UNIVERSITY OF DELHI

CNC-II/093/1/EC-1275/25/07(ii)
Dated: 31.07.2025

NOTIFICATION

Sub: Amendment to Ordinance V

(ECR 07-10/ dated 23.05.2025)

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

The following under the Faculty of Inter-Disciplinary & Applied Sciences based on UGCF/PGCF, are notified herewith for the information of all concerned:

(i) Change of nomenclature of M.Sc. Biophysics to M.Sc. Biophysics and Bioinformatics
(ii) Syllabi of M.Sc. Biophysics and Bioinformatics based on Postgraduate Curriculum Framework 2022 (PGCF) - **Annexure-1**
(iii) Change of nomenclature of M.Tech. Microwave Electronics to M.Tech. in Microwaves and Communication
(iv) Syllabi of M.Tech in Microwaves and Communication - **Annexure-2**

REGISTRAR

Annexure-1

UNIVERSITY OF DELHI

MASTER OF SCIENCE (BIOPHYSICS AND BIOINFORMATICS)

based on

NEP-PGCF-2024

PROGRAMME BROCHURE

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2025 and Executive Council on YYYY, 2025

I. About the Department

Department Highlights

The Department of Biophysics was established in 1984 and is part of the FIAS (Faculty of Interdisciplinary and Applied Sciences) at the University of Delhi South Campus. The department currently has five faculty members engaged in various research areas in Biophysics and Bioinformatics.

About the Program

The M.Sc. Biophysics and Bioinformatics program offered by Delhi University is of two years' duration and is divided into four semesters. The various courses of the program are designed to include classroom teaching and lectures, hands-on practical and tutorials, dry and wet laboratory work, and dissertations.

Six categories of courses are being offered in this program: Discipline Specific Core Courses (DSC), Discipline Specific Elective Courses (DSE), Generic Elective Courses (GE), Skill Based courses (SB), Research methods/ tools/ writing courses under Research Track (RT), and Dissertation Research work. Students may opt for any Generic Elective courses offered by any other Department of the Faculty of Interdisciplinary and Applied Sciences. The Core Courses, the Elective Courses and Generic Electives are four credit courses each. As per the University guidelines, the student is required to accumulate twenty-two credits each semester, a total of eighty-eight credits, to fulfill the requirements for a Master of Science (PG) degree in Biophysics and Bioinformatics.

The M.Sc. in Biophysics and Bioinformatics is an interdisciplinary program designed to bridge the gap between biology, physics, and computational sciences. The course integrates biophysical principles, molecular biology, computational biology, and bioinformatics to generate, interpret, and analyze large-scale biological datasets. The curriculum integrates theoretical knowledge with practical skills to train students in modern biophysics and bioinformatics, making them competent for careers in academia, healthcare, pharmaceuticals, and biotechnology industries.

Program Objectives (POs):

The program aims at equipping the students with advanced knowledge and skills in the area of biophysics and bioinformatics, such as to enable them to address present lacunae in biological systems understanding, with the following detailed objectives:

1. Foundational Knowledge in Biophysics & Bioinformatics

- Introduce students to fundamental principles of biophysics, molecular biology, bioinformatics, and computational biology.
- Provide a strong foundation in chemical, physical, and mathematical principles underlying biological processes.
- Equip students with knowledge of macromolecular interactions, protein structure, and cellular mechanisms.

2. Skill Development in Experimental and Computational Techniques

- Train students in molecular biology, genetic engineering, proteomics, and bioinformatics methodologies.
- Develop proficiency in computational biology tools, bioinformatics databases, and molecular modeling.
- Provide hands-on experience in biophysical techniques like spectroscopy, chromatography, and electrophoresis.
- Familiarize students with cell culture techniques and proteomics-based analytical methods.
- Equip students with knowledge of gene regulation, genetic engineering, and genome editing technologies (e.g., CRISPR, TALENs).
- Develop skills in protein-protein interactions, and vaccine development.

3. Application of Biophysics and Bioinformatics in Research and Industry

- Enhance understanding of drug discovery, protein engineering, and genetic manipulation.
- Introduce applications of biophysics in disease modeling, structural biology, and vaccine development.
- Enable students to apply bioinformatics in genome sequencing, phylogenetic analysis, and personalized medicine.

4. Critical Thinking and Problem-Solving

- Encourage students to analyze and interpret biological data using statistical and computational approaches.
- Train students to design experiments for biomolecular research, drug development, and biomedical engineering.
- Develop skills in scientific communication, literature review, and data presentation.

5. Preparing for Advanced Research and Careers in Biotechnology & Healthcare

- Prepare students for careers in biotechnology, pharmaceuticals, computational biology, and academic research.
- Equip students with knowledge of current trends in biotherapeutics, vaccines, and bioenergetics.
- Provide exposure to ethical considerations, regulatory guidelines, and real-world applications in biosciences.

6. Genetic and Structural Insights into Biological Systems:

- Equip students with knowledge of gene regulation, genetic engineering, and genome editing technologies (e.g., CRISPR, TALENs).

- Develop skills in protein-protein interactions, drug discovery, and vaccine development.

7. Application of Biophysical and Bioinformatics Approaches:
    - Bridge the gap between wet-lab experiments and computational biology.
    - Enable the integration of machine learning and AI-driven approaches for analyzing biological datasets.

Program Specific Outcomes (PSOs):

Upon successful completion of the M.Sc. in Biophysics and Bioinformatics, graduates will be well-equipped to contribute to the biotechnology and biological data analysis industries in the following areas:

1. Biotechnology Industry Contributions
    - Drug Discovery & Development:
        - Apply computational modeling for drug design and screening.
        - Analyze protein-ligand interactions for pharmaceutical applications.
    - Genetic Engineering & Synthetic Biology:
        - Utilize CRISPR, gene editing, and molecular cloning for therapeutic and agricultural advancements.
        - Engineer microbial and plant-based biofactories for biopharmaceuticals and industrial enzymes.
    - Bioprocessing & Biomanufacturing:
        - Apply protein purification, expression optimization, and bioanalytical techniques in biopharmaceutical production.
        - Optimize fermentation and metabolic pathways using computational tools.
    - Vaccine & Biotherapeutic Development:
        - Design rational vaccines and immunotherapies.
        - Conduct immune response modeling for personalized medicine.

2. Biological Data Science and Analysis
    - Big Data Analytics in Life Sciences:
        - Analyze high-throughput genomic, transcriptomic, and proteomic datasets.
        - Use machine learning and AI for predictive modeling in personalized medicine.
    - Computational Biology & Bioinformatics Tools:
        - Perform sequence alignment, phylogenetics, and structural modeling.
        - Develop and use databases for genomic and proteomic research.
    - Systems Biology & Omics Data Integration:
        - Model biological networks for understanding disease mechanisms.
        - Integrate multi-omics data (genomics, transcriptomics, proteomics) for biomarker discovery.
    - Statistical & Programming Skills for Biological Data Analysis:
        - Use R, Python, and bioinformatics pipelines for statistical inference.
        - Apply machine learning algorithms to classify biological patterns and anomalies.

About Program Structure

The M.Sc. Biophysics and Bioinformatics program is divided into four semesters. The program structure is based on the Post Graduate Curricular Framework (PGCF) under (New Education Policy) NEP-2020.
The student is required to complete eighty-eight credits for the completion of the course and the award of a degree. The student has to accumulate twenty-two credits in each of the four semesters.
Under PGCF, during the first year of the program, the student is required to study mandatory six Discipline Specific Core courses (three DSC in each semester), and a total of four Discipline Specific Elective courses (two DSE in each semester). The student can also opt for 1GE from another sister department from FIAS instead, thus making this combination as 1DSE+1GE. In addition, the student will also be required to study 1 mandatory Skill based course (SBC) of 2 credits in each semester of the first year.

In the second year of the program, the student will choose any one of the three structures: Program Structure 1 (PG with only coursework), or Program Structure 2 (PG with coursework and research), or Program Structure 3 (PG with research) as per the university guidelines. The details of the course credits and the courses available under each category of courses (DSC, DSE, GE, SB, RT) are elaborated in the tables ahead.

A minimum of 75% attendance in the practical and theory classes would be mandatory requirement for appearing in exams and obtaining the degree.

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. BIOPHYSICS AND BIOINFORMATICS COURSE (NEP-PGCF)

First year (Common in Program Structure 1, 2 and 3)

Semester-1

	Credits in each course			
	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC01: Biophysical Chemistry	3	0	1	4
BP-DSC02: Molecular Biology	3	0	1	4
BP-DSC03: Protein Sciences: Emerging Frontiers	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE01: Cellular Proteomics	3	1	0	4
BP-DSE02: Statistics and Programming for Life Sciences	3	0	1	4
BP-DSE03: Vaccines and Biotherapeutics	3	0	1	4
Generic Elective courses*				
#BP-DSE01: Cellular Proteomics	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
BP-SBC01: Specialised Laboratory – I: Molecular Biology	0	0	2	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

***** *(a student can opt for either two DSE course, or one DSE with one GE)*

#BP-DSE01 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. BIOPHYSICS AND BIOINFORMATICS COURSE (NEP-PGCF)

First year (Common in Program Structure 1, 2 and 3)

Semester-2

	Credits in each course			
Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC04: Computational Biology and Bioinformatics	3	0	1	4
BP-DSC05: Cellular Biophysics and Bioenergetics	3	0	1	4
BP-DSC06: Genetic Engineering	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE04: Environmental Biophysics	3	1	0	4
BP-DSE05: Biophysical methods: Fundamental Techniques	3	0	1	4
BP-DSE06: Text Mining Methods in Biology	3	0	1	4
Generic Elective courses*				
#BP-DSE04: Environmental Biophysics	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
BP-SBC02: Specialised Laboratory – II: Cell Biology and Bioinformatics	0	0	2	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

***** *(a student can opt for either two DSE course, or one DSE with one GE)*

#BP-DSE04 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC01: BIOPHYSICAL CHEMISTRY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSC01: BIOPHYSICAL CHEMISTRY	4	3	0	1	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to introduce the students to the essentials of biophysical perspectives in daily biology.
- The student will understand association of molecules.
- They will be understand the drug delivery vehicles and preparation.
- The students will be delivered the knowledge about role of thermodynamics in biological systems and how hydrodynamics play a role in biological interactions
- The students will be motivated to learn the vitamin's role and behaviour of animals and how they learn and keep memorize the events during their life cycle.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to use different equation and theory to prepare the biological solutions.
- Student will be able to analyse the association process of macromolecules.
- Student will be able to learn about effect of drugs on biomacromolecules.
- Student will be able to study the various high affinity interactions and behaviour and learning of animals.

SYLLABUS OF BP-DSC-01

Theory component (45 hours)

UNIT I (20 hours)

Electrostatics, Simple Salts: Debye-Huckel Theory, Buffering systems used in biochemistry; Handerson-Haselbach equation, Factors affecting structure and stability of macromolecule, chemical kinetics: association and dissociation reactions in biology Self-Assembly and Polymerization

UNIT II (10 hours)

Biological functions of carbohydrates, mutarotation and tautomerism, formation of liposomes and role in drug delivery systems

UNIT III (5 hours)

Role of energetics and thermodynamics to study protein-ligand interactions, detailed perspective of protein DNA/hydrodynamics

UNIT IV (10 hours)

Vitamins and their role as co-enzymes, hormones: functions and disorders, high affinity interactions and their role in biophysics: biotin and streptavidin, Antigen-antibody interactions, affinity and avidity, repurposing of drugs, biophysical perspective of neurobiology: learning and memory, animal behaviour

Practical component (30 hours)

List of Practicals

- Preparation of biological solution in different mediums,
- Experiments to analyse self-association of proteins (eg. Lysozyme),
- Effect of ligands on the structure and stability of protein.
- Protein-drug binding assays
- DNA-drug binding assays

Essential/recommended readings

Theory: **Latest edition of the following**

1. David Sheehan; PHYSICAL BIOCHEMISTRY: PRINCIPLES AND APPLICATIONS; John Wiley & Sons Ltd
2. Freifelder, David Michael; Physical biochemistry: applications to biochemistry and molecular biology; W.H. Freeman and Company.
3. Wilson And Walker; Principles And Techniques Of Biochemistry And Molecular Biology; CAMBRIDGE UNIVERSITY PRESS

Practical:

1. Wilson And Walker; Principles And Techniques Of Biochemistry And Molecular Biology; CAMBRIDGE UNIVERSITY PRESS
2. Holger Gohlke; Protein-Ligand Interactions; Willey VCH.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC02: MOLECULAR BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSC02: MOLECULAR BIOLOGY	4	3	0	1	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to introduce the students to the essential concepts of molecular biology.
- The students will learn about the physical and chemical architecture of the genomes and genetic material of organisms across all kingdoms of organisms.
- They will become familiar with molecular mechanisms of DNA replication, transcription, translation, DNA repair, and gene regulation in prokaryotic and eukaryotic organisms.
- The student will study the techniques and perform experiments related to the subject to understand these mechanisms.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to describe the structures of DNA/RNA and the genome organization of prokaryotes and eukaryotes.
- Students will be able to compare and contrast the mechanisms of bacterial and eukaryotic DNA replication, transcription, and translation.
- Students will be able to utilize concepts of DNA repair and recombination as molecular biology tools to design therapeutic solutions to various genetic disorders.
- Students will be able to explain gene regulation occurring at various levels in both prokaryotic and eukaryotic organisms.
- Students will be able to describe post-transcriptional processes, RNA editing, RNAi, and miRNA processing.
- Students will be able to describe the translation mechanism in prokaryotes and eukaryotes, the regulation of translation, and post-translational processing

SYLLABUS OF BP-DSC02

Theory component (45 hours)

UNIT I **(10 hours)**

a) **Nucleic acid structure and function:** DNA double helix: endo- and exo- sugars, *syn*- and *anti*- conformation of N-bases, W-C and Non-W-C base pairing, roll, slide and twist in DNA; DNA supercoiling: Supercoiling, superhelical density, Lk, Wr and Tw, topoisomerases; DNA melting; RNA structure.

b) **Introduction to genomes**: Genome architecture of bacteria, eukaryotes, organelle, and viruses; Linear and circular chromosomes, single-stranded and doubles stranded DNA/RNA viral genome; Organization of genes and chromosomes: Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, DNase I sensitive regions, heterochromatin, euchromatin, DNA methylation.

UNIT II **(18 hours)**

a) **DNA replication:** Chemistry of replication, arrangement of replicons in a genome, various modes of replication, DNA polymerases and other replication enzymes; Synthesis of leading and lagging strands; DNA replication in prokaryotes and eukaryotes: initiation, elongation, and termination; Telomere maintenance and chromatin assembly; Segregation of chromosomes to daughter cells; Regulation of replication, DNA copy number maintenance,

b) **DNA repair and recombination:** DNA damage: pyrimidine dimer, nick and gap in DNA, AP sites, base mispairing; Mismatch, base excision and nucleotide-excision repair mechanisms, SOS response; Non-homologous end joining (NHEJ); Homologous recombination; Recombination as a molecular biology tool: CRISPR-Cas systems for editing, regulating and targeting genomes; Transposition: DNA transposons and retroposons and mechanism.

UNIT III **(9 hours)**

Transcription and RNA processing: Prokaryotic transcription**:** RNA polymerase, promoters, sigma factors, initiation, elongation and termination (Rho-dependent and independent); Eukaryotic transcription: types of RNA polymerases, promoters and enhancers, transcription factors, TBP and TAFs; RNA processing and modification: splicing, alternative splicing, capping, polyA addition, rRNA processing, base modification, tRNA processing, and modifications; RNA editing: RNAi and miRNAs, antisense RNA; Post-transcriptional gene regulation.

UNIT IV **(8 hours)**

Translation: The genetic code; Translation initiation, elongation, termination, ribosome recycling in prokaryotes and eukaryotes; IRES in eukaryotes; Codon anticodon interaction; Polycistronic and monocistronic synthesis; Regulation of gene expression in prokaryotes (operons, sigma factors, anti-sigma factors, anti-sense RNA) and eukaryotes (RNA stability, UTR regulation, Riboswitch, RNA interference); Post-translational gene regulation; Covalent modification of proteins: phosphorylation, methylation, acetylation adenylation, arginylation; *In-vitro* translation systems.

Practical component **(30 hours)**

1. Preparation of buffers, reagents, and media.
2. Isolation of genomic DNA of *E. coli*.
3. Isolation of plasmid DNA of *E. coli*.
4. Estimation of DNA/protein concentration using spectroscopy.
5. Analysing various biophysical conformations of the plasmid DNA using agarose gel electrophoresis.
6. Extraction of DNA from agarose gel.
7. Setting up of PCR reaction for gene amplification.
8. Analysis of PCR-amplified product using agarose gel filtration

Essential/recommended readings

Books: Latest editions of the following

1. Gene IX by Benjamin Lewin. Jones and Bartlett Publishers. 2007.
2. Molecular Biology by R.F. Weaver, 4th edition. McGraw Hill, USA. 2007.
3. Molecular Biology of the Gene by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. 6th edition. Benjamin Cummings. 2007.
4. Molecular Biology of the Cell by B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter. 5th edition. Garland Science, New York and London. 2007.
5. Biochemistry by J. M. Berg, J. L. Tymoczko, L. Stryer. 5th edition. W.H. Freeman and Company, USA. 2008.
6. Current Protocols in Molecular Biology edited by: F. M. Ausubel, R. Brent, R.E. Kingston, D. D. Moore, J. A. Smith, K. Struhl. John Wiley and Sons, Inc. 2007.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC03: PROTEIN SCIENCE: EMERGING FRONTIERS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSC03: PROTEIN SCIENCE: EMERGING FRONTIERS	4	3	0	1	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to provide students with an in-depth knowledge of the role of proteins in cellular systems, including their molecular structure, biological function, and evolution.
- Students will gain an understanding of the historical development of protein science, including key discoveries.
- The student will learn about the evolution of the experimental techniques used to study proteins in the lab.
- The students will be motivated to analyse the future research directions in protein science.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will gain a comprehensive understanding of protein biochemistry, including how proteins fold, function, and evolve.
- The student will be able to understand the relationship between the structure and function of proteins. They will be able to appreciate how protein folding influences biological activity.
- The students will come to appreciate how evolutionary studies foretell the sequence-structure-function relationships among proteins.
- The students will come to appreciate the variations in protein structure generated through post-translational modifications.
- The students will be able to trace the timeline of significant breakthroughs in protein biochemistry, appreciate the interdisciplinary nature of protein research, and critically analyse the impact of these discoveries on modern applications in biotechnology and medicine.

SYLLABUS OF BP-DSC03

Theory component (45 hours)

UNIT I: Protein Structure and Function (6 hours)

- Overview of Protein structure: Amino acids and peptide bonds, Levels of protein structure - primary, secondary, tertiary, and quaternary
- Overview of Protein functions: enzymes, structural components, signalling, and transport
- The relationship between protein structure and function: protein domains and structural motifs
- The evolution of function through structural divergence and convergence
- Techniques to study protein structure and function: X-ray crystallography, Nuclear magnetic resonance (NMR) spectroscopy, Computational approaches

UNIT II: Protein Folding and Stability (8 hours)

- Introduction to the protein folding problem: Past and current theories of protein folding, Anfinson's Dogma, Levinthal's paradox, Molten globules, Folding landscapes, Thermodynamics and kinetics of protein folding.
- Cellular Proteostasis: Chaperones and protein folding machinery.
- Traditional and novel approaches to explore protein folding-unfolding pathways.
- Introduction to Inteins, prosequences and their role in generating structural variants.

UNIT III: (17 hours)

- **Post translation modifications:** Overview of protein translation modifications (PTMs): Types and methods for detecting PTMs, Functional implications of PTMs in cellular processes and diseases
- **Protein-protein Interactions:** Overview of protein-protein interactions (PPIs): Methods for detecting PPIs (yeast two-hybrid, co-immunoprecipitation), Functional implications of PPIs in cellular processes.
- Liquid-liquid phase separation: principles and examples.
- **Intrinsic Disorder in Proteins** Overview of Intrinsically disorder in proteins (IDPs): Methods for detecting Intrinsic disorder, Computational predictions, Functional implications of intrinsic disorder in proteins.
- **Proteins in diseases:** Protein Misfolding diseases (e.g., Alzheimer's, Parkinson's), prion diseases, Genetic mutations and their effects on protein function (cystic fibrosis, sickle cell anemia)

UNIT IV: Protein structure analysis and engineering (14 hours)

- Structural analysis and comparison, Prediction of protein function from structure
- Protein engineering methods: directed evolution, site-directed mutagenesis, applications in biotechnology- artificial proteins (designed enzymes, therapeutic proteins)
- Targeting proteins for therapeutic intervention: Drug development, Protein-ligand binding studies, Immunotherapy, and protein-based vaccines.
- Protein immobilization and application
- The role of AI in protein structure and function prediction- AlphaFold and beyond
- Future challenges in protein science- Biomolecule Design

Practical component **(30 hours)**

UNIT 1: Databases/Webservers for analysing the following:
1) Protein structures: ex PDB
2) Protein Domains and motifs: ex MEME, CDD, ProSite
3) Protein structural comparison and classification: ex SCOP/CATH
4) Protein function prediction: ex ProFunc
5) Protein-protein interactions: ex STRING, HProteome-BSite, CORUM, BindingDb
6) Post translation modifications: ex dbPTM, UniProt
7) Protein motion and dynamics: ex ProThermDB, MobiDb, Molmovdb
8) Protein evolution: ex DIVERGENCE
9) Protein structure and feature visualization: ex Proteopedia
10) Protein intrinsic disorder: ex DisProt,
11) Protein conformation Diversity: ex PCDB
12) Other Miscellaneous databases: ex RING, VFDB, CAMP

Essential/Recommended readings

Theory:
- **Books: Latest editions of the following**

1) Lesk, A. M. (2010). Introduction to Protein Science: Architecture, Function and Genomics. Oxford University Press.
2) Jenny, Gu & Phillipe, E. Bourne (2009). Structural Bioinformatics. Wiley-Blackwell.
- **Online Resources**:

Databases, as discussed in the practical component

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE01: CELLULAR PROTEOMICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE01: CELLULAR PROTEOMICS	4	3	1	0	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- This course is intended to introduce the student to the principles and practical considerations of animal and plant cell and tissue culture.
- Introduces the practice and process of culturing animal cells and cell lines in a laboratory. Focuses on routine maintenance and record-keeping, including media preparation, cryopreservation, and troubleshooting common culture problems.
- To introduce the utility of proteomics and its potential to understand complex biological phenomena and problems.

Learning outcomes

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

- Successfully maintain cultures of animal cells and established cell lines with good viability, minimal contamination, and appropriate documentation.
- Perform supportive or episodic tasks relevant to cell culture, including preparation and evaluation of media, cryopreservation and recovery, and assessment of cell growth/health.
- Recognize and troubleshoot problems common to routine cell culture.
- The students will have strong foundations and first-hand scientific understanding of current trends in Proteomics.

SYLLABUS OF BP-DSE01

Theory Component (45 hours)

UNIT I **(15 hours)**

Biology of the Cultured Animal Cells, Tissue & Organ: Historical, Advantages and limitations - medical/pharmaceutical products of animal cell culture and their applications. Risks in a tissue culture laboratory and safety biohazards.

Facilities for animal cell culture: Infrastructure, Equipment including Biosafety Cabinets and Laminar Air Flow, Culture vessel types (treated, Non-treated surfaces), the substrate, Nitrogen Container, CO2 incubator, Filter sizes, types (for aqueous solution, for DMSO soluble solution). Biology and characterization of cultured cells-cell adhesion, proliferation, differentiation, morphology of cells, and identification. Evolution of cell lines, development of continuous cell lines,

Culture Media: Balanced salt solutions, Complete media including proliferation, differentiation, Freezing, and wash media. Chemical, physical, and metabolic functions of different constituents of culture medium. Role of CO2, Serum, and Supplements. Serum-free media and their application: advantages and disadvantages of serum and serum-free media, replacement of serum, and development of serum-free media.

Unit II **(10 hours)**

Primary Cell Cultures and Sub-cultures: Types of primary cell culture, isolation of the tissue and preparation of primary cell culture, characteristics of limited life-span cultures, Techniques (mechanical disaggregation, enzymatic treatment, separation of viable and non-viable cells); Subculture and propagation

Cell Lines and Characterization: Establishment and properties of continuous cell lines; Characterization, authentication (lineage or tissue markers), cell morphology, chromosome content, DNA content, RNA and protein expression, enzyme activity, and antigen markers.

Cell Cloning: Cloning techniques, dilution and suspension cloning, scaling up in suspension and monolayer, large-scale production of cells using bioreactors, special requirements of cells growing at very low densities.

Stem Cell Culture : Embryonic and adult stem cells and their applications. Satellite Cells. Totipotent, Pluripotent and Multipotent stem cells.

Unit III **(5 hours)**

Applications of Animal Cell Culture: Production of high-value therapeutics (enzymes, hormones, monoclonal antibodies, cytokines, etc), virology, cancer research, gene therapy, drug development and cytotoxicity, and cryopreservation of cells.

Unit IV **(15 hours)**

Protein structure and function, An overview of systems biology, Evolution from protein chemistry to proteomics, Protein expression systems, Protein purification techniques, Protein molecular modifications for purification, Various expression systems for recombinant protein production
Protein characterization methods - I: Based on mass &size,
II: Based on electromagnetic property, Surface Plasmon Resonance, Isothermal Titration Calorimetry, Differential Scanning Calorimetry
Analysis of protein-protein interactions, Introduction to Proteomics, Interactomics Pull-down assay using tagged protein, Yeast two-hybrid system, Co-immunoprecipitation assay, Protein crosslinking methods, Photoreactive crosslinking, Analytical centrifugation, Fluorescence resonance energy transfer (FRET), Protein fragment Complementation assays, Hydrogen Deuterium Exchange (HDX) massspectrometry, Phage display, Hybridoma culture

Tutorial Component **(15 hours)**

- Good lab practices for *in vitro* culture,
- Aseptic maintenance of cell culture,
- Generation of Stable cell lines,
- Introduction to various Cell based assays.

Essential/Recommended readings

Theory:

Books: Latest editions of the following

1. Culture of Animal cells 4th Edi by Freshney, R.I.
2. Animal cell culture- practical approach by Edi. Jhon R.W. Masters ; Oxford
3. Introduction to Protein Structure, Carl Branden & John Tooze, Garland Science.
4. Proteomics: From protein sequences to function, S.R. Pennington & M.J. Dunn, Bios Scientific Publishers.
5. Biophysical Chemistry, Charles R. Cantor & Paul R. Schimmel, Freemann & Company.
6. Animal cell culture- practical approach by Edi. Jhon R.W. Masters ; Oxford
7. Protein Biochemistry and Proteomics (The Experimenter Series), R.Hubert, Academic Press,

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE02: STATISTICS & PROGRAMMING FOR LIFE SCIENCES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE02: STATISTICS & PROGRAMMING FOR LIFE SCIENCES	4	3	0	1	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- analyze different types of high-throughput datasets
- construct analysis modules in statistical programming packages
- use different R-packages to analyze the biological data.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Understanding of different components of a computer program
- Apply R for inference from data
- Use R-studio to write R scripts
- Reading and importing data from CSV, Excel, and text files into R
- Creating publication-ready plots
- Apply selected probability distributions to solve problems
- Apply and evaluate different learning algorithms and model selection.

SYLLABUS OF BP-DSE02

Theory component (45 hours)

UNIT I **(3 hours)**

Basics of Programming: Introduction to Perl/C/Python, Flowcharting, Decision table, Algorithms, Structured programming concepts, Concept of data-structure, if-else loops and decision, Use and definition of sub-routines.

UNIT II **(4 hours)**

Introduction to R Language and Environment of Statistical Computing and Graphics: Introduction to R, Getting Started - R Console, Data types and Structures, Exploring and Visualizing Data, Programming Structures, Functions, and Data Relationships.

Introduction to R-studio: R-studio screen, Workspace tab, History tab, Defining and Setting Working directory, Making script in R-studio, Installing and saving packages, Plotting different type of graphs.

UNIT III **(8 hours)**

Introduction to different types of data in biology; Descriptive statistics like mean, median, mode, quartiles, standard deviation, standard error; Different types of plots like scatter plot, bar graph, line graph, pie chart, box plot, frequency histogram; Understanding error bars.

UNIT IV **(10 hours)**

a) Probability and probability distributions: basic concepts of probability, conditional probability, Bayes theorem; binomial, multinomial, Poisson, exponential, and Gaussian distribution;

(10 hours)

b) Sampling distribution and central limit theorem. Hypothesis testing: Student's t-test, Z-test, Chi-squared test, ANOVA. Correlation, regression and estimation: Pearson correlation; Regression: linear, non-linear, single and multivariate; concept of likelihood and method of maximum likelihood.

(10 hours)

c) Tools for data of high throughput experiments: principle component analysis; Clustering of data: K-means algorithm, hierarchical clustering; Visualization tools: heat map, volcano plot.

Practical component **(30 hours)**

List of practical:

- Installation of R, R-studio and RMarkdown.
- Concepts of Command line, Procedural workflow, Working with variables, sequences, lists
- Working with loops
- Defining Functions
- Implementation of R-Loops with different examples.
- Implementation of data frames in R. Write a program to join columns and rows in a data frame using c bind and r bind in R.
- Making pie and bar charts using R.
- Performing statistical analysis on the given data using R to find Correlation and Covariance
- Writing an R program for Regression Modeling.
- Writing an R program to cluster data
- Writing an R program for derivation of principal components
- Writing an R program to draw volcano plot and heat map

Essential/recommended readings
Latest editions of the following books are recommended

Theory:

1. Statistical methods in Bioinformatics: An introduction (second edition). Warren. Ewens and Gregory Grant. ISBN: 0-387-40082-6
2. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids (first edition). Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison. ISBN: 978-0521540797

Practical:

1. Beyond Spreadsheets with R: A beginner's guide to R and RStudio (first edition). ISBN: 978-1617294594

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE03: VACCINES AND BIOTHERAPEUTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE03: VACCINES AND BIOTHERAPEUTICS	4	3	0	1	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of the course is to provide students with an overview of current developments in different areas of vaccines.
- To make students understand the basic concepts of activation of the immune system during infections and in response to various vaccine immunizations.
- To teach students about different vaccine formats and the advantages/limitations associated with individual formats.
- To introduce students to biotherapeutics and their role in supporting human medicine.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will understand the fundamental concepts of the human immune system and basic immunology.
- Students will be able to understand and differentiate the immune responses with respect to infection and vaccination.
- Students will learn about different types of vaccines and their applications in the health sector.
- Students will learn to correlate the specific requirements of using a particular type of vaccine format with a certain disease condition.
- Students will understand the importance of both the conventional and new emerging vaccine technologies.
- Students will understand the use of biomolecules and cells as therapeutic agents.
- Students will learn different technologies used in the production of biotherapeutics.

SYLLABUS OF BP-DSE03

Theory Component (45 hours)

UNIT I **(10 hours)**

Immune system and infection: Overview of Immune system; Effectors of the immune system; Innate and adaptive immunity; Activation of innate immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection; Immune response to infection; Protective immune response in bacterial, viral and parasitic infections; Primary and secondary immune responses during infection; Antigen presentation and role of antigen presenting cells: Dendritic/macrophages/B-cells; Humoral (antibody-mediated) responses; Cell-mediated responses: role of CD4+ and CD8+ T cells; Memory responses: memory and effector T and B cells, generation and maintenance of memory T and B cells.

UNIT II **(10 hours)**

Vaccination, Adjuvants, and Immune potentiators: Vaccination and immune response: route of vaccination – oral, intranasal, subcutaneous, intramuscular, and intravenous route; Vaccine components: Antigens, Adjuvants [mineral salts (Aluminum hydroxide, Calcium alginate), emulsion and surfactant-based formulations (MF59 and AS03), particulate delivery vehicles (microparticles, immune-stimulating complexes, VLPs), liposomes]; Immune potentiators: microbial derivatives (Monophosphoryl lipid A, CpG oligonucleotide, lipopolysaccharide, Bordetella pertussis, BCG), cells and cytokines/hormones (dendritic cells, IL-12 and GM-CSF); Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems (microbial adjuvants, liposomal and microparticles); Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and mucosal immunity.

UNIT III **(13 hours)**

a) **Vaccine types, and design**: History of vaccines; Conventional vaccines; Bacterial vaccines; Viral vaccines; Cancer vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Types of vaccines - live attenuated and inactivated vaccine, killed whole organism, toxoid, subunit vaccines, virus-like-particle, outer membrane vesicle, protein-polysaccharide conjugate, viral vectored, nucleic acid vaccine (DNA/mRNA), bacterial vectored, and antigen-presenting-cells.

b) **Introduction to Vaccine Technologies:** New Vaccine Technologies; Rationally designed vaccines; DNA vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (vaccine delivery systems); Disease-specific vaccine design: tuberculosis vaccine; malaria vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika, Corona); Case studies.

UNIT IV **(12 hours)**

Biotherapeutics: Molecular biology basics: DNA structure and function, gene expression regulation, protein structure and function, recombinant DNA technology; Protein Engineering: protein design and optimization, antibody engineering, protein purification techniques, protein stability and delivery mechanisms; Cell and Tissue Engineering: stem cell biology, cell culture techniques, tissue engineering strategies, regenerative medicine applications; Immunotherapy: Immune system components and functions, T-cell receptor engineering, Checkpoint inhibitors, CAR-T cell therapy; Gene Therapy: viral vector design, gene editing technologies (CRISPR), gene therapy delivery methods, clinical applications of gene therapy; Drug Delivery Systems: targeted drug delivery, nanomedicine approaches, biodegradable polymers, drug delivery to specific tissues; Clinical trials and regulatory aspects; Biomanufacturing processes; Ethical and societal implications.

Practical component **(30 hours)**

1. Understanding the nature of antigens found in pathogens through studying the cases of infections of bacterial, viral, and fungal origin, reported in the literature.
2. Understanding the elicitation of microbial-specific immune response in humans, through reported literature, and drawing a correlation between the microbes and the type of host response that generally resolves the infection.
3. Based on the above information, practicing designing of suitable vaccine candidates, aiming to elicit a desired immune response leading to preventive immunity against the pathogen.
4. Categorizing various in-use vaccines into their respective types to understand the common features of multiple formats that have become successful for a particular type of pathogen/infection.
5. Finding out the infections of the present times for which vaccines are not available.
6. Choosing one infection and its causative pathogen, proposing a hypothesis about the most suitable vaccine format for its prevention. Attempting to draw a flow chart of vaccine development proposal starting from the stage of antigen selection to the stage of product production.
7. Presenting the vaccine ideas through a class seminar.
8. Understanding the relevance of antibodies in vaccine effectiveness/potency through case studies of the reported vaccines, e.g., anti-hepatitis B virus, HBsAg vaccine.
9. Understanding the relevance of cellular immunity for the effective prevention of viral infections through studies against viral vaccines, e.g., Covaxin and Covishield.
10. Understanding the relevance of vaccines for managing various cancers through case studies, thereby identifying the underlying bottlenecks of research in this area.
11. Understanding the concepts of antibody engineering and undertaking a small project to find targets for designing therapeutic antibody molecule(s) for a contemporary disease with the help of literature and databases.

Essential/recommended readings

- **Latest editions of the following books**

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). Immuno Biology:the Immune System in Health and Disease. USA: Garland Science Pub.
2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). Kuby Immunology. New York: W.H. Freeman.
3. Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH.
4. Vaccinology: Principles and Practice, by Editors: W. John W. Morrow, Nadeem A. Sheikh, Clint S. Schmidt, D. Huw Davies; Wiley Blackwell, 2012
5. Gene IX by Benjamin Lewin. Jones and Bartlett Publishers. 2007.
6. Cleland and Craik, (2006), *Protein Engineering, Principles and Practice*, Vol 7, Springer, Netherlands.
7. Huang, N.F., L'Heureux, N., Song, L. (2018) Engineering Stem Cells for Tissue Regeneration. World Scientific Publishing Company.
8. Pelengaris, S. and Khan, M. (2013). The Molecular Biology of Cancer. Wiley-Blackwell, Publication, New Jersey.
9. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SKILL BASED COURSE – BP-SBC01:
SPECIALISED LABORATORY – I: Molecular Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-SBC01 SPECIALISED LABORATORY –I: Microbiology and Molecular Biology	2	0	0	2	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this skill enhancement laboratory course is to provide practical skills on basic microbiological techniques.
- To expose students to the microbiology lab environment, basic lab infrastructure, basic equipment handling, and safety guidelines.
- To develop skilled manpower capable of handling basic lab strains of bacteria e.g., *E. coli,* for future molecular biology and genetic engineering experiments.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- To students will be able to isolate, characterize and identify common bacterial organisms.
- Students will be able to calculate/determine the bacterial load of different samples.
- Students will be able to perform antimicrobial sensitivity tests.
- Students will learn about preserving bacterial cultures of short and prolonged durations.

SYLLABUS OF BP-SBC01

List of Practical **(60 hours)**

1. Introduction to sterilization, disinfection, and safety in microbiological laboratory.
2. Introduction to basic microbiology laboratory equipment and handling.
3. Preparation of culture media and pouring plates.
4. Isolation of bacteria in pure culture by the streak plate method.
5. Isolation of bacteria in pure culture by the serial dilution method.
6. Study of colony and growth characteristics of some common bacteria: *Bacillus, E. coli, Staphylococcus, Streptococcus, etc.*
7. Growth of bacterial culture and preparation of the growth curve.
8. Preparation of bacterial smear and Gram's staining.
9. Enumeration of bacteria: standard plate count.
10. Antimicrobial sensitivity test and demonstration of drug resistance.
11. Preparation of stock cultures: slants and stabs, and glycerol stock cultures
12. Determination of Minimum Inhibitory Concentration (MIC)
13. Isolation and identification of bacteria from soil/water samples.
14. Colony PCR
15. Analysis of PCR product and its size using agarose gel electrophoresis.
16. Case Study/Group discussing: on data analysis and results

Essential/recommended readings
Latest editions of the following

1. Cappuccino, J. G., & Welsh, C. (2016). Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company.
2. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). Collins and Lyne's Microbiological Methods (8th ed.). Arnolds.
3. Tille, P. M., & Forbes, B. A. Bailey & Scott's Diagnostic Microbiology.
4. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE – BP-DSC04: COMPUTATIONAL BIOLOGY AND BIOINFORMATICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSC04: COMPUTATIONAL BIOLOGY AND BIOINFORMATICS	4	3	0	1	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- find and access relevant information from different databases
- apply various algorithms to predict the study function and evolution of biological macromolecules.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students would be able to learn about the different types of molecular biology databases and formats in which data is stored in these data repositories.
- Students would learn about the initiatives taken by the global and Indian scientific communities to make the available data
- Students would be able to understand the concept of different forms of sequence alignment methods and the selection of appropriate alignment method
- Students would know the mechanisms of molecular evolution. He/she would be able to draw phylogenetic inferences and will be able to reconstruct phylogenetic trees based on several molecular markers and application of the State-of-the-Art bioinformatics tools
- Students would know about different types of genome sequencing methods and their usage in modern biomedical techniques.
- Students would know different features used to annotate a genome/ DNA sequence of interest. Interpret the genome annotation results and meaning of a biologically functional region.

SYLLABUS OF BP-DSC04

Theory component (45 hours)

UNIT I **(8 hours)**
Introduction; Types of databases in terms of biological information content; Protein and gene information resources; Specialized genomic resources; Different formats of molecular biology data; Selected examples of global and Indian Biological Data Repositories. Recent advances w.r.t. Biological data repositories.

UNIT II **(10 hours)**
Global and local alignment; Methods and algorithms of pairwise and multiple sequence alignment; Concept and use of alignment scoring matrices; Gene/protein and genome alignment methods; Database similarity searching using sequence alignment; Motif detection; Concept and use of protein families. Recent advances in Sequence alignment.

UNIT III **(7 hours)**
Concept of orthology, paralogy and homology in gene and protein sequences. Methods and tools for phylogenetic analysis; Creation, evaluation and interpretation of evolutionary trees; Advantages and disadvantages of phenetic and cladistic approaches. Recent advances w.r.t. molecular phylogenetics.

UNIT IV **(20 hours)**
a) Different Generation of DNA sequencing technologies; Standard formats of sequencing reads; Applications of DNA sequencing technologies (Genome sequencing, Transcriptomics, ChipSeq, metagenomics); Recent advances w.r.t. Sequencing technologies.
b) Organization and structure of prokaryotic and eukaryotic genomes - gene structure, exon, intron, ORF, CDS, UTR, alternative splicing, codon usage, Gene prediction methods – *ab-initio*, Homology & transcriptome/EST, Non coding RNA discovery and annotation. Functional annotation of genes - sequence homology-based annotation & Gene Ontology/ Pathway Mapping using Swiss-Prot, KEGG, and ENZYME database.

Practical component **(30 hours)**

- Exploring the NCBI, UniProtKB, IBDC data repositories and tools available on these databases for data analysis and retrieval.
- Retrieving the DNA sequence of a given item (by name or accession number) from GENBANK.
- Retrieving this protein sequence of a given organism from UniProtKB database.
- Performing a database search using the BLAST.
- Short-listing protein sequences of the highest similarity from the list of BLAST search results and doing a multiple sequence alignment (Using CLUSTALW or any other multiple sequence alignment tool).
- Performing functional annotation of a newly sequenced genome.
- Learning about the Phylip/MEGA program and its uses for the construction of phylogenetic trees .

Essential/recommended readings

***Theory:* Latest editions of the following**

1. Statistical methods in Bioinformatics: An introduction (second edition). Warren. Ewens and Gregory Grant. ISBN: 0-387-40082-6
2. Bioinformatics (fourth edition). Edited by Andreas D. Baxevanis, Gary D. Bader, David S. Wishart. ISBN: 978-1-119-33558-0.
3. A Cell Biologist's Guide to Modeling and Bioinformatics (first edition). Raquell M. Holmes ISBN: 978-0-470-13934-9
4. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids (first edition). Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison. ISBN: 978-0521540797
5. Bioinformatics and Functional Genomics (third edition). Jonathan Pevsner. ISBN: 978-1-118-58176-6
6. The Phylogenetic Handbook: A Practical Approach to DNA and Protein Phylogeny (first edition). Marco Salemi, Anne-Mieke Vandamme (editors). ISBN: 0-521-80390-X.

Practical:

1. Bioinformatics for Dummies (second edition). Jean-Michel Claverie and Cedric Notredame. ISBN: 978-0-470-08985.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC05: CELLULAR BIOPHYSICS AND BIOENERGETICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSC05: CELLULAR BIOPHYSICS AND BIOENERGETICS	4	3	0	1	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- Students will be able to enumerate the various pathways controlling the cell viability and function
- Students will understand the physical principles involved in cell function maintenance.
- Students will understand the integration of principles of energetics to cellular systems.

Learning Outcomes

The Learning Outcomes of this course are as follows.

- Should understand the structural organization &function of living cells.
- Should understand the biophysical principles of the cellular mechanism of signaling.
- Should understand the principles of healthy development of an embryo and its protection.
- Should understand the biophysical principles of programmed cell death & their relevance in cancer.
- Should be able to apply thermodynamics in cellular & biochemical processes.

SYLLABUS OF BP-DSC05

Theory component (45 hours)

UNIT I **(10 hours)**

The Dynamic Cell: Architecture and Life Cycle of Cells, Cells into Tissues. Cell Organization: Microscopy and Cell Architecture, Organelles of the Prokaryotic/Eukaryotic Cell. Regulation of Eukaryotic Cell Cycle: Overview of the Cell Cycle and its Control, Biophysical Principles of Molecular Mechanisms for Regulating Mitotic Events, Checkpoints in Cell-Cycle Regulation.

UNIT II **(10 hours)**

Biophysics of Cell Signaling: Strategies of chemical signaling, Signaling mediated by intracellular receptors, Extracellular Signaling, Cell-Surface Receptors, G Protein–Coupled Receptors and Their Effectors, Phosphoinositol cycle, Role of Kinases, e.g. MAP Kinase Pathways, Second Messengers, Ca oscillations, Interaction and Regulation of Signaling Pathways, Molecular Mechanisms of Vesicular Traffic, From Plasma Membrane to Nucleus, Bacterial and plant two-component signaling systems, Bacterial Chemotaxis and Modeling.

UNIT III **(13 hours)**

a) **Cell Differentiation and Developmental Biophysics**: Cellular differentiation, Molecular mechanism of cell differentiation: Role of morphogens, protein kinase C, cytoskeleton, extracellular matrix.

b) **Biophysics of Apoptosis:** Relevance of Programmed Cell Death, Necrosis & Apoptosis, Mechanisms of Apoptosis, Role of beta Amyloid, Caspases and Mitochondrial proteins.

c) **Cancer:** Tumor Cells and the Onset of Cancer, Proto-Oncogenes and Tumor-Suppressor Genes, Oncogenic Mutations Affecting Cell Proliferation, Mutations Causing Loss of Cell-Cycle Control, Mutations Affecting Genome Stability.

UNIT IV **(12 hours)**

Energy production in the cell: Oxidation-reduction reactions, coupled reactions and group transfer.
Bio-Energetics: Gibb's Free Energy, Gibb's Law of Chemical Reactions; Entropy and enthalpy driven reactions, Biological Oxidation: Aerobic Oxidation and Photosynthesis, Oxidation of Glucose and Fatty Acids to CO2; Structure and Properties of Mitochondria, Cytochrome c, Chemiosmotic Coupling, Electron Transport and Oxidative Phosphorylation, Photosynthetic Stages and Light-Absorbing Pigments, Molecular Analysis of Photosystems
Bioenergetics in Health and Diseases: Regulators of mitochondrial metabolism,
Blood-based bioenergetics, Bioenergetic-dependent neurodevelopmental disorders include neural tube closure defects, microcephaly, intellectual disability, and autism spectrum disorders

Practical component **(30 hours)**

1. Demonstration/Familiarizing students with the basic operations of different microscopes
2. Demonstration/Familiarizing students with the sample preparation fixation and other procedure for various microscopic techniques such as oil immersion, electron microscopy, confocal microscopy etc.
3. Demonstration/Familiarizing students with histochemical techniques
4. Cell components fractionation using Linear/stepped gradient (Sucrose/Percoll/Histopaque)
5. Visualizing phosphorylated protein sample in SDS-PAGE using diamond stain or other methods
6. Demonstration/Familiarizing students with cell culture basics such as cell line revival, subculturing and cryopreservation.
7. Cell viability determination/assays
8. Cell harvesting for different assays such as crosslinking, proteomics etc.

Essential/Recommended readings
Latest editions of the following

Theory:

Latest editions of following books are recommended:

1. Molecular Cell Biology 6th Edition by Harvey Lodish, Arnold Beck and Chris A. Keiser
2. Essential Cell Biology, Fourth Edition By Bruce Alberts, Dennis Bray, Karen Hopkin, lexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter
3. The Cell, A Molecular Approach – 6th Edition – Geoffrey M. Cooper, Robert E. Hausman – Sinauer Associates, Inc.
4. Molecular and Cellular Biophysics, Meyer B Jackson , (Cambridge)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC06: GENETIC ENGINEERING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSC06: GENETIC ENGINEERING	4	3	0	1	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of the course is to teach students various approaches to conducting genetic engineering for biological research applications and in biotechnology industries.
- To make students capable of analyzing, altering, and recombining different types of DNA fragments and sequences.
- To equip students with detailed knowledge of various techniques and tools used in the field of genetic engineering and their application in the generation of products of commercial use in health, agriculture, industrial, and research sectors.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will understand methods to analyze DNA/RNA/proteins.
- Students will understand the basics of gene cloning, the construction of various libraries, and gene identification.
- Students will be able to analyze gene expression by PCR, hybridization, and sequencing-based techniques.
- Students will be able to use different techniques to engineer proteins for studying the dynamics of protein-protein and protein-DNA interaction and proteome analysis.
- Students will understand the importance and application of genetic engineering technologies in biology and medicine.
- Students will learn about gene editing technologies and their application in gene therapy.

SYLLABUS OF BP-DSC06

Theory component (45 hours)

UNIT I **(14 hours)**

a) **Tools of Genetic Engineering:** Impact of genetic engineering in modern society; General molecular tools: restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; Host strains; Basics of cloning: cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric tailing for ligation free cloning; Labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes; Hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.

b) **Types of vectors**: Plasmids; Bacteriophages; M13mp vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors: insertion and replacement vectors; Cosmids; Artificial chromosome vectors (BACs; YACs); Principles for maximizing gene expression; Expression vectors; pMal; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Methodologies to enhance soluble expression of heterologous proteins; Mammalian expression and replicating vectors; Yeast vectors; Shuttle vectors; Baculovirus and Pichia vector system; Plant-based vectors: Ti and Ri as vectors.

UNIT II **(9 hours)**

Hybridization techniques and PCR: Radioactive and non-radioactive labeling of nucleic acids and proteins; Southern, northern, western, fluorescence *in situ* hybridization (FISH), and detection of chromosomal abnormalities; Principles of PCR; Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested, reverse-transcription PCR, real-time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR; Cloning of PCR products, T-vectors; Proofreading enzymes; PCR based site-specific mutagenesis; PCR in molecular diagnostics, viral and bacterial detection.

UNIT III **(14 hours)**

a) Sequencing and mutagenesis methods: Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; RNA sequencing; Chemical synthesis of oligonucleotides; Mutation detection: SSCP, DGGE, RFLP; Mutagenesis - insertion and deletion mutagenesis, site-directed mutagenesis.

b) Gene manipulation and protein-DNA interaction: Insertion of foreign DNA into host cells: transformation, electroporation, transfection; Construction of libraries: isolation of mRNA and total RNA; Reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; Construction of microarrays: genomic arrays, cDNA arrays and oligo arrays; Protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; Methyl interference assay, chromatin immunoprecipitation; Protein-protein interactions using yeast two-hybrid system; phage display.

UNIT IV **(8 hours)**

Application of Genetic engineering: Gene silencing techniques: siRNA and miRNA construction of shRNA vectors; Gene knockouts and gene therapy; Creation of transgenic plants; Debate over GM crops; Transgenics - gene replacement; Gene targeting; Creation of transgenic and knock-out mice; Disease model; Introduction to genome editing technologies: ZFNs, TALEN, Cre-Lox; Total and conditional gene knockouts; Origins of CRISPR, CRISPR Knockout basics; CRISPR Knockin (Inserting or Mutating DNA Sequences in the Genome), CRISPR-Based Gene Therapy (Gene editing, Clinical Applications).

Practical component (30 hours)

1. Preparation of buffers, reagents, and media (broth & plates).
2. Preparation of competent cells.
3. Transformation of *E. coli* with standard plasmids and calculation of transformation efficiency.
4. Isolation of vector plasmid from DH5(alpha) strain of *E. coli*.
5. Restriction digestion of the vector and insert DNA.
6. Agarose extraction of the digested vector and insert DNA.
7. Vector and insert DNA ligation.
8. Transformation of *E. coli* cells with ligation mix and plating on antibiotic-supplemented LB-agar plates.
9. Confirmation of the cloning by colony PCR and restriction mapping.
10. Expression of the recombinant protein in *E. coli* and analysis of the heterologous protein by SDS-PAGE.

Essential/recommended readings

- **Latest editions of the following**

1. Gene Cloning and DNA Analysis: An Introduction, 8th Edition (2020), Wiley-Blackwell
2. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene
3. Manipulation: An Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
4. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
5. Selected papers from scientific journals, particularly Nature & Science.
6. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.
7. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERAL ELECTIVE COURSE – BP-DSE04: ENVIRONMENTAL BIOPHYSICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE04: ENVIRONMENTAL BIOPHYSICS	4	3	1	0	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to learn the importance of environment, life and environment
- The student will acquire an increased understanding of impact of human life style on the environment.
- They will know about the historical perspective of environmental disasters.
- The students will know about the control of pollution, medicinal role of plants

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to familiar with environment and its importance to human being.
- Student will understand the correlation of different environmental parameters with living systems and their protection & sustenance.
- Student will be able to learn about biofuels, environmental imbalance and its consequences.
- Student will be able to understand the importance of biodiversity, conservation and various non-renewable energy sources

SYLLABUS OF BP-DSE04

Theory component (45 hours)

UNIT I **(15 hours)**
Acid rain, Photochemical smog- mechanism of formation and ecological effects, chemical involved in ozone layer depletion, Montreal and Kyoto protocol mechanism of global warming and Greenhouse effect.

UNIT II **(15 hours)**
Bhopal Gas tragedy, Chernobyl disaster, biogeochemical cycles, economic value of biodiversity: medicinal plants and their role as therapeutics

UNIT III **(10 hours)**
Conservation of biodiversity: In situ and ex situ conservation, covid-19 pandemic: outbreak, spread and prevention, environmental pollution.

UNIT IV **(5 hours)**
Changing Human behavior to Conserve Biodiversity, Plastics and the Environment.

Tutorials component **(15 hours)**
Reaction in atmosphere: Photochemical reactions, acid-base reactions, reaction of gases, Air and water pollution control, Non-Renewable Energy Resources, Hazardous Wastes, biofuels, Sustainability in Health Care, Energy Efficiency: What Has Research Delivered in the Last 40 Years?

Essential/recommended readings
Latest editions of following books are recommended:

1. Molles MC (2012) Ecology – Concepts and applications, 6th Edition, Mc Graw Hill
2. Stanley E Manahan; Environmental Chemistry; CRC Press.
3. Roy M. Harrison; Principles of Environmental Chemistry; RSC publishing
4. An Introduction to Environmental Biophysics by Campbell, Gaylon S., Norman, John M. (Springer)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE05: BIOPHYSICAL METHODS: FUNDAMENTAL TECHNIQUES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE05: BIOPHYSICAL METHODS: FUNDAMENTAL TECHNIQUES	4	3	0	1	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- Provide students with a foundational understanding of the basic biophysical methods used to study the structure and function of biological macromolecules, particularly proteins and nucleic acids.
- Students would be provided an understanding of the historical development of classical techniques such as spectroscopy, hydrodynamic methods, chromatography, and electrophoresis, with an introduction to their principles, applications, and limitations
- The student will be introduced to how these methods are used in modern biological research and biotechnology industry.
- The students will be motivated to analyze and discuss most appropriate methods for exploring varied research problems.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to comprehend and describe the fundamental principles of common biophysical techniques.
- The student will be able to choose and apply biophysical methods to study the structure, function, and interactions of biological molecules.
- The students will be able to design experiments and analyse data from techniques like UV-Vis spectroscopy, circular dichroism (CD), and fluorescence spectroscopy.
- Student will be able to carry out basic biophysical methods experiments in the laboratory.

SYLLABUS OF BP-DSE05

Theory component (45 hours)

UNIT I: (5 hours)

a) **Introduction to Biophysical methods:** Overview of biophysical methods and their role in biological research and clinical work, Basic concepts in physics and chemistry relevant to biophysical methods, Principles of energy, thermodynamics, and kinetics in biological systems

b) **Emergence of combination techniques:** Recent advances in methods involving a combination of the above techniques.

UNIT II: (14 hours)

a) Hydrodynamic Methods: Introduction to the hydrodynamic methods and their measurements: Diffusion, Osmosis, Viscosity, Applications of viscosity measurements in clinical sciences and biotechnology

b) Spectroscopic Methods: Introduction to spectroscopic techniques: Absorption, Emission, and Scattering of light, Implications of particle and wave nature of light, Quantized energy levels, Principles of UV-Vis spectroscopy: Beer-Lambert Law and its applications, Quantification of biomolecules (proteins, nucleic acids), Principles of fluorescence spectroscopy: Fluorescent probes and dyes, variations of techniques such as Fluorescence quenching and resonance energy transfer (FRET), Fluorescence recovery after photobleaching (FRAP), Principles of InfraRed Spectroscopy: absorption or transmission spectra for identifying functional groups in organic compounds and macromolecules, Circular Dichroism: Basic principles of CD spectroscopy, Applications in monitoring protein folding and stability via study of secondary and tertiary structure

UNIT III: (18 hours)

a) Chromatographic methods: Definition of chromatography, Principles of separation science: adsorption, partition, ion exchange, and size exclusion, types of chromatography based on different principles. Principle, method, types, and applications in biological research of Affinity chromatography, Ion exchange chromatography, Size exclusion chromatography, Hydrophobic chromatography, Reverse phase chromatography, Gas chromatography, Thin Layer chromatography, Paper chromatography, High Performance Liquid Chromatography

b) Electrophoretic Methods: Principles of Electrophoresis: Polyacrylamide and Agarose matrix for protein and nucleic acid analysis, Novel variations in electrophoresis: Native vs. SDS; 2D-Gel electrophoresis, Iso-Electric focusing, Capillary Electrophoresis: principle, method, and applications in biological context, Free flow electrophoresis: principle, method, and applications in biological context, Applications in clinical diagnostics and the therapeutic industry

UNIT IV: (8 hours)

a) Centrifugation methods The theoretical principles behind centrifugation methods, sedimentation force and coefficient, Svedberg constant, Types of centrifugal separations: differential, density gradient, Application of centrifugation in biomolecular research: separation of cellular components, proteins, nucleic acids, and organelles, Analytical ultracentrifugation: Introduction, principle of sedimentation velocity and sedimentation equilibrium, measurement of molecular weight, shape, and interactions among biomolecules, application in studying protein-protein interactions, protein folding, and conformational changes.

b) Optical Microscopy: Overview of microscopy, Historical development of microscopy, and its role in cell biology, Principles of light microscopy: resolution, magnification, and contrast, Types of light microscopy: bright-field, phase contrast, and differential interference contrast (DIC), Applications of light microscopy in studying cellular structures and biomolecular localization.

Practical component **(30 hours)**

List of Practical:

1) UV-Vis absorption spectroscopy to measure protein concentration
2) UV-Vis absorption spectroscopy to explore DNA concentration and melting
3) Fluorescence spectroscopy to study the effect of pH on protein stability
4) Fluorescence spectroscopy to study the effect of temperature on protein stability
5) Fluorescence spectroscopy to study the effect of denaturing agents on protein stability
6) Affinity Chromatography: HIS-Tag based purification
7) Ion Exchange chromatography: for protein purification
8) Size exclusion Chromatography: for quaternary structure estimation
9) Circular dichroism study to estimate the secondary structure of protein
10) Circular dichroism study to explore conformational changes in protein on heating

Essential/Recommended readings

- **Latest editions of the following**

Theory:

- **Books:**

a) *Bengt Nolting (2010). Methods in modern biophysics. Springer.*

b) *Jay A. Glasel, Murray P. Deutscher (1995). Introduction to Biophysical Methods for Protein and Nucleic Acid Research. Academic Press.*

- **Online Resources**:

Websites as discussed in class

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE06: TEXT MINING METHODS IN BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-DSE06: TEXT MINING METHODS IN BIOLOGY	4	3	0	1	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to provide students with the skills to apply text mining methods to biological and biomedical research using freely available online tools and databases.
- Students will learn how to extract biological information, scientific research findings from large corpora of scientific literature and biological databases.
- The students will gain hands-on experience with publicly available data and apply these methods to generate reviews and hypothesis.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will understand key concepts in text mining and its applications to biology.
- The student will be able to use popular web-based tools and databases (e.g., PubMed, Pubtator, STRING, BioBERT, TextRazor) for text mining.
- The student will be able to extract, analyze, and interpret biological information from scientific literature and other available online sources.
- The student will be able to conduct systematic literature reviews using advanced search tools and implement text mining techniques to answer biological research questions.

SYLLABUS OF BP-DSE06

Theory component (45 hours)

UNIT I: Introduction to Text Mining (6 hours)

- Definition and overview of text mining, Introduction to the types of data in biology (e.g., Scientific literature, clinical data, gene expression data)
- Importance of Text mining in the biological sciences, Advantage and challenges in text mining
- Basic concepts: unstructured vs. structured data, text pre-processing
- Introduction to K-mean clustering, Decision tree, Natural Language processing, K-nearest Neighbour

UNIT II (16 hours)

a) **Biological literature databases**: Structure of scientific literature, Introduction to biological literature sources: PubMed, PubMed Central, Google Scholar, Scopus, web of Science
b) **Web tools for Text Mining:** Introduction to Web-Based text mining tools: Pubtator, BioBert, Textrazor, Advantages and limitations of Web-Based text mining tools

UNIT III (16 hours)

a) **Data Interpretation and Visualization Tools:** Introduction to data visualization, Types of plots for data visualization: wordcloud, heatmaps, networks graphs and Scattered plots, Available tools for data visualization: cytoscape, matplotlib, Textalyzer, Infogram

b) **Tools and methods for Literature Review** Introduction to Scientific literature Analysis tools: LitMaps, Connected Papers, Paperscale, Scite, Advantages, strengths and Limitation of these tools

UNIT IV: Future of Text Mining (7 hours)

a) The role of AI and machine learning in advancing text mining for biology, deep learning and its application to biomedical text
b) Future trends in biomedical text mining, including NLP with pre-trained models (e.g., BioBERT, SciBERT

Practical component (30 hours)

UNIT I: Databases/Webservers:
1) Learning to access and extract information from PubMed.
2) Learning to use Pubtator
3) Learning to use BioBert
4) Learning to use and create graphs in Textrazor
5) Learning to use and create networks in Cytoscape
6) Learning to use and create graphs in Infogram
7) Learning to use and create graphs in Textalyzer
8) Accessing and extracting data from Paperscale
9) Analysing data using Scite
10) Extracting literature review data from LitMaps

Essential/Recommended readings

- **Latest editions of the following**

  Theory:

  - **Books:**
    Research papers and reviews on the topic as discussed in class.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SKILL BASED COURSE – BP-SBC02: SPECIALISED LABORATORY – II: Cell Biology and Bioinformatics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BP-SBC02: SPECIALISED LABORATORY -II : Cell Biology and Bioinformatics	2	0	0	2	as per admission guidelines	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this skill enhancement laboratory course is to provide practical skills on basic cell-based and computational techniques.
- To acquaint the students with the cell culture lab environment, basic lab infrastructure, equipment handling, and safety guidelines.
- To acquaint the students with the basics of computational biology by hands-on training.
- To develop skilled manpower equipped with bioinformatics know-how.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to maintain basic cell lines under aseptic conditions.
- Students will be able to develop stable lines and understand the basis of cell-based assays.
- Students will be able to extract data from the relevant biological databases.
- Students will be able to analyse data from the relevant biological databases

SYLLABUS OF BP-SBC02

List of practical **(60 hours)**

1. Demonstration of good laboratory practices with reference to cell and tissue culture.
2. Functioning and calibration of pH meter.
3. Brief account of Cell biology equipment working and their principles For ex: Different types of Microscopes, Laminar flow, incubators, autoclave.
4. Introduction to sterilization, disinfection, and safety in the cell culture laboratory.
5. Preparation of buffers.
6. Introduction to various components of Cell culture media for different cell lines.
7. Cell line revival and cryopreservation.
8. Cell subculturing.
9. Cell counting using a hemocytometer.
10. Determination of cell viability using trypan blue.
11. Cell lysate preparation using mechanical methods.
12. Spectrophotometric/colorimetric estimation of total protein in lysate.
13. Case study/Group Discussion: data analysis and results.
14. Retrieval of genomic and transcriptomic NGS reads from a public repository, for example, NCBI-SRA,
15. Quality control, pre-processing, and assembly of transcriptomic reads, determination of differentially expressed genes
16. Discovery of phenotypically important SNPs in a genome.
17. Retrieval of proteomic data from a public repository, determination and differentially expressed proteins, and their functional annotation.

Essential/recommended readings

- **Latest editions of the following**

1. Culture of Animal Cells 4th Edition by Freshney, R.I.
2. Animal cell culture- practical approach by Edi. Jhon R.W. Masters ; Oxford
3. Algorithms for Next-Generation Sequencing (first edition). Wind-Kin Sung ISBN: 978-1466565500
4. Introduction to computational proteomics (first edition). Golan Yona. ISBN: 978-0367452285

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Annexure-2

UNIVERSITY OF DELHI
M.Tech. Microwaves and Communication

PROGRAMME BROCHURE

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2025 and Executive Council on YYYY, 2025

M.Tech. in Microwave and Communication

The M.Tech programme in Microwave and Communication is a four semester, i.e., a two-year programme under Faculty of Interdisciplinary & Applied Sciences of University of Delhi. This programme was initially sponsored by the Department of Electronics, Government of India in 1976 with an M.Tech. in Microwave Electronics. This programme is re-structured with an aim to provide the necessary theoretical background and practical experience in the fields of Microwave Devices, Measurements, Microwave Passive and Active Circuits, Advanced Antennas, Monolithic Microwave Integrated Circuit (MMIC), EMI/EMC, Next-generation Communication systems, etc. The current course structure is updated based on the advancements in the field of RF, Microwave, THz to Optical Communication & Circuits. The course caters to all essential needs of the next-generation high-frequency systems while fulfilling the requirements of Research and Industrial applications.

For admission to this postgraduate program of the University of Delhi, all candidates (including those applying for Supernumerary seats) must register for the Common University Entrance Test (Postgraduate) CUET (PG) of the year of applying at pgcuet.samarth.ac.in. For admission and seat allotment, candidates must apply to the Common Seat Allocation System (PG) of the same year of the University of Delhi. So, the candidates must go through the PG Bulletin of Information before applying for M.Tech. (Microwave and Communication) for updated admission procedures.

Minimum Eligibility
For candidates belonging to UR/OBC-NCL/EWS category, the minimum eligibility is 50% marks in aggregate or equivalent grade in the qualifying examination as per the Program-Specific Eligibility.
For candidates belonging to SC/ST/PwBD category, the minimum eligibility is 45% marks in aggregate or equivalent grade in the qualifying examination as per the Program-Specific Eligibility

Admission Criteria:
For admission to M.Tech. (Microwave and Communication), the candidates must fulfill the Program Specific Eligibility and appear in the respective CUET paper. Refer to https://pgcuet.samarth.ac.in/ for the syllabus of the CUET paper.

<table>
<tr><th>Category</th><th>Program Specific Eligibility</th><th>CUET (PG) Paper Code</th></tr>
<tr><td>1A</td><td>B.Tech./ B.E./B.Sc. Engg.(4 years course) Electrical/ Electronics/ Electronics and Communication/ Instrumentation/ Radio Physics & Electronics Engineering from a recognized University</td><td rowspan="2">MTQP05*

(*as decided by the authorities conducting CUET PG)</td></tr>
<tr><td>1B</td><td>M.Sc. Electronics or M.Sc. Physics/Applied Physics with specialization in Electronics from a recognized University</td></tr>
</table>

Seats Offered by Department:

<table>
<tr><th>Category</th><th>UR</th><th>SC</th><th>ST</th><th>OBC</th><th>EWS</th></tr>
<tr><td rowspan="2">No. of Seats</td><td>13</td><td>5</td><td>3</td><td>9</td><td>3</td></tr>
<tr><td colspan="5">04 seats are reserved for candidates
sponsored from R&D organizations across India</td></tr>
</table>

In addition, Supernumerary seats will be as per University of Delhi rules & regulations.

Age Requirement

No student will be qualified for admission to the M.Tech course unless he/she is 21 years of age on or before 1st October of the year of admission. Relaxation of age limit up to a maximum period of six months based on individual merit may be granted by the Vice-Chancellor.

ORDINANCE

1. There shall be M.Tech. Course in Microwave and Communication in the Department of Electronic Science under the Faculty of Interdisciplinary and Applied Science.
2. The duration of the course will be four semesters which is two academic years.
3. A candidate seeking admission to this course must have passed B.Tech./ B.E./B.Sc. Engg.(4 years course) Electrical/ Electronics/ Electronics and Communication/ Instrumentation/ Radio Physics & Electronics Engineering from a recognized University with at least 50% marks for UR/OBC-NCL/EWS category and 45% marks for SC/ST/PwBD category or an equivalent grade.

   OR

   A candidate seeking admission must have passed M.Sc. Electronics or M.Sc. Physics with specialization in Electronics from a recognized University with at least 50% marks for UR/OBC-NCL/EWS category and 45% marks for SC/ST/PwBD category or an equivalent grade.
4. Candidates for M.Tech. programme will be selected for admission to **33 seats (13 UR, 05 SC, 03 ST, 09 OBC, and 03 EWS)** on the basis of performance in the CUET and **04 seats** are for candidates sponsored from R&D organizations across India. Out of these, the first 10 students will be eligible for a scholarship of Rs.600/- per month except the sponsored candidates.

Fee of the M.Tech programme

A fee will be as per University of Delhi rules & regulations. Candidates must visit the Department website for the updated fee structure.

SCHEME OF EXAMINATION

1. English shall be the medium of instruction and examination.

2. Examinations shall be conducted at the end of each Semester as per the Academic Calendar notified by the University of Delhi.

3. The system of evaluation shall be as follows

   3.1 Each theory paper will carry 4 credits i.e. 100 marks out of which 20 marks shall be reserved for internal assessment based on tests, seminars and assignments and 5 marks for attendance as per the table given in ATTENDANCE REQUIREMENT. The duration of written examination for each paper shall be three hours and will be of 75 marks. In the case of a student who has an essential repeat (ER) in one or more theory papers, the internal assessment marks will be carried forward.

   3.2 Examinations for practicals for semester I, II and III will comprise of 2 credits i.e. 50 marks. The end semester practical examination for semester I, II and III would be for 6 hours duration and will be of 60% of the total marks i.e. 30 marks. 40% of the total marks i.e. 20 marks will be for the internal assessment based on continuous evaluation throughout the semester.

   3.3 Each student has to take up a minor-project **(MTCP302)** based on the hardware and/or software in III semester which will be of 6 credits i.e. 150 marks under the supervision of a department faculty. The project evaluation will be based on the project report submitted by the student and a presentation to a panel of three examiners from the Department faculty as decided by the PG Committee of Courses of the Department every year. The 50% of the marks will be based on continuous internal assessment throughout the semester.

   3.4 Students will be required to work on the major project **(MTCP401)** in Semester IV which will be of 16 credits i.e. 400 marks. The project can be carried out in collaboration with an R & D Organization or industry of repute. The collaboration is to be established by the project coordinator.

   All students will have to go through a mid-semester project evaluation which will be of 30% of total marks i.e. 120 marks and facilitated by the project coordinator and internal supervisor of the student either through online or offline mode.

   On completion of the project work, the student will submit a dissertation and appear for a viva voce examination. The minimum mark required to pass the fourth Semester shall be 50% in project. A student, who fails in the Semester IV Examination, will be required to repeat the Project including the mid-semester evaluation. However, he/she may be allowed to complete it in the span period.

4. Examinations for courses shall be conducted only in the respective odd and even Semesters as per the Scheme of Examination. Regular as well as Ex-Students shall be permitted to appear/reappear in courses of odd semesters only at the end of odd semesters and for even semesters only at the end of odd semesters. There will be no scope for improvement or re-evaluation.

PASS PERCENTAGE AND PROMOTION CRITERIA

(a) The minimum marks required to pass in any paper in a semester shall be 40% in theory and 40% in Practical, wherever applicable. Also, the student must secure atleast 40% marks in the internal assessment (i.e. 10/25) and a minimum of 40% marks in the End semester examination (i.e. 30/75) of each theory paper.

(b) No student will be detained in the I or III Semester based on his/her performance in I or III Semester examination; i.e. the student will be promoted automatically from I to II and III to IV semester.

(c) A student shall be eligible for promotion from Part 1 to Part 2 of the course provided he/she has passed at least 3 core papers and 2 elective papers of I and II semesters taken together. However, the student will have to clear all ER or papers in which he/she is absent while studying in Part 2 of the programme.

(d) A student who has to reappear in a paper prescribed for semester I/III may do so only in the odd semester examinations to be held in November / December. A student who has to reappear in a paper prescribed for Semester II/IV may do so only in the even Semester examinations to be held in May/June.

(e) A student who reappears in a paper shall carry forward the internal assessment marks, originally awarded and the result will be prepared based on the student's current performance in the end semester examination.

(f) Students who do not fulfill the promotion Criteria (c) above shall be declared fail in the Part concerned and can take re-admission as per the University rules.

(g) A student who fails or is absent in any semester's practical examination/mini-project/major project will be declared fail in that semester and will have to take re-admission in the concerned semester in the span period only.

DIVISION CRITERIA

Successful candidates will be classified as per the University rules based upon SGPA and CGPA.

SPAN PERIOD

No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of four years from the date of admission to Part 1/Semester I of the M.Tech. Program.

ATTENDANCE REQUIREMENT

No student shall be eligible to take an examination unless he/she has attended at least 60% of the total number of lectures and 60% of practicals seperatly conducted in each semester, during his/her course of study. The 05 marks for the attendance will be as per the table give below:

Attendance percentage (A)	Marks allocated
60% ≤A<65%	1
65% ≤A<70%	2
70% ≤A<75%	3
75% ≤A<80%	4
80% ≤A	5

NOTE:

a) The calendar for the academic year will be as per University notifications.
b) The span period for the M.Tech. degree will be four years from the initial date of admission in a particular academic year.
c) A candidate who fails in Part 1 or Part 2 will be required to repeat that part of the course as a regular student only.
d) There will be no provision of an ex-student.
e) A candidate, who fails in the Semester IV Examination, will be required to repeat the Project. However, he/she may be allowed to complete it in the span period only.
f) The scholarship will be discontinued if the student fails to score at least 60% marks in any examination.
g) If a student fails in any paper, he/she will not be eligible for a merit position and the scholarship will be discontinued.

h) Subject to the statutes and ordinance of the University, M.Tech. Course students shall remain under the control and discipline of the Head, Department of Electronic Science under the Faculty of Interdisciplinary & Applied Sciences (FIAS).

DEPARTMENT OF ELECTRONIC SCIENCE
UNIVERSITY OF DELHI SOUTH CAMPUS

FRAMEWORK FOR M.TECH.(MICROWAVE AND COMMUNICATION)

Part/ Semester	Unique code	Name of Course	L	P	C	Page no.
Part 1	**Semester I**					1
1/I	**MTC101**	Electromagnetic Theory and Transmission Lines	**4**	**-**	**4**	1
	MTCL102	Microwave Planar Lines and Passive Components	**4**	**2**	**6**	3
	Choose any one out of the following					
	MTEL101	Microwave Characterization and Measurement Techniques	**4**	**2**	**6**	6
	MTEL102	Optical Communication Systems	**4**	**2**	**6**	9
	Choose any one out of the following					
	MTE103	Microwave Devices	**4**	**-**	**4**	11
	MTE104	EMI and EMC Technology	**4**	**-**	**4**	13
	Total credit in Semester I				**20**	
Part 1	**Semester II**					15
1/II	**MTC201**	Advanced Communication Theory	**4**	**-**	**4**	15
	MTC202	Microwave Active Circuits	**4**	**-**	**4**	17
	MTCL203	Advanced Antenna Theory and Techniques	**4**	**2**	**6**	19
	Choose any one out of the following					
	MTEL201	Computational Electromagnetics	**4**	**2**	**6**	22
	MTEL202	Radar Technology	**4**	**2**	**6**	23
	Choose any one out of the following					
	MTE203	Metamaterials and Metasurfaces: Concepts and Applications	**4**	**-**	**4**	25
	MTE204	Satellite Communication System	**4**	**-**	**4**	29
	Total credit in Semester II				**24**	

L-credits in lectures, P-credits in practicals, and C- total credits

SEMESTER I

MTC101. Electromagnetic Fields & Guided Wave Theory

Lecture Credits: 4 **Total Lectures: 60**

Course Learning Objectives

The Electromagnetic Theory and Transmission Lines course aims to give students a comprehensive understanding of Maxwell's equations to wave equations and to solve various problems related to wave propagation in different mediums and guided structures. Students will learn to solve the wave equation using rectangular, cylindrical, and spherical coordinates and plane waves moving through different materials. Boundary conditions to solve problems at the interface of various materials. Scalar, vector, and Hertz potentials relate to electromagnetic fields and gauges. The course will cover the transmission lines, including their RLCG model, matched, open, short circuit lines and quarter-wave transformers. Students will also learn about different modes (like TE, TM and Hybrid) and their field distribution in rectangular, circular, dielectric slab waveguides and cavities. Finally, they will learn the transverse Resonance Method. Students will build a strong foundation in theoretical skills needed to work with electromagnetic systems and networks.

Course Learning Outcomes

At the end of this course, students will have

CO1. To understand Maxwell's equations and boundary conditions.
CO2. Learn to solve wave equations in rectangular, cylindrical, and spherical coordinates.
CO3. Learn transmission lines and use of Smith to solve the matching problem.
CO4.Develop skills in solving field components for rectangular, circular, dielectric slab waveguides and cavities in different modes (like TE, TM and Hybrid)
CO5. Learn transverse resonance method to solve electromagnetic problems.

Syllabus Contents

Unit-1 **18 lectures**
Review of Maxwell's Equations and boundary conditions, time harmonic electromagnetic fields, generalized current concept, energy and power, complex power; Introduction to wave equation and its solutions: Plane waves in dielectric and conducting media, reflection and refraction of waves. Scalar, vector and Hertz potentials and their relations to fields, and gauges. Theorems and concepts: The source concept, duality, uniqueness, image theory, the equivalence principle, fields in half space, reciprocity, construction of solutions.

Unit-2 **12 lectures**
Basic theory of transmission lines; Computation of RLCG parameters of two-wire and classical

lines; Input Impedance, Short Circuit and Open Circuit lines, Quarter wave transformer, Smith Chart and its applications; Transient domain analysis of transmission lines.

Unit-3 **15 lectures**

Rectangular waveguide: Transverse Electric (TE), Transverse Magnetic (TM), and Dominant TE_{10} mode, Power Density and Power; Rectangular cavity: Transverse Electric (TE), Transverse Magnetic (TM) and Hybrid mode; Partially filled waveguides; Transverse Resonance Method (TRM).

Unit-4 **15 lectures**

Dielectric slab waveguide: Transverse Electric (TE) and Transverse Magnetic (TM); surface guided waves, non-resonant dielectric (NRD) guide. Circular waveguide: Transverse Electric (TE), Transverse Magnetic (TM) modes; Circular cavity.

Suggested Readings:

1. C.A. Balanis, "Advanced Engineering Electromagnetics,"2nd Ed. John Wiley & Sons,2012.
2. R. F. Harrington, "Time-Harmonic Electromagnetic Fields," 2nd Ed. McGraw-Hill, New York, 2001.
3. D. K. Cheng, "Field and Wave Electromagnetics," 2nd Ed., Addison Wesley,1989.
4. Matthew N. O. Sadiku, "Principles of Electromagnetics " 6th Ed. Oxford University Press,2015.
5. Kraus, Daniel A. Fleisch, "Electromagnetics: With Applications "5th Ed. WCB/McGraw-Hill,1999.

MTCL102. Microwave Planar Lines and Passive Components

Lecture Credits: 4 **Total Lectures: 60**

Course Learning Objectives

The main objective of this course is to give a comprehensive understanding and simulation exposure to the various transmission lines and their utility for the microwave passive component design that is involved in the microwave system design so that the students can design any passive components using simulation software and understand their behavior through the complete design procedural steps of developing circuit schematic, board files, and S-parameters based characterization.

Course Learning Outcomes

At the end of this course, students will have

CO1. Familiarization with the various types of planar transmission lines used in microwave technology
CO2. Pre-requisite knowledge to design microwave passive components based on the properties of planar transmission lines for microwave applications.
CO3. Knowledge of designing and understanding the microwave passive components with the help of simulating various microwave components
CO4. Understanding of the basic component designs and future scope of these components in the microwave industry

Syllabus Contents

Unit-1 **12 lectures**

S-parameter analysis of the microwave circuits; Conversion of Z, Y, ABCD transmission parameters to S-parameters and vice versa; Shift in reference planes, Generalized S-parameters for one-port and multiport networks, Cascade S-parameters, De-embedding of S-parameters; Applications of S-parameters on matching network design.

Unit-2 **15 lectures**

Review of the development of MIC, MMIC and application of the planar transmission line structures such as stripline, microstrip line, coplanar waveguide line and coupled microstrip line, LTCC Technology. Quasi-static and frequency-dependent closed-form models of planar lines for effective relative permittivity, characteristic impedance, dispersion models, dielectric, conductor, and radiation losses; effect of conductor thickness on parameters of planar transmission lines. Extraction of frequency-dependent RLGC parameters of planar transmission lines,

Unit-3 **15 lectures**

Discontinuities, Circuit models of discontinuities in microstrip lines and the coplanar waveguides: Open-ended, short, gap, step, bent, T-Junction and their compensation techniques. Microwave resonators: Transmission line resonators, Microstrip line resonators -rectangular, circular, and ring; Loaded and unloaded Q, Excitation of resonators.

Unit-4 **18 lectures**

Periodic structures, Filter design methods, Filter transformations; Richards' transformation and Kuroda's identities; Inverters, Coupled Line Filters, coupled-resonator filters; Three-port components: Resistive power divider, Wilkinson power divider. Four-port components: Branch line coupler, Hybrid ring coupler, Coupled line directional coupler, Lange coupler.; Even-odd mode analysis of dividers and couplers; Plane wave propagation in a Ferrite medium, Isolator, Circulator, delay lines and phase shifters; MEMS technology-based microwave components like switches, filters, phase shifters and delay lines.

Suggested Books:

1. David M. Pozar, Microwave Engineering, 4th Edition, John Wiley & Sons, Inc, 2012
2. Michael Steer, Microwave and RF Design: A System Approach, Scitech Publishig Inc., 2010.
3. T. C. Edwards & M. B. Steer, Foundations for Microstrip Circuit Design, John Wiley & Sons, 2016
4. Devendra K. Misra, Radio-Frequency and Microwave Communication Circuits: Analysis and Design, John Wiley & Sons, 2012
5. Subal Kar, Microwave Engineering: Fundamentals, Design And Applications, Orient Blackswan Pvt Ltd 2016.

Microwave Planar Lines and Passive Components Laboratory

Practical Credits: 2 **Total Lectures: 60**

List of Experiments:

A. MATLAB based:

1. To study the synthesis and analysis of the microstrip line and coplanar waveguide by plotting the characteristic impedance and effective relative permittivity.
2. To study the dispersion in the microstrip line by plotting the frequency-dependent permittivity with frequency.
3. To study the conductor and dielectric losses for microstrip and stripline lines as a function of frequency.

B. Software Based:

4. To design Hi-Low and Stub based Microstrip line low pass filters and high pass filters.
5. To design stub and coupled Microstrip line band pass and band stop filters.
6. To design 3 port Wilkinson equal and unequal power divider in a microstrip line.
7. To design 4-port equal and unequal power branch line coupler in a microstrip line.

C. Measurement-based:

8. To measure frequency and guide wavelength by the microwave test bench.
9. To measure the parameters of the microstrip filters using Vector Network Analyzer (VNA).
10. To measure the parameters of microstrip power dividers using VNA.
11. To measure the parameters of microstrip couplers VNA.

MTEL101. Microwave Characterization and Measurement Techniques

Lecture Credits: 4 **Total Lectures: 60**

Course Learning Objectives

The main objective of this course is to give a comprehensive understanding and hands-on exposure to the various characterization and measurement techniques applicable in the Microwave technology, so the students will able to understand the significance of the microwave parameters and their measurement techniques and apply for verification of the industry-oriented microwave component design and development of microwave systems, like mobile communication, microwave sensor analysis, Radar and Satellite etc.

Course Learning Outcomes

At the end of this course, students will have

CO1. Familiarization of the various microwave parameters and their measurements
CO2. Pre-requisite knowledge to perform design and development of any microwave component and their performance verification
CO3. Knowledge of the current broadband characterization techniques and signal analysis in the microwave industry
CO4. Understanding of the basic and advanced measurement techniques for material characterization at the microwave frequencies.

Syllabus Contents

Unit-1 **12 lectures**
Characteristic impedance, Reflection coefficient, Voltage standing wave ratio, VSWR meter, Wavelength and Frequency measurements; Phase velocity, Group velocity; Losses in transmission lines, return loss, insertion loss, reflection loss, mismatch loss; Scattering parameters, Properties of S-parameters, Examples of S-parameter matrices; Noise Figure and equivalent noise temperature.

Unit-2 **16 lectures**
Power sensors, Thermocouples and other thermoelectric sensors, Diode sensors, Thermistors and other bolometers, Calorimeters; Power measurements and calibration, Mismatch uncertainty, Direct power measurement, Ratio measurements; Pulsed power measurements; Attenuation measurements: Power ratio method, Voltage ratio method, Inductive voltage divider, AF substitution method, IF substitution method, RF substitution method, Important considerations for making attenuation measurements.

Unit-3 **18 lectures**
Elements of a microwave network analyzer, Block diagram of Network analyzer, Scalar network analyzer, Vector network analyzer, Calibration of a scalar network analyzer and vector network analyzer, Transmission measurements, Reflection measurements, Measurement errors, One-port error model, Two-port error model, one-port and two-port Calibration techniques, Calibration

and verification standards, Verification of VNA measurements, Dielectric measurement theory, Loss processes, Considerations for practical dielectric measurements, Q-factor and its measurement, Reflection/Transmission based measurement methods, Coaxial probes, Free-field methods, Time domain techniques. Resonator-based methods.

Unit-4 **14 lectures**

Measurement domains, Spectrum analyzer Architecture and its working, Types of spectrum analyzer, spectrum analyzer with harmonic mixer, spectrum analyzer with a tracking preselector, Spectrum analyzer with tracking generator, Typical specifications of Spectrum analyzer, Various controls of Spectrum analyzer, Spectrum analyzer applications, Noise Figure Measurement, Measurement of harmonic distortion, Intermodulation distortion measurement, Amplitude modulation, Frequency modulation, Pulse modulation, Phase noise.

Suggested books:

1. R.J. Collier (Editor), A.D. Skinner (Editor), Microwave Measurements (Materials, Circuits and Devices) 3rd Edition, The Institution of Engineering and Technology, 2007.
2. Joel P. Dunsmore, Handbook of Microwave Component Measurements: with Advanced VNA Techniques, 3rd Edition, John Wiley & Sons Ltd, 2020.
3. Valeria Teppati, Andrea Ferrero and Mohamed Sayed, Modern RF and Microwave Measurement Techniques, Cambridge University Press, 2013.
4. L. F. Chen, C. K. Ong, C. P. Neo, V. V. Varadan, V. K. Varadan, Microwave Electronics: Measurement and Materials Characterization, John Wiley & Sons, Ltd, 2004.
5. David M. Pozar, Microwave Engineering, 4th Edition, John Wiley & Sons, Inc, 2012.
6. Ananjan Basu, An Introduction to Microwave Measurements, CRC Press, 2014.

Microwave Characterization and Measurement Techniques Laboratory

Practical Credits: 2 **Total Lectures: 60**

List of Experiments:

1. To study the low VSWR and high VSWR (using the Double minima method) measurement of waveguide components.
2. To study the calibration of a given attenuator and a wave meter.
3. To determine impedance of various irises (vertical, horizontal, and rectangular cuts)
4. To study the model characteristics of Reflex Klystron (Output power ve Reflector voltage, frequency vs reflector voltage).
5. To study the characteristics of a Directional coupler (Directivity, coupling factor, isolation and insertion loss, S-parameters)
6. To study the characteristics of a Magic tee (Coupling factor, isolation and input VSWR, S-parameters)
7. To study the frequency response of the given filter and determine its characteristics (cutoff frequency or center frequency, bandwidth etc.)
8. To study the characteristics of isolator and circulator (Insertion loss, isolation and input VSWR, S-parameters)

9. To study the characteristics of a phase shifter (Insertion loss, phase and input VSWR).
10. To study the radiation pattern of (a) Horn antenna, (b) Dielectric rod antenna and obtain the antenna parameters (Gain, Directivity, HPBW).

MTEL102. Optical Communication System

Lecture Credits: 4 **Total Lectures: 60**

Course Learning Objectives

The main objective of this course is to give a comprehensive understanding and hands-on exposure to the various processes, industrial tools, protocols, and design specifics which are involved in free space optical communication and Optical Fiber Communication (OFC) so that the students can understand the complete details of the Optical Fiber beginning from components of Optical Fibers, different types of Fibers, sources, detectors and the link budget as applicable to the Optical Fiber Communication System.

Course Learning Outcomes

At the end of this course, students will have

- CO1 Familiarization of the various types of free space optical communication, Optical Fibers and its components
- CO2 Understanding of the Optical Fiber components, their characteristics and their applications.
- CO3 Pre-requisite knowledge to perform design of link budget of the Optical Fiber Communication System
- CO4 Understanding of the current trends, scope and future trends of the Optical Fiber Communication System.

Syllabus Content

Unit-1 **16 Lectures**

EM Spectrum and Optical Frequencies, Free space optical communication, link budget associated with free space optical communication, Deep space communication, Optical Satellite Communication, Intersatellite and on board optical communication; Introduction to OFC, Optical Spectral bands; Basic Optical Laws and definitions, Mode Theory of Circular Dielectric Waveguides, Optical Fiber modes and configurations; Cut off wavelength and V-number of Fibers; Single mode and multi-mode fibers, Step index and graded index fibers, structure of the graded index fibers, fiber materials, Fiber fabrication, Fiber optic cables; Attenuation, Signal Dispersion in Fibers, Intermodal and Intramodal dispersion, chromatic and waveguide dispersion, group delay, polarization mode dispersion.

Unit-2 **14 Lectures**

Optical Sources, Semiconductor physics for optical sources, direct and indirect band gap semiconductors, Energy momentum diagrams; Light emitting Diodes (LEDs), Physical Structures of LEDs; Lasing actions, Different types of Lasers, Laser Diodes, Structure of Laser Diodes, Fabry Perot Cavity in Laser Diodes; Light Source Linearity. Reliability Considerations; OFC transmitter considerations, source to fiber power launching, lensing schemes for coupling improvement, fiber splicing and optical fiber connectors, Intensity and Sub-intensity modulations.

Unit-3 **14 Lectures**

Optical Detectors, Physical Principles of photodiodes, Photodetector noise, Detector response time; Avalanche and Zener breakdown, Avalanche multiplication noise; Structure of InGaAs Avalanche Photodetectors (APDs), temperature effect on Avalanche Gain, Comparison of Photodetectors; Optical receiver system, Fundamental of receiver operation, Digital Receiver performance, Eye diagrams.

Unit-4 **16 Lectures**

Digital Links, Point to Point links, Power penalties, error control, codes for error control; Coherent detection; Analog links and its overview, Carrier to noise ratio, multi-channel transmission techniques; Microwave Photonics; Wavelength Division Multiplexing (WDM) and Dense Wavelength Division Multiplexing (DWDM); Diffraction gratings, tunable light sources. Basic applications and types of Optical Amplifiers, Semiconductor Optical Amplifiers; Erbium-Doped Fiber Amplifiers, Optical SNR, Raman Amplifiers; General Overview of non-linearities in optical fiber communication, Stimulated Raman and Brillouin Scattering; Optical Networks and Topologies, SONET/SDH; Optical Time domain reflectometry (OTDR).

Books Recommended:-

1. Optical Fiber Communications, Gerd Keiser, Tata Mc Graw Hills, 4^{th} edition, 2008.
2. Introduction to Fiber Optics, Ajoy Ghatak and K. Thayarajan, Cambridge University Press, 1999.
3. Optical Fiber Communications: Principles and Practice, John M. senior, Pearson education Ltd., 2009.
4. Fiber Optic communication systems, G. Agrawal, John Wiley and Sons, 1992.

List of Experiments for Optical Communication System Laboratory: -

1. a. Measurement of Fiber Optic Numerical Aperture
   b. Measurement of Fiber Optic using Optical Power Meter
2. a. Setting up Fiber Optical Analog Link
   b. Setting up Fiber Optical Digital Link
3. a. Study of Intensity Modulation Technique using Analog Input Signal
   b. Study of Intensity Modulation Technique using Digital Input Signal
4. a. Study of VI Characteristics of three different LED
   b. Study of Gaussian Illumination profile of three different LED
5. a. Study of Single sided, Double sided, and Triple sided Edge Diffraction
   b. Study of Two different gratings with two different Lasers
6. a. Measurement of Single Knife-Edge Diffraction using Power Meter
   b. Measurement of Polarizer and Analyzer using Power Meter
7. a. Measurement of Half Wave Plate using Power Meter
   b. Measurement of Quatre Wave Plate using Power Meter
8. Study of five different Optical Structures and their refraction and reflection patterns.

MTE103. Microwave Devices

Lecture Credit: 4 **Total Lectures: 60**

Course Learning Objectives:

The objective of this course is to provide knowledge of various microwave devices to the students. It comprises of the detailed knowledge of conventional as well as latest devices of RF and microwave engineering. Students will be able to study microwave semiconductor devices & their related applications. Moreover, they will learn about microwave sources and the integration of microwave devices with microwave-integrated circuits (MIC) and Monolithic Microwave Circuits (MMIC).

Course Learning Outcomes:

At the end of the course, students will be able

CO1. To understand about the microwave devices, MIC & MMIC technologies, and related industrial requirements.

CO2. To have knowledge of unipolar and bipolar microwave devices including various microwave diodes and Transferred Electron devices.

CO3. To attain the knowledge of three terminal microwave devices and their advancement in accordance with the latest technology.

CO4. To gain knowledge of microwave sources and their applications and advancement.

Syllabus Contents

Unit-1 **12 lectures**

Introduction to Microwave Engineering, Concept of guided and unguided medium, Need of High Frequencies for industrial applications, Modern Applications of Microwave Engineering, Microwave components and devices: active and passive, Introduction to Microwave integrated circuits (MIC), Technology of hybrid MICs, and Monolithic Microwave Circuits (MMIC), Surface Mount Devices (SMD) & through-hole components, Integration of microwave devices with MIC and MMIC structures, Electronic packaging, Basics of RF device packaging and thermal management.

Unit-2 **15 lectures**

Introduction and classifications of Microwave solid state devices, Unipolar and Bipolar Devices, Tunnel Diode, Varactor Diode, Schottky diode, Avalanche Transit Time Devices: Read, IMPATT, TRAPATT, BARITT, comparison of microwave diodes with pn junction diode, integration of microwave diodes with microstrip structures and their effects in frequency agility, beam switching and other RF applications.

Transferred electron devices (TED): Gunn Diode; Gunn effect, Ridley–Watkins–Hilsum theory, Modes of operation, Limited Spacecharge Accumulation (LSA) mode of Gunn diode, Applications of TEDs.

Unit-3 **18 lectures**

Microwave Transistors, Concept of Hetero-junction, Hetero-junction Bipolar Transistor (HBT), Field Effect Transistors (FETs); Junction Field Effect Transistor (JFET), metal-oxidesemiconductor field-effect transistor (MOSFET), Metal-Semiconductor Field-Effect Transistor (MESFET); structure, mechanism, modes of operation, transconductance and cut off frequency, High Electron Mobility Transistor (HEMT) and pHEMT; structure, mechanism, & applications.

Unit-4 **15 lectures**

Microwave Sources: Microwave Triodes, Introduction to vacuum tubes, Linear and O-Type Tubes, Klystron; two cavity and multi-cavity, velocity modulation process, bunching process, output power and beam loading, Reflex Klystron; Power Output and efficiency, Traveling wave tubes (TWT), Slow wave structures, Magnetron; Construction & operation, Conventional tube design, Hull or single-anode magnetron, Split-anode magnetron, Cavity magnetron, Applications of magnetron in Radar, Heating and Lighting, Health hazards.

Suggested Books:

1. David M. Pozar, Microwave Engineering, 4/e, Wiley India, 2012
2. Robert E. Collin, Foundation of Microwave Engineering, 2/e, Wiley India, 2012.
3. Samuel Y. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003.
4. George Kennedy & Bernard Davis, Electronic Communication system, 4th ed, Tata McGraw Hill Education Private Limited, 1999.
5. Leo Maloratsky, Passive RF and Microwave Integrated Circuits, Elsevier, 2006.

MTE104. EMI and EMC Technology

Lecture Credits: 4 **Total Lectures: 60**

Course Learning Objectives

To provide the students with a comprehensive understanding of electromagnetic compatibility (EMC) and interference (EMI) for their future aspects of modern technologies. It will develop knowledge about the sources of electromagnetic interference and the need for EMC, common EMC/EMI terminology, techniques for identifying EMI sources, their measurements, and control techniques.

Course Learning Outcomes

At the end of this course, students will have
CO1. Information on Sources of EMI
CO2. Exposure of Test Methods for EMC/EMI
CO3.Understanding of EMI control techniques
CO4.Awareness of the regulatory landscape and compliance requirements related to EMI/EMC.
CO5.Knowledge of EMC best practices in product design and development.

Syllabus Contents

Unit-1 **10 lectures**
Basics of Electromagnetic Fields and Waves, Overview of Electromagnetic Compatibility and Interference, Importance of EMC/EMI in Modern Technologies, Key Concepts in Signal and Power Integrity, Conducted and Radiated Emissions.

Unit-2 **16 lectures**
EMI Sources: Antennas, Transmitters, Receivers, and Propagation; Techniques for Identifying EMI Sources; EMI Coupling Modes: Equipment Emissions and Susceptibilities; Common-Mode Coupling and Differential-Mode Coupling Mechanisms: Field to Cable, Ground Impedance, Ground Loop and Coupling Reduction Techniques; Other Coupling Mechanisms: Power Supplies and Victim Amplifiers.

Unit-3 **16 lectures**
Federal Communications Commission (FCC) and International Special Committee on Radio Interference (CISPR) standards and requirements; Conducted emissions test: Voltage method, Current probe method; Radiated Emission test: Open area test site, Semi-anechoic chamber; Conducted immunity test: Substitution method; Radiated immunity test: Reverberation and semi-anechoic chamber test; Electrostatic discharge test.

Unit-4 **18 lectures**
Designing for Electromagnetic Compatibility, Grounding Techniques: Grounding Schemes (Single Point, Multi-Point and Hybrid), Shield Grounding and Bonding; Shielding techniques: Apertures, Gaskets, Printed circuit board level; Filtering and Suppression Methods, Advanced

Strategies for EMC/EMI Mitigation. Shielding effects: Absorption loss, reflection loss, multiple reflection loss; Shielding modelling: metallic enclosure, EMI gasket, cavity resonance; Shielding Effectiveness measurements: Modified radiation method, Dual mode stirred chamber, Transverse electromagnetic (TEM) cell, Coaxial holder, Dual chamber test.

Suggested Books:

1. Dipak L. Sengupta, Valdis V. Liepa, Applied Electromagnetics and Electromagnetic Compatibility, Wiley Inter Science, 2006.
2. Clayton R. Paul, Introduction to Electromagnetic Compatibility, 2nd edition, Wiley, 2006.
3. Bogdan Adamczyk, Foundations of Electromagnetic Compatibility, Wiley, 2017.
4. Xingcun Colin Tong, Advanced Materials and Design for Electromagnetic Interference Shielding, CRC Press, 2008.
5. L. A. Kumar and Y. U. Maheswari, Electromagnetic Interference and Electromagnetic Compatibility, CRC Press, 2023.

SEMESTER II

MTC201. Advanced Communication Theory

Lecture Credits:4 **Total Lectures: 60**

Course Learning Objectives

This course provides an in-depth exploration of advanced communication theory with a focus on wave propagation and its various effects. The course covers the principles of modern communication systems, signal processing, and the effects of various propagation environments. Special attention will be given to the analysis and modeling of wireless channels, including the impact of fading, multipath, and atmospheric conditions on signal propagation. A significant portion of the course is dedicated to understanding the behavior and applications of random processes in communication.

Course Learning Outcomes

At the end of this course, students will have
CO1. Be able to model and analyze communication systems using random processes.
CO2. Understand and apply key concepts in wave propagation in different environments.
CO3. Evaluate the performance of communication systems under various propagation conditions.
CO4. Develop the ability to design and optimize communication systems considering theoretical and practical constraints.

Syllabus Contents

Unit-1 **12 lectures**
Brief history of communication systems, Analog and digital transmission, Review of Fourier analysis, linear systems; Digital Communication techniques, Sampling, quantization, and coding of signals, Modulation and demodulation of ASK, FSK, PSK, QAM, Multiplexing FDM, TDM.

Unit-2 **15 lectures**
Probability and random variables; Baye's theorem; Probability density and probability distribution functions, statistical expectation, and characteristic functions, various continuous and discrete distributions, multiple random variables, transformation of PDFs; Random Processes: description of random and ergodic process, mean, correlation and covariance functions, Stationary and non-stationary process, power and energy; Multiple random process; Random processes in frequency domain; Fourier transform of random processes, power spectrum of stochastic processes; Markov process.

Unit-3 **15 lectures**
Free space propagation model, 2-ray ground reflection model, Basic principle of Diffraction and scattering from obstacles, Atmospheric attenuation; Practical link budget design; Troposphere propagation; Indoor and Outdoor Propagation models, Fading characteristics and multipath; Large-

scale and Small-scale fading, Statistical channel models of fading: Rayleigh, Rician, Diversity techniques.

Unit-4 **18 lectures**

Multiple Access Techniques: Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Code Division Multiple Access (CDMA), Spread Spectrum Techniques, Direct sequence spread spectrum; Orthogonal Frequency Division Multiplexing (OFDM); MIMO Systems: Basic principles, spatial multiplexing, diversity gain; Channel capacity and Shannon's Theorem, Error control coding, Channel Estimation and Equalization; Methods to combat multipath fading; Introduction to Data communication, Wireless protocols: IEEE 802.xx, Network layers; Routing, mobility management, Transport layer protocols for wireless networks; Introduction to software defined radio.

Suggested Books:

1. D. C., Montgomery, & G. C. Runger, Applied statistics and probability for engineers. John Wiley & Sons, 2020.
2. T. S. Rappaport, Wireless communications: principles and practice. Cambridge University Press, 2024.
3. B. Sklar, Digital communications: fundamentals and applications. Pearson Publications, 2021.
4. B. A. Forouzan, Data communications and networking. Huga Media, 2007.
5. Hwei P. Hsu, Schaum's Outlines: Probability, Random Variables, and Random Processes, McGraw-Hill Education, 2019.
6. Simon Haykin, Digital Communication Systems, Wiley, 2013.

MTC202. Microwave Active Circuits

Lecture Credits:4 **Total Lectures: 60**

Course Learning Objectives

The main objective of this course is to give a comprehensive understanding and hands-on exposure to the various processes, industrial tools, protocols, and design specifics which are involved in Microwave Active Circuits Designing so that the students can design any Active circuit component like Amplifiers, Oscillators, Mixers, etc. for a specific application using industry-standard software after going through the complete procedural steps.

Course Learning Outcomes

At the end of this course, students will have

- CO1 Familiarization of the various types of Microwave devices/components
- CO2 Understanding of the Microwave Active components, their characteristics and their applications.
- CO3 Pre-requisite knowledge to perform design of these microwave active components
- CO4 Understanding of the current trends and scope of the microwave active circuits industry

Syllabus Content

Unit-1 **16 Lectures**

Introduction to RF and Microwave active circuits and its application to MMIC; Description of a complete system; Review of the Transmission Lines, Reflection coefficient & VSWR; Analytic solutions for Impedance matching using Quarter wave, Single stub and Double Stub Matching; Impedance matching using Z and ZY Smith Chart; Signal flow diagram; Derivation of Reflection and Transmission coefficients using Signal Flow Graphs; Derivation of Gain (Unilateral and Bilateral) using Signal Flow Graphs; Equivalent circuit and models of microwave diode and transistor.

Unit-2 **14 Lectures**

S-parameter description of active devices; Classification of RF amplifiers for low noise, medium power and high-power application; Biasing, stability and Noise consideration; Matching considerations for maximum power and minimum reflection; Different types of Power Amplifiers and their characteristics.

Unit-3 **14 Lectures**

Design of microwave amplifier circuits: Narrow band amplifiers; Unilateral and Bi-lateral amplifier designs, Input and Output Stability Circles, broad band amplifiers, broadband matching; Potentially Stable and Unconditionally Stable Conditions; Constant Gain Circles; Unilateral Figure of Merit; Maximum Available Gain and Maximum Stable Gain; Low Noise Amplifiers: Input and Output Stability Circles for LNA; Considerations on the improvement of S/N ratio; 3-dB compression Points; Intermodulation Products; Dynamic Range; Spurious Free Dynamic Range (SFDR) considerations; Gain bandwidth product; Multistage Amplifiers; Cascaded Amplifier Designs.

Unit-4 **16 Lectures**

Classification and Design of microwave oscillators: characteristics and performance evaluation; Bark-Hausen Criterion for Oscillation; Types of Oscillators: Negative Resistance and Positive Feedback Oscillators; Signal Flow Graphs for Single Port and Dual Port Oscillators; Conversion of Dual port to Single port Oscillators; Phase locked loop circuit, Voltage Controlled Oscillators (VCOs), Phase Noise; Dielectric Resonator based Oscillators. Basic mixer concept: Frequency domain characteristics, Losses in Microwave Mixers; Single ended mixer design, Single and double balanced mixer; Image Rejection Mixer and Harmonic Mixer; Microwave Detectors; Microwave Switches: Single Pole Single Throw (SPST) and Single Pole Double Throw (SPDT) Switches.

Suggested Books:

1. Microwave Transistor Amplifier: Analysis and Design, Gonzalez Guillermo, Prentice Hall,1984.
2. Microwave Circuit Analysis and Amplifier Design, Samuel, Y. Liao, Prentice Hall, 1987.
3. High-Frequency Amplifier, Ralph S. Carson, Wiley-Interscience 1982.
4. Microwave Engineering 4th edition, D. M. Pozar, John Wiley & Sons, 2011.

MTCL203. Advanced Antenna Theory and Techniques

Lecture Credits: 4 **Total Lectures: 60**

Course Learning Objectives

The course Antenna Theory and Technique aims to provide a comprehensive understanding of the theory of various antennas. Students will learn electromagnetic radiation theory and antenna analyzing parameters such as directive gain, polarization characteristics, beam width, and efficiency. They will explore various types of antennas and their applications in communication systems. Students will learn to derive the field components of various antennas like wire antennas, aperture antennas, parabolic reflector antennas and microstrip patch antennas. Students will study various feed techniques such as probe feed, microstrip line feed, and insert feed. The course also covers circularly polarized microstrip antennas. Students will also learn antenna arrays, including linear and planar arrays with Binomial and Chebyshev distribution patterns. Finally, students will learn modern antennas, including mobile handset and base station antennas, and they will also gain insights into feed networks for microstrip antenna arrays. This course will provide the necessary theoretical foundations to design, analyze, and optimize antennas.

Course Learning Outcomes

At the end of this course, students will have

CO1. To understand the radiation mechanism in antenna and various antenna parameters.

CO2. Learn to derive the field components of a wire antenna like a dipole, loop, helix and Yagi-Uda.

CO3. Learn to compute the field components of various aperture antennas.

CO4. Develop skills in solving field components for square, rectangular and circular microstrip patch antenna

CO5. Learn the linear and planar antenna arrays and provide the knowledge of beam scanning using Binomial and Chebyshev distribution.

Syllabus Contents

Unit-1 **15 lectures**

Theory & mechanism of electromagnetic radiation, Coordinate system and transformation of field quantities in different coordinate systems, Basic concept and definition: Input impedance, Bandwidth, Gain, Directivity, Radiation Pattern, Beam width, Polarization, Co-polarization, Cross-polarization, Axial ratio, Efficiency; Concept of Far-field and Near Field, Introduction to RADAR and its equation. Radiation Integrals and Auxiliary Potential Functions and their application to the analysis of wire antenna, dipole, loop antenna, helix antenna and Yagi-Uda Antenna.

Unit-2 **15 lectures**

Introduction to two-element Array; Aperture antenna: Introduction, theory of aperture antenna including the Fourier transform method and application to slot, waveguide and horn antenna; Design consideration of parabolic reflector antenna.

Unit-3 **15 lectures**

Microstrip antenna: Rectangular and Circular patch; Feed to microstrip antenna: probe feed, microstrip line feed, aperture feed, electromagnetically fed microstrip patch; Circularly polarized microstrip antenna. Effect of Perfect Electric Conductors (PEC) and Perfect Magnetic Conductors (PMC) on the performance of Antenna.

Unit-4 **15 lectures**

Theory of linear array: Two-element and multi-element array, isotropic and non-isotropic array, Binomial and Chebyshev distribution; Planar array, phased array and adaptive antenna; Feed network of microstrip antenna array; MIMO Antenna, Antenna for mobile communication: handset antenna and base station antenna.

Suggested Books:

1. C. A. Balanis, "Antenna Theory Analysis and Design," 3rd Ed. Wiley Interscience,2009.
2. J. D. Kraus, Ronald Marhefka, and Ahmad S. Khan "Antennas and Wave Propagation" 5th Ed. McGraw Hill Education, 2017.
3. Warren L. Stutzman and Gary A Thiele, "Antenna theory and design" 2nd Ed. Wiley India Pvt Ltd., 2009.
4. I J Bahl and P Bhartia, "Microstrip Antennas" Artech House,1980.
5. R E Collin, "Antennas and Radio Wave Propagation", 4th Ed. McGraw-Hill Inc., US,1985.
6. Robert S Elliot, "Antenna Theory and Design" Revised Ed. Wiley-IEEE Press, 2003.

Advanced Antenna Theory and Techniques Laboratory

Practical Credits: 2 **Total Lectures: 60**

List of Experiments:

1. To design a Dipole antenna and analysis of its various parameters.
2. Study the Effect of Perfect Electric Conductor (PEC) and Perfect Magnetic Conductor on dipole antenna's performance.
3. To study and design of rectangular and circular microstrip patch antennas.
4. To study the effect of various feeds in the microstrip patch antenna.
5. To study and design of Aperture antenna (rectangular slot)
6. To study and design of circularly polarized microstrip patch antenna.
7. To study and design of planar microstrip array antenna.
8. Measurement of antenna parameters using a Vector Network Analyzer.
9. Measurement of the radiation pattern of microstrip patch antennas, and analysis of co-polarization and cross-polarization.

MTEL201. Computational Electromagnetics

Lecture Credits: 4 **Total Lectures: 60**

Course Learning Objectives

The course on Computational Electromagnetics aims to provide students with a comprehensive understanding of numerical methods and computational techniques used to solve electromagnetic problems. Students will gain a knowledge of Maxwell's equations and boundary conditions, along with various numerical methods and their classifications. The course will delve into the finite difference time domain (FDTD) method, including its principles, formulations, stability, accuracy, and applications in microwave circuit simulation. Additionally, students will explore contour integration, conformal mapping, and integral equation methods, including the method of moments. The course will conclude with an introduction to advanced topics like the finite element method, Monte Carlo methods, mode matching methods, coupled cavity methods, and the lattice Boltzmann method.

Course Learning Outcomes

At the end of this course, students will have
CO1. To understand the fundamental principles of electromagnetics.
CO2. Explore FDTD methods used in computational electromagnetics.
CO3. Learn conformal computational techniques to solve electromagnetic problems.
CO4. To explore advanced topics in microwave engineering through computational approaches.

Syllabus Contents

Unit-1 **12 lectures**
Review of Maxwell's computational equations, Boundary conditions Dirichlet and Neumann. Basics of Computational Methods, Overview of numerical methods, Classification of EM problems and respective methods, 2D and 3D modelling.

Unit-2 **18 lectures**
Cell structures, grid pattern, and fundamentals of Finite difference technique. Basic principles and formulation of Parabolic, Hyperbolic, and Elliptic model; Implicit and Explicit method, Stability and Accuracy, 3D Yee’s Model. Source Excitation in FDTD, Perfectly Matched Layer and Absorbing Layer, Modelling and simulation of microwave circuits, and Application of FDTD method.

Unit-3 **16 lectures**
Direct Construction Approach for Green’s Function, Eigenfunction Expansion of Green’s Function. Conformal mapping, Cauchy’s integral theorem, and Calculus of Residues. Fundamental of Method of Moments (MoM), Integral Equations for electromagnetic problems, Green's functions and Basis functions, and Solution techniques for MoM.

Unit-4 **14 lectures**

Fundamentals of Finite Element Method (FEM), Variational principles and weak formulations, Mesh generation and refinement, Finite Element Discretization and Governing Equation. Introduction to Monte Carlo Methods, and Mode Matching Methods.

Suggested Books:

1. M. N. O. Sadiku, Computational Electromagnetics with MATLAB, CRC Press, Fourth Edition, 2018.
2. D. B. Davidson, Computational Electromagnetics for RF and Microwave Engineering. Cambridge University Press, Second Edition, 2010.
3. R. Garg, Analytical and Computational Methods in Electromagnetics. Artech House, 2008.
4. J.-M. Jin, Theory and Computation of Electromagnetic Fields. John Wiley & Sons, 2015.
5. K. Chang, Encyclopedia of RF and Microwave Engineering (6 Volume Set), Second Edition. Wiley, 2023.

Computational Electromagnetics Laboratory

Practical Credits: 2 **Total Lectures: 60**

List of Experiments:

Computational Electromagnetics Laboratory using MATLAB or Python Programming

1. To implement finite difference approximations for first and second derivatives.
2. To compare the derivative of the following function with its Finite Difference Technique processed form and plot it.
   i) sin (x) and sin (cos (tan (x^2))) by forward difference technique
   ii) sec (x) by backward difference technique
   iii) 1/x by central difference technique
3. To simulate the propagation of a plane wave using the 1D FDTD method.
4. To solve the heat diffusion problem by Finite Difference Time Domain (FDTD) Technique.
5. To solve the wave problem in a single dimension by FDTD Technique.
6. To solve the Elliptic PDE for Laplace equation by using the FDTD Technique.
7. To analyze the dispersion error and Courant stability criterion.
8. To calculates the 2D Green's function for the Helmholtz equation in free space.
9. To find the charge distribution on the rod using MOM/FDTD/FEM, where metal rod length of 1m is maintained at 2.0V potential.
10. To form global matrices of the Finite Element Method, consider the global stiffness matrix assembly for a simple 1D problem with 3 elements and 4 nodes.

MTEL202. RADAR Technology

Lecture Credits: 4 **Total Lectures: 60**

Course Learning Objectives

The main objective of this course is to give a comprehensive understanding and hands-on exposure to the various processes, industrial tools, protocols, and applications which are involved in RADAR systems so that the students can understand the principles behind RADAR Communication and its system perspectives.

Course Learning Outcomes

At the end of this course, students will have

CO1 Familiarization of the various types of RADARs

CO2 Understanding of the RADAR components, their characteristics and their applications.

CO3 Pre-requisite knowledge to understand detection theory and signatures used in RCS and its allied components

CO4 Understanding of the current trends and scope of the RADAR systems industry

Syllabus Content

Unit-1 **16 Lectures**

Introduction to RADAR - definition and basic concepts, Block Diagram; Friss free space equation and RADAR equation; RADAR equation under different cases – range performance, Signal to Noise Ratio Considerations, Power requirements at transmitter and receiver ends; Radar Cross Section (RCS) – Different types, detectability of different geometries and their RCS signatures; Introduction to Stealth Technology.

Unit-2 **14 Lectures**

Theory of detection, Detectability of the different RADAR signatures; Clutter Theory, Representation of Clutter under different conditions, sea clutter, urban clutter, desserts; Introduction to the concept of Ducting, Conditions at which ducting takes place; Minimum detectible signal, Effect of weather, Land and Sea Clutter effects on the EM signals, Detection of various Targets.

Unit-3 **14 Lectures**

Types of RADAR – Continuous wave (CW) and Frequency modulated Radar, Moving Target Indicator (MTI) and Pulsed Doppler Radar, Tracking Radar, Synthetic Aperture RADAR (SAR) and Inverse Synthetic Aperture RADAR (ISAR); Light Detection and Ranging (LIDAR), its components, transmitters and receivers in LIDAR.

Unit-4 **16 Lectures**

Elements of RADAR – Transmission details, Klystron amplifier, Travelling wave tubes (TWT) Amplifier, Magnetron Amplifier, Solid State Transmitters, Phase shifters and its application in Transmitters; Receiver Details, Noise Figure, Mixers, Displays, Pulse Position Indicator (PPI) and Digital Displays; Circulator and Antenna elements, Signal Processing design, Matched filter

Receiver, Constant False Alarm rate (CFAR) Receivers. Examples of different types of RADAR in operation (application specific), Radio Frequency Identification (RFID), propagation of RADAR Waves, Round of Earth approximation, Refraction, Diffraction, Attenuation, Over the Horizon (OTH) RADAR, Air Surveillance RADAR, Bistatic RADAR, millimeter waves and future of RADAR Technology.

Suggested Books:

1. Introduction to RADAR Systems, Merill L Skolnik, Tata Mc Graw Hills, 2003.
2. Introduction to RADAR analysis, Bassem R. Mazhafa, CRC Press, 2000.
3. RADAR Signal analysis and processing using MATLAB, Bassem R. Mazhafa, CRC Press, 2008.

RADAR Technology Laboratory

Practical Credits: 2 **Total Lectures: 60**

List of Experiments:

RADAR Technology Laboratory using MATLAB

1. To study the different components of RADAR Communication System. Measurement of Range and Velocity using RADAR kit.
2. To establish the Friss equation and RADAR Range equation for different power levels and RCS
3. To plot the Pulse Position Indicator (PPI) using MATLAB GUIDE
4. To write a MATLAB code to understand Constant False Alarm Rate (CFAR)
5. To plot the RCS responses for different objects
6. To plot the Clutter response along with RCS of different objects
7. To simulate the concept of SAR using Simulink on MATLAB
8. To simulate the concept of ISAR using Simulink on MATLAB

MTE203. Metamaterials and Metasurfaces: Concepts and Applications

Lecture Credits: 4 **Total Lectures: 60**

Course Learning Objectives

Electromagnetic metamaterials and Metasurfaces find potential applications in advanced communication, defence and energy sectors by leading to innovative designs of filters, sensors, radomes/shields, antennas, intelligent reflectors, energy harvesting structures, as well as superlenses. The subject of electromagnetic metamaterials is an interdisciplinary one, involving fields as circuit design, electromagnetics, classical optics, solid state physics, microwave / antenna engineering and material sciences. Besides the conventional spatial metamaterials, recently, there has been an emphasis on using time-modulation to realize extensive EM properties. In this course, students learn the basic concepts of Metamaterials and Metasurfaces and their application in the design of filters, sensors, radomes/shields, antennas, intelligent reflectors, energy harvesting structures, as well as superlenses.

Course Learning Outcomes

At the end of this course, students will have

CO1. To understand the basic concepts of Metamaterials and Metasurfaces
CO2. To learn the theory and properties of negative permittivity and permeability media.
CO3. To learn the Composite Right-Left Handed (CRLH) Transmission Lines
CO4. To learn the concept of Negative and Zeroth-Order Resonators
CO5. To learn the Artificial High-Impedance Surface, Artificial Magnetic Conductor (AMC), Electromagnetic Bandgap Structures (EBG)

Syllabus Contents

Unit-1 **14 lectures**
General Historical perspective and idea of Metamaterials (MTMs), Maxwell's Equations and EM Boundary Conditions, Formulation and Solution of Wave-equation, Phasor Concepts, Plane-wave propagation in simple medium, Dispersive model for the dielectric permittivity, Phase velocity and group velocity.

Unit-2 **16 lectures**
Metamaterials and homogenization procedure, Ionospheric Plasma, Metals and plasmons at optical frequencies, Wire mesh structures such as low-frequency plasmas, Diamagnetism in a stack of metallic cylinders, Split-ring resonator media; Media with negative permittivity and permeability: theory and properties, Origins of negative refraction and other properties, Design of Superlenses for optics.

Unit-3 **14 lectures**
Ideal Homogeneous CRLH TLs (Composite Right-Left Handed Transmission Lines), LC Network Implementation and distributed 1D CRLH Structures, Conversion from Transmission Line to

constitutive Parameters, Dual-band and enhanced band guided wave components. Negative and Zeroth-Order Resonators, Zeroth-Order Resonators based antenna, Backfire-to-Endfire (BE), Leaky-Wave (LW) Antennas and their Electronic Scanning.

Unit-4 **16 lectures**

Artificial High-Impedance Surface design, Artificial Magnetic Conductor (AMC), EBG (Electromagnetic Bandgap Structures), Gain-enhancement in antennas using MTM superstrates, Design of FSS Radomes for EMI Shielding and Absorbers, Beam-steering using Intelligent Reflecting Surfaces (IRS).

Suggested Books:

1. D. K. Cheng, Field and Wave Electromagnetics, Pearson Education Asia Ltd, Second Ed. 2006.
2. S. A. Ramakrishna and T. M. Grzegorczyk, Physics and Applications of Negative Refractive Index Materials, CRC Press, Taylor & Francis Group and SPIE Press, 2009.
3. G. V. Eleftheriades and K. G. Balmain, Negative Refraction Metamaterials: Fundamental Principles and Applications, Copyright: IEEE, John Wiley & Sons, Inc., Hoboken, New Jersey, 2005.
4. C. Caloz and T. Itoh, Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications, The Engineering Approach, John Wiley & Sons, Inc., Hoboken, New Jersey, 2006.

MTE204. Satellite Communication System

Lecture Credits: 4 **Total Lectures: 60**

Course Learning Objectives

The course on Satellite Communication System aims to provide students with a comprehensive understanding of satellite systems, knowledge of orbits and satellite launching. Students will gain a knowledge of satellite sub-systems, link analysis, G/T and C/N ratio analysis. The course will delve into atmospheric effects on propagation and knowledge of different multiple access techniques. Additionally, students will explore the earth station technologies. The course will conclude with an introduction of satellite packet communication methods and protocols.

Course Learning Outcomes

At the end of this course, students will have
CO1. To understand the fundamental principles of satellite systems.
CO2. Explore satellite sub-systems, link analysis, and analysis of G/T and C/N ratio.
CO3. Learn about the effects of atmosphere on propagation and multiple access techniques.
CO4. Develop the knowledge of earth station technologies.
CO5. The knowledge of satellite packet communication methods and protocols.

Syllabus Content

Unit-1 **14 lectures**

Introduction to Satellite Systems, Orbit and Description: A brief History of Satellite Communication, Satellite Frequency bands, Satellite Systems, Applications, Orbital Period and Velocity, Effects of Orbital inclination, Azimuth and Elevation, Coverage and Slant range, Eclipse, Orbital perturbations, Placement of a Satellite in a Geo-Stationary Orbit, Satellite systems in India, Propagation effects: Introduction, Atmospheric Absorption, Cloud Attenuation, Tropospheric and Ionospheric Scintillation and Low angle fading, Rain Induced attenuation, rain-induced cross polarization interference, applications of satellite.

Unit-2 **14 lectures**

Satellite Sub-Systems: Altitude and orbit control system, TT & C Sub-System, Altitude control Sub-System, Power Systems, Communication Subsystems, Satellite antenna Equipment. Satellite Link: Satellite uplink and downlink analysis; Spot beam, multiple beam, frequency reuse, Basic transmission theory, Satellite receiving systems, system noise temperature and Gain to noise temperature (G/T) ratio, Basic Link Analysis, Interference Analysis, Design of satellite links for specified carrier-to-noise ratio (C/N), (with and without frequency Re-use), Link Budget.

Unit-3 **14 lectures**

Multiple Access: Frequency Division Multiple Access (FDMA), Intermodulation, Calculation of C/N. Time Division Multiple Access (TDMA), Frame structure, Burst structure, Satellite Switched TDMA Onboard processing, Demand Assignment Multiple Access (DAMA) – Types of Demand Assignment, Characteristics, CDMA Spread Spectrum Transmission and Reception.

Unit-4 **18 lectures**

Earth Station Technology: Transmitters, Receivers, Antennas, Tracking systems, Terrestrial Interface, Power Test methods, Lower Orbit Considerations. Satellite Navigation & Global Positioning Systems: Radio and Satellite Navigation, GPS Position Location principles, GPS Receivers, GPS C/A code accuracy, Differential GPS, Global Navigation Satellite System (GNSS), Indian Regional Navigation Satellite System (IRNS).

Satellite Packet Communications: Message Transmission by FDMA: M/G/1 Queue, Message Transmission by TDMA, TDMA Frame, PURE ALOHA-Satellite Packet Switching, Slotted Aloha, Non-terrestrial satellites, Low Earth Orbit (LEO) satellites, small satellite, CubeSat.

Suggested Books:

1. Timothy Pratt, Charles Bostian and Jeremy Allnutt, Satellite Communications, 2nd Edition, John Wiley & Sons, 2003.

2. Wilbur L. Pritchand, Robert A Nelson and Henri G. Suyderhoud, Satellite Communication Engineering, 2nd Edition, Prentice Hall, 1993.

3. Tri. T.Ha, Digital Satellite Communications, 2nd Edition, McGraw Hill.1990,

4. Dennis Roddy, Satellite Communications, 2nd Edition, McGraw Hill, 1996.

5. M. Richharia, Satellite Communications: Design Principles, 2nd Edition, BS Publications, 2003.

6. K. N Raja Rao, Fundamental of Satellite Communications, Prentice Hall India Pvt., Limited, 2004.