physiology, Prentice Hall India Ltd.
11. Sebastian, M.M. Animal Physiology. Dona Publications, Changanacherry.
12. Norris: Vertebrate Endocrinology, Fourth Edition, 2007, Academic Press

24-811-0609- ECONOMIC ZOOLOGY (4C; 4L+0T+0P) (Academic Level 300)

Course Description: This course explores the economic significance of animals in various aspects of human life, including agriculture, medicine, industry, and conservation. Students will examine the role of animals in providing food, fibre, and other resources, as well as their impact on human health, the economy, and the environment.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1. Understand the economic importance of animals in agriculture, medicine, industry, and conservation.	Understand
C.O.2. Identify different animal species and their contributions to human society.	Apply

C.O.3. Analyze the impact of human activities on animal populations and ecosystems.	Analyze
C.O. 4. Explore strategies for sustainable management and conservation of economically valuable species, especially by addressing the local needs	Apply
C.O. 5. Ability for self-employment through pisciculture, diary, silk worm and poultry	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2							
CO3	2						1	
CO4							1	1
CO5						2	1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Insect pests and their economic importance: Common Pests of paddy, Sugarcane, Tea, vegetables and Fruits (Distribution, food plants, life-history, damage caused, prevention and control measures of the Insect pests to be dealt with)

MODULE II: Apiculture: Introduction, species of honey bees, social organisation and life history of honey bees; selection of bees for apiculture, methods of bee keeping (indigenous and modern methods), products of bee keeping (honey and bee wax), bee keeping as an industry.

MODULE III: **Fish and Fisheries**: Culture fisheries: - Introduction to fish culture, types of cultivable species. Freshwater fish culture technique and management of fish culture farm, harvesting and marketing. Capture fisheries: - Commercially important fisheries of Kerala. Fishing tools-crafts and gears. Preservation and processing of fish and fisheries.

MODULE IV: **Poultry**: Introduction, habitat of fowl: food and feeding of fowls- breeds of fowls (indigenous and exotic breeds); eggs and hatching, rearing of chickens; poultry products (eggs and meat); by-products of poultry. **Dairy industry**: Introduction- breeds of dairy animals (cow, buffalo, goat); Milk: processing of milk, marketing and distribution of milk, milk products (Curd, cream, Butter, Ghee, khoya, cheese).

MODULE V: **Sericulture**: Origin and history of the Sericulture Industry in India with special reference to Kerala. Introduction to different silkworms with special reference to Kerala and a brief account of their food plants. Different species of silkworm, their habit and habitat. Types of Cocoon and silk produced by them.

REFERENCES

1. Yadav Manju (2003). Economic Zoology, Discovery Publishing House.
2. Shukla and Upadhyaya (2014). Applied And Economic Zoology, Rastogi Publishers
3. Jabde Pradip V (2005). Textbook of applied Zoology, Discovery Publishing House, New Delhi. Suggested Readings
4. Ahsan Jawaid, Sinha Prasad S. (2000). A handbook on Economic Zoology. S. Chand and Co.

24-811-0610 ANIMAL FORMS AND FUNCTIONS (4C; 4L+0T+0P)
(Academic Level 300)

Course Description: This course aims to provide a thorough knowledge of structural details and a comparative account of the different organ systems of the body from lower to higher vertebrates, and proto-chordate, thus enabling them to appreciate the incredible vertebrate diversity. It helps students propose possible homology between structures and understand how they evolved as the vertebrates dwelled in different habitats. The structural modifications of the digestive, circulatory, respiratory, and skeletal systems relate to the distribution of animals in their different comfort zones of habitat and ecological niches.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Explain a comparative account of the different vertebrate systems	Understand
C.O. 2: Discuss the structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates; and the digestive system and its anatomical specializations concerning different diets and feeding habits.	Understand
C.O.3: Describe the evolution of the heart, modification in aortic arches	Understand
C.O. 4: Discuss the evolution of the brain, sense organs and excretory organs to a complex, highly evolved form in mammals	Understand
C.O.5: Analyse the structure and functions relationship of animals which furnish with survival advantages in a habitat	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2							
CO3	2							
CO4	2							
CO5	2							

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I
Modes of Feeding and Digestion: Feeding mechanisms: suspension, deposit, cropping and sucking (herbivorous) and raptorial (carnivorous), Intracellular and extracellular digestion: food vacuole and gastrovascular cavity, Types of excretion and Mode of Excretion Open tubular: metanephridia, Closed saccular: protonephridia, Malpighian tubules and kidney.

MODULE II
Respiratory Organs, Structure and function of gills, trachea, book lungs and vertebrate lungs.

MODULE III
Circulatory systems: Pattern of circulation in non-chordates and chordates, hemocoel, open and closed circulatory systems, the difference in chambers, evolutionary significance.

MODULE IV

Nervous system: Patterns of the nervous system in non-chordates, Organization of the nervous system in vertebrates: central and autonomic system, Receptors and sense organs, Phonoreception in fish and mammals, Photoreception in insects and mammals

MODULE V

Reproduction Types of asexual reproduction: fission, regeneration and parthenogenesis, Sexual reproduction: primary and accessory sex organs and their function

REFERENCES

1. Miller and Harley: Zoology (6th ed. 2005, W.C. Brown)
2. Nigam: Biology of Non-chordates (1997, S Chand)
3. Nigam: Biology of Chordates (1997, S Chand)
4. Parker and Haswell: Textbook of Zoology, Vol. II (2005, Macmillan)
7. Purves et al: Life-the Science of Biology, (7th ed. 2004, Sinauer)
8. Tortora and Anagnostakos: Principles of Anatomy and Physiology (6th ed. 1986, Harper and Row).
9. Schmidt Nielson: Animal Physiology (5th ed. 2005, Cambridge)

SEMESTER VII

24-811-0701- BIOCHEMISTRY (4C; 4L+0T+0P) (Academic Level 300)

Course Description: This course aims to enrich the understanding of the fundamental principles and properties, classification, structure and function significance of biomolecules with a special focus given to enzyme catalysis, kinetics and applications. The course provides application-oriented insights on biochemical techniques involved in characterization, activity studies, structure prediction, and validation of physical, chemical and biological properties of biomolecules. The course covers the methodology and instrumentation aspects of a clinical biochemistry lab. Also introduces the concepts of glycobiology, proteomics and the emerging fields of glycomics and lipidomics.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Understanding the fundamentals of biochemistry	Analyse
C.O. 2: Examine the chemistry of various biomolecules and apply the techniques to identify/purify/predict the structure/synthesise carbohydrates, lipids and their derivatives	Analyse
C.O. 3: Examine the chemical properties and interpret the quantity of various biomolecules and apply the techniques to identify/purify/predict the structure/synthesise proteins and nucleic acids	Analyse
C.O. 4: Investigate the general properties of enzymes using various methods, apply enzyme kinetics to study the nature of enzymes and inhibitors in terms of Km and Vmax Compare the affinity of Enzymes to substrates in terms of Km	Analyse
C.O. 5: Apply the techniques and handle the equipment used in the clinical diagnosis of diseases, Based on theoretical knowledge, set up the working model of a clinical biochemistry lab by a flow chart	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	1						
CO3	2	2	1					
CO4			2	1	1			
CO5				1	1	1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Chemical foundations of life: Overview of weak interactions in aqueous systems, Organic reaction mechanisms (Group-transfer reactions, oxidation and reductions, coupled reactions, Elimination, Isomerization and rearrangements), Thermodynamics of phosphate compounds (Phosphoryl-transfer reactions, High energy compounds and Biological energy transducers (ATP, NADH, NADPH, FADH, CoASH), ATP cycle, structural basis of free energy change during hydrolysis of ATP, High Energy phosphate compounds, Nernst equation and Redox-potentials. Thermodynamics principles in biology and energetics.

MODULE II: Glycobiology and Lipid Biology: Basic structure and reactions and classifications of carbohydrates and lipids, Carbohydrates and lipids as an energy sources, matter and information molecules. Glycoconjugates and their significance, Glycolipids, Carbohydrate based biomaterials and their applications. Techniques of extraction, separation and structure prediction, applications in biomedical sciences, glycomics and lipidomics.

MODULE III: Proteins and Nucleic acids: Chemical, Biological and Physical properties of Protein and nucleotides and types and classification, Structural organization of proteins, Ramachandran Plot, Globular and fibrous proteins, techniques involved in separation, purification, and sequencing and synthesis of peptides/proteins and techniques involved in structure prediction, Proteomics, Protein-ligand interactions and applications in drug development, Structure-activity relationships, and nucleotides as energy and information molecules.

MODULE IV: Enzymes: Examples of Enzymatic reactions, chymotrypsin, hexokinase, enolase etc. Reaction rates and Equilibria, Reaction coordinate diagram, Enzyme substrate complex, mechanisms of catalysis. Enzyme kinetics, Michaelis-Menton Equation, Line weaver burk plots and other representations, enzyme inhibition and allosteric enzymes and bisubstrate reactions. Applications of enzymes, enzyme significance of isozymes in disease diagnosis, enzymes as therapeutic targets and the scope of enzyme engineering.

MODULE V: Clinical Biochemistry- Definition and scope of clinical biochemistry in diagnosis, analyses, collection and preservation of biological fluids (blood, urine & CSF), normal values, reagents for analysis, Requirements of setting up of clinical laboratory, collection preparation, preservation, and handling of clinical samples, quality control, Safety measures in clinical laboratory and practices, common techniques and equipment used in clinical diagnosis of communicable and non-communicable diseases.

REFERENCES

1. Lehninger, A. L., Nelson, David L., Cox, Michael M. (2013).Principles of Biochemistry.6th revised edition
2. Biocatalysis: Biochemical Fundamentals and Applications .2nd reprint Edition. Imperial College Press.
3. Combs Jr, G. F., & McClung, J. P. (2016). The vitamins: fundamental aspects in nutrition and health. Academic press.
4. Lurton, R. (2010).Clinical Biochemistry.2nd Edition. Viva books.
5. White, Abraham. (2004).Principles of Biochemistry.6th edition. Tata Mcgraw-Hill.
6. Cooper T.G. (2015). Tools of Biochemistry.2nd edition, Wiley-Interscience 11. Sadasivam S. and Manickam A.(2009).
7. Biochemical Methods, 2ndedn.New Age International Ltd Publishers.
8. Mu, P., & Plummer, D. T. (1988). Introduction to practical biochemistry. Tata McGraw-Hill Education.
9. Jayaraman J.(1992).Laboratory manual in Biochemistry.John Wiley
10. Enzymes: biochemistry, biotechnology, clinical chemistry. Elsevier. 5. Chaplin, M.F. Buke, C.(1990). Enzyme technology.Cambridge University Press. 6. Grundwald, D. Peter. (2016).
11. Biocatalysis: Biochemical Fundamental and Applications.2nd reprint Edition. Imperial College Press 7. Grunwald, P. (2009).
12. Biocatalysis: biochemical fundamentals and applications. Imperial College Press.

SEMESTER VIII

BSc HONORS WITH RESEARCH

24-811-0801 MOOC1 (4C; 4L+0T+0P) (Academic Level 300)

BSc HONORS

24-811-0801- CELLULAR METABOLISM (4C; 3L+0T+2P) (Academic Level 300)

Course Description: This advanced course in biochemistry includes the study of metabolic pathways, energetics, regulation of carbohydrates, amino acids, fatty acids, nucleic acids as well as Electron transport chain and Photosynthesis. In addition, the course offers a deep understanding of analysing the energetics of metabolic pathways, interpretation of metabolic syndromes and disorders at clinical point of view, basic concepts to develop diagnostic protocols and therapeutic strategies against metabolic errors. Also provides insights in to predicting metabolic pathways and hub proteins with respect to disease pathogenesis, identification and validation of metabolites as biomarkers.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Compare and contrast biosynthetic and catabolic pathways of carbohydrates based on enzymes involved, intermediates and their regulation Interpret the energetics of carbohydrate metabolic pathways. Interpret the metabolic disorders of carbohydrates and examine how they can be diagnosed clinically	Apply
C.O. 2: Understanding basic metabolic pathways of Lipids and their conjugates Examine the energetics of lipid metabolic pathways. Develop the protocols to interpret the metabolic disorders of lipids and examine how they can be diagnosed clinically	Analyze
C.O. 3: Understanding basic metabolic pathways of Purine and Pyrimidines. Examine the energetics of purine and pyrimidine metabolic pathways. Develop the protocols to interpret the metabolic disorders of purine and pyrimidine and examine how they can be diagnosed clinically.	Analyse
C.O. 4: Understanding basic metabolic pathways of amino acids and proteins. Examine the energetics of protein metabolic pathways. Develop the protocols to Interpret the metabolic disorders of amino acids and proteins and examine how they can be diagnosed clinically.	Analyse
C.O. 5: Interpret metabolic pathways based on proteomics data, Design metabolomic models/protocols to explore novel biomarkers, therapeutic targets and development of therapeutics and diagnostics strategies	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8

CO1	2	2						
CO2	2	1	2					
CO3		2	2	2				
CO4	2	1						
CO5		2	1			1	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Overview of carbohydrate metabolism, basic concepts, Glycolysis, Krebs cycle, Electron Transport chain, Photosynthesis, aerobic and anaerobic respiration, ATP synthesis, Energetics, Pentose phosphate pathway, Gluconeogenesis, Glycogenesis, Glycogenolysis, Regulation of carbohydrate metabolism. Inborn errors of carbohydrate metabolism and diagnosis, Galactosemia and Glycogen storage diseases, Metabolic syndrome and life style diseases, Diabetes and Lactose intolerance

MODULE II: Lipid metabolism: Biosynthesis and degradation and regulation fatty acids metabolic pathways, Ketone bodies: formation and utilization. Biosynthesis and degradation and regulation of cholesterol, Eicosanoids biosynthesis, Disorders of Lipids:Clinical features and laboratory findings in disorders of triglyceride, lipoprotein and cholesterol metabolism, lipoprotein and apolipoprotein metabolism; HDL, LDL, VLDL, apoA, apoB, apoC, apoE and their receptors. Fat absorption, transport, storage and metabolism, Investigation and principles of treatment of hyperlipidemia, Inbpre errors of lipid metabolism, lipid storage diseases and diagnosis.

MODULE III: Nucleic Acid metabolism: Biosynthesis and degradation of purines and pyrimidines, regulation of purines and pyrimidines biosynthesis. Biosynthesis of ribonucleotides and deoxyribonucleotides. Uric acid overproduction and underexcretion; pathology and differential diagnosis of gout, treatment of gout, Enzyme disorders of nucleotide metabolism (Lesh-Nyhan syndrome and Orotic acid urea, diagnosis and treatment

MODULE IV: Amino acid metabolism and disorders: Protein degradation and turn over, Amino acid synthesis, Catabolism of amino acid nitrogen - transamination, deamination, ammonia formation; urea cycle, regulation and disorders of amino acid metabolism. Clinical features and laboratory findings in disorders of amino acid protein metabolism, protein misfolding and associated clinical pathogenesis, prion proteins and relevance in neurodegenerative diseases.

MODULE V: Metabolomics and application: Pathway analysis and enrichment by *in-silico* prediction and experimental validation, Networks and interactions between metabolites, pharmaceuticals, SNPs and Proteins, techniques of Metabolic profiling and fingerprinting and their applications, diagnosis of metabolic genetic diseases and syndrome, metabolite target analysis, metabolic applications within animals, plants and microbes, transcriptomics and proteomics in system biology and synthetic biology.

Suggested Practical

1. Estimation of carbohydrates (Sugars), proteins, cholesterol and triglycerides and nucleic acids by spectroscopic analysis

2. Basic metabolic panel: Clinical biochemical tests for glucose, calcium, electrolytes and Liver function and Kidney function test
3. Chromatographic Techniques to study metabolic intermediates
4. Fluorescence spectroscopy to study ligand-protein interaction
5. Proteomics Data analysis, *In-silico* prediction of metabolic pathways, hub proteins,
6. In silico system biology model development, development of metabolic prediction models.

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2. Stryer, Lubertet al., (2015).Biochemistry.8thedition.W.H. Freeman and Co.
3. Lehninger, A. L., Nelson, David L., Cox, Michael M. (2013).4.Principles of Biochemistry.6th revised edition. Freeman and Co.
4. Devlin, Thomas. M. (2010). Text book of Biochemistry with Clinical Correlations- 7th edition. John Wiley & Sons.
5. Harper's illustrated biochemistry (2015) Peter J. Kennelly, Kathleen M. Botham, Owen P. McGuinness, Victor W. Rodwell, P. Anthony Weil
6. Metabolomics: Methods and Protocols, Weckwerth, Wolfram (2014)
7. Metabolomics: A powerful tool in systems Biology (2007) Jens Nielsen, Michael C. Jewett

24-811-0804- CRITICAL ANALYSIS OF CLASSICAL PAPERS (2C; 2L+0T+0P) (Academic Level 400)

Course Description:

This course aims to equip students with essential skills in effectively communicating scientific concepts and critically analysing research literature. Through interactive lectures and paper presentations, the students will learn how to articulate complex ideas with clarity and precision, while also improving their ability to evaluate the validity, reliability, and significance of research findings. Each week, two-hours will be dedicated to this course, during which each student is given the opportunity to present a research paper of their interest and follow it up with a group discussion with their classmates and teachers. By the end of the course, students will have developed the proficiency to craft well-structured scientific reports, deliver compelling presentations, and engage in insightful discussions on contemporary scientific issues, thus empowering them to excel in both academic and professional settings.

Course Outcomes (CO) After completing the course, the student will be able to:

Course Outcome		Cognitive Level
C.O.1.	Appreciate the path-breaking work published in research papers	Understand
C.O.2.	Apply data analysis tools and logical reasoning in the in-depth study and critical analysis of primary literature data	Apply
C.O.3.	Generate hypothesis from primary literature and anecdotal data	Analyse
C.O.4.	Ability to effectively summarize a compendium of research work or information	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	1				1	1	
CO3				2	1			
CO4							1	2

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Source of Scientific Information: Journals (current and back volumes): Indexing journals, abstracting journals, research journals, review journals, e-journals; Impact factor; NCBI-Pub Med., Data Bank and Data Mining; INFLIBNET, INSDOC.

MODULE II: Scientific communication - Writing: Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

MODULE III: Student presentations

Guidelines for selecting research papers for presentation:

1. Impact factor: Research papers selected for presentation should have an Impact Factor exceeding 5, ensuring the inclusion of high-quality, influential studies that have made significant contributions to their respective fields.
2. Citation metrics: Preference should be given to papers with a substantial number of citations, indicating widespread recognition and influence within the scientific community. Papers demonstrating robust citation metrics serve as reliable indicators of their importance and relevance in the field.
3. Relevance and timeliness: Papers should be selected based on their relevance to current research trends and emerging topics within the discipline. Emphasis should be placed on choosing papers that address timely issues and contribute to advancing knowledge in key areas of interest.
4. Rigorous peer review: Papers undergoing rigorous peer review processes, preferably from reputable publishers/journals (Springer, John Wiley & Sons, Taylor & Francis, Elsevier etc), with stringent editorial standards, should be prioritized. This ensures the integrity and reliability of the research findings presented, enhancing the credibility of the selected papers.
5. Contribution to advancing knowledge: Selected papers should represent significant advancements or breakthroughs in their respective fields, offering novel insights, innovative methodologies, or transformative outcomes that contribute to the advancement of scientific knowledge and understanding.

General guidelines for paper presentation:

1. A total duration of 40 minutes, with an additional 20 minutes designated for interactive discussion, is allocated for each student presentation.
2. Adherence to the assigned time limit is strongly encouraged to ensure effective time management during the presentation session.

3. The presenting student is required to submit a concise summary (1-2 pages) of the research paper of their choice one-day prior to their presentation.
4. Other students in the batch are required to submit their summaries within two days following the presentation.
5. Students are urged to utilize the subsequent assessment criteria as a reference while preparing for their presentations, as they will be evaluated based on the following marking pattern.

Criteria	**Maximum Marks**
The Standard and Quality of the paper selected	20
Presentation, Delivery, and Time management	30
Subject Knowledge/ Answering Questions	20
Summary writing	10
Overall quality	20
Total	100

24-811-0805- ANALYTICAL TECHNIQUES (4C; 4L+0T+0P) (Academic Level 400)

Course Description: Analytical Techniques in Biological Sciences is designed to provide students with a comprehensive understanding of the various analytical methods and instruments used in the field of biology. The course will cover theoretical principles, practical applications, and hands-on experience with a variety of techniques commonly employed in biological research. Emphasis will be placed on the critical evaluation of data and the selection of appropriate analytical methods for specific biological questions.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	**Cognitive Level**
C.O. 1: Introduce students to the fundamental principles underlying analytical techniques in biological sciences.	Understand
C.O. 2: Familiarize students with a range of analytical methods used for the study of biological systems.	Understand
C.O. 3: Provide students with practical skills in using laboratory instruments and equipment for biological analysis.	Remember and Apply
C.O. 4: Develop students' ability to interpret and critically evaluate data obtained from analytical techniques.	Apply
C.O. 5: Enable students to design experiments and select appropriate analytical methods for specific research questions in biology.	Analyse

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2	2							
CO3	2	2	1					
CO4		2	1					

CO5			2	1	1	1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to Analytical Techniques in Biology- Overview of analytical methods. Importance of analytical techniques in biological research. **Spectroscopic Techniques**- UV-Visible Spectroscopy, Fluorescence Spectroscopy, Infrared Spectroscopy Nuclear Magnetic Resonance (NMR) Spectroscopy, FTIR, Raman Spectroscopy. Principles of Mass Spectrometry

MODULE II: Chromatographic Techniques- Planar chromatography: Paper and Thin-layer chromatography Gas Chromatography (GC), Liquid Chromatography (LC), High-Performance Liquid Chromatography (HPLC), Thin-Layer Chromatography (TLC). **Molecular Techniques**: Types of PCR: multiplex, nested; reverse-transcription PCR, real-time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, ARMS; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; microarray: 16S rRNA typing; EST; SAGE; Blotting techniques - Southern, Northern

MODULE III: Electrophoretic Techniques- General principles, electrophoresis of nucleic acids: Agarose, pulse-field and sequencing gels, Capillary electrophoresis, Single-molecule electrophoresis. Electrophoresis of proteins: SDS-PAGE, native gels, gradient gels, isoelectric focusing, two-dimensional gels, gel-free protein electrophoresis

MODULE IV: Microscopic Techniques-Light microscopy; lenses and microscopes, refractive index, magnification, resolution: Rayleigh's Approach, Dark-field; Phase Contrast, Differential Interference Contrast; Fluorescence microscopy; Confocal microscopy; Electron microscopy: TEM and SEM. Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM), Atomic Force Microscopy (AFM).

MODULE V: Centrifugation: Basic principles of sedimentation, Types of centrifuges: Micro centrifuge, High speed & Ultracentrifuges; Types of rotors, Preparative and analytical ultracentrifugation methods; preparative centrifugation; differential and density gradient centrifugation; analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

REFERENCES

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3. Chang R (1971). Basic principles of spectroscopy. McGraw
4. Stanford J R (1975). Foundation of Biophysics. Academic Press.
5. Henry B Bull (1971). An Introduction to physical biochemistry. F A Devis Co.
6. Michael M Cox and David N Nelson: Principles of Biochemistry
7. Donald L Pavia (2015) Introduction to Spectroscopy. Congregate Learning India Pvt.Ltd.
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10. Marimuthu R. 2011n Microscopy and Microtechnique. MJP Publishers

11. Prakash S. Bisen and Anjana Sharma. Introduction to instrumentation in life sciences. Publishers-Taylor and Francis Ltd. CRC press
12. Sivasankar B. Bio-separations; Principles and Techniques. Publisher: PHI Learning Pvt. Ltd

24-811-0806- CANCER BIOLOGY (4C; 4L+0T+0P) (Academic Level 400)

Course Description: This course aims to provide an inclusive outline of the biology and pathology of cancer by exploring the role of mutations, and dysregulated signalling pathways in cell survival, apoptosis, cell cycle regulation, angiogenesis, metastasis and cancer stemness. The course enriches the basic principles of diagnostics and therapeutic strategies for cancers. In addition, it fosters a deeper insight into techniques to unravel the mechanisms of cancer evolution.

Course Outcomes (CO): After completing the course student will be able to

Course outcomes		**Cognitive level**
C.O.1	Understanding the fundamentals of carcinogenesis	Understand
C.O.2	Understand the basic principles of genetics and epigenetic changes associated with carcinogenesis and demonstrate the methods to identify genetic and epigenetic changes	Understand
C.O.3	Examine intricate signalling events associated with cancer to interpret receptors, oncogenes and enzymes for developing therapeutics.	Analyse
C.O.4	Investigate the role of various mutations/oncogenes/proteins in determining the angiogenic/metastatic and stemness potential of cancer	Analyse
C.O.5	Apply the techniques to evaluate and identify novel biomarkers and therapeutic targets	Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2	2							
CO3	2							
CO4	2		2	1	1			
CO5			2		1		1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to cancer, types, etiology and incidence; Causes of Cancer, Types of carcinogens: Chemical, Physical and Biological, cancer as a genetic disease, tumour viruses, Oncogenes and tumour suppressor genes, Oncogenesis, immune evasion mechanisms, Clonal evolution, Stages of carcinogenesis and signalling.

MODULE II: Genetics and Epigenetics aspects of Carcinogenesis - Defects in DNA repair and their link to cancer; Driver and passenger mutations, mutational analysis, genomic instability, heterogeneity, Epigenetic changes in cancer, methylation, Histone Acetylation,

Non-coding RNAs, miRNAs in cancer, Cancer metabolism and Warburg effect, Techniques employed to identify non-coding RNA, microRNA and epigenetic changes.

MODULE III: Sustaining proliferative signalling: role of growth factors and receptors, complex signalling enabling enhanced survival, cell cycle deregulation, Major pathways in cancer: Ras, EGFR, Wnt, MAPK, AKT, mTOR, Jak-Stat, etc, anti-apoptotic pathways, Bcl2 family proteins, role of P53, events enabling replicative immortalization, role of telomere, Techniques employed in unravelling survival/ apoptosis/cell cycle machinery.

MODULE IV: Angiogenesis, **Metastasis and Cancer Stem cells**: factors aiding the mechanism of angiogenesis, hypoxia (vegf), metastasis (metalloproteinases, EMT), and cancer stem cell maintenances, side cell population, (stem cell markers and efflux pumps), mechanism of tumour aggression and relapse, Techniques employed to elucidate the mechanism of angiogenesis, metastasis and identification of stem cells.

MODULE V: Diagnosis and Therapeutics of Cancer: Diagnostic techniques and methods, biopsy, histopathology, cytology, FISH, FACS, PET, MRI, CT, mammogram and others; Endoscopy methods, Cancer predisposition, SNPs, RFLP, NGS, Single-cell RNA sequencing, exome sequencing, identification and validation of novel markers and therapeutic targets, cancer treatments, surgery, radiation, chemotherapy, immunotherapy, targeted therapy, and precision medicine.

REFERENCES

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2. Lauren Pecorino Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics, 4th Edition, 2016, Oxford University Press
3. Peter J Selby Margaret A Knowles, An Introduction To Cellular And Molecular Biology of Cancer by 4th Edition, 2005, Oxford University Press.
4. John E. Niederhuber, James O. Armitage, James H Doroshow, Michael B. Kastan, Joel E. Tepper, 6th Ed, Abeloff's Clinical Oncology, 2019, Elsevier.
5. Cancer Medicine, Waun Ki Hong, Robert Bast Jr, William Hait, Donald Kufe, Raphael Pollock, Ralph Weichselbaum, James Holland, Emil Frei, 2010, McGraw-Hill Education.
6. Eds: Sang Hyun Cho and Sunil Krishnan Cancer nanotechnology: principles and applications in radiation oncology, , 2013, CRC Press 7.
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24-811-0807- MOLECULAR NEUROBIOLOGY (4C; 4L+0T+0P)
(Academic Level 400)

Course Description: The course structure is aimed at providing in-depth knowledge of molecular and cellular neurobiology by giving emphasis on human neurobiology. The course introduction focuses on neuroanatomy, neurodevelopment, cell types of the nervous system and mechanisms of neural communication. During the later stages of this course, students get a chance to learn about more integrated functions of the nervous system like sensory processing

and the programming of motor functions. In addition, students will also get a basic understanding about how new memories are formed, stored, and retrieved in the brain. The course also focuses on the neuroscience of brain diseases and describes the current methods in neuroscience research.

Course Outcomes(CO): After completing the course the student will be able to:

Course outcomes		**Cognitive level**
C.O.1	Demonstrate a solid understanding of basic neuroanatomy and nervous system function on a molecular, cellular and systems level.	Understand
C.O.2	Analyse how neurons are connected and how it communicates in neuronal circuits that control our behaviour.	Analyse
C.O.3	Analyse the functions of the nervous system such as the regulation of sensation, integration and response; with special emphasis on cognitive functions like learning and memory.	Analyse
C.O.4	Understand and Analyse the neurological disorders such as Alzheimer's disease, Parkinson's Disease, Amyotrophic lateral sclerosis (ALS), Huntington's disease, Schizophrenia, psychiatric disorders, Traumatic Brain Injury and Stroke.	Analyse
C.O.5	Analyse the neurobiological techniques, such as brain histology, optogenetics, electrophysiology, CLARITY, behavioural analyses and transgenics, also identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution.	Analyse/ Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2		2	2					
CO3		2	2	1				
CO4	2	1						
CO5	2	2		1				

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Organization of the nervous system: Organization of nervous system; CNS, PNS, Neuroanatomy, Meninges, Cerebrospinal fluid, Blood Brain Barrier, Neuron structure and classification, Glial cells: Structure and function of glial cells, Glial – Neuronal interplay, Neurotrophic factors, Neurogenesis; Birth and migration of neurons, Neural stem cells, Brain changes across the lifespan.

MODULE II: Propagation of nerve impulses and molecular mechanisms of neurotransmission: Biological and electrical properties of neurons, Ionic Basis of the Resting Membrane Potential, Ionic Basis of the Action Potential, Molecular Mechanisms of Action Potential Generation, Propagation of Action Potentials, Synaptic Transmission, Neurotransmitters; chemistry, synthesis, storage, release and uptake, Ionotropic Neurotransmitters Receptors, Metabotropic Neurotransmitters Receptors and Postsynaptic

Mechanisms, Synaptic Integration, Long-Term Potentiation and Depression, Spike-Timing Dependent synaptic Plasticity, Hebb's Postulate

MODULE III: Neural Control Systems: Sensory Systems; The Visual System, Audition, Vestibular Sensation and Chemical Senses, Movement and Motor Control, Neural control of; Immune, Cardiovascular, Endocrine and Enteric nervous systems

MODULE IV: Complex Brain Functions and Brain Disorders: Circadian Rhythms, Sleep; Brain Waves and Sleep Stages, Neurobiology of Emotion, Reward and Addiction, Learning and Memory; Cognitive development, Visual Recognition, Language, Short-term, long-term and Working Memory.
Neurodegenerative disorders; Alzheimer's, Parkinson's, Huntington's and Prion Diseases Amyotrophic Lateral Sclerosis, Epilepsy, Psychotic disorders, Schizophrenia, Bipolar disorder

MODULE V: Neurobiology Techniques: Neuronal cell culture, Animal behaviour analysis in Neuroscience, Electrophysiology**,** Whole Brain Imaging; fluorescence, functional magnetic resonance imaging (fMRI), positron emission tomography (PET), Electrochemical techniques; exocytosis measurements, fast-scan cyclic voltammetry, Calcium imaging, Optogenetics, CLARITY

REFERENCES

1. Principles of Neural Science (6th Edition) by Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell, McGraw Hill Education; 2021
2. Neuroscience (7th Edition) by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, Richard D. Mooney, Michael L. Platt, Leonard E. White; 2023
3. Neuroscience: Exploring the brain (Enhanced Edition 4th Edition) by Mark F Bear, Barry W. Connors, Michael A. Paradiso; 2020
4. Basic Neurochemistry Principles of Molecular, Cellular, and Medical Neurobiology. (9th Edition) by Scott Brady, George Siegel; 2024
5. From Neuron to Brain (6th Edition) by John G. Nicholls, A. Robert Martin, David A. Brown, Mathew E. Diamond, David A. Weisblat, Paul A. Fuchs; 2020
6. Neurobiology (3rd Edition) by Gordon M. Shepherd, 1994
7. Basic Clinical Neuroscience (3rd Edition) by Paul A. young, Paul H. young and Daniel L. Tolbert; 2015
8. Molecular Neuroscience: A Laboratory Manual by Rusty Lansford; Cold Spring Harbor
9. Laboratory Press; 2014
10. Purifying and Culturing Neural Cells: A Laboratory Manual by Ben A. Barres, and Beth Stevens, 2014
11. Molecular Neurobiology, A Practical Approach-1. Chad and H. Wheal; 1991

24-811-0808- PLANT MICROBE INTERACTIONS (4C; 4L+0T+0P)
(Academic Level 400)

Course Description: This advanced course in Plant-Microbe interactions includes the study of Plants as microbial habitat, cellular plant pathogens and the diseases they cause, Defence of plants and stress responses, Invasion of plant tissue-establishment of symbiotic relations; pathogen invasion strategies, Resistance mechanisms against attack by plant pathogens and

plant immune system, Methods employed for disease diagnosis, Molecular Basis of Plant Disease Resistance, Plant defence responses against viruses, and Engineering pathogen resistance in crop plants

Course outcomes (CO): After completing the course the student will be able to

Course Outcome		**Cognitive Level**
C.O.1	Analyse the importance of plant-microbe interactions concerning plant diseases	Analyse
C.O.2	Understand and analyse the different plant defence mechanisms and discuss interactions between plants and non-pathogenic/symbiotic bacteria and fungi in agriculture, horticulture and forestry	Understand/Analyse
C.O.3	Apply the conventional and advanced methodology to study the plant-pathogen interaction	Apply
C.O.4	Apply the knowledge on the molecular plant disease resistance mechanisms	Apply
C.O.5	Discuss plant viral diseases and apply that knowledge to generate engineered disease-resistant plants	Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	3							
CO2	2	2	2	1				
CO3	2		2	1				
CO4		2	2	1				
CO5			1				2	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Plants as microbial habitat; Introduction to plant-microbe interactions: importance, variety, and two examples (*Fusarium oxysporum* and *Xanthomonas campestris*), symbiotic relations (mycorrhiza, rhizobium), plant diseases cycle, control of plant diseases

MODULE II: Overview of plant defence mechanisms, Infection mechanisms; attachment; enzymes; the role of toxins and other compounds; secondary metabolites of commercial value

MODULE III: Methodology to study plant-microbe interaction- culture techniques, transcriptome profiling, metabolic profiling, proteomics, microscopy, and spectroscopic techniques

MODULE IV: Resistance mechanisms against insect attack; gene-for-gene interactions; The plant immune system- Connecting virulence & resistance; induced resistance

MODULE V: Plant defence responses against viruses, Plant virus transmission; Engineering pathogen resistance in crop plants

REFERENCES

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2. Bhadauria, Vijai. "OMICS in plant disease resistance. "*Current Issues in Molecular Biology* 19.1 (2016): 1-2.

3. Bouarab, Kamal, Normand Brisson, and Fouad Daayf, eds. *Molecular plant-microbe interactions*. CABI, (2009).
4. Butter, Nachhattar Singh. *Insect Vectors and Plant Pathogens*. CRC Press, (2018).
5. Chrispeels, Maarten J., and David E. Sadava. *Plants, genes, and crop biotechnology*. Jones & Bartlett Learning, (2003).
6. Jones, Jonathan DG, and Jeffery L. Dangl. "The plant immune system." *nature* 444.7117 (2006): 323-329.
7. Khaled, Alfadhl Yahya, et al. "Early detection of diseases in plant tissue using spectroscopy–applications and limitations." *Applied Spectroscopy Reviews* 53.1 (2018): 36-64.
8. Schirawski, Jan, and Michael H. Perlin. "Plant–microbe interaction 2017—the good, the bad and the diverse." *International Journal of Molecular Sciences* 19.5 (2018): 1374.
9. Sharma, Pradeep, Dinesh Yadav, and R. K. Gaur, eds. *Bioinformatics in Agriculture: Next Generation Sequencing Era*. Elsevier, (2022).
10. Tronsmo, Anne Marte, et al. *Plant pathology and plant diseases*. CABI, (2020).

24-811-0809-BIOFUELS AND BIOENERGY (4C; 4L+0T+0P) (Academic Level 400)

Course Description:
This course focuses on bioenergy and the utilization of biomass and biomass waste for energy recovery. The conversion of waste to biofuels, bioenergy and bio-products has been included in the course. The course encompasses thermochemical energy processes (combustion, gasification, pyrolysis), mechanical and chemical processes (oil extraction and trans-esterification), finally biochemical processes (fermentation, anaerobic digestion and bio-electrochemical system). The emphasis is given to Bio-electrochemical systems. The Bio-electrochemical systems used for the conversion of waste to energy such as microbial fuel cells and microbial electrochemical cells has been detailed in this course.

Course Outcomes (CO)
After completing the course the student will be able to:

Course Outcome		Cognitive Level
CO 1	Comprehend various technologies used for the synthesis of Biofuel and generation of energy	Understand
CO 2	Illustrate the detailed mechanism and technologies used for the conversion of waste to Bioenergy	Understand
CO 3	Learn the development of microbial fuel cell systems for bio-electricity production	Understand
CO 4	Learn the development of microbial electrochemical systems for bio-hydrogen production	Analyse
CO 5	Practical application of the Bio-electrochemical system	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	1						
CO3		1			1			
CO4			2	1		1		
CO5			2		1		1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Module I: Fundamental concepts in understanding Biofuel/Bioenergy production, Renewable feedstock and their production, Biomass pre-processing: drying, size reduction, and densification, Various Biofuels/Bioenergy from biomass

Module II: Biomass conversion to heat and power: thermal gasification of biomass, anaerobic digestion, Biomass conversion to Biofuel: thermos-chemical conversion, syngas fermentation, Biochemical conversion to ethanol: biomass pre-treatment, Different enzymes, enzyme hydrolysis, and their applications in ethanol production. Biodiesel production from oil seeds, waste oils and algae

Module III: Conversion of waste to Biofuels, bio-products and Bioenergy, Types of waste and their distributions, Strategies for waste management, Waste preparation and Pre-treatment for conversion, Technologies for conversion of waste to energy and products.

Module IV: Bioenergy derived from Electro-chemically active biofilms**:** Bioelectricity production, Synthesis of metal Nano-particles, Bio-hydrogen production, Environmental remediation, Microbial fuel cell: Types of Reactors, Methodology**,** Polarization curve, Coulombic efficiency, cyclic voltammetry, Tafel Analysis and Microbial electrolysis cell.

Module V: Environmental impacts of Biofuel production, Energy balance and life-cycle analysis of Biofuel production, Value-added processing of Biofuel residues and co-products;

REFERENCES

1. Lee, S., & Shah, Y. T. (2012). *Biofuels and bioenergy: processes and technologies*. CRC Press.
2. Hakeem, K. R., Jawaid, M., & Rashid, U. (Eds.). (2014). *Biomass and bioenergy: Applications*. Springer.
3. Luque, R., & Clark, J. (Eds.). (2010). *Handbook of biofuels production: Processes and technologies*. Elsevier.
4. Nelson, V. C., &Starcher, K. L. (2015). *Introduction to renewable energy*. CRC press.
5. Cheng, J. (Ed.). (2017). *Biomass to renewable energy processes*. CRC press.
6. Logan, B.E., 2008. Microbial Fuel Cells. Wiley & Sons, Inc., Hoboken, NJ.
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24-811-0810- BIOPROCESSING METHODS AND TECHNIQUES (4C; 4L+0T+0P) (Academic Level 400)

Course Description: This course gives the student an insight into bioprocesses for industrial applications. Differences between bio- and chemical processes, types of bioprocesses, screening for industrially important organisms, strain improvement strategies are all part of this course. In addition, the kinetics of fermentation in batch and continuous mode, the mass transport processes, reactor design, types of reactors, process control and downstream processing of biological are included.

Course Outcomes (CO): After completing the course the student will be able to:

Course outcomes	**Cognitive level**

C.O. 1	Employ various methods of strain improvement of industrial organisms	Understand
C.O. 2	Employ batch processes, as well as sterilization processes for application	Understand
C.O. 3	Evaluate factors that contribute to the enhancement of cell and product formation during the fermentation process	Understand
C.O. 4	Analyse kinetics of cell and product formation in batch, continuous and fed-batch cultures	Analyse
C.O. 5	Differentiate the rheological changes during the fermentation process	Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2	2	2					
CO2		2	2		1			
CO3			2		1			
CO4			2	1	1			
CO5					2		1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Range of fermentation technology and its chronological development. Basic principle component of fermentation technology. Types of microbial culture. Isolation and screening of industrially useful microorganisms, Primary and secondary screening. Strain improvement in industrial microbiology: mutation and genetic manipulations. Culture Preservation techniques. Screening, detection and assay of fermentation products (physical, chemical and biological assay).

MODULE II: Growth kinetics, primary and secondary metabolites. Feedback inhibition and repression. Types of fermentations: aerobic and anaerobic; submerged and Solid State; Importance of media in fermentation, media formulation and modification. Design of fermentation media Kinetics of growth in batch, continuous, fed- batch fermentation, Storage of cultures for repeated fermentations,

MODULE III: Design of bioprocess vessels: Significance of impeller, Baffles, Sparger, Types of culture/ production vessels: Air-lift, Cyclone column, Packed Tower and their application in production process, Principles of upstream processing. Sterilization: thermal death kinetics, batch & continuous sterilization systems, Sterilization of air, fibrous filters; sterile filtration of biological.

MODULE IV: Introduction to Oxygen requirement in Bioprocess. Energetics of microbial growth in fermenter: Reaction rates, Heat and Mass Transfer, Transport phenomenon in reactors, macroscopic balance of energy and energy flow. Design of a fermenter, instrumentation and process control; Types of fermenter Parts and their functions. Auxiliary instrumentation of bioreactors; Microprocessor controlled fermenters. online measurements; Monitoring variables such as temperature, aeration, agitation, pressure, pH, foaming; Computers in bioprocess control systems; Economic aspects of bioprocess.

MODULE V: Introduction to Upstream and downstream processing of industrial fermentations: Cell disruptions, Flocculation, Filtrations, Ultra Filtration, Ultra centrifugation, Gel filtration, Chromatographic methods, two phase aqueous separations, Cell and Enzyme immobilization. Fermentation of Antibiotics (Penicillin, Streptomycin), Organic

acids (Citric acid, Lactic acid), Enzymes (Penicillin G, Streptokinase), Ethanol and Recombinant Proteins (Insulin).

REFERENCES

1. Sambamurthy, K. 2007,.*Pharmaceutical engineering*. New Age International.
2. Stanbury, P. F., Whitaker, A., & Hall, S. J. 2013, *Principles of fermentation technology*. Elsevier.
3. Peppler, H.J & Perlman,D.2014, .*Microbial technology Vol. I &Vol.II*, 2nd edition, Elsevier
4. Ed. Moo & young 2011,.*Comprehensive Biotechnology*. I, &II, 2nd edition Pergamon Pres.
5. Coulson, J. M.*et al*., 2006,.Chemical Engineering. I & II, 6th edition, Elsevier.
6. Cruger & Cruger 2005,.*Text Book of Industrial Microbiology*.2nd sub edition, Panima pub.
7. Cassida L.E.J.R. 2015, *Industrial Microbiology*. New Age International.
8. Pauline M. Doran 2013,*Biochemical Engineering principles*, Second edition, Elsevier
9. Bisswanger, H. (2013). *Practical Enzymology*. 2ndedn. Wiley-VCH.
10. S. Kulandaivelu, Sr., S. Janarthanan .K. Practical Manual on Fermentation Technology, 2012, International Publishing House Pvt. Limited

SEMESTER IX

24-811-0904 ONLINE COURSE (2C; 2L+0T+0P) (Academic Level 500)

24-811-0905- NGS AND DATA ANALYSIS (4C; 4L+0T+0P) (Academic Level 500)

Course Description: This course provides a strong understanding of the different Next-generation sequencing platforms, which have become the premier tools in genetic and genomic analysis. The course will also provide a better overview of the different public datasets and different file formats in the NGS platforms. The course provides hands-on experience on the R and Linux platforms, which are the inevitable tools for NGS data processing. The course will also introduce the basics of structural biology and molecular docking. The course layout has adapted to the needs of beginners in the field of life science and allows students with no or little background in bioinformatics to get a first hands-on experience in this fast-evolving topic

Course Outcomes (CO): After completing the course the student will be able to:

Course outcomes		**Cognitive level**
C.O.1	Explain the fundamentals of next-generation sequencing technologies	Understand
C.O.2	Explain the NGS workflow, data files and formats	Understand
C.O.3	Analyse and visualize data using R	Analyse
C.O.4	Effectively analyse and interpret RNA sequencing and genome data	Analyse
C.O.5	Effectively predict and analyse the structure of proteins	Analyse

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2	1							
CO3	1			2				
CO4	1	1	1	2		2		
CO5	1	2						

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to Next Generation Sequencing (NGS): Principles of NGS technology, Major Applications of NGS, Different NGS Platforms: Illumina, Ion Torrent Semiconductor Sequencing, Pacific Biosciences SMRT, Oxford Nanopore Technologies. Data mining: Database for biological datasets, accessing information from public databases, Sequence storage and retrieval and various file formats

MODULE II: Operating Systems and Concepts: Basic introduction to different Operating systems. Linux: Introduction to Linux, basic commands used for Navigation and Directory controls. File Maintenance Commands, Display Commands and print commands, working with the files, file attributes, pipes, wildcards, working with processes working with basic editors. Basic regular expressions, string search applications using regular expressions. Spreadsheet applications: An introduction to the different spreadsheet applications

MODULE III: Introduction to R: Defining the R project, Obtaining R, Generating R codes, Scripts, Text editors for R, Graphical User Interfaces (GUIs) for R, R Studio, R Packages. R Objects and data structures: Variable classes, Vectors and matrices, data frames and lists, Data sets included in R packages, Summarizing and exploring data, Reading data from external files- tables, fasta files, Storing data to external files, creating basic plots like histograms, scatterplots and bar charts, Creating and storing R workspaces.

MODULE IV: RNA Seq and Genome sequencing: Principles of RNA Sequencing and experimental design, De novo and Resequencing approaches. File format and Quality control: Quality control of datasets obtained from public datasets, Filtering, adapter removal, Mapping, RNA-Seq Data Normalization, Identification of Differentially Expressed Genes, Functional Analysis of identified genes. Genome sequencing: Principles of Genome sequencing and experimental design, Sequencing Strategies for De novo Assembly: Assembly of Contigs, Assessment of Genome Characteristics, Contig Assembly Algorithms; Scaffolding, Assembly Quality Evaluation and Gap Closure. Comparative genomics: Tools and applications

MODULE V: Structural databases: Introduction to structural databases, Protein Data Bank, Molecular Modelling Data Bank, Protein structure prediction- homology modelling, fold recognition, template free modelling. Protein folding problems, Introduction to drug designing and docking methods to generate new structures, Tools for molecular docking.

REFERENCES

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2. Gentleman, R. (2008). *R programming for bioinformatics*. CRC Press.
3. Gentleman, R., Carey, V., Huber, W., Irizarry, R., & Dudoit, S. (Eds.). (2006). *Bioinformatics and computational biology solutions using R and Bioconductor*. Springer Science & Business Media.
4. Gentleman, R., Carey, V., Huber, W., Irizarry, R., & Dudoit, S. (Eds.). (2006). *Bioinformatics and computational biology solutions using R and Bioconductor*. Springer Science & Business Media.
5. Jones, N. C., Pevzner, P. A., & Pevzner, P. (2004). *An introduction to bioinformatics algorithms*. MIT press.
6. Mandoiu, I., & Zelikovsky, A. (2016). *Computational methods for next-generation sequencing data analysis*. John Wiley & Sons.
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8. Pevsner, J. (2015). *Bioinformatics and functional genomics*. John Wiley & Sons.
9. Sarwar, S. M., & Koretsky, R. M. (2016). *UNIX: the textbook*. CRC Press.
10. Sung, W. K. (2017). *Algorithms for next-generation sequencing*. CRC Press.

24-811-0906- ENVIRONMENTAL MICROBIOLOGY (4C; 4L+0T+0P)
(Academic Level 500)

Course description: This course gives the student an insight into environmental microbiology including a brief history and development of environmental microbiology; aerobiology, aquatic microbiology, microbial diversity insoil and in extreme environments; culture-dependent and culture-independent approaches for understanding microbial diversity in the environment; microbial interactions; microbes in biodegradation of organic compounds, microbes in waste management including liquid waste and solid waste, bioremediation of environmental pollutants

Course outcomes (CO) : After completing the course, the student will be able to

Course outcomes		**Cognitive level**
C.O.1	Discuss the significant contributions of microbiologists, the emergence of environmental microbiology, biogeochemical roles, and significant applications of microbes in solving environmental pollution problems	Understand
C.O.2	Discuss the diversity of microbes in the air, aquatic environments, and drinking water and apply the same for the conservation of the environment and sustainable utilization of environmental resources	Apply
C.O.3	Discuss the diversity of microbes in soil and in extreme environments for the conservation of the environmentand apply the same for sustainable utilization of environmental microorganisms	Apply
C.O.4	Discuss about indicator organisms, municipal solid and liquid waste management and apply using waste management techniques	Apply
C.O.5	Discuss the bioremediation of environmental and metal pollutants and use microbes for bioremediation or organic and metal pollution	Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2	2	1	1					
CO3	1							
CO4	2		1	1		2		
CO5	1					1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Brief history and development of environmental microbiology: History and development of microbial ecologyhighlighting significant contributions of microbiologists and emergence of environmental microbiology, and significant applications of microbes in solving environmental pollution. Microbial biogeochemistry, C, N, S, P, Fe cycles. Role of microorganism in the maintenance of the fertility of soil and self-purification of rivers and aquatic bodies; Environmental Concerns in releasing genetically engineered microorganisms in environment; Microorganisms in biological warfare and bioterrorism. **Culture-dependent and culture-independent approaches** for Understanding microbial diversity in the environment.

MODULE II: Aerobiology- -Microbial contamination of air – Sources of contamination-

Microbial indicators of air pollution. Enumeration of bacteria in air, Air sampling devices. Air sanitation. Effect of Air Pollution on Plants and Humans. **Aquatic microbiology:** Diversity of microbes in aquatic environments, Microbiology of drinking water, – Water pollution and water borne pathogens –Bacteriological examination of water – Indicator organisms. Purification and disinfection of water. Role of microbes in marine fouling and corrosion. Marine microbes and climate change.

MODULE III: Microbial diversity in soil: Diversity of microbes in terrestrial (agricultural and desert soils) environments, and animal (cattle, termites, pests such as cockroaches and nematodes, and human beings), plants and their role in the ecosystem. **Microbial diversity in extreme environments:** Occurrence, diversity, adaptations and potential applications of oligotrophs, thermophiles, psychrophiles, barophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles.

MODULE IV: Indicator Microorganisms, Total Coliforms, Fecal Coliforms and *Escherichia coli*. Fecal Enterococci. *Clostridium perfringes*. Bacteroides and Bifidobacterium. Heterotrophic Plate Count, Bacteriophages. Municipal Wastewater Treatment, Drinking Water Treatment The Nature of Wastewater, Conventional Wastewater Treatment. Oxidation Pools. Septic Tanks. Wetlands Systems Sludge Processing. Treatment of Industrial effluents (distillery, textile, pulp and paper).. **Solid waste management:** composting, anaerobic digestion & biomethanation

MODULE V: Microorganisms and Organic Pollutants, The Overall Process of Biodegradation, Contaminant Structure, Toxicity, and Biodegradability. microbial degradation of cellulose, lignocellulose, paper, textiles, leather, rubber, emerging contaminants and xenobiotics. Environmental Factors Affecting Biodegradation, Biodegradation of Organic Pollutants. Bioremediation. Bioremediation of environmental pollutants: Petroleum hydrocarbons **Genetically modified microorganisms and Biotechnology.**

Microorganisms and Metal Pollutants. Metals in the Environment. Metal Solubility, Bioavailability, and Speciation. Metal Effects on the Microbial Cell. Mechanisms of Microbial Metal Resistance and Detoxification, Microbial Metal Transformations, Microbial Approaches in the Remediation of Metal-Contaminated Environments.

REFERENCES

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2. A.H. Varnam& M.G. Evans, 2000 Environmental Microbiology Manson Publishing Ltd.,.
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10. A. Singh and O.P. Ward, 2004. Applied Bioremediation and Phytoremediation by Springer,.
11. K-E.L. Eriksson, R.A. Blanchettee and P. Ander, Springer, 1990. Microbial and Enzymatic Degradation ofWood and Wood components,
12. Christon J Hurst;Ronald L Crawford;Jay L Garland;David Allen Lipson;Aaron Lewis Mills 2017, Manual ofenvironmental microbiology Washington, D.C. : ASM Press,
13. I.L.Pepper and C.P.Gerba, 2004, Environmental Microbiology-A Laboratory Manual. Elsevier, Academic press

24-811-0907- MICROBIOME (4C; 4L+0T+0P) (Academic Level 500)

Course description: This course provides an overview of the role of microbiome in human health and disease. It focuses on conceptual frameworks and technologies for understanding how microbiomes, particularly gut microbiomes impact human health and well-being. This course will cover the various microbiomes such the gut, soil, plant, oral, skin etc. The course will also discuss the dysbiosis and rebalancing of the microbiome, The course will also cover various omics techniques used to study the microbiome and microbiome strategies for the treatment of diseases

Course outcomes (CO) After completing the course, the students will be able to:

Course outcomes		**Cognitive level**
C.O.1	Illustrate ecological principles of the human microbiomes, and the importance of conservation of the global microbiomes of peoples from different human populations to development and health	Understand
C.O.2	Discuss the growing importance of considering the human gut microbiome in the treatment and prevention of diseases and illness and to assess the potential of the microbiota (probiotics) and diet (prebiotics) to achieve and maintain health	Apply
C.O.3	Discuss the significance of the microbiome of the environment, soil, water, plant, skin, oral cavity etc and to apply the same for maintaining human health and ecological balance	Apply
C.O.4	Discuss and understand the current technologies in next-generation sequencing and metagenomics in interpreting the role of the human microbiome	Apply
C.O.5	Discuss the application of microbiome for therapeutic purposes	Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2	1	1	1					
CO3	2		1				1	
CO4	1	2						
CO5	1	1					1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to the human microbiome. Human microbiome at various taxonomic levels, from the domains of bacteria, fungi and viruses down to species and strain-level differences. Other microorganisms of the human microbiome, The mycome and virome in health and disease. Pathobionts and pathogens, Opportunistic infections, Spore-forming opportunists. Dynamics of microbiome from birth to adulthood. The importance of organismal microbiomes for immunity and metabolism.

MODULE II: The gut microbiome, Diet and the human microbiome, Microbial imbalances and perturbations: Dysbiosis and the gut microbiome, Antibiotics and the human microbiome, Drug metabolism by the microbiome, Behaviour and the microbiome (the gut-brain axis),

Rebalancing of the microbiome: Probiotics, prebiotics and the human microbiome, Current probiotics– from faecal transplants to yoghurts

MODULE III: The skin microbiome. Environmental Microbiome. (Soil, water). Plant microbiome, Animal microbiome. Oral Microbiome, The Microbiome of the Geno-urinary System Oncobiome. Specialised pathogens and their tricks, Food poisoning, enteropathogenic *E. coli* and *Salmonella* (type III secretion systems II), Yersinia and the black death (type III secretion systems I) STDs and *Neisseria gonorrhoeae* (genomic flexibility)

MODULE IV: Introduction to metagenomics and next generation sequencing. DNA-based analysis of microbial communities, 16S rRNA gene amplicon sequencing and shotgun metagenomics sequencing methods. Functional analysis of the microbiome from DNA sequence functional analysis, meta-transcriptome, metabolome, proteome, and glycome.

MODULE V: Exchange between the human microbiome and the built environment. Comparative microbiomes from other animals. Next-generation therapies for microbial dysfunction and pathology Phage therapy. Microbiome engineering and its promises. Use of animals in microbiome research.

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1. The Gut Microbiome in Health and Disease (2018). Dirk Haller. The Gut Microbiome in Health and Disease. ISBN 978-3-31-990544-0, 978-3-31-990545-7
2. Fundamentals of Microbiome Science: How Microbes Shape Animal Biology. (2018). Angela e Douglas. ISBN. 978140088982
3. The Microbiomes of Humans, Animals, Plants, and the Environment. 2021. Andrés Moya. ISBN: 2662-6128, PRINT ISSN: 2662-611X
4. The Marine Microbiome. 2022. Lucas J. Sta, Mariana Silvia Cretoiu
5. Gut Microbiome-Related Diseases and Therapies. 2021. Maria Gazouli. George Theodoropoulos

24-811-0908 MOLECULAR VIROLOGY *(*4C, 4L+0T+0P) (Academic Level 500)

Course description- The aim of this course is to provide basic knowledge of viruses, viral diseases, and topics important to the control of viral infections including vaccines and antiviral therapy. Replication mechanisms, molecular pathogenesis, host-pathogen interactions, immune evasion strategies, development of antivirals and vaccines, and the relationship between viral evolution and emerging viruses will be taught using representative viruses from different viral families. Rather than covering most of the important microorganisms, select representative model organisms will be taught in detail with the goal that students will be able to apply knowledge and concepts in self-study moving forward in their education and careers. The course also covers currenttrends in emerging viral infections important to public health and biosafety practices in virology laboratories.

Course outcomes (CO) - After completing the course, the students will be able to

Course outcomes		Cognitive level
C.O.1	Understand the classification and nomenclature of viruses, nature of viruses and their structure	Understand
C.O.2	Describe molecular details of replication of viruses with different nucleic acid genomes	Analyse
C.O.3	Describe some of the major viral diseases, their pathogenic mechanisms, transmission and clinical symptoms. Describe how specific viruses evade and/or subvert host innate and adaptive immune functions	Analyse
C.O.4	Employ testing viral diseases by various techniques and conduct diagnostic tests for viral diseases and explain how specific antiviral therapies interfere with viral biology to treat infection	Apply
C.O.5	Employ biosafety practices for handling infectious viruses	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	1						
CO3	2		1	2		1		
CO4	2		2	1	1			
CO5	2		1					

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Introduction to virology: History and principles of virology, Virus structure and morphology, Classification, and nomenclature of viruses, ICTV and Baltimore. Routes of entry and transmission, acute and persistent infections, tissue tropism

MODULE II- The viral replication cycle: Replication strategies for DNA and RNA genome viruses, Host-pathogen interactions, viral receptors, attachment and entry of enveloped and non-enveloped viruses, Viral entry pathways-fusion, endocytosis, uncoating, cytoplasmic trafficking, nuclear entry, replication, maturation, and release

MODULE III: Molecular Pathogenesis and Transmission of viral diseases:

(1) dsDNA Viruses: Herpesvirus (Adeno virus, Herpes simplex virus, Pox Virus),

(2) ssDNA Viruses : Parvovirus

(3) dsRNA viruses – reoviruses

(4)+ ssRNA Viruses: Picornavirus (Poliovirus), Coronavirus.

(5) **–ss**RNA Viruses: Orthomyxovirus (Influenza virus), paramyxoviruses, rhabdoviruses

(6) ssRNA viruses with Reverse Transcriptase – retroviruses.

(7) dsDNA viruses with Reverse Transcriptase – hepadnaviruses

Emerging and re-emerging viruses that infect humans and animals: Filovirus (Ebola virus), Nipah, SARS-CoV2, Togavirus (Chikungunya virus), Flavivirus (Dengue Virus), *etc.*

Viral oncogenesis. Immune response to viral infection, viral immune escape mechanism.

MODULE IV: Detection and prevention: Eradication of viral diseases. Diagnosis of viral diseases: microscopy, serological diagnosis-ELISA. PCR immunocytochemistry, immunohistochemistry, haemagglutination, Western blot. Cultivation and enumeration of animal viruses. Plaque assay, LD 50 and TCID 50. **Antiviral agents and vaccines**: Interferons - mode of action and importance in therapy. Antivirals and antiretrovirals-mechanism of action, HAART therapy. Viral vaccine- Different types and their production — Killed and attenuated vaccines, recombinant viral vaccine, subunit vaccines. Virus as vectors for vaccination. Adjuvants.Vaccine delivery. Anti-sense RNA, siRNA, ribozymes

MODULE V: Biosafety in virology laboratory: Classification of viruses into hazard groups. Bio-safety level and biosafety cabinets. Disinfection, decontamination, solid and liquid waste disposal in virology laboratory

REFERENCES

1. Knipe David N, Hawley Peter M, Fields Virology Vol.I, 6th ed. 2013, Lippincott Williams and Wilkins, A,Wolters, Kluwer Business, USA
2. Knipe David N, Hawley Peter M Fields Virology Vol.II, , 6th ed. 2013, Lippincot Williams and Wilkins, A,Wolters, Kluwer Business, USA
3. Aseheson, Nicolas H, Fundamental of Molecular Virology2nd ed. 2011, Wiley, New Delhi.
4. D. R. Harper,1st Molecular Virology- edition, 1994, Bio Sci. Pub
5. Anathanarayan& C.K. J. Paniker, Text book of Microbiology-R. 9th edn.,2013, Orient Blackswan Pub
6. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka Principles of Virology: MolecularBiology, Pathogenesis, and Control of Animal Viruses. Latest edition. Publisher: American Society Microbiology.
7. R. Ian Freshney. Culture of Animal Cells: A Manual of Basic Technique. Wiley.
8. Brian WJ Mahy and Hillar O Kangro. Virology Methods Manual Elsevier
9. John R. Stephenson, Alan Warnes. Diagnostic Virology Protocols: Methods in Molecular Medicine. HumanaPress. Springer Link
10. https://www.who.int/news-room/fact-sheets/detail/nipah-virus
11. https://novel-coronavirus.onlinelibrary.wiley.com/
12. https://www.nih.gov/coronavirus
13. https://www.ncbi.nlm.nih.gov/books/NBK554776/
14. Editors: Nicholas Johnson,The Role of Animals in Emerging Viral Diseases Academic Press, 2014, Pages 365
15. Brenda S. P. Ang, Tchoyoson C. C. Lim, Linfa Wang. Nipah Virus Infection Journal of Clinical Microbiology,Volume 56 Issue 6 e01875-17, June 2018, Chapter 11 - Nipah Virus: A Virus with Multiple Pathways of Emergence. Pages 293-315 A Review Article:
16. Editors: Saxena, Shailendra K. (Ed.)2019 Coronavirus Disease 2019 (COVID-19) ,Epidemiology, Pathogenesis, Diagnosis, and Therapeutics
17. Marco Cascella; Michael Rajnik; Arturo Cuomo; Scott C. Dulebohn; Raffaela Di Napoli.2019Features, Evaluation and Treatment Coronavirus (COVID-19) - https://www.ncbi.nlm.nih.gov/books/NBK554776/

24-811-0909- ENVIRONMENTAL BIOTECHNOLOGY (4C; 4L+0T+0P)
(Academic Level 500)

Course Description: Environmental Biotechnology explores the application of biological principles and processes to address environmental challenges. This interdisciplinary field integrates concepts from microbiology, biochemistry, engineering, and environmental science to develop sustainable solutions for pollution control, waste management, and resource recovery. Students will gain an understanding of the role of microorganisms, plants, and biotechnological techniques in mitigating environmental pollution, enhancing ecosystem resilience, and promoting environmental sustainability.

Course outcomes (CO): After completing the course. the student will be able to:

Course outcomes		**Cognitive level**
C.O.1	Discuss the fundamental principles in the fields of Environmental biotechnology that uses biology to tackle environmental issues sustainably,	Understand
C.O.2	Discuss the vital role microorganisms play in environmental processes and develop skills to apply microbial-based solutions to address environmental challenges effectively.	Understand
C.O.3	Appreciate practical knowledge and skills in selecting, designing, and implementing bioremediation strategies for various environmental contaminants, contributing to the development of sustainable solutions for pollution remediation and environmental protection	Understand
C.O.4	Discuss about waste management principles and sustainability and device strategies for bioconversion of waste to value-added products, and circular economy	Apply
C.O.5	Explain the importance of environmental monitoring, techniques for assessing air, water, and soil quality,	Understand

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	1							
CO2	2	2						
CO3	2		2	2		1		
CO4	1		2	2	2			
CO5	1		1					

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to Environmental Biotechnology- Overview of environmental biotechnology, Importance and scope of environmental biotechnology in addressing environmental issues, Historical development and milestones in environmental biotechnology, Principles of sustainable development and their relevance to environmental biotechnology

MODULE II: Environmental Microbiology-Microbial ecology and diversity in natural environments, Microbial metabolism and interactions relevant to environmental processes, Biodegradation and bioremediation processes, Role of microorganisms in wastewater treatment, soil remediation, and pollution control

MODULE III: Bioremediation Techniques-Introduction to bioremediation techniques and strategies, Physicochemical methods vs. bioremediation approaches, Microbial degradation of organic pollutants, Phytoremediation and its applications in environmental clean-up, Case studies and real-world applications of bioremediation technologies

MODULE IV: Waste Management and Resource Recovery- Principles of waste management and environmental sustainability, Anaerobic digestion for organic waste treatment and energy recovery, Composting techniques and applications in organic waste management, Bioconversion of waste to value-added products (e.g., biofuels, bioplastics), Circular economy concepts and their integration into waste management strategies

MODULE V: Environmental Monitoring and Assessment- Importance of environmental monitoring and assessment, Techniques for monitoring air, water, and soil quality, Biomonitoring approaches using indicator species and bioindicators, Risk assessment methodologies for environmental contaminants**.** Remote sensing and GIS applications in environmental monitoring and management

REFERENCES

1. Environmental Biotechnology: Principles and Applications" by Bruce Rittmann and Perry McCarty (2019)
2. "Biotechnology for Environmental Management and Resource Recovery" by G. Sridevi and T. Satyanarayana (2017)
3. "Environmental Biotechnology: A Biosystems Approach" by Daniel Vallero and Chris Callahan (2010)
4. "Principles of Environmental Biotechnology" by T. K. Bhattacharya and S. A. Dhillon (2015)
5. "Bioremediation: Principles and Applications" by Ronald L. Crawford and Don L. Crawford (2017)
6. "Handbook of Environmental Engineering: Environmental Biotechnology and Biodegradation" edited by Myer Kutz (2019)
7. "Environmental Biotechnology: Basic Concepts and Applications" by Indu Shekhar Thakur (2016)
8. "Biotechnology for Environmental Protection in the Pulp and Paper Industry" edited by Pratima Bajpai (2018)

24-811-0910- PLANT BIOTECHNOLOGY (4C, 4L+0T+0P) (Academic Level 500)

Course Description: This course integrates plant physiology with plant tissue culture techniques, covering gene identification, transgenic plant creation, and advanced methods like Map-based cloning. It includes practical training in tissue culture and genetic transformation, alongside discussions on secondary metabolite production, genetic diversity preservation, and plant-based carbon sequestration for climate change mitigation.

Course outcomes (CO)
After completing the course the student will be able to:

Course outcomes		Cognitive level
C.O.1	Discuss the fundamental principles and techniques in the fields of plant physiology and practical skills and theoretical knowledge to create and manipulate plant tissues for various applications.	Understand
C.O.2	Device strategies to provides a solid introduction to plant genome analysis and gene identification techniques, essential for understanding plant genetics and improving crop traits	Analyse
C.O.3	Appreciate the latest techniques that provides a comprehensive overview of gene transfer methods used to produce transgenic plants with desired traits.	Understand
C.O.4	Formulate strategies of genetic engineering that offers powerful tools for enhancing agricultural productivity, improving crop quality, and addressing global food security challenges	Analyse
C.O.5	Explain the enhancing secondary metabolite production, preserving genetic diversity, and utilizing plant-based carbon sequestration for climate change mitigation.	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3		2					
CO2	2		2	1				
CO3	2	1	2					
CO4	2	2		1				
CO5	2					2	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: **Overview of uniqueness of plants:** General Introduction on physiological processes of higher plants, water relations of plants-, Includes transpiration (water loss), guttation (water exudation), and plasmolysis (cellular water loss). Photosynthesis: Process converting light energy into chemical energy (glucose) in chloroplasts. Involves light reactions (ATP/NADPH production) and Calvin cycle (CO2 fixation).Different pathways (C3, C4, CAM) optimize photosynthesis under varying conditions.

Plant Tissue Culture: Basic concepts: Totipotency: Cells' ability to regenerate into whole plants. Organogenesis: Formation of organs from cultured tissues.Somatic Embryogenesis: Embryo formation from somatic cells. Techniques: Techniques:
Callus, cell suspension, anther, ovule, root, shoot tip, and meristem cultures.
Protoplast culture for genetic manipulation. Micropropagation for rapid, mass plant production. Medicinal and ornamental plant conservation and propagation. Somaclonal variations and their implications. Artificial seed development for plant propagation and storage.

MODULE II: **Plant Genome analysis**; Gene Isolation –Gene Tagging: Identifying genes

by linking them to visible markers. Insertional Mutagenesis: Introducing foreign DNA to disrupt gene function and create mutants. Molecular Markers:DNA sequences aiding genetic mapping and trait analysis (e.g.,RFLP, RAPD, AFLP SSRs, ESTsSNPs), Mapping Populations, Marker-Assisted Selection (MAS) / Genomic Selection: **Identification of Candidate Genes**: Genetic Information (Positional Cloning) Biochemical and Expression Analysis: Transformation: Mutant Populations and Knockout Systems: Heterologous Expression Systems: Protein Analysis

MODULE III: The Gene transfer Techniques for the production of Transgenic: Indirect Gene transfer Methods: **Structural Features of Ti Plasmid, Mechanism of Gene Transfer to Plants, Molecular Events in Agrobacterium-Mediated Gene Transfer.** Direct gene transfer methods: **Particle Bombardment (Biolistics), Silicon Carbide Fiber-Mediated Transformation, Electroporation, Microinjection, PEG-Mediated Transformation.** Reporter Genes: Genes encoding proteins with easily detectable phenotypes (e.g., β-glucuronidase, green fluorescent protein) Scorable and Selectable Markers: (e.g., antibiotic resistance agents (e.g., herbicides, antibiotics)for the identification and propagation of transgenic cells or plants.

MODULE IV: Applications of Genetic Engineering in Agriculture: **Golden Rice:** Engineered to produce beta-carotene, addressing vitamin A deficiency. **Bt Crops:** (Cotton, Brinjal, Mustard) Provide pest resistance via Bt toxin expression**. Crop Resistance Traits: Herbicide Resistance:** Enables weed control with specific herbicides. **Pathogen Resistance:** Protection against viruses, bacteria, and fungi. **Oil Modification:** Alters oil composition for improved nutrition or industrial use. **Current Status of Transgenic Plants:** Commercial adoption in India and globally, notably Bt cotton. **Abiotic Stress Resistance:** Developing crops resilient to drought, salinity, etc.

RNAi Applications: Antisense RNA: Targets specific mRNA for gene regulation. **Genome Editing Tools:** ZFNs, TALENs, CRISPR-Cas9 for precise modifications, **Control of Pollination:** Ensure genetic purity via male sterility or GURT, Production of Biopharmaceuticals: Use plants for antibody, vaccine production, with strict regulation.

MODULE V: Plant Metabolic Engineering; Secondary metabolite production: plant products of industrial importance, cell suspension culture, growth kinetics and cell viability, nutrient media optimization; Scale-up studies: elicitors and precursors; Modes of culture: batch, fed-batch and continuous cultures, cell immobilization, biotransformation; Principles, design and operation of bioreactors: instrumentation, agitation, aeration system, temperature, foam control; Downstream processing: extraction, cell disruption, chromatography and purification of metabolites.

Germplasm Conservation: Importance of genetic diversity in agriculture and biodiversity conservation, Overview of germplasm conservation techniques. Role of germplasm conservation in climate change resilience.

Carbon Sequestration in Plants: Strategies for enhancing carbon fixation, Biomass production and carbon storage in plant tissues, Soil carbon sequestration through plant-microbe interactions, Reforestation, afforestation, and carbon farming practices.

REFERENCES

1. Plant Biotechnology: Current and Future Applications of Genetically Modified Crops" by Nigel Halford and Angela Karp (2019).

2. "Plant Biotechnology and Agriculture: Prospects for the 21st Century" edited by Arie Altman (2021).
3. "Plant Biotechnology: Principles and Applications" by Satbir Singh Gosal and G. S. Chauhan (2020).
4. "Plant Biotechnology: The Genetic Manipulation of Plants" by Adrian Slater, Nigel W. Scott, and Mark R. Fowler (2010).
5. "Plant Biotechnology: Recent Advancements and Developments" edited by Sunil Kumar and Surajit Das (2021).
6. Chilton, M. D., & Tu, J. (2020). Plant Metabolic Engineering. Springer.
7. Tanksley, S. D., & McCouch, S. R. (Eds.). (2021). Plant Genetic Resources and Climate Change. John Wiley & Sons.
8. "Principles of Plant Biotechnology: An Introduction to Genetic Engineering in Plants" by H. S. Chawla (2011).
9. "Plant Biotechnology and Genetics: Principles, Techniques, and Applications" by C. Neal Stewart Jr. (2008).
10. "Introduction to Plant Biotechnology" by H. S. Chawla (2013).
11. "Plant Biotechnology: The Genetic Manipulation of Plants" by Adrian Slater, Nigel W. Scott, and Mark R. Fowler (2008).
12. "Plant Biotechnology: Techniques and Applications" by C. Neal Stewart Jr. (2010).

24-811-0911- STEM CELL AND REGENERATIVE MEDICINE (4C; 4L+0T+0P) (Academic Level 500)

Course description: Stem cell research and regenerative medicine are one of the fastest-growing areas of biomedical research worldwide. Stem cells are specialized cells, which are undifferentiated and capable of self-renewal and have the potential to develop into differentiated cell types. Stem cells act as organisms reserve cells that replace specialized cells that are damaged or lost during the development. During this course, we explore several aspects of stem cell biology like the microenvironments or the niches that are required to maintain stem cells, asymmetric cell division, the genes required for stem cell fate, and the use of stem cells for medical/therapeutic applications. In addition, students will also get an insight into stem cell transplantation and tissue engineering in regenerative medicine and the ethical issues involved in this field of research.

Course Outcomes (CO): After completing the course the student will be able to:

Course outcomes		Cognitive level
C.O.1	Describe different types of stem cells and their specific characteristics and how they differ from fully differentiated cells.	Understand
C.O.2	Analyse the role of various intrinsic and extrinsic factors important for stem cell renewal and differentiation.	Analyse
C.O.3	Analyse the validity of applications of stem cells for regenerative medicine and the possible problems that need to be overcome.	Analyse
C.O.4	Apply techniques based on the use of Embryonic/Fetal, Induced pluripotent and Adult stem cells for regenerative medicine applications to human diseases.	Apply
C.O.5	Analyse the ethical issues associated with Embryonic/Fetal, Induced pluripotent, Adult stem cells and stem cell therapy with a global bioethics perspective and identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution.	Analyse& Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	2	2					
CO3	2	1	1					
CO4	2		1	1				
CO5	1					1	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Origin of stem cells: Origin of stem cells in organogenesis, Properties of Stem cells, Cell fate determination, Cell potency, Embryonic stem cells, Adult/Tissue-specific stem cells, Induced pluripotent stem cells (iPSCs), Cord blood stem cells and amniotic fluid stem cells, Developmental plasticity, Dedifferentiation, Trans-differentiation, Somatic Cells by Nuclear Transfer

MODULE II: Tissue-specific/Adult stem cells: Hematopoietic Stem Cells, Mesenchymal Stem Cells, Neural Stem Cells, Epithelial Stem Cells, Skin Stem Cells, Other tissue-specific stem cells, Cancer stem cells, Adult stem cells in tissue homoeostasis.

MODULE III: Regulation of Stem Cell Fate and Function: Stem cell niche, Morphogens and growth factors, Control of gene expression, Epigenetic regulation, Positional identity and polarity in regeneration, Cellular differentiation and environmental insults/Stress, Morphallaxis, Epimorphosis

MODULE IV: Tissue Engineering and Regenerative Medicine: Three-dimensional cell culture, Organ culture, Organotypic culture, Animal models of stem cell research, Preclinical study design, engineered scaffolds and matrices, Bioprinting of organs and tissues, Artificial skin substitute, Assessing potential stem cell risks and complications, Stem cell therapeutic efficacy and stability, Tumorigenicity

MODULE V: Stem cells from the laboratory to the clinic: Modes of cell and tissue delivery, Biobanking of stem cells, *In vivo* regeneration of tissues by cell transplantation, Immuno-isolation techniques, Regulatory perspectives, good laboratory/manufacturing practice (GLP/GMP), Ethical considerations in regenerative medicine, Autologous stem cell therapy, Xenograft and Allograft.

REFERENCES

1. Principles of regenerative medicine (3rd Edition) by Robert Lanza, Tony Mikos, Robert Nerem; Elsevier Academic Press; 2019
2. Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells (v. 1). Academic Press; 2013
3. Stem Cells: scientific facts and fiction by Christine Mummery; Ian Sir Wilmut; AnjaVan, De, Stolpe; Bernard Roelen; Elsevier Academic Press; 2011
4. Essentials of Stem Cell Biology. (3rd Edition) By Robert Lanza and Anthony Atala, Elsevier Academic Press; 2013
5. Imaging and Tracking Stem Cells: Methods and Protocols (1st Edition) by Kursad Turksen, Springer Science; 2013
6. Stem Cells & Regenerative Medicine (1st Edition), KrishnaraoAppasani and Raghu K. Appasani; Springer Science, 2011
7. Human Stem Cell Technology and Biology: A Research Guide and Laboratory Manual (1st Edition) by Gary S. Stein, Maria Borowski, Mai X. Luong, Meng-Jiao Shi, Kelly P. Smith, Priscilla Vazquez, Wiley-Blackwell; 2011
8. Stem Cells in Regenerative Medicine: Science, Regulation and Business Strategies; (1st Edition) Alain A. Vertes, NasibQureshi, Arnold I. Caplan, Lee E. Babiss; Wiley-Blackwell; 2015
9. Purifying and Culturing Neural Cells: A Laboratory Manual by Ben A. Barres, and Beth Stevens, 2014
10. Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells (v. 1). Academic Press; 2013

24-811-0912- BIOPHARMACEUTICALS (4C; 4L+0T+0P) (Academic Level 500)

Course Description: This course introduces the basic principles of drug action and the principles of pharmacokinetics and pharmacodynamics. Techniques for drug development: Drug design, targeting & delivery; Drug discovery and development: Lead development, Preclinical and clinical studies, Pharmaceuticals derived from plants, microorganisms, fungi and marine organisms; Production of recombinant products and Good manufacturing practices (GMP) are the other topics covered.

Course Outcomes (CO): After completing the course the student will be able to:

Course outcomes		**Cognitive level**
C.O.1	Discuss the basic principles of drug action and the principles of pharmacodynamics and pharmacokinetics.	Understand
C.O.2	Explain the application of various techniques for drug development: Drug design, targeting & delivery	Understand
C.O.3	Devise strategies for drug discovery and development and to evaluate drugs derived from different sources.	Apply

C.O.4	Describe the production of recombinant biopharmaceutical products such as hormones, thrombolytic agents, antiviral agents and recombinant vaccines.	Understand
C.O.5	Explain Good manufacturing practices (GMP) and design standard operating procedures (SOPs) for the production of biopharmaceuticals.	Understand

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2	2	3	3					
CO3	2							
CO4	2					2		
CO5	1					2	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: **Basic principles of drug action**: Drug administration: drug dose, basis of dose-response curves and its significance, therapeutic index, therapeutic window, dosage forms, routes of administration; Pharmacokinetics: absorption, distribution, metabolism and elimination of drugs; Pharmacodynamics: types and mechanism of drug action, receptor-mediated drug action, stimulation of second messenger system, drug-receptor interactions, agonists, partial agonists, reversible and irreversible antagonist; Pharmacogenetics.

MODULE II: **Techniques for drug development**: Drug design: ligand and receptor-based, Techniques for measuring receptor-drug binding and its uses in new drug development, Techniques used in assay of drugs, quantification of drugs in the body, Targeted drug delivery, Application of nanomaterials in targeted drug delivery, molecular medicine.

MODULE III: **Pharmacognosy:** Importance of natural drug substances, Drugs derived from natural sources such as plants, bacteria, fungi, marine organisms: antibiotics, antivirals and anticancer compounds. **Phases of Drug Development**: drug discovery, preclinical studies; Clinical studies; review by the regulatory authority, drug approval process and post-market drug safety monitoring.

MODULE IV: **Production of recombinant products**: Insulin, human growth hormone, erythropoietin, interferon, recombinant vaccines, Food vaccines, Pharming, Monoclonal antibody-based therapeutic agents.

MODULE V: **Quality and regulatory guidelines for biopharmaceutical production:** Good manufacturing practices (GMP) for the production of recombinant biopharmaceutical products and the establishment of standard operating procedures (SOPs) for a production process, certification of pharmaceutical products

REFERENCES

1. Calbreath, D. F., and Ciulla, A. P. (1992). Clinical chemistry: a fundamental textbook. WB Saunders Company.

2. Walsh, G. (2003). Biopharmaceuticals: biochemistry and biotechnology. John Wiley & Sons.
3. Walsh, G. (2007). Pharmaceutical Biotechnology: Concepts and applications. John Wiley & Sons.
4. Thompson, A. (1991). Bioactive compounds from Marine organisms. Aspect Publications Ltd.
5. Satoskar, R. S., Rege, N., & Bhandarkar, S. D. (2015). Pharmacology and Pharmacotherapeutics-E- Book. Elsevier Health Sciences.
6. Katzung, B. G., Masters, S. B., & Trevor, A. J. (2004). Basic & clinical pharmacology.
7. Purohit, S. S., Kakrani, H. N., & Saluja, A. K. (2003). Pharmaceutical biotechnology. Agrobios (India).

24-811-0913- GENE SILENCING AND GENOME EDITING (4C; 4L+0T+0P)
(Academic Level 500)

Course Description: The Gene Silencing and Genome Editing course explores the principles, techniques, and applications of RNA interference (RNAi) and genome editing technologies. This course provides students with a comprehensive understanding of the molecular mechanisms underlying RNAi and genome editing, as well as practical skills in designing and implementing experiments utilizing these techniques. Ethical considerations and current advancements in the field are also discussed.

Course Outcomes (CO)
After completing the course the student will be able to:

Course outcomes		**Cognitive level**
C.O.1	Understand the molecular mechanisms of RNA interference.	Understand
C.O.2	Explore the principles and applications of genome editing technologies.	Understand
C.O.3	Develop skills in designing and executing RNAi and genome editing experiments using computational approaches	Analyse
C.O.4	Analyse the ethical implications of RNAi and genome editing.	Analyse
C.O.5	Analyse case studies to comprehend real-world applications and challenges of RNAi and genome editing.	Analyse

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2	1	2						
CO3	2			1				
CO4	1							
CO5	2			2		2	2	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to RNA Interference (RNAi)- Definition and historical context; Mechanisms of RNAi: Small interfering RNA (siRNA) and microRNA (miRNA); Applications in gene regulation, functional genomics, and therapeutics. **RNAi Techniques**- Design and synthesis of siRNA and miRNA; Delivery methods for RNAi molecules; Assays for evaluating RNAi efficiency and specificity

MODULE II: Genome Editing Technologies- Overview of genome editing tools: CRISPR-Cas9, TALENs, ZFNs, etc.; Molecular mechanisms of genome editing; Applications in gene knockout, knock-in, and modulation

MODULE III: **CRISPR-Cas9 Technology**- CRISPR components: Guide RNA (gRNA), Cas9 protein; Designing gRNA for target specificity; Applications in genome editing and gene regulation. **Practical Applications of RNAi and Genome Editing**- Gene silencing in model organisms and cell lines; Genome editing for disease modelling and therapeutic development; RNAi and genome editing in agriculture and biotechnology

MODULE IV: Ethical Considerations in RNAi and Genome Editing- Ethical guidelines and regulatory frameworks; Germline editing vs. somatic cell editing; Case studies: Ethical dilemmas in RNAi and genome editing research and applications

MODULE V: Current Trends and Future Directions-Advances in RNAi and genome editing technologies; Emerging applications in medicine, agriculture, and biotechnology; Challenges and opportunities in the field. **Case Studies and Discussion**- Analysing landmark studies in RNAi and genome editing B. Debating ethical issues and societal implications

REFERENCES

1. "RNA Interference: Methods for Plants and Animals" (2008) edited by T. Doran and C. Helliwell, eISBN : 978-1-78064-365-6
2. Genome Editing-Current Technology Advances and Applications for Crop Improvement (2022) edited by: Shabir Hussain Wani and Goetz Hensel. Springer
3. "CRISPR-Cas: A Laboratory Manual"(2009) edited by Jennifer A. Doudna and Prashant Mali. CSH Press
4. "RNA Interference: Challenges and Therapeutic Opportunities" (2015) edited by Mouldy Sioud, Springer
5. "Ethics of Genome Editing" (2021) European Group on Ethics in Science and New Technologies

Minor Courses in Chemistry

24-808-0101 Introduction to Atomic structure, Bonding and Quantitative Analysis (4 Credits)

LTP 3-0-2 Level: 100
Pre-requisite: None

CO	CO Statement	CL
CO1	Appreciate the evolution of quantum mechanics and correlate the concepts to modern atomic structure.	Apply
CO2	Analyse the structure and bonding in simple molecules by applying the concepts of MOT.	Analyse
CO3	Correlate the physical and chemical properties of elements based on their periodic classification.	Apply
CO4	Perform a statistical analysis of experimental data	Apply
CO5	Quantitative estimation through titrimetric analysis	Analyse

CO No	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	1	1	0
CO2	2	2	1	1	1	0
CO3	2	2	3	2	1	0
CO4	2	2	2	1	1	0
CO5	1	1	1	1	2	1

Module I (11 hrs)

Atomic structure I - Blackbody emission and temperature, Photoelectric effect, Double slit experiment, Line spectrum of elements, Rutherford's experiment, Bohr's atomic model, Failure of Classical mechanics, Evolution of quantum mechanics - Heisenberg's uncertainty principle and its significance, wave particle duality, de Broglie equation.

Module II (11 hrs)

Atomic Structure -II - Quantum atomic model, hydrogen atomic orbitals and quantum numbers, atomic orbital equations (no derivation required), Sign of wave functions. Radial and angular wave functions. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams.

Module III (12 hrs)

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Lande equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Solvation energy, Covalent bond, Valence Bond theory, Resonance and resonance energy, Molecular orbital theory. bonding, non- bonding, antibonding molecular orbitals (concept only) elementary pictorial approach of homo- and hetero-
diatomic molecules H_2, B_2, C_2, O_2, N_2, CO, NO and CO_2, H_2O etc.

Module IV (11 hrs)

Periodic Properties: Atomic weights, Development of periodic law, The modern periodic table, Basis of periodic classification, orbital types and periodic table, Commonality in electronic configurations, Atomic sizes, ionization energy, Electronegativity, Electron Affinity, Polarizability and polarizing power, Relative orbital energies and overlap, Trends associated with properties – Physical and chemical, Anomalies in periodic properties.

Module V (Lab 30 hrs)

Titrimetric analysis and calculations: Different types of titrations - neutralization, redox (permanganometry, dichrometry, iodometry, iodimetry), complexometric (EDTA titrations) and precipitation titrations.

Principle of all types of titrations, titration curves, indicators. Significant figures, Accuracy, Precision, Error, Types of errors- Determinate and Indeterminate errors, Distribution of random errors, Mathematical Expression for error- Absolute and Relative error, Methods to reduce error, Statistical tools for expressing precision- Standard deviation, Relative standard deviation, Variance, Comparison of results- Student's t test, f test, Criteria for rejecting a value-Q test, Confidence interval

Recommended Books

1. Shriver, D. F., Atkins, P. W. and Langford, C. H. Inorganic Chemistry, 4th Ed., W.H. Freeman & Company, 2006.
2. Housecroft, C. and Sharpe, G., Inorganic Chemistry, 4th Edn., Pearson, 2012.
3. Atkins, P.W. and Paula, J. Physical Chemistry, 8th Edn., Oxford Press, 2006
4. Lee, J.D. Concise Inorganic Chemistry, 5th Edn., John Wiley & Sons, 1999.
5. Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, 3rd Ed., Oxford, 1994.
6. Day, M.C. and Selbin,J. Theoretical Inorganic Chemistry, 2nd Edn., ACS Publications, 2002.
7. Skoog, West, Holler, Crouch, Fundamentals of Analytical Chemistry, Wiley, 9th Edn.
8. Fifield, F. W., Kealey, D., Principles and Practice of Analytical Chemistry, Academic Press, 5th Edn.
9. Robinson, J. W., Skelly Frame, E. M., Frame, G. M., II, Undergraduate Instrumental Analysis, Prentice Hall, 2009
10. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edn, ELBS, 1998.

24-808-0102 Chemistry in Everyday Life (4 Credits)

L-T-P 4-0-0 Level:100
Pre-requisite: None

CO	CO Statement	CL
CO1	Understand the importance and the role of chemistry in everyday life	Understand
CO2	Learn about chemicals that lay the foundation for life	Understand
CO3	Understand the type of chemicals used in household activities, cosmetics and medicine	Apply
CO4	Apply knowledge of chemistry to improve quality of life	Apply

CO No	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	1	2	0	1	1
CO2	3	1	2	1	2	0
CO3	2	2	3	2	1	1
CO4	2	2	2	1	1	1

Module I (10 hrs)

Molecules of Life - Cellular and chemical foundations of life, water unique properties, Carbohydrates
and their sources, monosaccharides and disaccharides, examples, Lipids, Amino acids, Nucleic acids, Vitamins, Nutrients, Enzymes, Hemoglobin, structure and function, effect of CO, chlorophyll.

Module II (15 hrs)

Chemistry for food: chemicals used in kitchen, Butter and edible oils, composition, importance, properties, saturated and unsaturated fatty acids, hydrogenated oils, milk and dairy products, chemistry of cooking, chemical and physical changes during cooking, microwave cooking, nutrients and their stability during cooking, food preservation, colouring and flavouring agents, Beverages, food adulteration, food poisoning.

Module III (10 hrs)

Chemistry for cleaning: Soaps, chemical composition, preparation, cleaning action, synthetic detergents, bleaching, other house hold cleaning agents, tooth paste, mouth wash, sanitizers, shaving cream, shampoo disinfectants and antiseptics

Module IV (10 hrs)

Chemistry for cosmetics: Basic concepts-composition and classification, Skin chemistry, deodorants, antiperspirants, perfumes fragrances, effect of sunlight on skin, vitamin D, skin burns, sun screens, skin and hair care products, talcum powder, lipstick, moisturizers, colouring and bleaching agents, cosmetic formulations, baby care products

Module V (15 hrs)

Chemistry for medicines: Contribution of chemistry to human health and historical developments in medicine, Classification and nomenclature, Structure and function of: Analgesics – aspirin, paracetamol, Anthelmintic drug: mebendazole, Antiallergic drug: Chlorpheniramine maleate, Antibiotics: Penicillin V, Chloromycetin, Streptomycin. Sulfa drugs, Anti-inflammatory agent: Oxypheno-butazone, Antimalarials: Primazuine phosphate & Chloroquine, tranquilizer, antidepressants, antihistamines, drugs for chemotherapy, Generic and brand names

Recommended Text Books:

1. Chemistry in Daily Life by KIRPAL SINGH, PHI Learning Pvt Ltd
2. Chemistry Connection, The Chemical Basis of Everyday Phenomena, Karukstis, Kerry K. and Van Hecke, Gerald R, Harcourt/Academic Press (2003)
3. Chemistry in the Marketplace (5th ed.) Harcourt Brace (1998)
4. Introduction to Industrial Chemistry, B. K. Sharma: Goel Publishing, Meerut (1998)
5. Medicinal Chemistry by Asthoush Kar
6. Drugs and Pharmaceutical Sciences Series, Marcel Dekker, Vol.II, INC, New York.
7. Foods – Facts and Principles. N. Shakuntala Many and S. Swamy, 4th ed. New Age International (1998).

24-808-0201 Introduction to Physical Chemistry and Inorganic Qualitative Analysis (4 Credits)

L-T-P 3-0-2 Level: 100
Pre-requisite: None

CO	CO Statement	CL
CO1	Differentiate the properties of real gases from those of a perfect gas and predict the properties	Apply
CO2	Predict changes in thermodynamic parameters during a process and predict the spontaneity.	Analyse
CO3	Apply the concepts of chemical kinetics and photochemistry to calculate rate/ rate constants/quantum yield of different types of reactions	Apply
CO4	Understand the basic surface phenomena and extended application to adsorption.	Apply
CO5	Understand the basic principles of qualitative inorganic analysis and to identify the cations and anions in a given solution	Analyse

CO No	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	1	1	0
CO2	3	3	2	1	1	0
CO3	3	2	2	1	1	0
CO4	3	2	2	1	1	0
CO5	3	3	3	1	1	0

Module I (11 hrs)
Gaseous State: Kinetic Theory of gases, Maxwell Boltzmann distribution of molecular velocities (Qualitative approach), Different types of velocities, Gas Laws, Ideal gas equation, Real gases- Deviation from ideal behavior- Compressibility factor, Van der Waals equation, Virial equation, PV isotherms, Continuity of states, Law of corresponding states, Critical phenomena and critical constants. Transport properties.

Module II (12 hrs)
Thermodynamics: State functions, Reversible and irreversible processes, Isothermal and adiabatic processes, First, second and third laws of thermodynamics, Concepts of work, heat, Internal energy, enthalpy, Heat capacity, entropy, Gibbs energy, Helmholtz energy, Work done in isothermal and adiabatic reversible and irreversible processes, Entropy and free energy as criteria for spontaneity and equilibrium, Unattainability of absolute zero. Standard states. Entropy and free energy changes during isothermal and adiabatic processes, Changes in entropy and free energy with Temperature and pressure, Gibbs Helmholtz equation, Maxwells relations,

Joule Thomson effect- Inversion temperature, Application of J.T effect - Liquefaction of gases.

Module III (12 hrs)

Chemical Kinetics: Rate laws, Order and molecularity, Zero, first, second and third order reactions-

Integration of rate equations, Half-life period, Arrhenius equation. Theories of Reaction rate- Collision Theory, Transition state theory (elementary concepts), Unimolecular reactions- Lindemann mechanism. Complex Reactions -Consecutive, Parallel and Opposing reactions (elementary concepts), Steady state approximation. Chain reactions, Branched chain reactions (basic concepts)

Photochemistry: Photochemical laws, Beer-Lambert Law, Quantum yield, Photophysical and photochemical processes- Jablonski Diagram, Fluorescence, Phosphorescence-, Chemiluminescence,

Bioluminescence, Photosensitisation.

Module IV (9 hrs)

Surfaces and Interfaces: Surface free energy and Surface tension, Contact angles and Wetting, Surface films. capillarity, vapour pressure of droplets. Kelvin equation. pressure difference across curved surface -Laplace equation, Surface wetting- hydrophilicity and hydrophobicity.

Adsorption: Physical and chemical adsorption, adsorption isotherms- Langmuir (kinetic derivation), Freundlich and BET (No derivation) isotherms, Determination of surface area using Langmuir and BET isotherms, Catalysis- Homogeneous and heterogeneous, Enzyme catalysis.

Acid Base concepts: Theories of acids and bases- Arrhenius Theory, Bronsted-Lowry definition, pH, PKa , PKb, Lux Flood Definition, Solvent system definition, Lewis Definition, Usanovich Definition,

Generalised concepts: Ionic product of water, Common ion effect, Solubility product, Acid strength, Degree of hydrolysis of salts, Buffer solutions, Mechanism of buffer action, Henderson equation.

Module V (Lab 30 hrs)

Systematic qualitative analysis of mixtures containing two acid and two basic radicals from the list given below by semi micro method

Pb^{2+}, Cu^{2+}, Bi^{2+}, Cd^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mg^{2+},

NH_4^+, CO_3^{2-}, SO_4^{2-}, NO_3^-, F^-, Cl^-, $C_2O_4^{2-}$, CH_3COO^-, PO_4^{3-}

Recommended Books

1. P.W Atkins, Julio De Paula, Physical Chemistry, Oxford University Press, 10th/11th edn, 2017/2018.
2. Ira.N.Levine, Physical Chemistry, Tata Mc Graw Hill, 6th edn (Indian) 2011.
3. R.A.Alberty & R.J.Silbey, Physical Chemistry, Wiley Publishers, 4th edn, 2004.
4. T. Engel and P. Reid, Physical Chemistry, Pearson, 3rd Edn, 2013.
5. K J Laidler, J.H Meiser, Physical Chemistry, 4th edn 2003.
6. K. J. Laidler, Chemical-Kinetics, Paperback Edn., 2018.
7. M. R. Wright, An Introduction to Chemical Kinetics, Wiley, 2004.

24-808-0202 ELECTROCHEMISTRY, SOLID STATE AND COLLOIDS (4 Credits)
L-T-P 4-0-0 Level: 100
Pre-requisite: None

CO	CO Statement	CL
CO1	Describe the theories of ionic conductance and apply the concepts to calculate conductance of a given system	Apply
CO2	Describe the mechanism of electronic conductance at charged interfaces.	Apply
CO3	Describe the regular arrangement of atoms in crystals and the symmetry of their arrangement	Analyse
CO4	Explain the properties of solids and correlate their mechanical, electrical, optical, and magnetic properties with their constituent atoms and molecules.	Analyse
CO5	Describe various types of colloids, their stability and properties	Analyse

CO No	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	1	3	2	1
CO2	3	3	1	3	2	1
CO3	3	3	1	3	3	2
CO4	3	3	1	3	3	2
CO5	3	3	1	3	3	2

Module I (12 hours)

Introduction- Ionics, Electrodics, Electrochemical Cells, Electrodes, Electrolytes, Half Reactions, Electrochemical Work, Equilibrium electrochemistry-Half- reactions and electrodes, Types of cells, Types of electrodes- Standard hydrogen electrode, Calomel electrode, Quinhydrone electrode. Ion – Solvent, Ion – Ion Interactions, Ionic and Electronic Conductance, Conductance Measurement, Equivalent Conductance, Kohlrausch's Law, Ostwalds dilution law, Ionic Mobility, Walden's rule, abnormal conductance, Conductometeric titrations.

Module II (12 hours)

Transport Number- Factors Influencing, measurement- Hittorf's and moving boundary methods. Debye-Huckel Theory, Ionic Atmosphere, time of Relaxation, Mechanism of Electrolytic Conductance, Debye Huckel Onsager equation for strong electrolytes. Electrode – Ion interface, liquid junction potential, Double Layer, Overvoltage (Elementary idea)

The electromotive force, Standard potentials, Applications of standard potentials, Determination of solubility product and activity coefficient, pH determination, Potentiometric titrations, Redox indicators principle. Activity and Activity Coefficient of Electrolytes. Corrosion of metals- different forms of corrosion and prevention. Electrochemical Theory of corrosion – methods of prevention. Fuel Cell, Batteries (Elementary idea)

Module III (12 hours)

Crystal structures and symmetry, Crystallographic point groups, space group, unit cells, Miller indices, Seven crystal systems and Bravais lattices, Simple, body centered and face centered systems, Packing in solids- packing diagrams, close packing,- hcp and ccp structures, XRD, Braggs equation – derivation, Powder and rotating crystal technique. Identification of cubic crystals based on interplanar ratio

Module IV (14 hours)

Ionic solids with formula MX (CsCl, NaCl, Zinc Blende and Wurtzite Structures), MX2 (Fluorite and Antfluorite Structures, Cadmium Halides, CaF2, Rutile, Anti-rutile, betacristobalite), other crystal systems (Bismuth tri-iodide, Corundum, Rhenium Trioxide etc.), Mixed oxides (Spinel, Perovskite, Ilmenite). The properties of solids**,** Mechanical properties Electrical properties, Impact on nanoscience: Nanowires, Optical properties, Magnetic properties.

Point Defects in crystals- stoichiometric and non-stoichiometric defects, Line defect, surface defects, Liquid Crystals- Classification and application

Module V (10 hours)

Colloids: Lyophilic and Lyophobic colloids, Preparation of colloids, Kinetic, optical and electrical properties, Electrical double layer Models for double layer: Helmholtz, Gouy- Chapman and Stern models, Zeta potential. Stability of colloids, Protective colloids- Gold number, Flocculation, Hardy Schulze rule, Surfactants, micelles, Donnan membrane equilibrium, Dorn effect, Sedimentation potential and streaming potential, Emulsions, Gels, Sols.

Recommended Books:

1. J. Bockris and A.K.N. Reddy, Modern Electrochemistry, 2nd Edn., Wiley, New York, 1998
2. R. Crow, Principles and Applications of Electrochemistry, , 4th edn, 1994.
3. S. Glasstone, An Introduction to Electrochemistry, Paperback edn., 2007
4. L.V. Azaroff, Introduction to Solids, McGraw Hill, 1960.
5. A. R. West, Solid State Chemistry, Wiley Student (Indian) Ed., (2014)
6. A.K. Galwey, Chemistry of Solids, Chapman and Hall, London, 1967. 35
7. Lesley Smart and Elaine Moore, Solid State Chemistry, Chapman and Hall, 1995
8. H. V. Keer, Principles of the Solid State Wiley Eastern Ltd, New Delhi, 1993.

9. C. N. R. Rao and J. Gopalakrishnan, New Directions in Solid State Chemistry. 2nd edn, Cambridge Uty Press, 1997.
10. P.W. Atkins, Julio De Paula, Physical Chemistry, Oxford University Press, 10th/11th edn, 2017/2018

24-808-0301 Introduction to Organic Chemistry and Organic Qualitative Analysis (4 Credits)

L-T-P 3-0-2 Level: 100
Pre-requisite: None

CO	CO Statement	CL
CO1	Assign the nomenclature of simple organic molecules following IUPAC rules and identify various functional groups in organic chemistry.	Apply
CO2	Apply the concepts of isomerism and analyse the conformation and configuration of organic molecules.	Apply
CO3	Describe the different types of organic reactions.	Understand
CO4	Understand the different chemical bonding in organic molecules and reactive intermediates.	Understand
CO5	Understand the nature of biomolecules and develop an insight into the importance of organic chemistry in life.	Understand

CO No	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	1	1	1	1
CO2	2	3	1	1	1	1
CO3	2	3	3	2	1	1
CO4	2	2	2	1	1	1
CO5	1	2	1	1	2	1

Module I (10 hrs)
Localized and delocalized chemical bonding, the concept of aromaticity, writing proper Lewis structures, hybridization, reactive intermediates (carbynes, carbenes, carbocation, carbanion, radicals, arynes, nitrenes), Geometry of organic molecules.. "Symbolism" in Organic Chemistry.

Module II (30 hrs)
Nomenclature and functional groups in organic molecules: Rules of IUPAC system of nomenclature, naming of common organic compounds. Introduction to organic functional groups- alcohols, ethers, halides, amines, nitro compounds.
Organic Qualitative Analysis Lab:Identification of simple organic compounds. Preparation of derivatives.

Module III (10 hrs)
Stereochemistry: Configuration and conformation- Concept of configuration, classification of stereoisomers, optical isomerism, chirality, wedge formula, Fischer projection, Newman projection, perspective formula. Relative and absolute configurations, sequence rules, D & L, R

& S systems of nomenclature. Enantiomers, meso form, diastereoisomers, epimers, anomers. Geometrical Isomerism: E-Z notation. Conformational analysis: Strain in molecules, acyclic molecules, cyclohexane, substituted cyclohexanes- A values.

Module IV (10 hrs)

Basics of reaction mechanism: Classification and an overview of organic reactions. Electron pushing diagrams. Basics of reaction coordinate diagrams, intermediates, transition states, exothermic and endothermic reactions, activation energy, rates of reactions and rate-determining step. Aliphatic Nucleophilic substitutions - SN1, SN2, substitutions on aromatic carbon, Addition reactions - polar and nonpolar addition - addition of Bromine and hydrogen halides to double bonds - Markownikoff's rule and peroxide effect., Elimination - E1, E2, E1CB, pyrolytic elimination.

Module V (15 hrs)

Introduction to carbohydrates: General introduction to carbohydrates, ring-chain tautomerism, glycosidic linkage, classification, monosaccharides, disaccharides, oligosaccharides, polysaccharides, reducing and nonreducing sugars, structure of aldohexoses, fructose and ribose, "sugar-like" artificial sweeteners, basic introduction to amino acids, proteins and nucleic acids.

Recommended Text Books

1. J. G. Smith, Organic Chemistry, 3rd edn., 2011.
2. Clayden J., Greeves, N. Warren, S., Organic Chemistry, 2nd edn. Oxford University Press, 2001.
3. Bruice, P.Y. Organic Chemistry, 7th edn., Prentice Hall Inc., 2013.
4. March, J., Smith, D., March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 7th edn., Wiley, 2013.
5. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry (parts A and B), 5th edn., Springer, 2008.
6. J. McMurry, Organic Chemistry, 5th edn., Brooks/Cole, 2000.
7. P. Sykes, Guidebook to Mechanism in Organic Chemistry, 6th edn., Prentice Hall, 1986.
8. Pavia, D.L. Lampman, G.M. Kriz, G.S. and Engel, R.G. Introduction to Organic Laboratory Techniques: A small scale Approach, 2nd Ed., 2007.
9. Dey, B.B. Sitaraman, M.V. and Govindachari, T.V. Laboratory Manual of Organic Chemistry, 3rd Ed., Viswanathan, 1957.
10. Furniss, B.S. Hannaford, A.J. Smith, P.WG. Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Longman, 1989

24-808-0302 Elements of Symmetry and Spectroscopy (4 Credits)

L-T-P 4-0-0 Level: 100

Pre-requisite: None

CO	CO Statement	CL
CO1	Analyze the symmetry of any given molecule and assign the point group	Analyse
CO2	Explain the principles of rotational, vibrational, Raman, electronic, fluorescence and NMR spectroscopic techniques	Understand
CO3	Predict the applications and uses of the spectroscopic techniques	Analyse

CO No	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	1	3	2	1
CO2	3	3	1	3	2	1
CO3	3	3	1	3	3	2

Module I (10 hrs.)

Symmetry as a universal theme. Different symmetry classes and symmetry operations (discussion with suitable examples). Applications of symmetry to a) Polar molecules b) chiral molecules. Symmetry properties of orbitals (basic concepts); concept of point groups, identification of molecular point groups in some simple molecules.

Module II (8 hrs.)

Spectroscopy and its importance in chemistry. Link between spectroscopy and quantum chemistry. Electromagnetic radiation and its interaction with matter. origin of linewidths in molecular spectra, Transition dipole moment and Fermi's Golden Rule, Einsteins Coefficients, Lasers and Masers; Types of spectroscopy. Difference between atomic and molecular spectra. Separation of molecular energies into translational, rotational, vibrational and electronic components. Born-Oppenheimer approximation, Postulates of quantum mechanics, quantum mechanical operators.

Module III (16 hrs.)

Rotational Motion: Schrödinger equation of a rigid rotator and brief discussion of its results (solution not required). Quantization of rotational energy levels. Microwave (pure rotational) spectra of diatomic molecules. Selection rules. Structural information derived from rotational spectroscopy. determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational Motion: Schrödinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). concept of zero-point energy. Quantization of vibrational energy levels. Selection rules, IR spectra of diatomic molecules. Structural information derived

from vibrational spectra. Vibrations of polyatomic molecules. Group frequencies. Effect of hydrogen bonding (inter- and intramolecular) and substitution on vibrational frequencies.
Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Module IV (12 hrs.)
Electronic Spectroscopy: Electronic excited states. Free Electron model, its application to electronic spectra of polyenes. Franck-Condon principle, electronic transitions, Beer Lambert's Law, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model. Colour and constitution, chromophores, auxochromes, bathochromic and hypsochromic shifts.

Module V (14 hrs.)
NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin–Spin coupling and coupling constant; Anisotropic effects, Interpretation of NMR spectra of simple compounds. Carbon-13 NMR, introduction to polarization transfer and NOE, 2D NMR, MRI, Solid state NMR
Principle of fluorescence spectroscopy, Quenching of fluorescence, Mechanisms of quenching

Recommended Books:

1. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Ed. Tata McGraw-Hill: New Delhi, 2006.
2. W.Kemp, Organic Spectroscopy, 3rd Ed., Palgrave, 1991.
3. G. M. Barrow, Physical Chemistry, 6th Ed., McGraw-Hill College, 1996.
4. P.W. Atkins and J.Paula, Physical Chemistry, 8th Ed., Oxford Press, 2006.
5 .I. N. Levine, Physical Chemistry, 6th Ed., McGraw-Hill Education, 2008.
6. F. A. Cotton, Chemical Applications of Group Theory, 3rd Ed., Wiley Interscience, New York, 2008.
7. M. S. Gopinathan and V. Ramkrishnan, Group Theory in Chemistry, 2nd Ed., Vishal Publishing Co., 2013.
8. H. Gunther, NMR Spectroscopy, 2nd ed., John Wiley, 2005.

Multidisciplinary Courses in Chemistry

24-808-0103 General Chemistry -1 (3 Credits)
L-T-P 3-0-0 Level: 100
Pre-requisite: None

CO	CO Statement	CL
CO1	Appreciate the evolution of quantum mechanics and correlate the concepts to modern atomic structure.	Apply
CO2	Analyse the structure and bonding in simple molecules by applying the concepts of MOT.	Analyse
CO3	Correlate the physical and chemical properties of elements based on their periodic classification.	Apply
CO4	Perform a statistical analysis of experimental data	Apply

CO No	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	1	1	0
CO2	2	2	1	1	1	0
CO3	2	2	3	2	1	0
CO4	2	2	2	1	1	0

Module I (11 hrs)
Atomic structure I - Blackbody emission and temperature, Photoelectric effect, Double slit experiment, Line spectrum of elements, Rutherford's experiment, Bohr's atomic model, Failure of Classical mechanics, Evolution of quantum mechanics - Heisenberg's uncertainty principle and its significance, wave particle duality, de Broglie equation.

Module II (11 hrs)
Atomic Structure -II - Quantum atomic model, hydrogen atomic orbitals and quantum numbers, atomic orbital equations (no derivation required), Sign of wave functions. Radial and angular wave functions. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams.

Module III (12 hrs)
Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Lande equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Solvation energy, Covalent bond, Valence Bond theory, Resonance and resonance energy, Molecular orbital theory. bonding, non- bonding, antibonding molecular orbitals (concept only) elementary pictorial approach of homo- and hetero-
diatomic molecules H_2, B_2, C_2, O_2, N_2, CO, NO and CO_2, H_2O etc.

Module IV (11 hrs)
Periodic Properties: Atomic weights, Development of periodic law, The modern periodic table, Basis of periodic classification, orbital types and periodic table, Commonality in electronic

configurations, Atomic sizes, ionization energy, Electronegativity, Electron Affinity, Polarizability and polarizing power, Relative orbital energies and overlap, Trends associated with properties – Physical and chemical, Anomalies in periodic properties.

Recommended Books

1. Shriver, D. F., Atkins, P. W. and Langford, C. H. Inorganic Chemistry, 4th Ed., W.H. Freeman & Company, 2006.
2. Housecroft, C. and Sharpe, G., Inorganic Chemistry, 4th Edn., Pearson, 2012.
3. Atkins, P.W. and Paula, J. Physical Chemistry, 8th Edn., Oxford Press, 2006
4. Lee, J.D. Concise Inorganic Chemistry, 5th Edn., John Wiley & Sons, 1999.
5. Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, 3rd Ed., Oxford, 1994.
6. Day, M.C. and Selbin,J. Theoretical Inorganic Chemistry, 2nd Edn., ACS Publications, 2002.

24-808-0203 General Chemistry II (3 Credits)

L-T-P 3-0-0 Level: 100
Pre-requisite: None

CO	CO Statement	CL
CO1	Differentiate the properties of real gases from those of a perfect gas and predict the properties	Apply
CO2	Predict changes in thermodynamic parameters during a process and predict the spontaneity.	Analyse
CO3	Apply the concepts of chemical kinetics and photochemistry to calculate rate/ rate constants/quantum yield of different types of reactions	Apply
CO4	Understand the basic surface phenomena and extended application to adsorption.	Apply

CO No	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	1	1	0
CO2	3	3	2	1	1	0
CO3	3	2	2	1	1	0
CO4	3	2	2	1	1	0

Module I (11 hrs)
Gaseous State: Kinetic Theory of gases, Maxwell Boltzmann distribution of molecular velocities (Qualitative approach), Different types of velocities, Gas Laws, Ideal gas equation, Real gases- Deviation from ideal behavior- Compressibility factor, Van der Waals equation, Virial equation, PV isotherms, Continuity of states, Law of corresponding states, Critical phenomena and critical constants. Transport properties.

Module II (12 hrs)
Thermodynamics: State functions, Reversible and irreversible processes, Isothermal and adiabatic processes, First, second and third laws of thermodynamics, Concepts of work, heat, Internal energy, enthalpy, Heat capacity, entropy, Gibbs energy, Helmholtz energy, Work done in isothermal and adiabatic reversible and irreversible processes, Entropy and free energy as criteria for spontaneity and equilibrium, Unattainability of absolute zero. Standard states. Entropy and free energy changes during isothermal and adiabatic processes, Changes in entropy and free energy with Temperature and pressure, Gibbs Helmholtz equation, Maxwells relations, Joule Thomson effect- Inversion temperature, Application of J.T effect - Liquefaction of gases.

Module III (12 hrs)
Chemical Kinetics: Rate laws, Order and molecularity, Zero, first, second and third order

reactions-
Integration of rate equations, Half-life period, Arrhenius equation. Theories of Reaction rate- Collision Theory, Transition state theory (elementary concepts), Unimolecular reactions- Lindemann mechanism. Complex Reactions -Consecutive, Parallel and Opposing reactions (elementary concepts), Steady state approximation. Chain reactions, Branched chain reactions (basic concepts)
Photochemistry: Photochemical laws, Beer-Lambert Law, Quantum yield, Photophysical and photochemical processes- Jablonski Diagram, Fluorescence, Phosphorescence-, Chemiluminescence,
Bioluminescence, Photosensitisation.

Module V (9 hrs)

Surfaces and Interfaces: Surface free energy and Surface tension, Contact angles and Wetting, Surface films. capillarity, vapour pressure of droplets. Kelvin equation. pressure difference across curved surface -Laplace equation, Surface wetting- hydrophilicity and hydrophobicity.
Adsorption: Physical and chemical adsorption, adsorption isotherms- Langmuir (kinetic derivation), Freundlich and BET (No derivation) isotherms, Determination of surface area using Langmuir and BET isotherms, Catalysis- Homogeneous and heterogeneous, Enzyme catalysis.
Acid Base concepts: Theories of acids and bases- Arrhenius Theory, Bronsted-Lowry definition, pH, PKa , PKb, Lux Flood Definition, Solvent system definition, Lewis Definition, Usanovich Definition,
Generalised concepts: Ionic product of water, Common ion effect, Solubility product, Acid strength, Degree of hydrolysis of salts, Buffer solutions, Mechanism of buffer action, Henderson equation.

Recommended Books

1. P.W Atkins, Julio De Paula, Physical Chemistry, Oxford University Press, $10^{th}/11^{th}$ edn, 2017/2018.
2. Ira.N.Levine, Physical Chemistry, Tata Mc Graw Hill, 6^{th} edn (Indian) 2011.
3. R.A.Alberty & R.J.Silbey, Physical Chemistry, Wiley Publishers, 4^{th} edn, 2004.
4. T. Engel and P. Reid, Physical Chemistry, Pearson, 3^{rd} Edn, 2013.
5. K J Laidler, J.H Meiser, Physical Chemistry, 4^{th} edn 2003.
6. K. J. Laidler, Chemical-Kinetics, Paperback Edn., 2018.
7. M. R. Wright, An Introduction to Chemical Kinetics, Wiley, 2004.

24-808-0303 General Chemistry III (3 Credits)

L-T-P 3-0-0 Level: 100
Pre-requisite: None

CO	CO Statement	CL
CO1	Assign the nomenclature of simple organic molecules following IUPAC rules	Apply
CO2	Apply the concepts of isomerism and analyse the conformation and configuration of organic molecules.	Apply
CO3	Describe the different types of organic reactions.	Understand
CO4	Understand the different chemical bonding in organic molecules and reactive intermediates.	Understand
CO5	Understand the nature of biomolecules and develop an insight into the importance of organic chemistry in life.	Understand

CO No	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	1	1	1	1
CO2	2	3	1	1	1	1
CO3	2	3	3	2	1	1
CO4	2	2	2	1	1	1
CO5	1	2	1	1	2	1

Module I (10 hrs)
Localized and delocalized chemical bonding, the concept of aromaticity, writing proper Lewis structures, hybridization, reactive intermediates (carbynes, carbenes, carbocation, carbanion, radicals, arynes, nitrenes), Geometry of organic molecules.. "Symbolism" in Organic Chemistry.

Module II (7 hrs)
Nomenclature and functional groups in organic molecules: Rules of IUPAC system of nomenclature, naming of common organic compounds. Introduction to organic functional groups- alcohols, ethers, halides, amines, nitro compounds.

Module III (10 hrs)
Stereochemistry: Configuration and conformation- Concept of configuration, classification of stereoisomers, optical isomerism, chirality, wedge formula, Fischer projection, Newman projection, perspective formula. Relative and absolute configurations, sequence rules, D & L, R & S systems of nomenclature. Enantiomers, meso form, diastereoisomers, epimers, anomers. Geometrical Isomerism: E-Z notation. Conformational analysis: Strain in molecules, acyclic molecules, cyclohexane, substituted cyclohexanes- A values.

Module IV (8 hrs)

Basics of reaction mechanism: Classification and an overview of organic reactions. Electron pushing diagrams. Basics of reaction coordinate diagrams, intermediates, transition states, exothermic and endothermic reactions, activation energy, rates of reactions and rate-determining step. Aliphatic Nucleophilic substitutions - SN1, SN2, substitutions on aromatic carbon, Addition reactions - polar and nonpolar addition - addition of Bromine and hydrogen halides to double bonds - Markownikoff's rule and peroxide effect., Elimination - E1, E2, E1CB, pyrolytic elimination.

Module V (10 hrs)

Introduction to carbohydrates: General introduction to carbohydrates, ring-chain tautomerism, glycosidic linkage, classification, monosaccharides, disaccharides, oligosaccharides, polysaccharides, reducing and nonreducing sugars, structure of aldohexoses, fructose and ribose, "sugar-like" artificial sweeteners, basic introduction to amino acids, proteins and nucleic acids.

Recommended Text Books

1. J. G. Smith, Organic Chemistry, 3rd edn., 2011.
2. Clayden J., Greeves, N. Warren, S., Organic Chemistry, 2nd edn. Oxford University Press, 2001.
3. Bruice, P.Y. Organic Chemistry, 7th edn., Prentice Hall Inc., 2013.
4. March, J., Smith, D., March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 7th edn., Wiley, 2013.
5. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry (parts A and B), 5th edn., Springer, 2008.
6. J. McMurry, Organic Chemistry, 5th edn., Brooks/Cole, 2000.
7. P. Sykes, Guidebook to Mechanism in Organic Chemistry, 6th edn., Prentice Hall, 1986.
8. Pavia, D.L. Lampman, G.M. Kriz, G.S. and Engel, R.G. Introduction to Organic Laboratory Techniques: A small scale Approach, 2nd Ed., 2007.
9. Dey, B.B. Sitaraman, M.V. and Govindachari, T.V. Laboratory Manual of Organic Chemistry, 3rd Ed., Viswanathan, 1957.
10. Furniss, B.S. Hannaford, A.J. Smith, P.WG. Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, 5 th Ed., Longman, 1989

MULTIDISCIPLINARY COURSES

DEPARTMENT OF COMPUTER SCIENCE

Semester 1						
24-813-0103	**Computational Thinking for problem solving (Course Level 100-199)**	**TYPE**	**L**	**T**	**P**	**CREDIT**
		CS MDC	**3**	**1**	**0**	**3**

Course Outcomes (CO)		**Revised BT Level**
After the completion of the course, the students will be able to:		
CO1	Recognizing and Defining Computational Problems	**Understand**
CO2	Designing algorithms for simple problems using computational thinking principles	**Apply**
CO3	Applying inductive and deductive reasoning, and Boolean logic to solve problems	**Apply**
CO4	Designing solutions and solution processes based on problem definitions.	**Apply**
CO5	Programming CT artifacts using Python	**Analyze**

CO – PSO Mapping

CO	PSO1	PSO2	**PSO3**
CO1	3	-	**-**
CO2	3	2	**3**
CO3	3	3	**1**
CO4	1	3	**3**
CO5	-	3	**2**

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1

Elements of Computational Thinking - Understanding computational thinking - Decomposing problems, Recognizing patterns, Generalizing patterns, Designing algorithms for simple problems

Module 2

Understanding Algorithms and Algorithmic Thinking - Defining algorithms in depth, Designing algorithms, Analyzing algorithms - Big-Oh notation.

Module 3

Understanding Logical Reasoning - Inductive reasoning, Deductive reasoning. Using Boolean logic and operators. Identifying Logical Errors and Debugging. Understanding the problem definitions - Learning how to decompose problems - Converting the flowchart into an algorithm. Designing Solutions and Solution Processes

Module 4

Identifying Challenges within Solutions - Identifying errors in algorithm design - Debugging algorithms -Comparing solutions - Refining and redefining solutions

Module 5

Introduction to Python, Using Computational Thinking in Simple Challenges, Using Python in Experimental and Data Analysis Problems - Classification and Clusters, Using Computational Thinking and Python in Statistical Analysis

References

1. Applied Computational Thinking with Python - Second Edition. By Sofía De Jesús, Dayrene Martinez
2. Karl Beecher, Computational Thinking – A beginners guide to problem solving and programming, BCS, 1e, THE CHARTERED INSTITUTE FOR IT, 2017
3. Peter J. Denning, Matti Tedre, Computational Thinking, MIT Press, 2019
4. Peter William Mcowan, Paul Curzon, Power Of Computational Thinking, World Scientific, 2017

Semester 2						
24-813-0203	**Foundations of Programming** **(Course Level 100-199)**	**TYPE**	**L**	**T**	**P**	**CREDIT**
		CS MDC	**3**	**1**	**0**	**3**

Course Outcomes (CO)		**Revised BT Level**
After the completion of the course, the students will be able to:		
CO1	Understand the fundamentals of programming and learn to write programs.	**Understand**
CO2	Analyze the different the programming structures such as decision making statements, loops, arrays and functions.	**Analyze**
CO3	Understand the basic concepts of OOP and learn how to create and initialize objects using constructors.	**Understand**
CO4	Understand and analyze the different types of inheritance.	**Understand**
CO5	Understand the usage of polymorphism, template classes, namespaces and exception handling	**Understand**

CO – PSO Mapping

CO	PSO1	PSO2	PSO3	PSO4
CO1	3	2	-	-
CO2	3	2	-	-
CO3	3	2	**1**	-
CO4	3	2	**1**	-

CO5	3	2	**1**	**-**

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1(8 Lectures)

Introduction to Programming: Basic Difference between Procedure Oriented Language and Object Oriented Language. Fundamentals of C: Features of C language, structure of C program, comments, header files, data types, constants and variables, operators, expressions, evaluation of expressions, type conversion, precedence and associativity, I/O functions.

Module 2(10 Lectures)

Simple statements, Decision making statements, Looping statements, Nesting of control structures, break and continue statement. Array & String: Concept of array, One and Two dimensional arrays, declaration and initialization of arrays, String, String storage, Built-in string functions.

Module 3 (8 Lectures)

Functions: Concept of user defined functions, prototype, definition of function, parameters, parameter passing, calling a function

Module 4(10 Lectures)

Introduction to OOP: Basic properties, Classes and Objects, Member functions and variables, Abstract data types (ADT), Encapsulation. Constructors: Parameterized Constructors, Copy Constructors, Dynamic Constructors, Destructors.

Module 5 (8 Lectures)

Inheritance and Access Control: Member access control in classes, Friend functions and classes, Public Private and Protected Inheritance, Polymorphism: Runtime and compile time polymorphism, overloading functions and operators, Defining Operator Overloading

References

1. Yashavant Kanetkar: Let Us C, 15e,BPB Publications, 2016.
2. Herbert Schildt: C: The Complete Reference, 4e, McGraw Hill Education, 2017.
3. Pradip Dey, Manas Ghosh: Computer Fundamentals and Programming in C, 2e, Oxford University Press, 2013.
2. Bjarne Stroustrup: C++ Programming Language, 4e, Addison-Wesley, 2013.
3. Bjarne Stroustrup: Programming: Principles and Practice Using C++, 2e, Addison- Wesley, 2014.
4. Stanley Lippman, Josée Lajoie, Barbara Moo: C++ Primer, 5e, Addison-Wesley, 2012.
5. Paul Deitel, Harvey Deitel: C++ How to Program, 10e, Pearson, 2016.
6. Timothy Budd: Introduction To Object-Oriented Programming, Pearson Education, 2008.
7. Walter J. Savitch, Kenrick Mock: Problem Solving with C++, 9e, Pearson Education, 2017.
8. Ira Pohl: Object-Oriented Programming Using C++, 2e, Addison-Wesley,1996.

Semester 3						
24-813-0303	**Fundamentals of Data Structures** **(Course Level 200-299)**	**TYPE**	**L**	**T**	**P**	**CREDIT**
		CS MDC	**3**	**1**	**0**	**3**

Pre-requisites: 24-813-0103, 24-813-0203

Course Outcomes (CO)		**Revised BT Level**
After the completion of the course, the students will be able to:		
CO1	Understand the basic concepts of programming	**Understand**
CO2	Use elementary and advanced data structures such as Array, Linked list, Tree and to solve real world problems efficiently.	**Apply**
CO3	Implement searching and sorting methods.	**Apply**
CO4	Implement object oriented concepts in programming	**Apply**

CO – PSO Mapping

CO	PSO1	PSO2	PSO3	PSO4
CO1	3	2	**1**	**-**
CO2	3	2	**1**	**-**
CO3	3	2	**1**	**-**
CO4	3	2	**1**	**-**

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1

Introduction to programming methodologies – structured approach, stepwise refinement techniques, programming style, documentation. Elementary data organization - Data structure - Data structure operation, Review of basic programming questions

Module 2

Array, Records and Pointers: Introduction, Linear array, Representation of linear array in memory, Traversing linear array, Inserting and Deleting, Sorting methods, Searching methods.

Module 3

String - representation of strings, concatenation, substring searching and deletion.

Linked List: Introduction, Linked list, Representation of Linked list in memory, Searching a linked list,

Module 4

Stacks, Queues, Recursion - Introduction, Stacks, Queues, Operations on stacks and Queues, Implementation of Stacks and Queues using arrays and linked list, Applications.

Module 5

Tree - Introduction, Terminology of Binary tree, Types of Binary tree, Traversing of binary tree,

References

1. Samanta D.: Classic Data Structures, 2e, Prentice Hall India, 2009.
2. Richard F. Gilberg, Behrouz A. Forouzan: Data Structures: A Pseudocode Approach with C, 2e, Cengage Learning, 2005.
3. Aho A. V., J. E. Hopcroft, J. D. Ullman: Data Structures and Algorithms, Pearson Publication, 1983.
4. Tremblay J. P., P. G. Sorenson: Introduction to Data Structures with Applications, 2e, Tata McGraw Hill, 1995.
5. Peter Brass: Advanced Data Structures, Cambridge University Press, 2008.
6. Lipschutz S.: Theory and Problems of Data Structures, Schaum's Series, 1986.
7. Wirth N.: Algorithms + Data Structures = Programs, Prentice Hall, 2004.
8. Horwitz E., S. Sahni, S. Anderson: Fundamentals of Data Structures in C, University Press (India), 2008.

DEPARTMENT OF COMPUTER SCIENCE

MINOR COURSES

Semester 1						
24-813-0101	**Computational Thinking with Python** **(Course Level 100-199)**	**TYPE**	**L**	**T**	**P**	**CREDIT**
		DSC	**4**	**1**	**2**	**4**

Course Outcomes (CO)		**Revised BT Level**
After the completion of the course, the students will be able to:		
CO1	Recognizing and Defining Computational Problems	**Understand**
CO2	Designing algorithms for simple problems using computational thinking principles	**Apply**
CO3	Applying inductive and deductive reasoning, and Boolean logic to solve problems	**Apply**
CO4	Designing solutions and solution processes based on problem definitions.	**Apply**
CO5	Testing and Refining Computational Artifacts	**Analyze**

CO – PSO Mapping

CO	PSO1	PSO2	**PSO3**	**PSO4**
CO1	3	-	**-**	**-**
CO2	3	2	**3**	**-**
CO3	3	3	**1**	**-**
CO4	1	3	**3**	**-**
CO5	-	3	**2**	**-**

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module -1 (8 Lectures)

Elements of Computational Thinking - Understanding computational thinking - Decomposing problems, Recognizing patterns, Generalizing patterns, Designing algorithms for simple problems

Module 2(8 Lectures)

Understanding Algorithms and Algorithmic Thinking - Defining algorithms in depth, Designing algorithms, Analyzing algorithms.

Module 3 (8 Lectures)

Understanding Logical Reasoning - Inductive reasoning, Deductive reasoning. Using Boolean logic and operators. Identifying Logical Errors and Debugging

Module 4(8 Lectures)

Understanding the problem definitions - Learning how to decompose problems - Converting the flowchart into an algorithm. Designing Solutions and Solution Processes,

Module 5 (8 Lectures)

Identifying Challenges within Solutions - Identifying errors in algorithm design - Debugging algorithms -Comparing solutions - Refining and redefining solutions

References

1. Applied Computational Thinking with Python - Second Edition. By Sofía De Jesús, Dayrene Martinez

2. Karl Beecher, Computational Thinking – A beginners guide to problem-solving and programming, BCS, 1e, THE CHARTERED INSTITUTE FOR IT, 2017

3. Peter J. Denning, Matti Tedre, Computational Thinking, MIT Press, 2019

4. Peter William Mcowan, Paul Curzon, Power Of Computational Thinking, World Scientific, 2017

Semester 1						
24-813-0102	**Practical Applications of AI (Course Level 100-199)**	**TYPE**	**L**	**T**	**P**	**CREDIT**
		DSC	**4**	**1**	**0**	**4**

Course Outcomes (CO)		**Revised BT Level**
After the completion of the course, the students will be able to:		
CO1	Understanding of AI Concepts	**Understand**
CO2	Demonstrate knowledge of various AI algorithms, techniques, and models	**Apply**
CO3	Apply AI techniques to solve real-world problems and demonstrate critical thinking skills	**Apply**
CO4	Understand knowledge-based systems.	**Understand**
CO5	Know ethical concerns	**Understand**

CO – PSO Mapping

CO	PSO1	PSO2	**PSO3**	**PSO4**
CO1	3	-	**-**	**-**
CO2	3	2	**2**	**-**
CO3	3	2	**2**	**-**
CO4	3	-	**2**	**-**
CO5	-	3	**1**	**3**

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1(8 Lectures)

AI in Practice: Robotic Systems, Computer Vision, Natural Language ProcessingEducation, Government, Healthcare, Technology, Commerce, Manufacturing, Agriculture

Module-2(10 Lectures)

Artificial Intelligence, Machine Learning, Neural Networks, Perceptron, Deep Learning, Explainable AI, Generative AI, Prompt Engineering, GPT

Module-3 (8 Lectures)

Familiarisation of AI Software Python, R, Google Colab, Anaconda, UIPath, Power BI.

Practical Generative AI Examples, Creating presentations, Opening Excel files and draw graphs automatically, Make new pictures and music.

Module-4(8 Lectures)

Ethical concerns raised by AI, The role of ethics in the development of AI, Different ways of operationalizing fairness in the context of AI, Transparency and AI systems, AI and the Sustainable Development Goals, Applying AI to address the SDGs, The positive and negative impact of AI on the SDGs

Module-5 (6 Lectures)

Case Study 1: Contributions of AI towards developing vaccines

Case Study 2: AI for disaster management

References

1.Artificial Intelligence and Machine Learning by Vinod Chandra S. S and Anand Hareendran S, PHI, 2014.

2.Machine Learning: The New AI by Ethem Alpaydin, The MIT Press, 2016

3.https://microsoft.github.io/AI-For-Beginners/Introduction to AI, Evolution of AI, Turing test, Categories of AI, Applications of AI, Problem Definition as a State Space Search, Production System, Control StrategiesEthem Alpaydin, Machine Learning: The New AI, MIT Press, 2016

Semester 2						
24-813-0201	**Fundamentals of programming (Course Level 100-199)**	**TYPE**	**L**	**T**	**P**	**CREDIT**
		DSC	**4**	**1**	**2**	**4**

Course Outcomes (CO)		**Revised BT Level**
After the completion of the course, the students will be able to:		
CO1	Understand the programming fundamentals and write programs.	**Understand**
CO2	Analyse the different programming structures such as decision-making statements, loops, arrays, and functions.	**Analyze**
CO3	Understanding the basic concepts of OOP and learning how to create and initialize objects using constructors.	**Understand**
CO4	Understand and analyze the different types of inheritance.	**Understand**
CO5	Understand the usage of polymorphism, template classes, namespaces, and exception handling	**Understand**

CO – PSO Mapping

CO	PSO1	PSO2	**PSO3**	**PSO4**
CO1	3	2	-	-
CO2	3	2	-	-
CO3	3	2	**1**	-

CO4	3	2	**1**	**-**
CO5	3	2	**1**	**-**

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1(8 Lectures)

Introduction to Programming: Basic Difference between Procedure Oriented Language and Object Oriented Language, Concepts of Machine level, Assembly level and High-level programming, Flow charts and Algorithms.

Module 2(8 Lectures)

Fundamentals of C: Features of C language, structure of C program, comments, header files, data types, constants and variables, operators, expressions, evaluation of expressions, type conversion, precedence and associativity, I/O functions.

Module 3 (8 Lectures)

Simple statements, Decision-making statements, Looping statements, Nesting of control structures, break and continue statements. Array & String: Concept of array, One and Two-dimensional arrays, declaration and initialization of arrays, String, String storage, Built-in string functions.

Module 4(8 Lectures)

Functions: Concept of user-defined functions, prototype, definition of function, parameters, parameter passing, calling a function. Introduction to OOP: Basic properties, Classes and Objects, Member functions and variables, Abstract data types (ADT), Encapsulation.

Module 5 (8 Lectures)

Inheritance and Access Control: Member access control in classes, Friend functions and classes, Public Private, and Protected Inheritance, Single – Multiple – Multilevel – Hierarchical – Hybrid inheritance.Polymorphism: Runtime and compile time polymorphism.

References/Text Books

1. Yashavant Kanetkar: Let Us C, 15e,BPB Publications, 2016.
2. Herbert Schildt: C: The Complete Reference, 4e, McGraw Hill Education, 2017.
3. Pradip Dey, Manas Ghosh: Computer Fundamentals and Programming in C, 2e, Oxford University Press, 2013.
9. Bjarne Stroustrup: C++ Programming Language, 4e, Addison-Wesley, 2013.
10. Bjarne Stroustrup: Programming: Principles and Practice Using C++, 2e, Addison- Wesley, 2014.
11. Stanley Lippman, Josée Lajoie, Barbara Moo: C++ Primer, 5e, Addison-Wesley, 2012.
12. Paul Deitel, Harvey Deitel: C++ How to Program, 10e, Pearson, 2016.
13. Timothy Budd: Introduction To Object-Oriented Programming, Pearson Education, 2008.
14. Walter J. Savitch, Kenrick Mock: Problem Solving with C++, 9e, Pearson Education, 2017.

Ira Pohl: Object-Oriented Programming Using C++, 2e, Addison-Wesley,1996

Semester 2						
24-813-0202	**Computer Fundamentals 1** **(Course Level 100-199)**	**TYPE**	**L**	**T**	**P**	**CREDIT**
		DSC	**4**	**1**	**0**	**4**

Course Outcomes (CO)		**Revised BT Level**
After the completion of the course, the students will be able to:		
CO1	Understanding of the basic components of a computer system, including the CPU, memory, and storage	**Understand**
CO2	Gain proficiency in using common operating systems such as Windows or Linux	**Apply**
CO3	Acquire basic skills in computer programming and algorithmic thinking.	**Apply**
CO4	Understand fundamental concepts of computer networking, including protocols, topologies, and network devices.	**Understand**
CO5	Know ethical issues related to computer technology, including privacy, intellectual property, and social implications of automation	**Understand**

CO – PSO Mapping

CO	PSO1	PSO2	**PSO3**	**PSO4**
CO1	2	-	**-**	**-**
CO2	1	-	**-**	**-**
CO3	3	2	**1**	**-**
CO4	3	2	**3**	**-**

CO5	-	2	-	**3**

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module -1(8 Lectures)

Introduction, Basic Applications of Computer, Components of Computer, Connecting Computer Components, Computer Hardware & Software. What is an Operating System, Basics of Popular Operating Systems.

Module-2(10 Lectures)

Word Processing: Introduction, Document Creation & Editing, Saving, Text Formatting. Microsoft Excel & using Spreadsheets: Introduction, Rows, Columns & Cells, Basics Excel Formulas and Functions

Module-3 (8 Lectures)

Introduction to Internet, WWW and Web Browsers: Basic of Computer networks; LAN, WAN; Concept of Internet; Applications of Internet; Connecting to Internet; What is ISP; Knowing the Internet; Basics of internet connectivity related troubleshooting, Search Engines; Understanding URL; Domain name and IP Address

Module-4(8 Lectures)

Communications and collaboration: Basics of electronic mail; Getting an email account; Sending and receiving emails; Accessing sent emails; Using Emails; Document collaboration; Instant Messaging; Netiquettes.

Module-5 (6 Lectures)

Computer Security and Privacy: Importance of Computer Security, Common Security Threats, Malware (Viruses, Worms, Trojans), Network Security Measures Firewalls, Encryption, Access Control, User Authentication, Privacy Concerns and Data Protection

References

1. Computer Basics Absolute Beginner's Guide- Michael Miller

2. Absolute Beginners Guide to Computing - Wallace Wang

3. Computer Fundamentals: Concepts, Systems & Applications- 8th Edition- Priti Sinha, Pradeep K, Sinha

4. Computers Made Easy from Dummy to Geek- James Bernstein

Semester 3						
24-813-0301	**Data Structures (Course Level 200-299)**	**TYPE**	**L**	**T**	**P**	**CREDIT**
		DSC	**4**	**1**	**2**	**4**

Course Outcomes (CO)		**Revised BT Level**
After the completion of the course, the students will be able to:		
CO1	Understand different asymptotic notations to analyze performance of algorithms.	**Understand**
CO2	Use elementary and advanced data structures such as Array, Linked list, Tree and Graph to solve real world problems efficiently.	**Apply**
CO3	Implement searching and sorting methods.	**Apply**
CO4	Understand different memory management techniques and their significance.	**Analyze**

CO – PSO Mapping

CO	PSO1	PSO2	**PSO3**	**PSO4**
CO1	3	3	1	-
CO2	3	2	1	-
CO3	3	2	1	-
CO4	3	2	-	-

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1

Introduction to programming methodologies – structured approach, stepwise refinement techniques, programming style, documentation. Elementary data organization - Data structure - Data structure operation - Analysis of algorithms: frequency count, definition of Big O notation, asymptotic analysis of simple algorithms - Recursive and iterative algorithms.

Module 2

Array, Records and Pointers: Introduction, Linear array, Representation of linear array in memory, Traversing linear array, Inserting and Deleting, Sorting methods, Searching methods. String - representation of strings, concatenation, substring searching and deletion.

Module 3

Linked List: Introduction, Linked list, Representation of Linked list in memory, Searching a linked list, Memory allocation, Garbage collection, Insertion and deletion in linked list, doubly linked list, Circular linked list, applications of linked list: polynomials, Memory management, memory allocation and deallocation, First-fit, best-fit and worst-fit allocation schemes.

Module 4

Stacks, Queues, Recursion - Introduction, Stacks, Queues, Operations on stacks and Queues, Implementation of Stacks and Queues using arrays and linked list, Arithmetic expression evaluation, Recursion, DEQUEUE (double ended queue), Multiple Stacks and Queues, Applications.

Module 5

Tree - Introduction, Terminology of Binary tree, Types of Binary tree, Traversing of binary tree, Header Nodes, Threads. Binary search tree – creation, insertion and deletion and search operations, applications. B-Trees, B+-Trees. Hash Tables – Hashing functions – Mid square, division, folding, digit analysis, collusion resolution and Overflow handling techniques.

References

1. Samanta D.: Classic Data Structures, 2e, Prentice Hall India, 2009.
2. Richard F. Gilberg, Behrouz A. Forouzan: Data Structures: A Pseudocode Approach with C, 2e, Cengage Learning, 2005.
3. Aho A. V., J. E. Hopcroft, J. D. Ullman: Data Structures and Algorithms, Pearson Publication, 1983.
4. Tremblay J. P., P. G. Sorenson: Introduction to Data Structures with Applications, 2e, Tata McGraw Hill, 1995.
5. Peter Brass: Advanced Data Structures, Cambridge University Press, 2008.
6. Lipschutz S.: Theory and Problems of Data Structures, Schaum's Series, 1986.
7. Wirth N.: Algorithms + Data Structures = Programs, Prentice Hall, 2004.
8. Horwitz E., S. Sahni, S. Anderson: Fundamentals of Data Structures in C, University Press (India), 2008.

Semester 3						
24-813-0302	**Computer Fundamentals 2** **(Course Level 200-299)**	**TYPE**	**L**	**T**	**P**	**CREDIT**
		DSC	**4**	**1**	**0**	**4**

Course Outcomes (CO)		**Revised BT Level**
After the completion of the course, the students will be able to:		
CO1	Understanding basic concepts of Number systems and digital logic	**Understand**
CO2	Understand the basic concepts of Computer organization and architecture	**Understand**
CO3	Understand the basic working principles of operating system and its process	**Understand**

CO – PSO Mapping

CO	PSO1	PSO2	**PSO3**	**PSO4**
CO1	2	-	**-**	**-**
CO2	2	-	**-**	**-**
CO3	2	-	**-**	**-**

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1(8 Lectures)

Number Systems and Codes: Binary Number system – Binary to decimal – decimal to binary – hexadecimal – ASCII code Digital Logic: The Basic Gates – NOT, OR, AND - Universal Logic Gates – NOR, NAND. Boolean Laws and Theorems.

Module-2(10 Lectures)

Basic Computer Organization and Design: Instruction codes - stored program organization - Computer registers and common bus system - Computer instructions - Timing and control - Instruction cycle: Fetch and Decode - Register reference instructions.

Module-3 (8 Lectures)

Central Processing Unit: General register organization - stack organization – instruction formats - addressing modes - Input-output organization: Peripheral devices - I/O interface - Memory organization: Memory hierarchy - Main memory - Auxiliary memory

Module-4(8 Lectures)

Overview of Operating Systems, Types of OS, OS Operations, Resource Management, Kernel Processes- Process concept, forks and pipes, Interrupt processing, Process Scheduling, CPU Scheduling Algorithms

Module-5 (6 Lectures)

Process Synchronization- Critical Section Problem, Mutex Locks, Semaphores, Deadlocks- Methods of Handling Deadlocks, Deadlock Prevention, Deadlock Avoidance

References/Text Books

1. Digital Principles and Applications – Donald P Leach, Albert Paul Malvino, GoutamSaha, 8th edition, McGraw-Hill Education, 3rd reprint 2015. R. P. Jain, “Modern Digital Electronic”, McGraw-Hill Publication, 4th Edition.
2. William Stalling, “Computer Organization and Architecture: Designing and Performance”, Pearson Publication 10TH Edition.
3. Computer System Architecture, M. Morris Mano, Pearson Education, 3rd edition.,2007
4. Operating System Principles, Abraham Silberchatz, Peter B. Galvin, Greg Gagne,10th Edition, Wiley Student Edition. 2018
5. Operating System-Internals and Design Principles, W.Stallings, 6th Edition, Pearson.
6. Strang, Gilbert. Modern Operating System, Andrew s Tanenbaum, 3rd Edition, PHI

Cochin University of Science and Technology
Department of Mathematics

Mathematics Elective Papers

(Semester: 1, 2 and 3)

Departmental / Inderdepartmental Elective

(Offered as a Minor for all students)

Semester I
24-803-0101 - Calculus I

Number of credits: 4
Number of hours per week: 4 hrs
Total No. of Hours: 72 hours

Objective: This course introduces the basic concepts from calculus that are required both in the applied and pure branches of science.

Course Outcome (CO): After completing the course, the student should be able to

No.	Course Outcome	Cognitive level
CO1	Evaluate the limit of a function and to do differentiation and integration	Evaluate
CO2	Apply the concepts in calculus to solve problems	Apply
CO3	Understand the basic concepts of calculus.	Understand

CO - PSO Mapping Table:

CO/PSO	PSO1	PSO2	PSO3	PSO4
CO1	3			
CO2	3	1		
CO3	3			

Prerequisites : Set theory, Operations on sets, functions, The set of natural numbers, Set of integers, Set of rational numbers, Set of real numbers and the set of Complex numbers.

Text books:

1. George B. Thomas and Ross L. Finney: *Calculus and Analytic Geometry.* Pearson Education India; 9th edition, (2010).

References:

1. Anton, Bivens and Davis, John: *Calculus single variable* 10th edition, Wiley and sons, Inc. (2012).
2. Tom M. Apostol: *Calculus, Vol I* (Second Edition), Wiley Student Edition, (2006).
3. N. Piskunov, M.I.R. Publisher, *Differential and Integral Calculus*, (Vol: I), (1977).
4. A Course in Calculus and Real Analysis, Ghorpade Sudhir, Limaye Balmohan V., Springer International Edition, (2006).

Syllabus

Module 1: Real Numbers and the Real Line, Coordinates, Lines, and Increments, Functions, Shifting Graphs, Trigonometric Functions, Rates of Change and Limits, Rules for Finding Limits, Target Values and Formal Definitions of Limits, Extensions of the Limit Concept, Continuity and Tangent Lines.
(Sections: Preliminaries 1, 2, 3, 4, 5, 1.1, 1.2, 1.3, 1.4, 1.5 and 1.6 of Text book 1).

Module 2: The Derivative of a Function, Differentiation Rules, Derivatives of Trigonometric Functions, The Chain Rule, Implicit Differentiation and Rational Exponents.
(Sections 2.1, 2.2, 2.4, 2.5 and 2.6 of Text book 1).

Module 3: Extreme Values of Functions, The Mean Value Theorem, The First Derivative Test for Local Extreme Values, Graphing with y' and y''.
(Sections 3.1, 3.2, 3.3 and 3.4 of Text book 1).

Module 4: Indefinite Integrals, Differential Equations, Integration by Substitution-Running the Chain Rule Backward, Riemann Sums and Definite Integrals, Properties, Area, and the Mean Value Theorem, The Fundamental Theorem, Substitution in Definite Integrals.
(Section 4.1, 4.2, 4.3, 4.5, 4.6, 4.7 and 4.8 of Text book 1).

Semester II
24-803-0201 - Calculus II

Number of credits: 4
Number of hours per week: 4 hrs
Total number of Hours: 72 hours

Objective: This course introduces the basic concepts from calculus that are required both in the applied and pure branches of science.

Course Outcome (CO): After completing the course, the student should be able to

No.	Course Outcome	Cognitive level
CO1	Evaluate the limit of a function using various rules	Evaluate
CO2	Apply the concepts in calculus to solve problems	Apply
CO3	Understand the basic concepts of sequences and series.	Understand

CO - PSO Mapping Table:

CO/PSO	PSO1	PSO2	PSO3	PSO4
CO1	3			
CO2	3	1		
CO3	3			

Prerequisites : This course is a continuation of Calculus I course offered in Semester I

Text books:

1. George B. Thomas and Ross L. Finney: *Calculus and Analytic Geometry.* Pearson Education India; 9th edition, (2010).

References:

1. Anton, Bivens and Davis, John: *Calculus single variable* 10th edition, Wiley and sons, Inc. (2012).
2. Tom M. Apostol: *Calculus, Vol I* (Second Edition), Wiley Student Edition, (2006).
3. N. Piskunov, M.I.R. Publisher, *Differential and Integral Calculus*, (Vol: I), (1977).
4. A Course in Calculus and Real Analysis, Ghorpade Sudhir, Limaye Balmohan V., Springer International Edition, (2006).

Syllabus

Module 1: Areas Between Curves, Finding Volumes by Slicing, Volumes of Solids of Revolution, Lengths of Plane Curves.
(Sections: 5.1, 5.2, 5.3 and 5.5 of Text book 1).

Module 2: L Hopital's Rule, Basic Integration Formulas, Integration by Parts, Partial Fraction, Improper Integrals.
(Sections: 6.6, 7.1, 7.2. 7.3 and 7.6 of Text book 1).

Module 3: Limits of Sequences of Numbers, Theorems for Calculating Limits of Sequences.
(Sections: 8.1 and 8.2 of Text book 1).

Module 4: Infinite series, The integral test for series of non negative terms, Comparison tests for series of non negative terms, Ratio and root test for series of non negative terms, Alternating Series, Absolute and Conditional Convergence. (Sections 8.3, 8.4, 8.5, 8.6 and 8.7 of text book 1).

Semester III
24-803-0301 - Calculus III

Number of credits: 4
Number of hours per week: 4 hrs
Total number of Hours: 72 hours

Objective: This course introduces the advanced concepts of calculus that are required both in the applied and pure branches of science.

Course Outcome (CO): After completing the course, the student should be able to

No.	Course Outcome	Cognitive level
CO1	Evaluate the limit of a function and to do differentiation and integration	Evaluate
CO2	Apply the concepts in calculus to solve problems	Apply
CO3	Understand the basic concepts of calculus.	Understand

CO - PSO Mapping Table:

CO/PSO	PSO1	PSO2	PSO3	PSO4
CO1	3			
CO2	3	1		
CO3	3			

Prerequisites : This is a continuation course of Calculus II offered in Semester II.

Text books:

1. George B. Thomas and Ross L. Finney: *Calculus and Analytic Geometry.* Pearson Education India; 9th edition, (2010).

References:

1. Anton, Bivens and Davis, John: *Calculus single variable* 10th edition, Wiley and sons, Inc. (2012).
2. Tom M. Apostol: *Calculus, Vol I* (Second Edition), Wiley Student Edition, (2006).
3. N. Piskunov, M.I.R. Publisher, *Differential and Integral Calculus*, (Vol: I), (1977).
4. A Course in Calculus and Real Analysis, Ghorpade Sudhir, Limaye Balmohan V., Springer International Edition, (2006).

Syllabus

Module 1: Conic Sections and Quadratic Equations, Classification of Conic Section by Eccentricity, Quadratic Equation and Rotations, Parametrization of Plane Curves, Calculus with Parametrized Curves, Polar coordinates, Cylindrical and Spherical coordinates, Vector valued functions and space curves, Arc length and the unit tangent vector, Curvature, torsion and the TNB frame.
(Sections 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, and 10.7 of the text book 1).

Module 2: Functions of several variables, Limits and continuity, Partial derivatives, Differentiability.
(Sections 12.1, 12.2, 12.3 and 12.4 of the text book 1).

Module 3: Linearization and Differentials, The chain rule, Partial derivatives with constrained variables, Directional derivatives, Gradient and tangent planes, Extreme values and saddle points, Lagrange multipliers, Taylor's formula.
(Sections 12.5, 12.6, 12.7, 12.8, 12.9 and 12.10 of the text book 1).

Module 4: Double integrals, Areas, Double integral in polar form, Triple integrals in Rectangular coordinates, Masses, moments in three dimension.
(Sections 13.1, 13.2, 13.3, 13.4 and 13.5 of the text book).

Cochin University of Science and Technology
Department of Mathematics

Mathematics Elective Papers

(Semester: 1, 2 and 3)

Interdepartmental Multidisciplinary Course

(Offered for students not taking Mathematics as major. Can be counted towards minor or multidisciplinary)

Semester I
24-803-0103 - Mathematical Methods I

Number of credits: 3
Number of hours per week: 3 hrs
Total No. of Hours: 54 hours

Objective: This course introduces basic Complex analysis and Differential equations techniques which are important tools in all branches of science.

Outcome: After completing the course, the student is expected to

No.	Course Outcome	Cognitive level
CO1	Understand basic differential equations and know how to solve them.	Understand
CO2	Evaluate complex integrals and higher order complex derivatives	Evaluate

CO - PSO Mapping Table:

CO/PSO	PSO1	PSO2	PSO3	PSO4
CO1	3			
CO2	3	1		

Prerequisites: Basic theory, formulas and techniques of differential and integral calculus of one variable.

Text book:

1. Advanced Engineering Mathematics, Erwin Kreyszig, 8th Edition. John Wiley and Sons, Inc., New York, (1999).

Reference books:

1. Calculus, Vol I (Second Edition), Tom M. Apostol, Wiley Student Edition, (2006).
2. Calculus and Analytic Geometry (Ninth Edition), George.B.Thomas and Ross.L.Finney, Pearson Education, Inc, (2006)
3. Complex variables and Applications (5th Edition) , J. W. Brown, R.V. Churchill, McGrawHill Higher Education, (1990).
4. Complex Analysis (3rd edition), L.V. Ahlfors, McGrawHill Book Company, (1979).

Syllabus

Module 1: Basic concepts and ideas, Geometric meaning, Exact equations, Linear differential equations, Applications Homogeneous Linear differential equations of second order.
(Chapter 1, Section 2.1 of Text book 1).

Module 2: Homogeneous Linear differential equations of second order with constant coefficients, Euler Cauchy equations, Existence and uniqueness theory, Wronskian, Non homogeneous

equations, Solutions by undetermined coefficients and by variation of parameters.
(Sections 2.2-2.3, Sections 2.6-2.10 of Text book 1).

Module 3: Complex Numbers, Polar form, Analytic Function, Cauchy-Riemann Equations, Elementary Functions, logarithm. Complex Integration, Cauchy's Integral Theorem and Integral Formula (without proof), Higher Derivatives (without proof).
(Section 12.1-12.4, 12.6-12.8, 13.1-13.4 of Text Book 1).

Semester II
24-803-0203 - Mathematical Methods II

Number of credits: 3
Number of hours per week: 3 hrs
Total No. of Hours: 54 hours

Objective: This course introduces Laplace Transform and Fourier series which are important tools in all branches of science. Also, Numerical Methods in General, Numerical Methods in Linear Algebra and Numerical Methods for Differential Equations are introduced. This course also introduces the abstract concept of Groups which is useful in all branches of science.

Outcome: After completing the course, the student is expected to

No.	Course Outcome	Cognitive level
CO1	Know Laplace Transform and Fourier series and their applications to various branches.	Remember
CO2	Apply numerical techniques for interpolation, integration and differentiation	Apply

CO - PSO Mapping Table:

CO/PSO	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	
CO2	3			

Prerequisites: Basic theory, formulas and techniques of differential and integral calculus of one variable.

Text books:

1. Advanced Engineering Mathematics, Erwin Kreyszig, 8th Edition. John Wiley and Sons, Inc., New York, (1999).

Reference books:

1. Calculus, Vol I (Second Edition), Tom M. Apostol, Wiley Student Edition, (2006).
2. Calculus and Analytic Geometry (Ninth Edition), George.B.Thomas and Ross.L.Finney, Pearson Education, Inc, (2006)
3. Complex variables and Applications (5th Edition) , J. W. Brown, R.V. Churchill, McGrawHill Higher Education, (1990).
4. Complex Analysis (3rd edition), L.V. Ahlfors, McGrawHill Book Company, (1979).
5. Joseph A. Gallian: *Contemporary Abstract Algebra*, Eight Edition, University of Minnesota Duluth, 2017.

Syllabus

Module 1: Power Series, Power series representation of Analytic functions,Taylor series and Maclaurin series, Practical methods for power series. Laplace Transform, Transforms of Derivatives and integrals, Second Shifting theorem.
(Section 14.2-14.5, 5.1-5.3 of Text Book 1).

Module 2: Periodic functions, Fourier Series, Functions of any period, Half-Range Expansion, Fourier Series (Contd.): Complex Fourier Series, Forced Oscillations, Fourier Transform. (Section 10.1-10.10 of Text Book 1).

Module 3: Introduction, Solution of Equations by Iteration, Interpolation, Spline Interpolation, Numeric Integration and Differentiation, Linear Systems: Gauss Elimination (Section 17.1-17.5 of the Text Book)

Semester III
24-803-0303 - Matrix Theory and Graph Theory

Number of credits: 3
Number of hours per week: 3 hrs
Total No. of Hours: 54 hours

Objective: This course introduces the basic concepts from linear algebra and Graph Theory that are required both in the applied and pure branches of science.

Outcome: After completing the course, the student is expected to

No.	Course Outcome	Cognitive level
CO1	Know the fundamental concepts of linear algebra and graph theory.	Remember
CO2	Apply the basic results in linear algebra and graph theory for problem-solving.	Apply

CO - PSO Mapping Table:

CO/PSO	PSO1	PSO2	PSO3	PSO4
CO1	3			
CO2	3	2	1	

Text books:

1 Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition. John Wiley and Sons, Inc., New York, (2011).

2 John Clark Derek Allen Holton - A first look at graph theory, Allied Publishers, 1991.

Reference books:

1 S. Kumaresan: *Linear Algebra: A Geometric Approach*, PHI Learning, 2009.

2 Howard Anton and Chris Rorres: *Elementary Linear Algebra* with Supplemental Applications, 11th Edition, John Wiley, 2015.

3 R Balakrishnan and K Ranganathan: *A Text Book of Graph Theory*, Springer.

Syllabus

Module 1: Matrices, Vectors: Addition and Scalar Multiplication, Matrix Multiplication, Linear Systems of Equations, Gauss Elimination, Linear Independence, Rank of a Matrix, Vector Space, Solutions of Linear Systems: Existence, Uniquenes.
(Sections 7.1-7.5 of Text book 1).

Module 2: Determinants, Cramer' s Rule, Inverse of a Matrix, Gauss–Jordan Elimination, The Matrix Eigenvalue Problem, Determining Eigenvalues and Eigenvectors, Some Applications of Eigenvalue Problems, Symmetric, Skew-Symmetric, and Orthogonal Matrices.
(Sections 7.7, 7.8, 8.1 - 8.3 of Text book 1).

Module 3: An introduction to graph: Definition of a Graph, More definitions, Vertex Degrees, Sub graphs, Paths and cycles, the matrix representation of graphs. Trees. Definitions and Simple properties, Bridges, Spanning trees, Cut vertices and Connectivity, Euler's Tours, the Chinese postman problem, Hamiltonian graphs, The travelling salesman problem.
(Sections 1.1 - 1.7, 2.1 - 2.3, 2.6, 3.1 - 3.4 of Text book 2)

Cochin University of Science and Technology
Department of Mathematics

Mathematics Core Papers

(Semester: 1 - 6)

Core papers

(Offered for students opting Mathematics as Major or Minor)

Semester I
24-803-0102 - Basic Analysis I

Number of credits: 4
Number of hours per week: 5 hrs
Total number of Hours: 90 hours

Objective: This course starts with the structure of Natural Numbers. This course is planned to introduce the notions real number system, Convergence of sequence and series.

Learning Outcomes: After completing the course students will be able to

No.	Course Outcome	Cognitive level
CO1	Know basics of calculus and important notions on the set of real numbers.	Remember
CO2	Understand sequence of real numbers and evaluate their convergence.	Understand
CO3	Apply limit theorems and series convergence tests.	Apply

CO - PSO Mapping Table:

CO/PSO	PSO1	PSO2	PSO3	PSO4
CO1	3			
CO2	3			
CO3	3			

UNIT 1: Introduction to Natural numbers and Rational Numbers, The set of all Real numbers, Completeness axiom (Sections 1, 2, 3 and 4)

UNIT 2: Extended real number system.Limit of sequence (Sections 5, 6, 7 and 8)

UNIT 3: Limit theorems, Monotone Sequences and Cauchy Sequences (Sections 9, and 10)

UNIT 4: Subsequences, Limsup's and Liminf's, Series (Sections 11, 12 and 14)

UNIT 5: Alternating Series and Integral Tests, Continuous functions, Properties of continuous functions (Sections 15, 17 and 18)

Text Book: Kenneth A. Ross Elementary Analysis: The Theory of Calculus, Second Edition, Springer-Verlag (2013).

References:-

1. Terence Tao, Analysis I and II, Third Edition, Springer 2016.
2. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, Fourth Edition, Wiley India Edition (2011).
3. N.L Carothers, Real Analysis, Wiley 2000.
4. Halsey L. Royden, Real Analysis, Prentice Hall, Upper Saddle River, NJ, (1988).
5. Tom M. Apostol, Mathematical Analysis, Addison-Wesley, Reading, MA, (1974).
6. A. K. Sharma, Real Analysis, Discovery publishing house Pvt. Lts., New Delhi, (2008).

7. D Somasundaram and B. Choudhary, A first course in mathematical analysis, Narosa, Oxford, London,(1996).

8. S Kumaresan, Topology of Metric Space, Alpha Science international Ltd, Harrow, UK, (2005)

Semester II
24-803-0202 - Basic Analysis II

Number of credits: 4
Number of hours per week: 5 hrs
Total number of Hours: 90 hours

Objective: This course starts with the notion of continuous functions. This course is planned to introduce the notions continuity, Convergence of sequence and series of functions and some metric space notions.

Learning Outcomes: After the completion of the course the students will be able to

No.	Course Outcome	Cognitive level
CO1	Understand the notions of limit, continuity and uniform continuity of functions.	Understand
CO2	Understand power series, their convergence, integration and differentiation.	Understand
CO3	Know basic properties and results of derivatives.	Remember
CO4	Know the basics of Riemann integration.	Remember

CO - PSO Mapping Table:

CO/PSO	PSO1	PSO2	PSO3	PSO4
CO1	3			
CO2	3			
CO3	3			
CO4	3			

UNIT 1: Uniform Continuity, Limit of functions, Power Series (Sections 19, 20 and 23)

UNIT 2: Uniform Convergence, More on Uniform Convergence, Differentiation and Integration of Power Series (Sections 24, 25 and 26)

UNIT 3: Basic Properties of the Derivative, The Mean Value Theorem (Sections 28 and 29)

UNIT 4: L'Hospital's Rule, Taylor's Theorem (Sections 30 and 31)

UNIT 5: The Riemann Integral, Properties of the Riemann Integral, Fundamental Theorem of Calculus (Sections 32, 33 and 34)

Text Book: Kenneth A. Ross Elementary Analysis: The Theory of Calculus, Second Edition, Springer-Verlag (2013).

References:-

1. Terence Tao, Analysis I and II, Third Edition, Springer 2016.
2. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, Fourth Edition, Wiley India Edition (2011).
3. N.L Carothers, Real Analysis, Wiley 2000.
4. Halsey L. Royden, Real Analysis, Prentice Hall, Upper Saddle River, NJ, (1988).

5. Tom M. Apostol, Mathematical Analysis, Addison-Wesley, Reading, MA, (1974).

6. A. K. Sharma, Real Analysis, Discovery publishing house Pvt. Lts., New Delhi, (2008).

7. D Somasundaram and B. Choudhary, A first course in mathematical analysis, Narosa, Oxford, London,(1996).

8. S Kumaresan, Topology of Metric Space, Alpha Science international Ltd, Harrow, UK, (2005)

Semester III
24-803-0302 - Matrix Theory I

Number of credits: 4
Number of hours per week: 5 hrs
Total number of Hours: 90 hours

Objective: This course introduces the basic concepts from linear algebra that are required in all branches of science.

Outcome: After completing the course, the student is expected to

No.	Course Outcome	Cognitive level
CO1	Understand the fundamental concepts and applications of linear algebra.	Understand
CO2	Know how to use the computer software MATLAB.	Remember

CO - PSO Mapping Table:

CO/PSO	PSO1	PSO2	PSO3	PSO4
CO1	3	1		
CO2	3	2	1	2

Text books:

1 Ron Larson: *Elementary Linear Algebra*, 8th Edition, Cengage Learning, 2016.

Reference books:

1 S. Kumaresan: *Linear Algebra: A Geometric Approach*, PHI Learning, 2009.

2 Howard Anton and Chris Rorres: *Elementary Linear Algebra* with Supplemental Applications, 11th Edition, John Wiley, 2015.

3 Michael Artin: *Algebra*, Pearson Prentice Hall, . Linear Algebra: A First Course with Applications

Syllabus

Module 1: Introduction to Systems of Linear Equations, Gaussian Elimination and Gauss-Jordan Elimination, Applications of Systems of Linear Equations, Computational Aspects using computer software MATLAB.
(Sections 1.1 - 1.3 of Text book 1).

Module 2: Operations with Matrices, Properties of Matrix Operations, The Inverse of a Matrix, Elementary Matrices, Computational Aspects using computer software MATLAB.
(Sections 2.1 - 2.4 of Text book 1).

Module 3: Markov Chains, More Applications of Matrix Operations, The Determinant of a Matrix, Determinants and Elementary Operations, Computational Aspects using computer software MATLAB.
(Sections 2.5,2.6, 3.1, 3.2 of Text book 1)

Module 4: Properties of Determinants, Applications of Determinants, Vectors in R^n, Vector Spaces, Subspaces of Vector Spaces, Computational Aspects using computer software MATLAB.
(Sections 3.3, 3.4, 4.1 to 4.3 of Text book 1).

Module 5: Spanning Sets and Linear Independence, Basis and Dimension, Rank of a Matrix and Systems of Linear Equations, Computational Aspects using computer software MATLAB. (Sections 4.4 to 4.6 of Text book 1).

INTERNATIONAL SCHOOL OF PHOTONICS

Minor and MDC Courses in Photonics

Semester I
Introduction to Photonics (DSC B)
Geometrical and Physical Optics (DSC C)
General Optics (MDC)

Semester II
Applied Optics (DSC B)
Mathematical Physics I (DSC C)
Mathematical Methods (MDC)

Semester III
Mechanics (DSC C)
Nano-Bio photonics (DSC B)
Basic Mechanics (MDC)

Semester VII(Electives)
Optoelectronics (DSE)
Non-Linear Optics (DSE)
Nanophotonics (DSE)
Laser spectroscopy (DSE)
Quantum Optics & Quantum Computing (DSE)
Advanced Electromagnetic Theory (DSE)

Semester VIII (Electives)
Optomechanical Engineering (DSE)
Laser Systems and Laser Applications (DSE)
Biophotonics (DSE)

Detailed Syllabus

23-812-0101 Optics I: Geometrical and Physical Optics
(Level 100)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the concept of radiometry and photometry.	Understand	5	4
CO2	Explain the principles of colourimetry, chromaticity coordinates and human colour vision.	Understand	6	4
CO3	Apply matrix methods in optics.	Apply	6	2
CO4	Interpret various types of aberration and dispersion phenomena in optical system	Apply	6	4
CO5	Explain the interference phenomena by division of wavefront and division of amplitude.	Understand	5	4
CO6	Describe the concept of coherence and superposition in optics	Understand	6	4
CO7	Analyse the principles of thin film interference.	Apply	5	4
CO8	Analyse various systems based on the principle of interference.	Apply	6	4
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	1	1	3			
CO2	3	1	1	3			
CO3	3	1	1	3			
CO4	3	1	1	3			
CO5	3	1	1	3			
CO6	3	1	1	3			
CO7	3	1	1	3			
CO8	3	1	1	3			

3-High; 2-Medium; 1-Low

Module I

Photometry and Radiometry- quantities and units, Colourimetry- chromaticity coordinates, UCS chromaticity coordinates, UCS diagrams, RGB colour mixing and colour purity, colour temperature, CCT, Visual basis of colourimetry, Human eye and colour deficiency, colour vision model.

Module II

Optical path, Fermat's principle, Dispersion- normal and anomalous dispersion, Wood's experiment, achromatism in prisms, dispersion without deviation.

Aberrations- Spherical aberration, coma, astigmatism, distortion, chromatic aberration.

Matrix methods in Optics- Paraxial rays, Matrix representation of translation, refraction, reflection of light rays, ABCD law, lens waveguide.

Module III

Superposition of two sinusoidal waves, path difference and phase difference, Analytical and graphical methods. Coherent sources, spatial and temporal coherence, complex representation of light waves, Interference of two monochromatic waves, optical beats.
Theory of interference and bandwidth, Interference by division of wave front, Young's double slit experiment, Fresnel's bi-prism, Lloyd's mirrors.

Module IV
Interference by division of amplitude, two beam interference, parallel sided plates, colour of thin films, wedge shaped film, Haidinger and Fizeau fringes, Newton's rings - reflected and transmitted systems, Radius of rings and expression for wavelength, Michelson interferometer, Determination of wavelength separation and standardization of meter. Types of fringes- localized and non-localised fringes in white light.

Reference

1. Optics, Ajoy Ghatak, 7th Edition,Tata McGraw Hill, (2020) (Text)
2. A Textbook of Optics, N Subrahmaniam and Brij Lal, M N Avadhanulu, S Chand and
3. Company, 23rd Edition, (2006) (Text)
4. Handbook of Applied Photometry, C De Cusatis, AIP. (1997) (Text)
5. Light emitting diodes- E Fred Scheubert, Cambridge University Press (2006)
6. Modern Optics, A B Gupta, Books & Allied Ltd; 4th Revised edition (2013)
7. Optics, Eugene Hecht and A R Ganesan, 5th Edition, Pearson Education (2017)
8. Fundamentals of Optics, Jenkins and White, McGraw Hill Education, 4th edition (2017)
9. Wave optics and applications, R.S Sirohi, Orient Longman, (1993)

24-812- 0102 Introduction to Photonics

(Level 100)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the basic properties of photons and how photons interact with atoms.	Understand	7	0
CO2	Understand the concept of photonics, its application and recent advancement in the field of photonics.	Understand	8	0
CO3	Understand the concept of LASER and lasing action, spectral width and gain of the laser.	Understand	6	0
CO4	Understand the different types of LASER and its application in the field of photonics.	Understand	9	0
CO5	Understand the history and basic concept of light propagation through the optical fiber.	Understand	7	0
CO6	Understand the construction of optical fiber, its types, transmission characteristics and fundamentals of communication system.	Understand	7	0
CO7	Understand the basics and principles of holography and its recording and reconstruction.	Understand	8	0
CO8	Understand the difference between holography and ordinary photography and its application in the current scenario.	Understand	8	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1					
CO2	3	3	1					
CO3	3	3	1					
CO4	3	3	1					
CO5	3	3	1					
CO6	3	3	1					
CO7	3	3	1					
CO8	3	3	1					

3-High; 2-Medium; 1-Low

Module I

Photon, properties of photon, Interaction of photons with atoms: energy loss mechanisms- photoelectric effect, Compton scattering, pair production, linear attenuation coefficient, mass attenuation coefficient.

Introduction to photonics, applications of photonics, recent advancement in the field of photonics.

Module II

LED and LASER, advantages of LASER over LED, spontaneous and stimulated emissions, Einstein coefficients, rates of stimulated emission and absorption, condition for amplification by stimulated

emission, meta-stable state and lasing action, spectral width of LASER, gain for self-sustained oscillations in the lasing cavity, LASER rate equation.
Examples of types of lasers: fiber laser, gas laser, tunable lasers: semiconductor lasers, Applications of lasers.

Module III
Introduction to optical fibre, historical development in the field of optical fibre, advantages, disadvantages, and applications of optical fibre communication, principle of light propagation in optical fibre, optical fibre fabrication, types of optical fibres: single mode and multimode fibres.
Transmission characteristics of optical fibre: attenuation, absorption, scattering losses, bending loss, dispersion, intra modal dispersion, inter modal dispersion.
Fundamentals of optical fiber communication systems.

Module IV
Holography-hologram, basic principle of holography, principle of hologram construction, construction of a hologram, recording and reconstruction of the image, comparison with ordinary photography, applications of hologram.

References

1. Photonics: Elements and Devices, V V Rampal, Wheeler, Delhi, 1992.
2. Introducing Photonics, Brian Culshaw, University of Strathclyde, Cambridge University press, 2020.
3. Fundamentals of Photonics, Bahaa E. A. Saleh, Malvin Carl Teich, Wiley, 1991.
4. Lasers: Fundamentals and Applications, K. Thyagarajan, Ajoy Ghatak, Springer New York, NY, 2010, 2nd edition.
5. An Introduction to Fiber Optics, Ajoy K. Ghatak, K. Thyagarajan, Cambridge University Press, 2012.
6. Three-dimensional holographic imaging, Chung J. Kuo, Meng Hua Tsai, John Wiley & Sons, 2002,

24-812-0103 General Optics MDC

(Level 100)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the concept of radiometry and photometry.	Understand	5	0
CO2	Explain the principles of colourimetry, chromaticity coordinates and human colour vision.	Understand	6	0
CO3	Apply matrix methods in optics.	Apply	6	0
CO4	Interpret various types of aberration and dispersion phenomena in optical system	Apply	6	0
CO5	Explain the interference phenomena by division of wavefront and division of amplitude.	Understand	5	0
CO6	Describe the concept of coherence and superposition in optics	Understand	6	0
CO7	Analyse the principles of thin film interference.	Apply	5	0
CO8	Analyse various systems based on the principle of interference.	Apply	6	0
	Total Number of Hours		45	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	1	1	3			
CO2	3	1	1	3			
CO3	3	1	1	3			
CO4	3	1	1	3			
CO5	3	1	1	3			
CO6	3	1	1	3			
CO7	3	1	1	3			
CO8	3	1	1	3			

3-High; 2-Medium; 1-Low

Module I

Photometry and Radiometry- quantities and units, Colourimetry- chromaticity coordinates, UCS chromaticity coordinates, UCS diagrams, RGB colour mixing and colour purity, colour temperature, CCT, Visual basis of colourimetry, Human eye and colour deficiency, colour vision model.

Module II

Optical path, Fermat's principle, Dispersion- normal and anomalous dispersion, Wood's experiment, achromatism in prisms, dispersion without deviation.

Aberrations- Spherical aberration, coma, astigmatism, distortion, chromatic aberration.

Matrix methods in Optics- Paraxial rays, Matrix representation of translation, refraction, reflection of light rays, ABCD law, lens waveguide.

Module III

Superposition of two sinusoidal waves, path difference and phase difference, Analytical and graphical methods. Coherent sources, spatial and temporal coherence, complex representation of light waves, Interference of two monochromatic waves, optical beats.
Theory of interference and bandwidth, Interference by division of wave front, Young's double slit experiment, Fresnel's bi-prism, Lloyd's mirrors.

Module IV
Interference by division of amplitude, two beam interference, parallel sided plates, colour of thin films, wedge shaped film, Haidinger and Fizeau fringes, Newton's rings - reflected and transmitted systems, Radius of rings and expression for wavelength, Michelson interferometer, Determination of wavelength separation and standardization of meter. Types of fringes- localized and non-localised fringes in white light.

Reference

1. Optics, Ajoy Ghatak, 7th Edition,Tata McGraw Hill, (2020) (Text).
2. A Textbook of Optics, N Subrahmaniam and Brij Lal, M N Avadhanulu, S Chand and
3. Company, 23rd Edition, (2006) (Text).
4. Handbook of Applied Photometry, C De Cusatis, AIP. (1997) (Text).
5. Light emitting diodes- E Fred Scheubert, Cambridge University Press (2006).
6. Modern Optics, A B Gupta, Books & Allied Ltd; 4th Revised edition (2013).
7. Optics, Eugene Hecht and A R Ganesan, 5th Edition, Pearson Education (2017).
8. Fundamentals of Optics, Jenkins and White, McGraw Hill Education, 4th edition (2017).
9. Wave optics and applications, R.S Sirohi, Orient Longman, (1993)

24-812-0201 Mathematical Physics I

(Level 100)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the concepts of vector calculus and matrices.	Understand	8	0
CO2	Utilize vector calculus, matrix inversion and fundamental theorems of vector calculus to interpret physical phenomena effectively.	Apply	8	0
CO3	Understand differentiation of hyperbolic and inverse hyperbolic functions, and the application of Taylor's and McLaurin's theorems.	Understand	8	0
CO4	Apply numerical techniques for integration, integration, polynomial fitting and interpolation.	Apply	6	0
CO5	Understand curvilinear coordinates.	Understand	8	0
CO6	Apply curvilinear coordinates for effectively representing mathematical operations like integrations and differentiations.	Apply	8	0
CO7	Understand first order equations and partial differential equations.	Understand	8	0
CO8	Apply numerical methods for solving differential equations.	Apply	6	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	2	1	1	2	1	1	
CO2	3	2	1	1	2	1	1	
CO3	3	2	1	1	2	1	1	
CO4	3	2	1	1	2	1	1	
CO5	3	2	1	1	2	1	1	
CO6	3	2	1	1	2	1	1	
CO7	3	2	1	1	2	1	1	
CO8	3	2	1	1	2	1	1	

3-High; 2-Medium; 1-Low

Module I

Vector calculus: vector differentiation, gradient, divergence and curl, solenoidal and irrotational vector point functions. Vector integration, line, surface and volume integration, Green's theorem, Gauss theorem and Stokes theorem, physical interpretations.

Matrices: orthogonal, symmetric, skew symmetric, Hermitian and skew Hermitian matrices, elementary transformations of a matrix. Similarity and unitary transformation of matrices, diagonalization of matrices, Eigenvalues and eigenvectors, Cayley-Hamilton theorem, solution of algebraic equations using matrices, consistent and inconsistent equations.

Module II

Differential calculus: differentiation of hyperbolic and inverse hyperbolic functions. Taylor's and Mclaurin's theorems, Application to expansion functions.

Partial differentiation: partial derivatives and total differential coefficients. Euler's theorem on homogeneous function, chain rule for partial derivatives, errors and approximations.

Numerical differentiation: first and second order derivatives.

Integral calculus: numerical integration: trapezoidal, Simpson's and Gaussian quadrature methods.

Least-square curve fitting: straight line and polynomial fits, Interpolation: Newton's and Lagrange's formulas

Module III

Curvilinear coordinates: description of curvilinear coordinate system, expression for square of distance element, metric-scale factors, differential distance vector, line integral, area element and area vector, volume element and volume integral, conversion of unit vectors in spherical and cylindrical coordinates into rectangular coordinates and vice versa.

Gradient, divergence, curl and Laplacian operators in curvilinear coordinate systems.

Module IV

Ordinary differential equations: first order equation, variables separable, homogeneous and non-homogeneous equations, integrating factor, Bernoulli's equations, enact equations, second order linear differential equations with constant coefficients. Complementary function and particular integrals, solution using auxiliary equation.

Numerical solutions of ordinary differential equations: Euler's method and Runge-Kutta methods.

Partial differential equations: derivation of PDE by elimination of arbitrary constants and arbitrary coefficients. Concept of Jacobian. Solution of Lagrange's differential equations, Partial differential equation of the second degree, Laplace, Helmholtz and Poisson equations.

References

1. Mathematical Methods for Physicists G. B. Arfken and H. J. Weber, Academic Press, 2001 (Text).
2. Mathematical Methods in the Physical Sciences, 3rd. Ed., M. L. Boas, John Wiley, 2005 (Text).
3. Advanced Engineering Mathematics - 10th Ed., Erwin Keryszig, Wiley, 2011 (Text).
4. Mathematical Methods for Physics and Engineering - 3rd Ed., K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press, 2006 (Text).
5. Vector Analysis with an Introduction to Tensor Analysis - Murray R Spiegel, Tata McGraw Hill (1975) Schaum Series (Text).
6. Differential Equations, Richard Bronson, Tata McGraw Hill, New Delhi, 1994 (Text).
7. Differential Equations and Linear Algebra, Stephen W. Goode and Scott A. Annin, Pearson, 2005 (Text)
8. Advanced Mathematics for Engineers Scientists, Murray R Spiegel, McGraw-Hill Education, 2009 (Text).
9. Matrices and Tensors for Physicists, A W Joshi, New Age International (1995)
10. Numerical Methods - Balagurusamy, Tata McGraw Hill, 2001 (Text).
11. Introductory Methods of Numerical Analysis, 5th Ed., S. S. Sastry, Prentice Hall of India, 2012 (Text).
12. Differential Equations - 3rd Ed., Shepley L. Ross, Wiley. 2007 (Text).
13. Introduction to Mathematical Physics, Harper Lee and Charlie Mackesy, Prentice Hall India, 1978.

24-812-0202 Applied Optics

(Level 100)

CO	CO statement	CL	Class Hrs	Lab Hrs
CO1	Explain the basic concepts of diffraction, including Fresnel's assumptions and rectilinear propagation of light.	Understand	8	0
CO2	Apply the Fresnel-Kirchhoff integral and Fourier transform in analysing Fraunhofer and Fresnel diffractions.	Apply	7	0
CO3	Compare and contrast different types of gratings, including blazed gratings.	Analyse	7	0
CO4	Analyse the resolution and dispersive power of spectrographs and monochromators based on grating properties.	Analyse	8	0
CO5	Describe the mathematical description of polarization and different states of polarization.	Understand	7	0
CO6	Analyse the properties of polarizers, wave plates, birefringent crystals, and circular polarizers.	Analyse	8	0
CO7	Identify dextro and levo rotatory substances and explain their optical activity.	Understand	7	0
CO8	Apply Jones and Muller matrix calculus to analyse polarizers, retarders, and rotators.	Apply	8	0
	Total number of hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	1	1	3			
CO2	3	1	1	3			
CO3	3	1	1	3			
CO4	3	1	1	3			
CO5	3	1	1	3			
CO6	3	1	1	3			
CO7	3	1	1	3			
CO8	3	1	1	3			

3-High; 2-Medium; 1-Low

Module I

Diffraction-Fresnel's assumptions, rectilinear propagation of light and Fresnel's theory, Fresnel's zones, theory of zone plate, Fraunhofer and Fresnel diffractions, Fresnel-Kirchhoff integral, Fourier transform in Fraunhofer diffraction, diffraction by a single slit, diffraction by a rectangular and circular aperture, limit of resolution, Fourier transforming property of lens, spatial frequency filtering

Module II

Diffraction grating, resolution of a grating, types of gratings, blazed gratings, Mountings for gratings- various mounting techniques, Grating spectrographs, resolution and dispersive power of spectrographs, single beam and double beam monochromators. Spectrometers and fluorimeters

Module III

Analysis of Polarization- Mathematical description of polarization, states of polarization, polarization ellipse, special forms, Elliptical parameters,

Double refraction, ordinary and extraordinary rays, Optical Anisotropy-Index ellipsoid, Nicol prism, Nicol prism as a polarizer. Wave plates, full wave plate, Quarter wave and Half wave plates, Birefringence-Birefringent crystals, polarisers, polarization beam splitters, Compensators and Variable retarders, Circular polarizers,

Module IV

Optical activity - Dextro and levo rotatory substances, optical activity in liquids, Half-shade plate, Laurent's half-shade polarimeter, Stress birefringence – Photoelasticity

Jones and Muller matrix calculus- Matrices for polarizer, retarder, and rotator in both representations, Neutral density filter, Muller matrix for Depolarizer

Stokes polarization parameters, Stokes vectors, Stokes parameters for polarized and unpolarized light, Stokes Intensity formula, Poincare sphere, Representation of polarization states

References

1. Optics, Eugene Hecht and A R Ganesan, 5th Edition, Pearson Education (2017).
2. Optics- Ajoy Ghatak, McGraw Hill (2020).
3. Polarized light – Edward Collet, Marcel Decker (1992).
4. Introduction to Optoelectronics- Wilson and Hawkes, PHI, (1996).
5. Wave optics and Applications - R. S. Sirohi, Orient Longmann (2001).
6. Optical Electronics - Thyagarajan and Ghatak, Cambridge India (2017).
7. Polarization of light - S. Huard, Wiley (1997).

24-812-0203 Mathematical Methods MDC

(Level 100)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the concepts of vector calculus and matrices.	Understand	5	0
CO2	Utilize vector calculus, matrix inversion and fundamental theorems of vector calculus to interpret physical phenomena effectively.	Apply	5	0
CO3	Understand differentiation of hyperbolic and inverse hyperbolic functions, and the application of Taylor's and McLaurin's theorems.	Understand	5	0
CO4	Apply numerical techniques for integration, integration, polynomial fitting and interpolation.	Apply	6	0
CO5	Understand curvilinear coordinates.	Understand	6	0
CO6	Apply curvilinear coordinates for effectively representing mathematical operations like integrations and differentiations.	Apply	6	0
CO7	Understand first order equations and partial differential equations.	Understand	6	0
CO8	Apply numerical methods for solving differential equations.	Apply	6	0
	Total Number of Hours		45	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	2	1	1	2	1	1	
CO2	3	2	1	1	2	1	1	
CO3	3	2	1	1	2	1	1	
CO4	3	2	1	1	2	1	1	
CO5	3	2	1	1	2	1	1	
CO6	3	2	1	1	2	1	1	
CO7	3	2	1	1	2	1	1	
CO8	3	2	1	1	2	1	1	

3-High; 2-Medium; 1-Low

Module I

Vector calculus: vector differentiation, gradient, divergence and curl, solenoidal and irrotational vector point functions. Vector integration, line, surface and volume integration, Green's theorem, Gauss theorem and Stokes theorem, physical interpretations.

Matrices: orthogonal, symmetric, skew symmetric, Hermitian and skew Hermitian matrices, elementary transformations of a matrix. Similarity and unitary transformation of matrices, diagonalization of matrices, Eigenvalues and eigenvectors, Cayley-Hamilton theorem, solution of algebraic equations using matrices, consistent and inconsistent equations.

Module II

Differential calculus: differentiation of hyperbolic and inverse hyperbolic functions. Taylor's and Mclaurin's theorems, Application to expansion functions.

Partial differentiation: partial derivatives and total differential coefficients. Euler's theorem on homogeneous function, chain rule for partial derivatives, errors and approximations.

Numerical differentiation: first and second order derivatives.

Integral calculus: numerical integration: trapezoidal, Simpson's and Gaussian quadrature methods.

Least-square curve fitting: straight line and polynomial fits, Interpolation: Newton's and Lagrange's formulas

Module III

Curvilinear coordinates: description of curvilinear coordinate system, expression for square of distance element, metric-scale factors, differential distance vector, line integral, area element and area vector, volume element and volume integral, conversion of unit vectors in spherical and cylindrical coordinates into rectangular coordinates and vice versa.

Gradient, divergence, curl and Laplacian operators in curvilinear coordinate systems.

Module IV

Ordinary differential equations: first order equation, variables separable, homogeneous and non-homogeneous equations, integrating factor, Bernoulli's equations, enact equations, second order linear differential equations with constant coefficients. Complementary function and particular integrals, solution using auxiliary equation.

Numerical solutions of ordinary differential equations: Euler's method and Runge-Kutta methods.

Partial differential equations: derivation of PDE by elimination of arbitrary constants and arbitrary coefficients. Concept of Jacobian. Solution of Lagrange's differential equations, Partial differential equation of the second degree, Laplace, Helmholtz and Poisson equations.

References

1. Mathematical Methods for Physicists G. B. Arfken and H. J. Weber, Academic Press, 2001 (Text).
2. Advanced Engineering Mathematics - 10th Ed., Erwin Keryszig, Wiley, 2011 (Text).
3. Mathematical Methods for Physics and Engineering - 3rd Ed., K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press, 2006 (Text).
4. Vector Analysis with an Introduction to Tensor Analysis - Murray R Spiegel, Tata McGraw Hill (1975) Schaum Series (Text).
5. Differential Equations, Richard Bronson, Tata McGraw Hill, New Delhi, 1994 (Text).
6. Differential Equations and Linear Algebra, Stephen W. Goode and Scott A. Annin, Pearson, 2005 (Text)
7. Advanced Mathematics for Engineers Scientists, Murray R Spiegel, McGraw-Hill Education, 2009 (Text).
8. Matrices and Tensors for Physicists, A W Joshi, New Age International (1995)
9. Numerical Methods - Balagurusamy, Tata McGraw Hill, 2001 (Text).
10. Introductory Methods of Numerical Analysis, 5th Ed., S. S. Sastry, Prentice Hall of India, 2012 (Text).
11. Differential Equations - 3rd Ed., Shepley L. Ross, Wiley. 2007 (Text).
12. Introduction to Mathematical Physics, Harper Lee and Charlie Mackesy, Prentice Hall India, 1978 (Text).
13. Mathematical Methods in the Physical Sciences, 3rd. Ed., M. L. Boas, John Wiley, 2005 (Text).

24-812-0301 Mechanics

(Level 200)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Explain the laws of mechanics, frames of reference, Galilean transformations and forces.	Understand	5	4
CO2	Apply the concepts of laws of mechanics, frames of reference, transformations and forces in order to solve problems involving these ideas.	Apply	6	4
CO3	Explain concepts of Lorentz transformations, relativity, non-absolute nature of space and time and its consequences.	Understand	6	2
CO4	Apply the concepts of relativistic mechanics to reformulate the classical ideas of mass, energy, momentum and their transformation.	Apply	6	4
CO5	Understand the principles of Lagrangian mechanics and solve problems involving generalized coordinates and constraints in mechanical systems.	Understand	5	4
CO6	Apply Hamilton's principle and Lagrange's equations of motion of particles and systems in various mechanical scenarios.	Apply	6	4
CO7	Understand the concepts of Hamiltonian mechanics and canonical transformations.	Understand	5	4
CO8	Apply the Hamilton-Jacobi equation to solve problems in classical mechanics.	Apply	6	4
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	2	1	2	1	1	1	
CO2	3	2	1	2	1	1	1	
CO3	3	2	1	2	1	1	1	
CO4	3	2	1	2	1	1	1	
CO5	3	2	1	2	1	1	1	
CO6	3	2	1	2	1	1	1	
CO7	3	2	1	2	1	1	1	
CO8	3	2	1	2	1	1	1	

3-High; 2-Medium; 1-Low

Module I

Frames of reference, Laws of Mechanics, Inertial frames of reference, Galilean transformation, Galilean invariance, Principle of relativity, Conservation of momentum, Non-inertial frames and fictitious forces, Centripetal force, Centrifugal force, Rotating frame of reference, Foucault's pendulum.

Module II

Michelson-Morley experiment, Ether hypothesis, Special theory of relativity, Lorentz transformations, Length contraction, Time dilation, Simultaneity, Addition of velocities, Relativistic Doppler's effect, Conservation of momentum and variation of mass, Relativistic energy, Relation between momentum and energy and conservation laws, Transformation of momentum and energy, Particles with zero rest mass.

Module III

Constraints: types of constraints, difficulties associated with constraints, generalized coordinates Kinetic energy of a system in terms of generalized velocities. Calculus of Variation: Hamilton's Principle, techniques of the calculus of variations, Lagrange's equation from Hamilton's principle. Generalized momenta, cyclic coordinates.

Applications of Lagrangian formulation: motion of a particle in space, Atwood's machine, bead sliding on rotating wire, simple pendulum, harmonic oscillator.

Module IV

Hamiltonian mechanics: Hamiltonian of a system, Hamilton's equations of motions, Canonical transformations, Generating functions.

Poisson Brackets: fundamental properties of PB, Equations of motion in Poisson Bracket form, PB and integrals of motion, Canonical invariance of PB, Lagrange brackets. Hamilton-Jacobi equation for Hamilton's principal function.

References

1. Mechanics, J C Upadhyaya, Ram Prasad and Sons, Agra 2017 (Text).
2. Mechanics D S Mathur, S Chand & Company, New Delhi 2007.
3. Classical Mechanics, H Goldstein, C Poole and J Safko, 3rd edition, Addison Wesley 2005 (Text).
4. Classical Mechanics – G Aruldhas, PHI learning, 2014.
5. Mechanics: Berkeley Physics Course, Vol. 1, Tata McGraw Hill Education, Noida, 2nd edition 2017.
6. The Feynman Lectures on Physics, Vol. I, Narosa Publishing House, New Delhi 2008.
7. Classical Mechanics- Rana and Joag, Tata McGrawHill 1992.
8. Classical Mechanics - V B Bhatia, Narosa Publishing House, New Delhi 1997.
9. Mechanics L. D Landau and E. N Lifshitz., Butterworth Heinemann,3rd edition 2002.

24-812-0302 Nano-Bio Photonics
(Level 200)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the basic theory and science of interaction of light with cells and tissues	Understand	8	0
CO2	Understand different light delivery systems	Understand	7	0
CO3	Understand fundamentals of optical imaging	Understand	7	0
CO4	Understand different optical imaging techniques	Understand	8	0
CO5	Understand different optical biosensors	Understand	10	0
CO6	Understand photodynamic therapy	Understand	5	0
CO7	Understand optical tweezers and analyze its applications	Understand	7	0
CO8	Understand different tissue engineering techniques using light	Understand	8	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3						
CO2	3	3						
CO3	3	3						
CO4	3	3						
CO5	3	3						
CO6	3	3						
CO7	3	3						
CO8	3	3						

3-High; 2-Medium; 1-Low

MODULE I

Photobiology; interaction of light with cells with cells and tissues, Photo-process in Bio polymers human eye and vision, Photosynthesis; Photo-excitation - free space propagation, optical fibre delivery system, articulated arm delivery, hollow tube wave-guides.

Optical coherence Tomography, Fluorescence microscopy, resonance energy transfer imaging

MODULE II

Bio-imaging: Transmission microscopy, Kohler illumination, microscopy based on phase contrast, darkfield and differential interference contrast microscopy, Fluorescence, confocal and multiphoton microscopy.

Applications of bio-imaging; Bio-imaging probes and fluoropores, imaging of microbes, cellular imaging and tissue imaging

MODULE III

Optical Biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, Biosensors based on fibre optics, evanescent waves and interferometric Flow Cytometry: basis, flurochromes for flow cytometry, DNA analysis. Laser activated therapy; Photodynamic therapy, photo-sensitizers for photodynamic therapy, two photon photodynamic therapy.

MODULE IV

Laser tweezers and laser scissors: design of Laser tweezers and laser scissors, optical trapping using non Gaussian optical beam, manipulation of single DNA molecules, molecular motors, semi conductor Quantum dots for bio imaging. Tissue engineering using light; contouring and restructuring of tissues using laser, laser tissue regeneration

References

1. Introduction to bio-photonics- P.N. Prasad Wiley Interscience (2003).
2. Biomedical Photonics -A handbook - editor Tuan. Vo Dinh (CRC Press) (2002).

24-812-0303 Basic Mechanics MDC
(Level 200)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Explain the laws of mechanics, frames of reference, Galilean transformations and forces.	Understand	5	0
CO2	Apply the concepts of laws of mechanics, frames of reference, transformations and forces in order to solve problems involving these ideas.	Apply	6	0
CO3	Explain concepts of Lorentz transformations, relativity, non-absolute nature of space and time and its consequences.	Understand	6	0
CO4	Apply the concepts of relativistic mechanics to reformulate the classical ideas of mass, energy, momentum and their transformation.	Apply	6	0
CO5	Understand the principles of Lagrangian mechanics and solve problems involving generalized coordinates and constraints in mechanical systems.	Understand	5	0
CO6	Apply Hamilton's principle and Lagrange's equations of motion of particles and systems in various mechanical scenarios.	Apply	6	0
CO7	Understand the concepts of Hamiltonian mechanics and canonical transformations.	Understand	5	0
CO8	Apply the Hamilton-Jacobi equation to solve problems in classical mechanics.	Apply	6	0
	Total Number of Hours		45	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	2	1	2	1	1	1	
CO2	3	2	1	2	1	1	1	
CO3	3	2	1	2	1	1	1	
CO4	3	2	1	2	1	1	1	
CO5	3	2	1	2	1	1	1	
CO6	3	2	1	2	1	1	1	
CO7	3	2	1	2	1	1	1	
CO8	3	2	1	2	1	1	1	

3-High; 2-Medium; 1-Low

Module I

Frames of reference, Laws of Mechanics, Inertial frames of reference, Galilean transformation, Galilean invariance, Principle of relativity, Conservation of momentum, Non-inertial frames and fictitious forces, Centripetal force, Centrifugal force, Rotating frame of reference, Foucault's pendulum.

Module II

Michelson-Morley experiment, Ether hypothesis, Special theory of relativity, Lorentz transformations, Length contraction, Time dilation, Simultaneity, Addition of velocities, Relativistic Doppler's effect, Conservation of momentum and variation of mass, Relativistic energy, Relation between momentum and energy and conservation laws, Transformation of momentum and energy, Particles with zero rest mass.

Module III

Constraints: types of constraints, difficulties associated with constraints, generalized coordinates Kinetic energy of a system in terms of generalized velocities. Calculus of Variation: Hamilton's Principle, techniques of the calculus of variations, Lagrange's equation from Hamilton's principle. Generalized momenta, cyclic coordinates.

Applications of Lagrangian formulation: motion of a particle in space, Atwood's machine, bead sliding on rotating wire, simple pendulum, harmonic oscillator.

Module IV

Hamiltonian mechanics: Hamiltonian of a system, Hamilton's equations of motions, Canonical transformations, Generating functions.

Poisson Brackets: fundamental properties of PB, Equations of motion in Poisson Bracket form, PB and integrals of motion, Canonical invariance of PB, Lagrange brackets. Hamilton-Jacobi equation for Hamilton's principal function.

References

1. Mechanics, J C Upadhyaya, Ram Prasad and Sons, Agra 2017 (Text).
2. Mechanics D S Mathur, S Chand & Company, New Delhi 2007.
3. Classical Mechanics, H Goldstein, C Poole and J Safko, 3rd edition, Addison Wesley 2005 (Text).
4. Classical Mechanics – G Aruldhas, PHI learning, 2014.
5. Mechanics: Berkeley Physics Course, Vol. 1, Tata McGraw Hill Education, Noida, 2nd edition 2017.
6. The Feynman Lectures on Physics, Vol. I, Narosa Publishing House, New Delhi 2008.
7. Classical Mechanics- Rana and Joag, Tata McGrawHill 1992.
8. Classical Mechanics - V B Bhatia, Narosa Publishing House, New Delhi 1997.
9. Mechanics L. D Landau and E. N Lifshitz., Butterworth Heinemann,3rd edition 2002.

24-812-0701 Optoelectronics
(Level 400)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Analyze the energy band structure of semiconductors to differentiate between direct and indirect bandgap materials.	Understand	4	4
CO2	Design basic circuits utilizing semiconductor principles, evaluating dynamic resistance and capacitance in pn junctions.	Apply	5	4
CO3	Evaluate LED materials, structures, and efficiencies to optimize luminous flux characteristics for various applications.	Analyze	5	6
CO4	Apply LED principles in optical fiber communications, designing circuits for efficient data transmission.	Apply	6	0
CO5	Apply the Shockley-Ramo theorem to assess external photocurrent in various photodetectors, considering noise characteristics.	Apply	5	4
CO6	Analyze the characteristics and applications of advanced photodetector technologies, such as avalanche photodiodes and pin photodiodes.	Evaluate	5	6
CO7	Assess the efficiencies and structures of various sensors and solar cells, optimizing performance for specific applications.	Analyze	5	6
CO8	Apply principles of optical computing, including QSD arithmetic and symmetric coding, in designing efficient computational systems.	Apply	10	0
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7
CO1	3	2			3		
CO2	3	2					
CO3	3	2		2			
CO4	3	2		2			
CO5	3	2		1			
CO6	3	2		1			2
CO7	3	2		1			2
CO8	3	2		1			

3-High; 2-Medium; 1-Low

Module I

Review of semiconductor concepts and energy bands, Semiconductor statistics, Extrinsic semiconductors, Direct and indirect bandgap semiconductors, pn Junction principles, pn junction reverse current, pn junction dynamic resistance and capacitances, recombination lifetime, pn junction band diagram, Heterojunctions.

Module II

Light-emitting diodes: Principles, Homo junction and hetero junction LEDs, Quantum well LEDs, LED materials and structures, LED efficiencies and luminous flux, Basic LED characteristics, LEDs for optical fibre communications, Phosphors and white LEDs, LED electronics, Semiconductor lasers.

Module III

Principle of the pn Junction photodiode, Shockley-Ramo theorem and external photocurrent, Absorption coefficient and photodetector materials, Quantum efficiency and responsivity, The pin photodiode, Avalanche photodiode, Heterojunction photodiodes, Schottky junction photodetector, Phototransistors, Photoconductive detectors, Basic photodiode circuits, Noise in photodetectors.
Image sensors: CMOS and CCD.

Module IV

Photovoltaic devices: Solar cells, Basic principles, Operating current and voltage, and Fill factor, Equivalent circuit of a solar cell, Solar cell structures and efficiencies.
Optical computing: QSD arithmetic, Symmetric coding, Optoelectronic implementation, Artificial neural networks, Optical implementation of neural networks, Optical architecture for pattern association, Optical logic gates, Optical backplane buses, Binary memory cell and Optical switches.

References

1. Optoelectronics and Photonics: Principles and Practices (Second Edition), S O Kasap, Pearson 2023 (Text)
2. Optoelectronic Devices and Systems (Second Edition), S C Gupta, PHI Learning Pvt Ltd 2015 (Text)
3. Optoelectronics Sensors and Instrumentation, M K Ghosh, Ed-Tech New Delhi 2018.
4. Semiconductor Optoelectronic Devices (second edition), Pallab Bhattacharya, Pearson 2017.

24-812-0705 Nonlinear Optics
(Level 400)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the concept of nonlinear susceptibilities, symmetries of nonlinear susceptibilities, index contraction and predict frequencies generated by nonlinear optical processes.	Apply	8	0
CO2	Analyze the theory of second order nonlinear effects - SHG, SFG DFG, OPO, Frequency Up/Down Conversion, principles of Phase-matching and Quasi Phase Matching conditions.	Analyze	7	0
CO3	Explain the concepts of Third order nonlinearity- third order susceptibility tensor, Degenerate four wave mixing.	Understand	9	0
CO4	Explain the theory behind Optical Phase Conjugation and its applications in image processing and distortion correction.	Understand	6	0
CO5	Explain the theory of nonlinear scattering mechanisms.	Understand	6	0
CO6	Understand the theories related to Self Focusing , Self Induced Transparency, and the propagation of optical solitons.	Understand	9	0
CO7	Explain the theory of nonlinear absorption processes - Saturable Absorption, Reverse Saturable Absorption, Two photon Absorption and its applications.	Understand	6	0
CO8	Analyze the theory of nonlinear Fabry-Perot etalon, optical bistability and its applications.	Analyze	9	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3						
CO2	3	3						
CO3	3	3						
CO4	3	3						
CO5	3	3						
CO6	3	3					2	
CO7	3	3					2	
CO8	3	3						

3-High; 2-Medium; 1-Low

Module I

Historical Overview of Nonlinear Optics, Non-linear polarization, physical origin of non-linear optical coefficients- Classical Anharmonic Oscillator Model, Miller's Rule, susceptibility tensors, Symmetries of nonlinear susceptibilities, Index contraction, d-matrix., Parametric and Non- parametric processes. Propagation of EMW through nonlinear media, Coupled amplitude equations for second-order processes $\chi^{(2)}$, Phase Matching conditions, Quasi Phase Matching (QPM) , second harmonic generation, sum and difference frequency generation, optical parametric processes (OPA and OPO), Frequency Up/Down conversion.

Module II

Third order nonlinearity: Third order susceptibility tensor, Degenerate four wave mixing , Phase conjugate optics- properties of phase conjugate light,Generation of phase conjugate light, FWM in optical Kerr media, coupled mode formulation, Resonators with OPC mirror, Imaging through distorting medium.

Module III

Nonlinear scattering processes - Stimulated Raman Scattering (SRS)-Quantum mechanical description of Raman scattering, Raman cross section and gain, SRS described by non-linear polarization, Anti Stokes Raman Scattering, Coherent Antistokes Raman Scattering (CARS).
Self action effects- intensity dependent refractive index, Self-focusing effect, Self-induced transparency- pulse area theorem.

Module IV

Nonlinear absorption- Two photon Absorption (TPA), Multiphoton absorption, Applications of nonlinear absorption, saturable and reverse saturable absorbers, Z-scan theory of closed aperture and open aperture scan. Nonlinear Fabry- Perot etalon (NLF), NLF as a computing element, Optical Bistability, Optical logic gates.

References

1. Hand book of Nonlinear optics-Richard L Sutherland, (Second Edition), Marcel Dekker Inc,(2003) (Text).
2. Nonlinear optics- Robert W Boyd, Academic Press, Elsevier, Inc (Third Edition) (2008), (Text).
3. Photonics, Elemental and Devices- V V Rampal, Wheeler Publishing (1992).
4. Lasers and Nonlinear optics- B B Laud, Wiley Eastern 3rd Edition, (2004).
5. Optical Electronics in Modern Communications -A Yariv, Oxford University Press(5th Edition), (1997).
6. Nonlinear Optics- Y R Shen, John Wiley Sons (1991).
8. Nonlinear Fibre Optics- Govind P Agarwal, Academic Press, 4th Edition(2007).
9. Quantum Electronics- A Yariv, John Wiley Sons (1989).
10. Fundamentals of Photonics-B E A Saleh, M C Teich, John Wiley Sons, 2nd edition (2007).
11. Physics of nonlinear optics-Guang S He and Song H Lie, world scientific , London (1999).
12. Fundamentals of Nonlinear Optics- P.E.Powers , CRC Press(2011).

24-812-0706 Nanophotonics
(Level 400)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Describe the basics of nanophotonics considering photon propagation under various interaction potentials.	understand	6	0
CO2	Explain the nanoscale optical interactions and apply nanoscale enhancement in near field optics and microscopy.	Apply	10	0
CO3	Explain the Quantum confinement effects in nanomaterials.	Analyze	8	0
CO4	Discuss nanostructural material behaviour and nanostructering techniques.	Analyze	8	0
CO5	Explain various methods of nano- structure fabrication.	understand	7	0
CO6	Characterization analysis of nanostructure size using experimental techniques.	Analyze	7	0
CO7	Explain nanoplasmonics and photonic band gap nanostructures.	Apply	7	0
CO8	Manipulate nanostructures to enhance secondary emission.	Analyze	7	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2			1	
CO2	3	3	1	1			1	
CO3	3	3	1	2			1	
CO4	3	3	1	1	1		1	
CO5	3	2	1	2	1		1	
CO6	3	3	1	2	1		1	
CO7	3	3	1	1			1	
CO8	3	3	1	1			1	

3-High; 2-Medium; 1-Low

Module I

Introduction to Nanophotonics – Breaking through diffraction limit, evanescent waves and optical near- field generation. Nanophotonics for real-time qualitative innovation.

Foundations of Nanophotonics- Photons and electrons- similarities and differences, Free-space propagation confinement of photons and electrons, propagation through classically forbidden zone: Tunnelling.

Localization under a periodic potential: bandgap, cooperative effects for photons and electrons, Nanoscale optical interactions: nanoscale confinement of electronic interactions, nanoscale electronic energy transfer, near-field interaction and microscopy, nanoscale enhancement of optical interactions.

Module II

Quantum confinement nature: Quantum well, Quantum wires, Quantum dots and Quantum rings.

Manifestation of quantum confinement: modification of optical properties, semiconductor quantum dots, Quantum confined stark effects, Dielectric confinement effects.

Molecular nanotechnology and Quantum dot lasers.

Nano-structural material behaviour- nanoparticles, nano clusters, and nanocrystals. Nanomaterials and nano structuring techniques – Carbon nanotubes, single walled and multiwalled carbon nanotubes.

Module III

Manufacturing methods of nanomaterials: Top-down approach, Bottom-up approach, Combined Top-down and Bottom-up manufacturing.

Growth methods of Nanomaterials and nanoparticles – MBE, MOCVD, LPE, LAVD.

Characterization of Nanomaterials – X-ray Diffraction (XRD), X-ray Photoelectron Spectroscopy (XPS), TEM, SEM, RHEED, EDS, SPM, STM.

Module IV

Nanoplasmonics: optical properties of metal-nano particles, size dependent absorption and scattering of coupled nanoparticles metal-dielectric core- shell nanoparticles, local electromagnetic fields in metal nanoparticles.

Photonic Crystals: Basic concepts: band gap and band structures in two and three dimensional lattices, periodic structures in nature, experimental methods of fabrication.

Plasmonic enhancement of secondary radiation: classification of secondary radiations, enhancement of emission and scattering of light, local density of states in plasmonic nanostructures.

Hotspots in plasmonic nanostructures, Raman-scattering enhancement in metal-dielectric nanostructures, luminescence enhancement in metal-dielectric nanostructures.

References

1. Nanophotonics- P N Prasad, Wiely Interscience(2003) (Text)
2. Principles of Nanophotonics- Motoich Ohtsu, KiyoshKohayish CRC Press (2012)
3. Nano materials Handbook- Ahemmed Bunaina, CRC Press , 2nd Edition (2009)
4. Nanostructured materials and Nanotechnology- Haro Singh Nalwa Academic Press (concise edition) USA (2002)

24-812-0707 Laser Spectroscopy
(Level 400)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Describe the importance of lasers in spectroscopy.	Understand	6	
CO2	Compare principles of photo acoustic and optothermal spectroscopy.	Analyze	6	
CO3	Enumerate the importance of ionization spectroscopy.	Analyze	8	
CO4	Discuss the difference between magnetic resonance and fluorescence spectroscopy.	Analyze	8	
CO5	Describe various multiphoton spectroscopic processes.	Understand	8	
CO6	Discuss the importance of Laser Raman Spectroscopy.	Understand	8	
CO7	Analyze various techniques to measure ultra short pulses.	Analyze	8	
CO8	Assess recent laser spectroscopic techniques for a particular use.	Evaluate	8	
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2			1	
CO2	3	3	1	2			1	
CO3	3	3	1	2			1	
CO4	3	3	1	2			1	
CO5	3	3	1	2			1	
CO6	3	3	1	2			1	
CO7	3	3	1	2			1	
CO8	3	3	1	2			1	

3-High; 2-Medium; 1-Low

Module I

Advantages of lasers in spectroscopy, Frequency Modulation, Intra-cavity Laser Absorption Spectroscopy, Cavity Ring-Down Spectroscopy, Fluorescence Excitation Spectroscopy, Photoacoustic Spectroscopy, Optothermal Spectroscopy.

Module II

Ionization Spectroscopy – photo-ionization, collision-induced and field ionization, Sensitivity of ionization Spectroscopy, Pulsed versus CW Lasers for photo-ionization, resonant two-photon ionization combined with mass spectroscopy, optogalvanic spectroscopy, laser magnetic resonance and Stark spectroscopy, laser induced fluorescence spectroscopy

Module III

Linear and nonlinear absorption, saturation spectroscopy, Polarization spectroscopy, Multiphoton spectroscopy, two-photon absorption spectroscopy, Doppler-Free Multiphoton Spectroscopy, Experimental techniques of linear Laser Raman Spectroscopy, Nonlinear Raman Spectroscopy, Coherent Anti-Stokes Raman Spectroscopy, Resonant CARS and BOX CARS, Surface Enhanced Raman Spectroscopy

Module IV

Time resolved laser spectroscopy, Measurement of Ultrashort Pulses, Streak Camera, Optical Correlator for Measuring Ultrashort Pulses, FROG Technique, SPIDER Technique, Lifetime Measurement with Lasers, Spectroscopy in the Pico-to-Attosecond Range, Applications, Laser Induced Breakdown Spectroscopy, Laser Cooling and trapping of atoms, Fluorescence Correlation Spectroscopy, Optical Frequency Combs

References

1. Laser Spectroscopy Vol. 2 Experimental Techniques, Wolfgang Demtröder, Springer Berlin Heidelberg (2008) (Text)
2. Femtosecond Optical Frequency Comb: Principle, Operation and Applications, Jun Ye, Steven T Cundiff, Springer New York, 2010
3. Photoacoustics and Photoacoustic Spectroscopy, A. Rosencwaig, Wiley Interscience, New York, 1980
4. Laser cooling and trapping, H J Metcalf and P Straten, Springer New York, 1999

24-812-0708 Quantum Optics and Quantum Computing
(Level 400)

Pre-requisite: 24-812-0404 Quantum Mechanics I & 24-812-0501 Quantum Mechanics II

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand quantized electromagnetic field and the origin of number states.	Understand	7	0
CO2	Illustrate the concept of coherent states and squeezed states.	Apply	8	0
CO3	Examine optical coherence, photon correlation, and photon statistics.	Apply	10	0
CO4	Summarize the squeezed light generation and applications.	Understand	5	0
CO5	Analyse the concepts of hidden variable, entanglement and interferometric measurements.	Analyze	9	0
CO6	Discover the interaction between atoms and quantised fields.	Analyze	6	0
CO7	Explain the concept of qubits and quantum gates.	Analyze	7	0
CO8	Classify various quantum algorithms and quantum hardware.	Analyze	8	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2	1	1		
CO2	3	3	1	2	1	2		
CO3	3	3	1	3	1	3		
CO4	3	2	1	3	2	1		
CO5	3	3	1	2	2	1		
CO6	3	3	1	3	3	3		
CO7	3	3	1	1	3	1		
CO8	3	2	1	1	3	1		

3-High; 2-Medium; 1-Low

Module I

Concept of density matrix and its properties: Quantization of EMF, Fock/Number states, Expansion in number states, Coherent States, Displacement operator, Squeezed States, Squeezing operator, Coherence properties of EMF: First order optical coherence, Photon correlation measurements, Hanbury Brown-Twiss experiments

Module II

Photon counting measurements, Classification of light by photon statistics, Photon bunching, Photon antibunching, Squeezed light: Generation and application of squeezed light, Resonant light atom interactions, Two level atom approximation, Rabi oscillations.

Module III

EPR argument, experimental studies, Bell's inequalities in quantum optics, nondemolition measurements, quantum coherence, Entanglement and interferometric measurements. Deflection of atoms by light, Kapitza- Dirac effect, Interaction between Atoms and quantized fields- dressed fields, Jaynes - Cummings model.

Module IV

Introduction to quantum bits (Qubits), Representation of qubits using Dirac notation, superposition and entanglement of qubits, basic quantum gates, no-cloning theorem and quantum teleportation, quantum algorithms, quantum computing hardware, applications of quantum computing.

References

1. Quantum Optics -D F Walls, G J Milburn Springer Verlag, 2nd edition (2008) (Text).
2. Quantum Optics an Introduction - Mark Fox Oxford University Press (2004) (Text).
3. Introduction to Quantum Optics From the Semi-classical Approach to Quantized Light, Alain Aspect , Claude Fabre , Gilbert Grynberg, Cambridge University Press, 2010, (Text).
4. Introductory Quantum Optics Christopher Gerry and Peter L knight, Cambridge University, 2004.
5. Quantum computing for everyone -Chris Bernhardt, MIT Press, Cambridge, 2019 (Text).
6. Quantum Computation and Quantum Information: 10th Anniversary Edition, Michael A. Nielsen & Isaac L. Chuang, MIT Press, Cambridge, 2011.
7. Optical Coherence and quantum optics, Leonard Mandel, Emil Wolf, Cambridge University Press, 2nd Edition (2013).
8. Fundamentals of Quantum Optics- John R Klauder and ECG Sudarshan, Dover publication (2006).
9. Quantum Optics- Werner Vogel, Dirk-Gunnar Welsch, Wiley VCH, 3rd edition (2006).

24-812-0709 Advanced Electromagnetic Theory
(Level 400)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the frequency dispersion characteristics of dielectrics, conductors, and plasma.	Understand	6	0
CO2	Apply the concepts of the dielectric function of metals to study their roles in defining phenomena like bulk, surface, and localized modes in small particles.	Apply	6	0
CO3	Understand the inhomogeneous electromagnetic wave equation.	Understand	4	0
CO4	Apply the knowledge of retarded fields to study the field of fast moving particles and the mechanism of radiation.	Apply	10	0
CO5	Illustrate electromagnetic scattering and antenna theory, including multipole expansion and Dyadic Green's functions, as well as their application in analyzing electric fields.	Understand	8	0
CO6	Apply Mie theory, antenna theory and Green's functions for the optical response of nanoscale structures.	Apply	8	0
CO7	Understand computational methods in electromagnetics, including analytical solutions and numerical techniques like FDTD and FEM.	Understand	8	0
CO8	Apply the analytical methods, FDTD and FEM to analyze electromagnetic response of simple systems.	Analyze	10	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	2	1	1	2	1	2	
CO2	3	2	1	1	2	1	2	
CO3	3	2	1	1	2	1	2	
CO4	3	2	1	1	2	1	2	
CO5	3	2	1	1	2	1	2	
CO6	3	2	1	1	2	1	2	
CO7	3	2	1	1	2	1	2	
CO8	3	2	1	1	2	1	2	

3-High; 2-Medium; 1-Low

Module I

Frequency dispersion characteristics of dielectrics, conductors and plasma, simple model of dispersion, anomalous dispersion and resonant absorption, low frequency behaviour and conductivity, high frequency behaviour and plasma frequency. Dielectric function of metals, Drude

model, Interband transitions, bulk plasmons, surface modes, localized modes in metallic particles, excitation of the localized modes.

Module II

Inhomogeneous electromagnetic wave equation, Retarded potentials and fields of a continuous charge distribution, Lienard-Wiechert potentials and electric and magnetic fields for a moving point charge, electric dipole radiation, magnetic dipole radiation, radiation by an arbitrary source, radiation pattern and power radiated by a moving point charge, total power radiated by an accelerated charge: Larmor formula and its relativistic generalization, angular distribution of radiation emitted by an accelerated charge, radiation reaction force.

Module III

Electromagnetic scattering and antennas: multipole expansion of potential, field of a dipole in coordinate-free form and plotting it using Octave, electric field due to a uniformly polarized sphere and plotting it using Octave. Dyadic Green's functions, plotting the electric near-field and far-field of a radiating dipole using Green's functions.

Rayleigh and Mie scattering, Mie modes, Mie modes in dielectric particles and their antenna properties.

Dipole antenna, fundamental antenna parameters, half-wave dipole, antenna array and diffraction. Antenna modes in metallic particles of simple geometry, dark and bright modes.

Module IV

Computational methods in electromagnetics: simple systems having analytical solutions, field of a homogeneous sphere placed in a quasi-static electric field, Finite Difference Time-Domain method (FDTD), Finite Element Method (FEM).

References

1. An Introduction to Computational Physics, Tao Pang, 2nd Ed. Cambridge University Press, 2006 (Text).
2. Classical Electrodynamics, J. D. Jackson, 3rd Ed. Wiley, 1998 (Text).
3. Principles of Nano Optics, Bert Hecht and Lukas Novotny, Cambridge University Press, 2012 (Text).
4. Antenna Theory: Analysis and Design, Constantine A. Balanis, 4th Ed. Wiley, 2016 (Text).
5. Computational Electrodynamics: The Finite Difference Time-Domain Method, Allen Taflove and Susan C. Hagness, Artech House 1995 (Text).
6. Computational Electromagnetics for RF and Microwave Engineering, David B Davidson, Cambridge University Press, 2011 (Text).
7. Computational Electromagnetics, Thomas Rylander, Par Ingelström, Anders Bondeson, Springer-Verlag, New York, 2013 (Text).

24-812-0806 Optomechanical Engineering
(Level 400)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the principles and materials required for opto-mechanical systems.	Understand	5	3
CO2	Understand basic drawings of optical components and systems.	Understand	6	3
CO3	Analyse the characteristics of the materials for opto-mechanical systems.	Analyse	5	4
CO4	Analyse the integrated tolerance	Analyse	6	4
CO5	Understand the design and mounting of small mirrors and lenses	Understand	6	4
CO6	Understand the various kinematic constraints in mounting	Understand	5	4
CO7	Model simple opto-mechanical mounts	Apply	6	4
CO8	Understand various methods of fabricating opto-mechanical mounts	Understand	6	4
	Total Number of Hours		45	30

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1	2	1	1		
CO2	3	3	1	2	1	2		
CO3	3	3	1	3	1	3	2	
CO4	3	2	1	3	2	1	2	
CO5	3	3	1	2	2	1	2	
CO6	3	3	1	3	3	3	2	
CO7	3	3	1	3	3	1		
CO8	3	2	1	3	3	1	2	

3-High; 2-Medium; 1-Low

Module I

Basic computerized drawing, drawings of optical components and systems, dimensional tolerances and error budgets. Principles of opto mechanical design-structural and kinematic aspects- vibration control. Materials properties and selection criteria.

Module II

Opto-Mechanical Characteristics of Materials: Materials for opto-mechanical systems - physical, mechanical, thermal properties, dimensional stability, hysteresis, Inhomogeneity and anisotropy, temporal stability, integrated tolerance analysis.

Module III

Design and Mounting of Small Mirrors and lenses, Surface contact mounting, stress variations with surface radius, preload, material, temperature, cemented and air space doublet, linear, tilt and rotary adjustment mechanisms, kinematic constraints and degrees of freedom, coupling methods, design guide lines.

Module IV

Analysis of the Opto-Mechanical Design Interface, structural analysis using Finite Element principles, modelling, analysis and optimization of simple opto-mechanical mounts, optimum design for minimum stress transfer, Fabrication methods.

References

1. Handbook of Optomechanical Engineering, Ahmad, Anees, CRC Press (2017).
2. Opto-Mechanical Systems Design, Volume 1_ Design and Analysis of Opto-Mechanical Assemblies, Paul Yoder, Daniel Vukobratovich, CRC Press (2015).
3. Optomechanical Systems Engineering, Keith J. Kasunic , Wiley (2015).

24-812-0807 Laser Systems and Laser Applications
(Level 400)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand about different type of laser systems.	Understand	8	0
CO2	Understand about classification of lasers.	Understand	7	0
CO3	Understand about laser welding.	Understand	7	0
CO4	Understand about material removal using lasers.	Understand	8	0
CO5	Understand about lasers in chemistry.	Understand	8	0
CO6	Analyze how lasers can be used to monitor ultrafast processes.	Analyze	7	0
CO7	Understand about holography.	Understand	7	0
CO8	Analyze applications of holography.	Analyze	8	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1				1	
CO2	3	3	1				1	
CO3	3	3	1				1	
CO4	3	3	1				1	
CO5	3	3	1				1	
CO6	3	3	1				1	
CO7	3	3	1				1	
CO8	3	3	1				1	

3-High; 2-Medium; 1-Low

Module I

Classification of lasers- two level, three level and four level laser systems.

He-Ne laser, Ar -ion laser, Kr- ion laser, He-Cd laser, Copper vapour laser, CO_2 laser, N_2 laser, Excimer laser, X-ray laser, FEL laser.

Module II

Industrial applications of lasers, Laser welding, laser surface treatments, laser-induced material removal- cutting, scribing, marking.

Module III

Lasers in chemistry- laser isotope separation, laser induced chemical reactions- IR photochemistry. Ultrafast processes in Bio-molecules-monitoring, fast chemical reactions, study of photochemical processes and stimulation photochemical reactions.

Module IV

Holography, Hologram recording and reconstruction, thin and thick holograms, applications of holography in NDT and pattern recognition.

References

1. Laser Fundamentals - William T Silfvast, Cambridge University Press, 2nd Edition(2008) (Text).
2. Laser Processing and Analysis of Materials- W WDuley , Plenum Press (1983)(Text).
3. Industrial applications of lasers- John F Ready, Accademic Press, USA, 2nd Edition, ISBN 0-12-583961-8 (1997)(Text).
4. Lasers, Principles , Types and Applications- K R Nambiar, New Age International Delhi (2004), (Text).
5. Laser picosecond Spectroscopy and photochemistry of Biomolecules, V S Letokhov(Ed.), Adam Hilger, Bristal and Philadelphia (1987).
6. Lasers and Non-linear optics – B B Laud, 3rd Edition, New Age International Private Limited, 2011.
7. Fundamentals of Photonics- B E Saleh , M Teich, John Wiley Sons 2nd Edition (2007).
8. Optical Holography- P Hariharan, Cambridge University Press, 2nd Edition (1996).
9. Lasers in Medicine – H K KCobener, Wiley Sons.
10. Laser Cooling and Trapping - H J Metcalf and P Van der Straten, Springer Verlag, (1999).
11. Optical computing – D G Beitelson , MIT Press, (2000).
12. Laser Processing and Chemistry- Dieter Bauerle, Springer Verlag, 3rd Edition (2000).
13. Wave Optics and its applications, R S Sirohi, Orient Longmann (2001).
14. Spectroscopy, Luminescence and radiation centre in minerals-A S Marfunin, Springer Verlag, NY (1997).
15. Luminescence in solids-DRVij, Plenum Press, New York (1998).

24-812-0808 Biophotonics
(Level 400)

CO	CO Statement	CL	Class Hrs	Lab Hrs
CO1	Understand the basic theory and science of interaction of light with cells and tissues.	Understand	8	0
CO2	Understand different light delivery systems	Understand	7	0
CO3	Understand fundamentals of optical imaging	Understand	7	0
CO4	Analyze different optical imaging techniques	Analyze	8	0
CO5	Understand different optical biosensors	Understand	10	0
CO6	Understand photodynamic therapy	Understand	5	0
CO7	Understand optical tweezers and analyze its applications	Understand	7	0
CO8	Analyze different tissue engineering techniques using light	Analyze	8	0
	Total Number of Hours		60	0

CO-PSO Mapping

CO\PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	1				1	
CO2	3	3	1				1	
CO3	3	3	1				1	
CO4	3	3	1				1	
CO5	3	3	1				1	
CO6	3	3	1				1	
CO7	3	3	1				1	
CO8	3	3	1				1	

3-High; 2-Medium; 1-Low

MODULE I

Photobiology; interaction of light with cells with cells and tissues, Photo-process in Bio polymers human eye and vision, Photosynthesis; Photo-excitation - free space propagation, optical fibre delivery system, articulated arm delivery, hollow tube wave-guides.

Optical coherence Tomography, Fluorescence microscopy, resonance energy transfer imaging

MODULE II

Bio-imaging: Transmission microscopy, Kohler illumination, microscopy based on phase contrast, darkfield and differential interference contrast microscopy, Fluorescence, confocal and multiphoton microscopy.

Applications of bio-imaging; Bio-imaging probes and fluorophores, imaging of microbes, cellular imaging and tissue imaging

MODULE III

Optical Biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, Biosensors based on fibre optics, evanescent waves and interferometric Flow Cytometry: basis, flurochromes for flow cytometry, DN Aanalysis. Laser activated therapy; Photodynamic therapy, photo-sensitizers for photodynamic therapy, two photon photodynamic therapy.

MODULE IV

Laser tweezers and laser scissors: design of Laser tweezers and laser scissors, optical trapping using non Gaussian optical beam, manipulation of single DNA molecules, molecular motors, semiconductor Quantum dots for bio imaging. Tissue engineering using light; contouring and restructuring of tissues using laser, laser tissue regeneration

Refences

1. Introduction to bio-photonics- P.N. Prasad Wiley Interscience (2003)
2. Biomedical Photonics -A handbook - editor Tuan.Vo Dinh (CRC Press) (2002)

24-807-0101: Mechanics

Credits: 4
Academic Level: 100
Hours per week: L - 3, T - 0, P - 2. Total Hours per semester: L - 45, P - 30

Course Objective

This course intends to develop the basics methods of analysing the mechanics of a system using the most fundamental rules of mechanics.

Course Outcome

CO	CO Statement	CL
CO1	Understand the Newtons laws of motion, the most fundamental rule of Mechanics	Understand
CO2	Enable the students to apply the Newtons law in order to analyse basic dynamics of physical systems	Apply
CO3	Acquire the capacity to use the energy conservation principle to understand the dynamics of a system	Apply
CO4	Familiarise the rules of understanding the different properties of the material world, like elasticity, surface tension, etc.	Understand
CO5	Perform simple experiments related to mechanics	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	1	2	1	0
CO2	1	2	1	0	0
CO3	0	2	1	0	0
CO4	0	1	1	0	0
CO5	0	0	2	3	0

Module I General introduction. Vectors: Notation, addition and multiplication of vectors, scalar and vector products, vector derivatives, velocity and acceleration, form invariance. Laws of motion: Equations of motion, motion under gravitational force, law of universal gravitation, motion under electric and magnetic forces, momentum conservation, friction. Frames of reference: inertial and non-inertial frames, absolute and relative velocity, Galilean and transformation.

Module II Conservation laws: Conservation of energy, conservative forces, power, Conservation of linear and angular momentum, center of mass frame, systems with variable mass. Harmonic oscillator: Example systems, importance in physics, kinetic and potential energy, damped harmonic oscillator, driven harmonic oscillator, superposition principle.

Module III Rigid-body dynamics: Equation of motion, angular momentum and kinetic energy, moments of inertia, rotations about fixed axes, moments and products of inertia: Principal axes and Euler's equations, Motion under inverse-square-law force: circular orbit, Kepler 's laws, Two-body problem.

Module IV Properties of matter: Elasticity, Stress, strain, elastic constants, Poisson's ratio relation connecting various elastic constants, Hydrodynamics, Streamline and turbulent flows-tubes of flow and equation of continuity energy possessed by a liquid- Bernoulli's theorem-Torricelli's theorem, Viscosity, critical velocity-flow of liquid through a capillary tube (Poiseulle's formula)-Stokes formula, Surface tension, surface energy.
Students will have to complete a set of experiments complementing the classroom teaching.

Text Books:

1. Mechanics, C. Kittel, W.D. Knight, M.A. Ruderman, C.A. Helmholz and B.J. Moyer, Berkeley Physics Course Vol 1, Tata McGraw-Hill Ltd (2008). (Chapters 1-9)

2. Elements of Properties of Matter, D. S. Mathur, S. Chand & Co (2008).

Reference Books:

1. University Physics, H.D Young and R.A. Freedman, 12-th Edition, Pearson (2009). (Chapters 1-14).

2. Mechanics, L.D. Landau and I.M. Lifshitz, 3rd edition, Elseviar (2007).

3. The Feynman Lectures on Physics Vol I, Narosa Publications (2003). (Chapters 1-25).

24-807-0102: Electromagnetic Phenomena

Credits: 4
Academic Level: 100
Hours per week: L - 4, T - 0, P - 0. Total Hours per semester : L - 60

Course Objective:

The course is designed to introduce the topic of electomagnetic phenomena.

Course Outcomes:

CO	CO Statement	CL
CO1	Enable the students to calculate electric field due to a charge distibution	Apply
CO2	Calculate the electric potential due to various charge distributions	Apply
CO3	Calculate the magnetic effect of electric current and understand the concept of electromagnetic waves	Apply
CO4	Equip students to deal with possible applications of electricity and magnetism	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	0	0
CO2	3	1	2	0	0
CO3	3	1	2	0	0
CO4	3	1	2	0	0

Module I Electrostatics: Electric field, Electric field of – a ring of charge, charged line segment, uniformly charged disk, two oppositely charged infinite sheets. Gauss's law – Calculation of electric field using Gauss's law- charged sphere (conducting and insulating), oppositely charged parallel conducting plates. Chapters 21-23 University Physics, H.D. Young, Roger A Freedman

Module II Electric potential, calculation of electric potential of – charged conducting sphere, oppositely charged parallel plates, infinite line/charged conducting cylinder, ring of charge, line of charge. Chapters 21-23 University Physics, H.D. Young, Roger A Freedman

Module III Magnetic effect of electric current and EM waves: Magnetic field, magnetic field lines and magnetic flux, motion of charged particles in a magnetic field, applications of motion of charged particles, Magnetic force on current carrying conductor, Hall effect, Ampere's law and application, Faraday's law, Displacement current and Maxwell's equations. Chapters 27-29 University Physics, H.D. Young, Roger A Freedman

Module IV Mutual and self Inductance. Magnetic field energy, R-L, L-C, L-C-R circuits, Phasors and Alternating Currents, Resitance and reactance, Power in AC circuits, Resonance, Transformers, Maxwell's equations and electromagnetic waves, Plane em waves and the speed of light, Sinusoidal em waves, Standing em waves. Chapters 30-32 University Physics, H.D. Young, Roger A Freedman

Text Books:

1. University Physics, H.D. Young, Roger A Freedman
2. Conceptual Physics - Paul G Hewitt.

Reference Books:

1. Waves, F.S. Crawford Jr, Berkeley Physics Course Volume 3, Tata McGraw-Hill Ltd (2008)
2. Cohen B. L., Concepts of Nuclear Physics, Tata McGraw Hill (2008). Introduction to Electrodynamics, D. J. Griffiths, 4th Edition, Cambridge University Press (2017).
3. Electricity and Magnetism, Purcell, Berkeley Physics Course Volume 2, Tata McGraw-Hill Ltd (2008)
4. The Feynman lectures Volume I and Volume II, Narosa (2003)

24-807-0201: Waves and Optics

Credits: 4
Academic Level: 100
Hours per week: L - 3, T - 0, P - 2. Total hours per semester : L - 45, P - 30

Course Objective

To impart the basic properties of oscillations and waves and to understand the interference and diffraction of light.

Course Outcome:

CO	CO Statement	CL
CO1	To introduce the mathematical foundation of Mechanics, complex numbers and oscillatory motion	Understand
CO2	To understand the concepts of oscillations of systems with more than one degree of freedom	Understand
CO3	To understand the concept of waves and comprehend the idea of interference of light	Understand
CO4	To understand diffraction of light	Understand
CO5	Perform simple experiments related to waves and optics	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	3	3	0	0
CO2	0	3	3	0	0
CO3	2	3	2	1	0
CO4	2	3	2	1	0
CO5	1	0	1	2	2

Module I Review of Mechanics- Complex Numbers- Free Oscillations- One degree of freedom- Stable equilibrium and Restoring Force- Free oscillations of Mass/Spring System- Energy of a Simple Harmonic Oscillator.

Module II Linear systems and Normal Modes- Two Coupled Pendulums- Systematic Method of Normal Modes- Matrix methods-Longitudinal Vibrations Modes-Transverse Vibrations-Energy of Coupled Systems and Normal co-ordinates-Coupled Electrical Oscillators. Systems with Many Degrees of Freedom-The Normal Modes in the Continuum limit-Vibrations of Taut String-Continuum model-Transverse oscillations of a String free at one end-Longitudinal Oscillations- Fourier Analysis

Module III Harmonic traveling waves- Standing waves-Dispersion and Group Velocity-Energy Transport by traveling wave- Superposition of harmonic waves Interference- The Superposition Principle- The interference between two point sources- Interference Experiments- Practical Applications of Interference.

Module IV Diffraction- Huygens- Fresnel Principle- Diffraction through a single slit- Diffraction through a Circular Aperture- Fraunhofer Diffraction through a Double slit- Diffraction Grating.
Students will have to complete a set of experiments complementing the classroom teaching.

Text Book:

1. A First course in Vibration and Waves, Mohammed Samiullah, Oxford University Press (2015) (Chapters 1 - 4,6,9,10).

Reference Books:

1. Physics of Waves and Oscillations, H. J. Pain, Wiley (2005) (Chapter 10).
2. Vibration and Waves, The M.I.T Introductory Physics Series, A.P.French, W.W. Norton & Company (1971)
3. Optics, E. Hecht, 4th Edition, Pearson education (2009) (Chapters 3-5).

24-807-0202: Thermodynamics

Credits: 4
Academic Level: 100
Hours per week: L - 4, T - 0, P - 0. Total hours per semester : L - 60

Course Objectives:

This course introduces basics of thermal physics to the students. The course aims to make the students understand and apply various concepts of thermodynamics.

Course Outcomes:

CO	CO Statement	CL
CO1	Demonstrate an understanding of the terminology, concepts and principles of thermal physics	Understand
CO2	Develop basics of Kinetic theory of gases	Understand
CO3	Demonstrate an understanding of basics of thermal transport	Understand
CO4	Demonstrate an understanding of laws of Thermodynamics	Understand
CO5	Demonstrate an understanding of various thermodynamic potentials and their uses	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	2	0	1
CO2	2	1	2	2	0
CO3	3	1	2	0	0
CO4	3	1	2	0	1
CO5	3	1	2	0	0

Module I Introductory material: Heat and heat capacity, basic probability, thermal equilibrium. Kinetic theory of gases: Maxwell-Boltzmann distribution, Pressure, Molecular effusion, mean free path and collisions.

Module II Transport and thermal diffusion: Transport properties in gases, The thermal diffusion equation. The first law of thermodynamics: Energy, Isothermal and adiabatic processes.

Module III The second law of thermodynamics: Heat engines and the second law, entropy and the second law.

Module IV Thermodynamic potentials: Internal energy, Enthalpy, Helmholtz function, Gibbs function, Maxwell's relations. Third law of thermodynamics.

Text Book:

1. Concepts in thermal physics, S.J. Blundell and K. M. Blundell, Oxford University Press (2008). (Chapters 1-16, Chapter-18)

Reference Books:

1. Statistical Physics, F. Reif, Berkeley Physics Course, Volume 3, Tata- McGraw-Hill (2008).
2. Heat and Thermodynamics, M. Zemansky and R. Dittman, 7th Edition, McGraw-Hill (1997).
3. University Physics, H.D Young and R.A. Freedman, 12-th Edition, Pearson (2009). (Chapters 17-20).

24-807-0301: Basic Mathematical Physics

Credits: 4
Academic Level: 200
Hours per week: L - 3, T - 0, P - 2. Total Hours per semester: L - 45, P - 30

Course Objective:

This course introduces basic mathematical tools used in physics to the students. The course aims to prepare the students for understanding and applying various mathematical formalisms used in physics.

Course Outcome:

CO	CO Statement	CL
CO1	Understand the basics of linear algebra and its applications in physics and engineering	Understand
CO2	Solve basic problems in probability, understand Binomial and Poisson probability distributions and solve basic problems in sample statistics	Apply
CO3	Acquire skill to solve first order and second order ordinary differential equation	Apply
CO4	Demonstrate an understanding of Heaviside unit step function and Dirac delta function, an understanding of Fourier series and its applications, use integral transforms like Fourier and Laplace transform to solve ordinary differential equations with constant coefficientst	Understand, Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	1	0	1
CO2	2	3	2	0	0
CO3	2	3	1	0	0
CO4	2	3	1	0	0

Module I Matrices and vector spaces: Vector spaces, linear operators, matrices, basic matrix algebra, functions of matrices, transpose, Hermitian conjugate, trace, determinant, inverse and rank. Special types of square matrices, Eigenvectors and eigenvalues, Change of basis and similarity transformation, diagonalisation, simultaneous linear equations.

Module II First order ordinary differential equations: General form of solution. First degree first order equations. Separable- variable equations, exact equations, inexact equations, integrating factors, linear equations, homogeneous equations, isobaric equations, Bernoulli's equation, miscellaneous equations. Solve second order differential equations with constant coefficients.

Module III Heaviside unit step and Dirac delta function. Fourier series, general properties, applications. Integral transforms: Fourier transforms, inversion theorem, Fourier transform of derivatives, convolution theorem. Elementary Laplace transforms, Laplace transform of derivatives, inverse Laplace transforms, solution of ordinary differential equations with constant coefficients.

Module IV Probability and statistics: Venn diagrams, probability, permutations and combinations, random variables and distributions, properties of distributions, important discrete distributions, Binomial, geometric and Poisson distributions. Experiments samples and populations, sample statistics, estimators and sampling distributions.
Students will have to complete a set of computer experiments complementing the classroom teaching.

Text Books:

1. K. F. Riley, M. P. Hobson and S. J. Bence, Mathematical methods for physics and engineering, Cambridge Universality Press (2006).

2. Tai L. Chow, Mathematical Methods for Physicists. A concise introduction, Cambridge University Press (2008).

3. George Arfken, Mathematical Methods for Physicists, Fourth (Prism Indian) 7th Edition, Elsevier (2012).

24-807-0302: Introductory Quantum Physics

Credits: 4
Academic Level: 200
Hours per week: L - 4, T - 0, P - 0. Total hours per semester : L - 60

Course Objective:

The course aims to develop an understanding of the theoretical framework of Quantum Mechanics and its applications.

Course Outcome:

CO	CO Statement	CL
CO1	Learn the experiments and models that lead to the development of quantum mechanics	Understand
CO2	Understand the atomic structure and the need for quantum mechanics	Understand
CO3	Understand the framework of quantum mechanics and solve elementary problems	nderstand, Apply
CO4	Learn to solve advanced problems in quantum mechanicst	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	0	1	0	1
CO2	2	2	1	1	0
CO3	2	2	1	0	1
CO4	3	3	2	0	0

Module I Review of Particle properties of waves and wave properties of matter - blackbody radiation, photoelectric effect, De Broglie waves, Describing a wave, waves of probability, phase and group velocities, particle diffraction, particle in a box, uncertainty principle - Gaussian and the uncertainty principle.

Module II Atomic structure: Electron orbits - the planetary model and its failure, Atomic spectra - spectral series, Review of the Bohr atom, Energy levels and spectra, Quantization of the atomic world, Nuclear motion, atomic excitation.

Module III The wave function, Review of the classical wave equation, Schrodinger's equation, Probability, Normalization, Well-behaved wavefunction; linearity and superposition, probability, expectation values, operators for energy and momentum, steady state equation, particle in a box - energy and momentum, Tunnel Effect

Module IV Harmonic oscillator - Analytic Method, Free particle, The schrodinger equation for Hydrogen Atom, Separation of variables, Quantum numbers, Electron probability density, angular variation of probability,

Text Books:

1. Concepts of Modern Physics, Arthur Beiser, Tata McGraw-Hill, 7th Edition, (2015).
2. Introduction to Quantum Mechanics, D. Griffiths, 2nd Edition, Cambridge University (2017).
3. Quantum Physics, H. C. Verma, Surya Publications, 2nd Edition (2009).
4. University Physics, H.D Young and R.A. Freedman, 12th Edition, Pearson (2009).

24-807-0404: Science Communication

Credits: 3
Academic Level: 200
Hours per week: L - 2, T - 1, P - 2. Total Hours per semester: L - 30, T - 15, P - 30

Course Objective

This course intends to develop communication and data presentation skills (oral, written, and presentation) of the students which will enable them to present scientific ideas clearly and concisely whether in an interview or in a scientific paper or presentation. The course explores various aspects of science communication, including communicating science to the general public, media, policymakers, and other scientists. Students will learn about different communication strategies, techniques, and tools to effectively communicate complex scientific information to a broad audience. The course will be mostly activity based.

Course Outcome

CO	CO Statement	CL
CO1	Present data and results of an experiment accurately and effectively	Apply
CO2	Understand the importance of effective science communication	Understand
CO3	Identify different target audiences and tailor communication strategies to meet their needs	Apply
CO4	Develop skills in writing for diverse audiences and purposes	Apply
CO5	Develop skills in oral presentation and public speaking	Apply
CO6	Understand the ethical considerations in science communication	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	0	2	0	3
CO2	0	0	2	0	3
CO3	0	0	2	0	3
CO4	0	0	2	0	3
CO5	0	0	2	0	3
CO6	0	0	2	0	3

Module I (Weeks 1-5) Good lab practices, Quantifying error in experiments and data analysis, Error propagation, Obtaining good statistical accuracy, Central Limit theorem.
Publishing scientific results: The structure of a scientific paper and presentation. Academic ethics & Intellectual property rights.

Module II Week 6 - 7: Writing for diverse audiences and purposes, Writing for the web and social media.
Activity: Developing concise science writing skills: Students have to prepare an article for the common man explaining a given scientific research paper/topic to the public.
Week 8 - 10: Preparing and delivering effective speeches, Engaging with the audience.
Activity: Students have to prepare and record a 5-10 min podcast explaining a scientific idea to the public.

Week 11-13: Handling questions and interviews
Activity: Each student takes turns attending a 10 min interview with other students on selected topics.
Week 14-16: Preparing and delivering effective presentations, Using visual aids to communicate science, Principles of data visualization.
Activity: Students have to prepare a 10 min PowerPoint presentation on a given topic.
Week 17-18: Final Project: Prepare a scientific report on an experiment the students performed in the lab with abstract, introduction, content, results and references.

Text Books:

1. Science Communication - A Practical Guide for Scientists, L. Bowater, K. Yeoman, Wiley
2. John Durant, and Bina Venkataraman. STS.034 Science Communication: A Practical Guide. Fall 2011. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.
3. Effective science communication, S.Illingworth and S. Allen, IOP.
4. The Scientist's Guide to Writing: How to Write More Easily and Effectively throughout Your Scientific Career by Stephen B. Heard
5. Communicating Science: A Practical Guide by Gavin Bremner and Alan S. J. King

24-807-0506: Introduction to Instrumentation, Mechanical design and Workshop for Undergraduates

Credits: 3
Academic Level: 200
Hours per week: L - 2, T - 1, P - 2. Total Hours per semester: L - 30, T - 15, L - 30

Course Objective:

The course aims to equip students with basic knowledge and hands-on experience in using various sensors, interfacing with microcontrollers, electrical measurements and 3D printing techniques. The course will provide them with the basics of mechanical design and introduce them to mechanical workshop practices.

Course Outcome:

CO	CO Statement	CL
CO1	Understand microcontroller programming and circuit design	Understand
CO2	Understand the fundamentals of electrical measurement techniques in physics research	Understand
CO3	Learn mechanical design with computer-aided design software specifically for additive manufacturing (3D printing)	Apply
CO4	Familiarize and hands-on training in mechanical and electrical workshops	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	1	3	3	0
CO2	0	1	3	3	0
CO3	0	1	3	0	0
CO4	0	1	3	0	0

Module I Microcontroller-based circuits: Introduction to Arduino-based microcontroller circuits and programming, interfacing sensors/ transducers and data acquisition and feedback system design, basics of IoT.

Module II Instrument accuracy, precision, sensitivity, range. Errors in measurements, introduction to various electrical measurement devices and their principles of operation, Electrical measurements: Measurement emphasis on two-probe, four-probe, dc and ac measurement basics.

Module III Mechanical design using CAD Software- Introduction to Computer-Aided Design (CAD) Introduction to 3D printing technologies and their applications, machining processes: milling, turning, drilling, etc.CNC machining and programming.

Module IV Lab/Workshop practice: Familiarizing basic workshop tools, heavy equipment. Electrical and Electronics Workshop: Basics of electrical wiring, ground etc, PCB design, Soldering, Lab Safety training.

Text Books:

1. Arduino Cookbook, Michael Margolis, O'Reilly Media (2011).
2. Experimental Techniques In Condensed Matter Physics At Low Temperatures by Robert C. Richardson (Editor),CRC Press 1st edition (2018).
3. 3D Modeling and Printing With Tinkercad: Create and Print Your Own 3D Models 1st Edition, James Floyd Kelly(author), Que Pub (2014).
4. Workshop Technology, Chapman W.A.J, 4-th edition, CBS Publishers(2001).
5. Other references includes manuals of equipment, application notes and research journals.

24-807-0603: Basic Skills in Vacuum Technology

Credits: 3
Academic Level: 200
Hours per week: L - 2, T - 1, P - 2. Total Hours per semester: L - 30, T - 15, P - 30

Course Objective

Vacuum technology finds extensive usage across various crucial sectors, including medical, analytical metrology, reliability testing, food sciences, semiconductor manufacturing, and optics, among others. This course is designed to educate upcoming technicians, engineers, and scientists on this essential subject offering a sturdy groundwork for their careers with plentiful opportunities for advancement.

Course Outcome

Upon completion of the course, students should acquire foundational skills in comprehending and managing:

CO	CO Statement	CL
CO1	Rough vacuum systems	Understand, Apply
CO2	High vacuum systems	Understand, Apply
CO3	Ultra-high vacuum systems	Understand, Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	0	2	2	0
CO2	1	0	2	2	0
CO3	1	0	2	2	0

Module I Vacuum an enabling technology: what is vacuum? Vacuum as an enabler, benefits of creating vacuum, Behavior of gases: states of matter, gas pressure, kinetic theory of gases, ideal gas law, mean free path, adsorption and desorption, diffusion and permeation, thermal conductivity, vapor pressure.

Module II Introduction to vacuum system-gas loads, throughput, pumping speed and conductance, vacuum systems an overview, schematic symbols and diagrams, simple rough vacuum system, characterizing vacuum systems.

Module III Rough vacuum systems-gas load in rough vacuum regime, rough vacuum pumps, rough vacuum gauges, rough vacuum pump down process, conductance, troubleshooting rough vacuum systems.

Module IV High vacuum and ultrahigh vacuum systems: diffusion pump, turbomolecular pumps, ion getter pumps, titanium sublimation pumps, cryopumps -operating principle, maintenance and applications.

Text Books:

1. Introduction to Vacuum Technology, David M. Hata; Elena V. Brewer; and Nancy J. Louwagie Milne Open Textbooks, Milne Library, State University of New York at Geneseo.
2. Handbook of Vacuum Technology, Karl Jousten, 2016 Wiley-VCH Verlag GmbH & Co. KGaA

24-807-0701: Classical Mechanics

Credits: 4
Academic Level: 400
Hours per week: L - 4, T - 1, P - 0. Total Hours per semester: L - 60, T - 15

Course Objective:

The course aims to develop an understanding of Lagrangian and Hamiltonian formulation which enables the students for simplified treatments of many complex problems in classical mechanics and provides the foundation for the modern understanding of dynamics. In a detailed way, since this course forms the foundation for the study of many areas of Physics such as Quantum mechanics, it apprises the students about Lagrangian and Hamiltonian formulations. The course aims:

- To define the concepts of Lagrangian Mechanics.
- To interpret the concepts of Hamiltonian Mechanics and explain generating function, canonical transformation, Poisson brackets. To formulate the method of Hamilton-Jacobi techniques.
- To illustrate the dynamics of a rigid body and non-inertial frames of reference.
- To formulate the method of Hamilton-Jacobi and action-angle variable techniques.
- Understanding the basics of non-linear dynamics in physics and their applications

Course Outcome:

CO	CO Statement	CL
CO1	Understanding the drawback of Newtonian formulation of mechanics. Construct Lagrangian for different physical systems and Lagrange's equation of motion and solve it. (Module 1)	Understand
CO2	Understanding the Hamiltonian formalism in solving physics problems and understanding the Poisson bracket method in tackling physical problems. Understanding the Hamiltonian-Jacobi formulation and its applications. (Module 2)	Understand
CO3	Understanding the techniques for solving the problems of rigid body mechanics based on Lagrange's formulation (Module 3)	Understand
CO4	Understanding the basic characteristic features of non-linear dynamics (Module 4)	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	0	1
CO2	3	3	3	0	0
CO3	2	2	2	0	1
CO4	2	3	3	0	2

Module I

Lagrangian formulation: Mechanics of a system of particles(brief review)- Constraints - Generalized coordinates - D'Alembert's principle and Lagrange's equations - Calculus of variations and Derivation of Lagrange's equations from it. Symmetry properties and Noether's theorem. Application of Lagrange's equation to Central force problem - equivalent one dimensional problem - classification of orbits - the differential equation for orbits - Kepler problem.

Module II

Hamiltonian Mechanics: Hamilton's equation from variation of principle (Principle of least action with fixed end points), cyclic coordinates. Equations of canonical transformation - examples. Poisson Brackets- Equations of motion , angular momentum Poisson Bracket relations. Hamilton-Jacobi equation - harmonic oscillator problem - Hamilton's characteristic function.

Module III

Rotational dynamics: Independent coordinates of a rigid body. Orthogonal transformations - Euler angles - rigid body equations of motion- angular momentum and kinetic energy of motion about a point- inertia tensor- Solving rigid body problems and Euler equations of motion- torque free motion of a rigid body- symmetric top. Rate of change of a vector, centrifugal and Coriolis forces.

Module IV

Nonlinear dynamics and chaos: Historical overview, FIxed points and stability, Linear stability analysis, Classification of Bifurcations, Chaotic trajectories, Liapunov exponent, Lorentz map, Logistic map: Cobweb diagram; Fixed points, Onset of chaos, Poincare maps, Fractals and dimensionality : Cantor set, Sierpinski carpet. (Sections from Text book 2)

Text Books:

1. H. Goldstein, C. Poole and J. Safko , Classical Mechanics, Third Edition, Pearson (2011).
2. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering. SH Strogatz, CRC Press, 2018.

Reference Books:

1. V. B. Bhatia , Classical Mechanics, Narosa (1997).
2. Landau and Lifshitz, Mechanics Vol. I, 3rd Edition, Butterworth-Heinemann (1976).
3. Rana and Joag, Classical Mechanics, McGraw-Hill Education (India) Pvt Limited, (2001).

24-807-0802: Mathematical Physics

Credits: 4
Academic Level: 400
Hours per week: L - 4, T - 1, P - 0. Total Hours per semester: L - 60, T - 15

Course Objective:

This course introduces different mathematical tools used in physics to the students. The course aims to prepare the students for understanding and applying various mathematical formalisms. The material covered in this course is very important for students as the mathematical techniques introduced find applications in every branch of physics and other quantitative sciences.

Course Outcome:

CO	CO Statement	CL
CO1	Demonstrate an understanding of the meaning of gradient, divergence and curl. Work with them in different coordinate systems, and solve problems involving scalar and vector fields	Understand, Apply
CO2	Demonstrate an understanding of basic tensor analysis	Understand
CO3	Solve problems involving calculus of functions of a complex variable	Apply
CO4	Solve a second order linear differential equation	Apply
CO5	Solve important partial differential equations such as Laplace equation, wave equation and Poisson equation by the method of separation of variables	Apply
CO6	Solve algebraic & differential equations, and calculate definite integrals numerically	Apply
CO7	Solve basic problems in probability and demonstrate a deep understanding of the Binomial, Poisson and Gaussian probability distributions	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	3	1	0	1
CO2	1	3	1	0	1
CO3	1	3	1	0	1
CO4	1	3	1	0	1
CO5	1	3	1	0	1
CO6	1	3	1	0	1
CO7	1	3	1	0	1

Module I

Review of vector calculus. Orthogonal curvilinear coordinates, cylindrical and spherical polar coordinates. Vector integration and integral theorems. Tensor analysis: Contravariant and covariant vectors, Basic operations with tensors, Quotient law, The line element and metric tensor.

Module II

Complex numbers, functions of a complex variable, mapping, branch lines and Riemann surface. Calculus of functions of a complex variable, elementary functions of z. Complex integration. Series

representations of analytic functions. Integration by the method of residues, evaluation of real definite integrals.

Module III

Solution of linear second order differential equations. The Euler linear equation. Solutions in power series - Frobenius method, Bessel's equation. Simultaneous equations. Partial differential equations, Solutions of Laplace's and wave equation, solution of Poisson's equation - Green's function method, Laplace and Fourier Transform methods.

Module IV

Numerical methods: Interpolation. finding roots of equations, graphical methods, method of linear interpolation, Newton's method. Numerical integration, the rectangular rule, The trapezoidal rule, Simpson's rule. Numerical solutions of differential equations, Euler's method, Runge-Kutta method, equations of higher order, system of equations. Least-squares fit.
Probability theory - definitions and sample space. Random variables and probability distributions. Calculating expectation and variance. The Binomial, Poisson and Gaussian distributions.

Text Books:

1. Mathematical methods for physics and engineering, K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge Universality Press (2006).

2. Mathematical Methods for Physicists Paperback (7th Edition), Arfken, Elsevier (2012).

Reference Books:

1. Mathematical Methods for Physicists: A Concise Introduction, Tai L. Chow, Cambridge University Press (2001).

24-807-0103: The World of Motion

Credits: 3
Academic Level: 100
Hours per week: L - 3, T - 0, P - 0. Total hours per semester: 45

Course Objective

The course intends to develop the basics methods of analysing the mechanics of a system using the most fundamental rules of mechanics.

Course Outcome

CO	CO Statement	CL
CO1	Understand the Newtons laws of motion, the most fundamental rule of Mechanics	Understand
CO2	Enable the students to apply the Newtons law in order to analyse basic dynamics of physical systems	Apply
CO3	Acquire the capacity to use the energy conservation principle to understand the dynamics of a system	Apply
CO4	Familiarise the rules of understanding the different properties of the material world, like elasticity, surface tension, etc.	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	1	2	1	0
CO2	1	2	1	0	0
CO3	0	2	1	0	0
CO4	0	1	1	0	0

Module I General introduction. Vectors: Notation, addition and multiplication of vectors, scalar and vector products, vector derivatives, velocity and acceleration, form invariance. Laws of motion: Equations of motion, motion under gravitational force, law of universal gravitation, motion under electric and magnetic forces, momentum conservation, friction. Frames of reference: inertial and non-inertial frames, absolute and relative velocity, Galilean and transformation.

Module II Conservation laws: Conservation of energy, conservative forces, power, Conservation of linear and angular momentum, center of mass frame, systems with variable mass. Harmonic oscillator: Example systems, importance in physics, kinetic and potential energy, damped harmonic oscillator, driven harmonic oscillator, superposition principle.

Module III Rigid-body dynamics: Equation of motion, angular momentum and kinetic energy, moments of inertia, rotations about fixed axes, moments and products of inertia: Principal axes and Euler's equations, Motion under inverse-square-law force: circular orbit, Kepler 's laws, Two-body problem.

Module IV Properties of matter: Elasticity, Stress, strain, elastic constants, Poisson's ratio relation connecting various elastic constants, Hydrodynamics, Streamline and turbulent flows-tubes of flow and equation of continuity energy possessed by a liquid- Bernoulli's theorem-Torricelli's theorem, Viscosity, critical velocity-flow of liquid through a capillary tube (Poiseulle's formula)-Stokes formula, Surface tension, surface energy.

Text Books:

1. Mechanics, C. Kittel, W.D. Knight, M.A. Ruderman, C.A. Helmholz and B.J. Moyer, Berkeley Physics Course Vol 1, Tata McGraw-Hill Ltd (2008). (Chapters 1-9)

2. Elements of Properties of Matter, D. S. Mathur, S. Chand & Co (2008).

Reference Books:

1. University Physics, H.D Young and R.A. Freedman, 12-th Edition, Pearson (2009). (Chapters 1-14).

2. Mechanics, L.D. Landau and I.M. Lifshitz, 3rd edition, Elseviar (2007).

3. The Feynman Lectures on Physics Vol I, Narosa Publications (2003). (Chapters 1-25).

24-807-0203: Oscillations in Nature

Credits: 3
Academic Level: 100
Hours per week: L - 3, T - 0, P - 0. Total hours per semester : L - 45

Course Objective:

To impart the basic properties of oscillations and waves and to understand the interference and diffraction of light.

Course Outcome:

CO	CO Statement	CL
CO1	To introduce the mathematical foundation of Mechanics, complex numbers and oscillatory motion	Understand
CO2	To understand the concepts of oscillations of systems with more than one degree of freedom	Understand
CO3	To understand the concept of waves and comprehend the idea of interference of light	Understand
CO4	To understand diffraction of light	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	0	3	3	0	0
CO2	0	3	3	0	0
CO3	2	3	2	1	0
CO4	2	3	2	1	0

Module I Review of Mechanics- Complex Numbers- Free Oscillations- One degree of freedom- Stable equilibrium and Restoring Force- Free oscillations of Mass/Spring System- Energy of a Simple Harmonic Oscillator.

Module II Linear systems and Normal Modes- Two Coupled Pendulums- Systematic Method of Normal Modes- Matrix methods-Longitudinal Vibrations Modes-Transverse Vibrations-Energy of Coupled Systems and Normal co-ordinates-Coupled Electrical Oscillators. Systems with Many Degrees of Freedom-The Normal Modes in the Continuum limit-Vibrations of Taut String-Continuum model-Transverse oscillations of a String free at one end-Longitudinal Oscillations- Fourier Analysis

Module III Harmonic traveling waves- Standing waves-Dispersion and Group Velocity-Energy Transport by traveling wave- Superposition of harmonic waves Interference- The Superposition Principle-The interference between two point sources- Interference Experiments- Practical Applications of Interference.

Module IV Diffraction- Huygens- Fresnel Principle- Diffraction through a single slit- Diffraction through a Circular Aperture- Fraunhofer Diffraction through a Double slit- Diffraction Grating.

Text Book:

1. A First course in Vibration and Waves, Mohammed Samiullah, Oxford University Press (2015) (Chapters 1 - 4,6,9,10).

Reference Books:

1. Physics of Waves and Oscillations, H. J. Pain, Wiley (2005) (Chapter 10).
2. Vibration and Waves, The M.I.T Introductory Physics Series, A.P.French, W.W. Norton & Company (1971)
3. Optics, E. Hecht, 4th Edition, Pearson education (2009) (Chapters 3-5).

24-807-0303: Quantitative Techniques in Physics

Credits: 3
Academic Level: 200
Hours per week: L - 3, T - 0, P - 0. Total Hours per semester: L - 45

Course Objectives

This course introduces basic mathematical tools used in physics to the students. The course aims to prepare the students for understanding and applying various mathematical formalisms used in physics.

Course Outcomes

Upon completion of this course, a student should be able to -

CO	CO Statement	CL
CO1	Understand the basics of linear algebra and its applications in physics and engineering	Understand
CO2	Solve basic problems in probability, understand Binomial and Poisson probability distributions and solve basic problems in sample statistics	Apply
CO3	Acquire skill to solve first order and second order ordinary differential equation	Apply
CO4	Demonstrate an understanding of Heaviside unit step function and Dirac delta function, an understanding of Fourier series and its applications, use integral transforms like Fourier and Laplace transform to solve ordinary differential equations with constant coefficientst	Understand, Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	1	0	1
CO2	2	3	2	0	0
CO3	2	3	1	0	0
CO4	2	3	1	0	0

Module I Matrices and vector spaces: Vector spaces, linear operators, matrices, basic matrix algebra, functions of matrices, transpose, Hermitian conjugate, trace, determinant, inverse and rank. Special types of square matrices, Eigenvectors and eigenvalues, Change of basis and similarity transformation, diagonalisation, simultaneous linear equations.

Module II First order ordinary differential equations: General form of solution. First degree first order equations. Separable- variable equations, exact equations, inexact equations, integrating factors, linear equations, homogeneous equations, isobaric equations, Bernoulli's equation, miscellaneous equations. Solve second order differential equations with constant coefficients.

Module III Heaviside unit step and Dirac delta function. Fourier series, general properties, applications. Integral transforms: Fourier transforms, inversion theorem, Fourier transform of derivatives, convolution theorem. Elementary Laplace transforms, Laplace transform of derivatives, inverse Laplace transforms, solution of ordinary differential equations with constant coefficients.

Module IV Probability and statistics: Venn diagrams, probability, permutations and combinations, random variables and distributions, properties of distributions, important discrete distributions, Binomial, geometric and Poisson distributions. Experiments samples and populations, sample statistics, estimators and sampling distributions.

Text Books:

1. K. F. Riley, M. P. Hobson and S. J. Bence, Mathematical methods for physics and engineering, Cambridge Universality Press (2006).

2. Tai L. Chow, Mathematical Methods for Physicists. A concise introduction, Cambridge University Press (2008).

3. George Arfken, Mathematical Methods for Physicists, Fourth (Prism Indian) 7th Edition, Elsevier (2012).

Semester I

Semester Credit: 21 (AEC: 6, Major: 4, Minor: 8, MDC: 3); Cumulative Credit: 21								
Code	Course	Course Type	Pre-requisites	H/W for L-T-P	Credits	Marks Distribution		
						CE	ES	Total
24-810-0101	Introductory Statistics	STAT Major - DSC, STAT Minor - DSC, STAT Disci - DSE	None	3-0-2	4	50	50	100
24-810-0102	Applied Statistics	STAT Minor - DSC	None	3-0-2	4	50	50	100
24-810-0103	Basic Statistics	MDC	None	2-0-2	3	50	50	100

24-810-0101 Introductory Statistics

Credits (H/W for L-T-P): 4 (3-0-2)
After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Identify different type of data and their preliminary analysis	Understand
2.	Interpret and analyse important measures of central tendency	Analyse
3.	Interpret and analyse various measures of dispersion and calculation of them	Analyse
4.	Illustrate various moments	Analyse
5.	Calculate skewness and kurtosis and their interpretations	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	2	3	2			3	
CO2	3	1	2				2	1
CO3	2	2		2			3	1
CO4	2	1					3	1
CO5	2	1					2	1

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction - scope and importance of statistics; Types of data - nominal, ordinal, interval, and ratio; Graphical representation of data- bar diagram, pie diagram, histogram, frequency polygon and ogives, Box-Whisker plot, stem and leaf diagram. (10 Hours)

Module 2:

Measures of central tendency- arithmetic mean, median, mode, geometric mean, harmonic mean and weighted averages; Examples and related problems for different types of data. (14 Hours)

Module 3:

Measures of dispersion - range, quartile deviation, mean deviation and standard deviation, combined mean and standard deviation, relative measures of dispersion, coefficient of variation; Partition values- quartiles, deciles, percentiles; Examples and related problems for different types of data; Lorenz curve and Gini index. (18 Hours)

Module 4:

Raw and central moments, interrelationship among first four moments; Skewness - Pearson's, Bowley's and moment measures, kurtosis; Examples and related problems for different types of data; Practical using MS excel- introduce various charts and diagrams, calculation of measures of central tendencies, dispersion, moments and measures of skewness and kurtosis. (18 Hours)

Text Books:

1. Gupta, S. C. and Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*, 12^{th} Edition. Sultan Chand & Sons, New Delhi.

2. Ross, S. M. (2017). *Introductory Statistics*, 4^{th} Edition. Academic Press, India.

References:

1. Elhance, D. N., Elhance V. and Aggarwal B. M. (2018). *Fundamentals of Statistics*. Kitab Mahal, New Delhi.

2. Gupta, S. P. (2021). *Statistical Methods*, 46^{th} Edition. Sultan Chand and Sons, New Delhi.

3. Spiegel, M. R., Schiller, J. and Srinivasan, R. (2000). *Theory and Problems of Probability and Statistics (Schaums Outlines)*, 4^{th} Edition. McGraw-Hill Education, New Delhi.

24-810-0102 Applied Statistics

Credits (H/W for L-T-P): 4 (3-0-2)
After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Distinguish different types of data collection methods and their preliminary analysis	Understand
2.	Interpret and understand bivariate data and properties	Apply
3.	Analyse association measures for bivaraite data	Analyse
4.	Examine the relationship between two variables using the method of regression	Analyse
5.	Practice the calculation of correlation and regression methods	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	2	1				2	
CO2	3	2	1				2	
CO3	3	1	2		1		3	
CO4	3	2			2		2	
CO5	2			2	2		2	3

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Primary and secondary data, population and sample, census and survey sampling, sampling and non - sampling errors, types of sampling - simple random sampling (with and without replacement), stratified sampling, systematic sampling, cluster sampling, non-probability sampling. (10 Hours)

Module 2:

Bivariate data, scatter diagram, Pearson's correlation coefficient, properties, Spearman's rank correlation coefficient, repeated ranks, ϕ coefficient, Cramers's V, Kendall's τ - related problems. (15 Hours)

Module 3:

Principle of least squares, linear regression, regression coefficients, properties, curve fitting - for straight line, quadratic curve, exponential curves - related problems. (20 Hours)

Module 4:

Practical using MS excel- calculation of correlation coefficient for different types of data; Curve fitting of straight line, quadratic curve, exponential and power curves; Calculation of regression coefficient and regression lines, interpreting the results. (15 Hours)

Text Books:

1. Gupta, S. C. and Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*, 12^{th} Edition. Sultan Chand & Sons, New Delhi.

2. Ross, S. M. (2017). *Introductory Statistics*, 4^{th} Edition. Academic Press, India.

References:

1. Elhance, D. N., Elhance V. and Aggarwal B. M. (2018). *Fundamentals of Statistics*. Kitab Mahal, New Delhi.

2. Gupta, S. P. (2021). *Statistical Methods*, 46^{th} Edition. Sultan Chand and Sons, New Delhi.

3. Spiegel, M. R., Schiller, J. and Srinivasan, R. (2000). *Theory and Problems of Probability and Statistics (Schaums Outlines)*, 4^{th} Edition. McGraw-Hill Education, New York.

24-810-0103 Basic Statistics

Credits (H/W for L-T-P): 3 (2-0-2)
After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Identify different type of data and their preliminary analysis	Understand
2.	Interpret and analyse important measures of central tendency	Analyse
3.	Interpret and analyse various measures of dispersion and calculation of them	Analyse
4.	Illustrate various moments	Analyse
5.	Calculate skewness and kurtosis and their interpretations	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	2	3	2			3	
CO2	3	1	2				2	1
CO3	2	2		2			3	1
CO4	2	1					3	1
CO5	2	1					2	1

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction - scope and importance of statistics; Types of data - nominal, ordinal, interval, and ratio; Graphical representation of data - bar diagram, pie diagram, histogram, frequency polygon and ogives. (10 Hours)

Module 2:

Averages - Arithmetic mean, median, mode, geometric mean, harmonic mean and weighted averages; Partition values; Examples and related problems for different types of data. (14 Hours)

Module 3:

Absolute measures of dispersion - range, quartile deviation, mean deviation and standard deviation, properties; Relative measures of dispersion; Examples and related problems for different types of data. (18 Hours)

Module 4:

Raw and central moments, interrelationship among first four moments, Skewness - Pearson's, Bowley's and moment measure, kurtosis; Examples and related problems for different types of data. (18 Hours)

Text Books:

1. Gupta, S. C. and Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*, 12^{th} Edition. Sultan Chand & Sons, New Delhi.

2. Ross, S. M. (2017). *Introductory Statistics*, 4^{th} Edition. Academic Press, India.

References:

1. Elhance, D. N., Elhance V. and Aggarwal B. M. (2018). *Fundamentals of Statistics*. Kitab Mahal, New Delhi.

2. Gupta, S. P. (2021). *Statistical Methods*, 46^{th} Edition. Sultan Chand and Sons, New Delhi.

3. Spiegel, M. R., Schiller, J. and Srinivasan, R. (2000). *Theory and Problems of Probability and Statistics (Schaums Outlines)*, 4^{th} Edition. McGraw-Hill Education, New Delhi.

Semester II

Semester Credit: 21 (AEC: 6, Major: 4, Minor: 8, MDC: 3); Cumulative Credit: 42								
Code	Course	Course Type	Pre-requisites	H/W for L-T-P	Credits	Marks Distribution		
						CE	ES	Total
24-810-0201	Introduction to Probability Theory	STAT Major - DSC, STAT Minor - DSC, STAT Disci - DSE	None	3-0-2	4	50	50	100
24-810-0202	Probability Distributions	STAT Minor - DSC	None	3-0-2	4	50	50	100
24-810-0203	Probability Theory and Random Variables	MDC	None	2-0-2	3	50	50	100

24-810-0201 Introduction to Probability Theory

Credits (H/W for L-T-P) : 4 (3-0-2)
After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Discuss the basic principles of probability including theorems on probability and use these principles in problem solving situations	Understand
2.	Demonstrate basic probability relations including conditional probabilities and Bayes' Law	Apply
3.	Employ the definitions of univariate and bivariate random variables	Apply
4.	Calculate the density and distribution function of a random variable	Analyse
5.	Differentiate the marginal density and distribution function from the joint density function and distribution function	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	2			3	3	1	
CO2	3	1		2	3	3	1	
CO3		3		1	3	3		
CO4	3	2		1	3	3		
CO5	3	2		1	3	3		

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Basic terminologies - introduction, random experiments, sample space, events and algebra of events, preliminaries of sets; Definitions of Probability - classical, statistical, and axiomatic; theorems on probability, addition theorem and extension, Boole's inequality. (10 Hours)

Module 2:

Conditional probability, multiplication theorem of probability, independence of events, pairwise independent events, extended axiom of addition and axiom of continuity, Bayes' theorem and problems on Bayes' theorem. (10 Hours)

Module 3:

One - dimensional random variables - introduction, definition and examples; Distribution function (DF) - definition, properties; Discrete random variable - probability mass function (pmf), discrete DF and problems; Continuous random variables - probability density function (pdf), continuous DF and problems; transformation of one dimensional random variable. (20 Hours)

Module 4:

Two - dimensional random variables - definition, joint, marginal and conditional probability distribution functions of discrete and continuous random variables; Distribution function - definition and properties, marginal DF, conditional DF; independence of random variables, generalization to n-dimensional random variable. (20 Hours)

Text Books:

1. Gupta, S. C. and Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*, 12^{th} Edition. Sultan Chand & Sons, New Delhi.

2. Ross, S. M. (2022). *A First Course in Probability*, 10^{th} Edition. Pearson Education Limited, London.

References:

1. Blitzstein, J. K. and Hwang, J. (2019). *Introduction to Probability*, 2^{nd} Edition. CRC Press, New York.

2. Grinstead, C. M. and Snell, J. L. (1997). *Introduction to Probability*. American Mathematical Soc.

3. Rohatgi, V. K. and Saleh, A. M. E. (2015). *An Introduction to Probability and Statistics*, 3^{rd} Edition. John Wiley & Sons, India.

4. Spiegel, M. R., Schiller, J. J. and Srinivasan, R. A. (2013). *Schaum's Outline of Probability and Statistics*, 4^{th} Edition. McGraw-Hill Education, New York.

5. Spiegel, M. R., Schiller, J. and Srinivasan, R. (2000). *Theory and Problems of Probability and Statistics (Schaums Outlines)*, 4^{th} Edition. McGraw-Hill Education, New York.

24-810-0202 Probability Distributions

Credits (H/W for L-T-P) : 4 (3-0-2)
After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Discuss various discrete distributions and properties	Understand
2.	Discuss various continuous distribution and properties	Understand
3.	Illustrate sampling distributions and interrelations	Analyse
4.	Demonstrate the fitting of distributions- binomial, Poisson, normal using Excel	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3				3	3		
CO2	3				3	3		
CO3			3		3	3	2	1
CO4	3		3		3	3	2	1

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Discrete distributions: Uniform, Bernoulli, binomial, Poisson, geometric - mean, variance, mgf, pgf and important properties; Negative binomial, hyper-geometric - definition and properties. (15 Hours)

Module 2:

Standard distributions - continuous type: uniform, normal, exponential, gamma, beta (type I and type II) - mean, variance, mgf, pgf and important properties; Lognormal, Pareto and Cauchy - definition and properties. (15 Hours)

Module 3:

Sampling distributions, distribution of sample mean and variance; Chi-square, Students-t, F-distributions - their interrelations and properties. (15 Hours)

Module 4:

Generating random variables; Fitting of distributions - binomial, Poisson, normal - theory and practical illustrations using MS Excel. (15 Hours)

Text Books:

1. Gupta, S. C. and Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*, 12^{th} Edition. Sultan Chand & Sons, New Delhi.

2. Ross, S. M. (2017). *Introductory Statistics*, 4^{th} Edition. Academic Press, India.

References:

1. Gupta, S. P. (2021). *Statistical Methods*, 46^{th} Edition. Sultan Chand and Sons, New Delhi.

2. Spiegel, M. R., Schiller, J. and Srinivasan, R. (2000). *Theory and Problems of Probability and Statistics (Schaums Outlines)*, 4^{th} Edition. McGraw-Hill Education, New York.

3. Elhance, D. N., Elhance V. and Aggarwal B. M. (2018). *Fundamentals of Statistics*. Kitab Mahal, New Delhi.

24-810-0203 Probability Theory and Random Variables

Credits (H/W for L-T-P) : 3 (2-0-2)
After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Discuss the basic principles of probability including theorems on probability and use these principles in problem solving situations	Understand
2.	Demonstrate basic probability relations including conditional probabilities and Bayes' Law	Apply
3.	Employ the definitions of univariate and bivariate random variables	Apply
4.	Calculate the density and distribution function of a random variable	Analyse
5.	Differentiate the marginal density and distribution function from the joint density function and distribution function	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	2			3	3	1	
CO2	3	1		2	3	3	1	
CO3		3		1	3	3		
CO4	3	2		1	3	3		
CO5	3	2		1	3	3		

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction, preliminaries of sets, random experiments, sample space, events and algebra of events; Definitions of probability – classical, statistical, and axiomatic; Theorems on probability - addition theorem and extension. (10 Hours)

Module 2:

Conditional probability, multiplication theorem of probability, independence of events, pairwise and mutual independent, Bayes' theorem and problems on Bayes' theorem. (10 Hours)

Module 3:

Random variables - introduction, definition and examples; Distribution function (DF) - definition, properties; Discrete random variable - probability mass function (pmf), discrete DF and problems; Continuous random variables - probability density function (pdf), continuous DF and problems. (20 Hours)

Module 4:

Definition, joint probability mass function, marginal probability mass function, conditional probability function; Distribution function - definition and properties, marginal DF; joint and marginal density function, conditional DF and conditional pdf, independence of random variables.
(20 Hours)

Text Books:

1. Gupta, S. C. and Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*, 12^{th} Edition. Sultan Chand & Sons, New Delhi.
2. Ross, S. M. (2022). *A First Course in Probability*, 10^{th} Edition. Pearson Education Limited, London.

References:

1. Spiegel, M. R., Schiller, J. J. and Srinivasan, R. A. (2013). *Schaum's Outline of Probability and Statistics*, 4^{th} Edition. McGraw-Hill Education, New York.
2. Spiegel, M. R., Schiller, J. and Srinivasan, R. (2000). *Theory and Problems of Probability and Statistics (Schaums Outlines)*, 4^{th} Edition. McGraw-Hill Education, New York.
3. Rohatgi, V. K. and Saleh, A. M. E. (2015). *An Introduction to Probability and Statistics*, 3^{rd} Edition. John Wiley & Sons, India.
4. Blitzstein, J. K. and Hwang, J. (2019). *Introduction to Probability*, 2^{nd} Edition. CRC Press, New York.
5. Grinstead, C. M.and Snell, J. L. (1997). *Introduction to probability*. American Mathematical Society.

Semester III

Semester Credit: 21 (Major: 4, Minor: 8, MDC: 3, VAC: 6); Cumulative Credit: 63								
Code	Course	Course Type	Pre-requisites	H/W for L-T-P	Credits	Marks Distribution		
						CE	ES	Total
24-810-0301	Statistical Methods	STAT Major - DSC, STAT Minor - DSC, STAT Disci - DSE	None	3-0-2	4	50	50	100
24-810-0302	Statistical Inference	STAT Minor - DSC	None	3-0-2	4	50	50	100
24-810-0303	An Introduction to Statistical Methods	MDC	None	2-0-2	3	50	50	100

24-810-0301 Statistical Methods

Credits (H/W for L-T-P) : 4 (3-0-2)
After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand the concept of mathematical expectation and its various properties	Understand
2.	Discuss various generating functions such as PGF, MGF, CGF, CF and its importance	Understand
3.	Understand different modes of convergence	Understand
4.	Evaluate various probability bounds using law of large numbers	Interpret

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3		2		3	3		
CO2	3			2	3	3		
CO3	3		2		3	3		
CO4	3			2	3	3		

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Mathematical expectation - mathematical expectation of a random variable and functions of a random variable, properties of expectation, inequalities of moments, conditional expectation. (15 Hours)

Module 2:

Generating functions - probability generating function, moment generating function, cumulant generating function and characteristic function; properties of generating function, uniqueness and inversion theorems (without proof) along with applications. (15 Hours)

Module 3:

Modes of convergence - convergence in probability, convergence in almost sure, convergence in distribution, convergence in r^{th} mean. (15 Hours)

Module 4:

Chebychev's inequality, weak law of large numbers, strong law of large numbers, central limit theorems (without proof). (15 Hours)

Text Books:

1. Rohatgi, V. K. and Saleh, A. M. E. (2015). *An Introduction to Probability and Statistics*, 3^{rd} Edition. John Wiley & Sons, India.

References:

1. Gupta, S. C. and Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*, 12^{th} Edition. Sultan Chand & Sons, New Delhi.

2. Hogg, R.V., Mckean, J. and Craig, A.T. (2018). *Introduction to Mathematical Statistics*, 8^{th} Edition. Pearson, USA.

24-810-0302 Statistical Inference

Credits (H/W for L-T-P) : 4 (3-0-2)
After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Apply various estimation and testing procedures to deal with real life problems	Apply
2.	Distinguish between point estimation and interval estimation	Analyse
3.	Apply various estimation and testing procedures to deal with real life problems	Apply
4.	Examine unbiasedness, consistency, efficiency, and sufficiency of estimators	Analyse
5.	Illustrate the testing of a statistical hypothesis, to draw valid conclusions	Analyse
6.	Apply large sample and small sample testing procedures and its applications	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	2		1	1	2	2	1
CO2	2		2	1	2	3		
CO3	1	2			2	2		
CO4	1	2			3	3		1
CO5	2	1			3	3		2
CO6	2				2	2		2

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Estimation - point estimation; Properties of estimators - unbiasedness, consistency, efficiency, sufficiency; Methods of estimation - method of moments, maximum likelihood method; properties of moment estimator and maximum likelihood estimator, illustrations for different distributions. (15 Hours)

Module 2:

Interval estimation; Confidence interval (CI) - CI for mean of a normal population (3 cases), difference of mean for two normal populations (3 cases), for variance, proportion of success and difference in proportion of success of binomial population. (15 Hours)

Module 3:

Testing of hypothesis - statistical hypotheses, simple and composite hypotheses, two types of errors, significance level, p - value, power of a test, Neyman - Pearson lemma (without proof), most powerful tests. (15 Hours)

Module 4:

Large sample tests, small sample tests, t - test, chi - square test for variance, goodness of fit, independence of attributes. (15 Hours)

Text Books:

1. Gupta, S. C. and Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*, 12^{th} Edition. Sultan Chand & Sons, New Delhi.

2. Rohatgi, V. K. and Saleh, A. M. E. (2015). *An Introduction to Probability and Statistics*, 3^{rd} Edition. John Wiley & Sons, India.

References:

1. Casella, G. and Berger, R. L. (2002). *Statistical Inference*, 2^{nd} Edition. Duxbury Advanced Series, USA.

2. Hogg, R.V., Mckean, J. and Craig, A.T. (2018). *Introduction to Mathematical Statistics*, 8^{th} Edition. Pearson, USA.

3. Wasserman, L. (2010). *All of Statistics: A Concise Course in Statistical Inference*, Springer, India.

24-810-0303 Introduction to Statistical Methods

Credits (H/W for L-T-P): 3 (2-0-2)
After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand the concept of mathematical expectation and its various properties	Understand
2.	Discuss various generating functions such as PGF, MGF, CGF, CF, and their importance	Understand
3.	Understand different types of modes of convergence	Understand
4.	Evaluate various probability bounds using law of large numbers	Interpret

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3		2		3	3		
CO2	3			2	3	3		
CO3	3			2	3	3		
CO4	3		2		3	3		

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Mathematical expectation - mathematical expectation of a random variable and functions of a random variable, properties of expectation, conditional expectation, important Inequalities. (15 Hours)

Module 2:

Generating Functions - probability generating function, moment generating function, cumulant generating function and characteristic function, properties of generating function. (15 Hours)

Module 3:

Modes of convergence - convergence in probability, convergence in almost sure, convergence in distribution, convergence in r^{th} mean, interrelations. (15 Hours)

Module 4:

Chebychev's inequality, weak law of large numbers, strong law of large numbers, central limit theorems. (15 Hours)

Text Books:

1. Gupta, S. C. and Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*, 12^{th} Edition. Sultan Chand & Sons, New Delhi.

2. Rohatgi, V. K. and Saleh, A. M. E. (2015). *An Introduction to Probability and Statistics*, 3^{rd} Edition. John Wiley & Sons, India.

References:

1. Hogg, R. V., McKean, J. W. and Craig, A. T. (2018). *Introduction to Mathematical Statistics*, 8^{th} Edition. Pearson, USA.