Program Outcomes (PO) Of B.Sc.

PO1. Scientific Knowledge: Apply fundamental principles of science (chemistry, biology, physics, etc.) to solve real-world problems.

PO2. Critical Thinking: Develop analytical and critical thinking skills to evaluate scientific data and research findings.

PO3. Problem Solving: Identify, analyze, and provide innovative solutions to complex problems through scientific reasoning.

PO4. Research Skills: Design and conduct experiments, analyze results, and interpret scientific data using appropriate methodologies.

PO5. Teamwork: Work effectively in teams, respecting diverse opinions, and contributing to collective scientific problem-solving.

PO6. Communication Skills: Communicate scientific concepts, findings, and ideas clearly and effectively, both orally and in writing.

PO7. Ethical Practices: Apply ethical principles and professional standards in scientific practices, ensuring integrity and responsibility in research.

PO8. Technical Proficiency: Gain practical skills in the use of laboratory equipment, software, and modern scientific tools for experimentation and analysis.

PO9. Interdisciplinary Knowledge: Understand and apply knowledge across multiple scientific disciplines for a holistic approach to solving complex problems.

PO10. Environmental Awareness: Evaluate the impact of scientific practices on the environment and society, promoting sustainable and eco-friendly approaches.

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Program Outcomes (PO) Of M.Sc.

PO1. Advanced Knowledge: Demonstrate comprehensive understanding and expertise in specialized fields of science through theoretical knowledge and practical application.

PO2. Research Competency: Conduct independent and original research, design experiments, and develop methodologies to solve advanced scientific problems.

PO3. Critical Analysis: Apply critical thinking and analytical skills to evaluate complex scientific data, interpret results, and develop reasoned conclusions.

PO4. Problem Solving: Address complex, real-world problems using advanced scientific principles and innovative problem-solving techniques.

PO5. Interdisciplinary Integration: Integrate knowledge from various scientific disciplines to foster a holistic understanding of scientific phenomena.

PO6. Technical Expertise: Attain advanced proficiency in the use of laboratory instruments, computational tools, and other scientific technologies.

PO7. Scientific Communication: Communicate scientific findings and ideas effectively, both orally and in written form, to a range of audiences including peers, specialists, and the public.

PO8. Ethics and Professionalism: Apply ethical principles, professional standards, and regulatory guidelines in scientific research and professional activities.

PO9. Innovation and Creativity: Foster creativity and innovation in scientific research, contributing to the development of new theories, technologies, and solutions.

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PO10. Global and Societal Awareness: Evaluate the broader impact of scientific developments on society, the environment, and global health, promoting responsible and sustainable scientific practices.

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Course Title: **Biotechnology Practicals**

Course Code: **253010102**

CO 1	Instrument Mastery: Proficiency in operating microscopes tailored for observing cell movement and motility-related instruments.
CO 2	pH Impact on Motility: Understand the direct influence of pH fluctuations on cell motility through controlled experiments.
CO 3	Staining Techniques for Motion: Apply stains to track and visualize cell movement patterns effectively under the microscope.
CO 4	Standard Solution Utilization: Prepare solutions known to affect cell motility, employing them in assays for quantification.
CO 5	Microscopic Analysis Skills: Acquire expertise in using microscopy to measure and analyze cell motility parameters like speed and direction.
CO 6	Experimental Design and Analysis: Design experiments examining factors affecting cell motility, collect data, and draw conclusions on their impact.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	High	High	Medium	Medium	High	High	High	High
CO 2	High	High	High	High	Medium	Medium	Medium	High	High	High
CO 3	High	High	High	High	Medium	High	High	High	High	High
CO 4	High	High	High	High	Medium	High	High	High	High	High
CO 5	High	High	High	High	Medium	High	High	High	High	High
CO 6	High	High	High	High	High	High	High	High	High	High

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B.Sc. Semester II

Course Title: **Origin & Evolution of life**

Course Code: **253010201**

CO 1	Explain the origin and evolution of life, including major theories, Miller's experiments, and cell differentiation.
CO 2	Understand the evolution and structural differences between prokaryotes, eukaryotes, mitochondria, and chloroplasts, and discuss the quest for extra-terrestrial life.
CO 3	Describe the general characteristics, body organization, and adaptive features of plants, with an emphasis on the Plantae kingdom.
CO 4	Analyze the general features of animals, their evolutionary history, body organization, and adaptation to various environments, focusing on the Animalia kingdom.
CO 5	Illustrate the structure, reproduction, and classification of fungi, algae, protozoa, and discuss their economic importance.
CO 6	Understand the structure and replication of viruses, as well as the characteristics of prions, viroids, and virusoids, and their role in extreme environments.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	High	High	High	High	High	High	High	High
CO 2	High	Medium	High	High	Medium	High	High	Medium	High	High
CO 3	High	Medium	High	High	High	High	High	Medium	High	High
CO 4	High	Medium	High	High	High	High	High	Medium	High	High
CO 5	High	Medium	High	High	High	High	High	Medium	High	High
CO 6	High	High	High	High	High	High	High	Medium	High	High

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Course Title: **Biotechnology Practicals**

Course Code: **253010202**

CO 1	Demonstrate proficiency in performing qualitative tests for the identification of various carbohydrates and interpreting the results effectively.
CO 2	Apply analytical techniques to detect and differentiate proteins in biological samples, enhancing understanding of protein structure and function.
CO 3	Develop the ability to perform lipid extraction and qualitative tests, fostering a deeper comprehension of lipid properties and their biological significance.
CO 4	Execute Cole's method for determining the viscosity of colloidal systems, gaining insight into molecular interactions in solutions.
CO 5	Investigate and evaluate different methods to observe and quantify cell motility, with an emphasis on understanding cellular dynamics and movement.
CO 6	Master various techniques for microbial culture preservation, ensuring the long-term viability and integrity of microorganisms for research and industrial applications.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	High	High	High	Medium	Medium	Medium	High	High	Medium
CO 2	High	High	High	High	Medium	Medium	Medium	High	High	Medium
CO 3	High	High	High	High	Medium	Medium	Medium	High	High	Medium
CO 4	High	High	High	High	Medium	Medium	Medium	High	High	Medium
CO 5	High	High	High	High	Medium	Medium	Medium	High	High	Medium
CO 6	High	High	Medium	High	Medium	Medium	Medium	High	High	Medium

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B.Sc. Semester III

Course Title: **Cellular Biology**

Course Code: **253010301**

CO 1	Understand the chemistry and ultrastructure of various cell components, including cell walls, membranes, organelles (mitochondria, chloroplasts, Golgi bodies, etc.), and cytoskeletal structures, and analyze the cellular diversity among prokaryotes, archaea, and eukaryotes.
CO 2	Explain the fundamental concepts of cellular metabolism, including oxidation-reduction reactions, energy generation, ATP synthesis, and the various metabolic pathways such as anabolism, catabolism, and respiration.
CO 3	Discuss the properties and mechanisms of enzymes, including catalysis and allosteric regulation, and how these enzymes coordinate cellular metabolism.
CO 4	Describe the processes of cell division, including the phases of mitosis, cell cycle regulation, and the role of cell growth, tumor development, senescence, and apoptosis.
CO 5	Explain the central dogma of molecular biology, the concept of genes, and the processes of transcription, translation, and gene expression, along with the operon model.
CO 6	Analyze the mechanisms of cell communication, including the roles of signaling molecules, receptors, junctions, plasmodesmata, and cell signaling pathways.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	High	Low	Medium	Medium	Medium	High	Medium
CO 2	High	High	Medium	High	Low	Medium	Medium	Medium	High	Medium
CO 3	High	High	Medium	High	Low	Medium	Medium	Medium	High	Medium
CO 4	High	High	Medium	High	Low	Medium	Medium	Medium	High	Medium
CO 5	High	High	Medium	High	Low	Medium	Medium	Medium	High	Medium
CO 6	High	High	Medium	High	Low	Medium	Medium	Medium	High	Medium

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Course Title: **Molecular Biology-I**

Course Code: **253010302**

CO 1	Understand the structure, properties, and features of prokaryotic DNA and explain the processes of unidirectional and bidirectional replication, including initiation, elongation, termination, the closed clamp, and rolling circle models.
CO 2	Analyze the mechanisms of DNA damage and the DNA repair systems in prokaryotes to understand how cells maintain genomic stability.
CO 3	Explain the process of prokaryotic transcription, including the roles of genes, promoters, and the stages of initiation, elongation, termination, and anti-termination, as well as post-transcriptional modifications.
CO 4	Understand the operon concept and describe the regulation of gene expression in prokaryotes through the Lac and Trp operons.
CO 5	Describe the genetic code, Wobble Hypothesis, and the steps of prokaryotic translation (initiation, elongation, termination), as well as the processes involved in post-translational modifications.
CO 6	Understand the Restriction-Modification system in prokaryotes, including the types, nomenclature, properties, and functions of restriction enzymes such as EcoRI, BamHI, and SmaI.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	High	Medium	High	Medium	Medium	High	Medium	High	Medium
CO 2	High	High	Medium	High	Medium	High	High	High	High	Medium
CO 3	High	High	Medium	High	Medium	High	High	High	High	Medium
CO 4	High	High	Medium	High	Medium	High	High	High	High	Medium
CO 5	High	High	Medium	High	Medium	High	High	High	High	Medium
CO 6	High	High	Medium	High	Medium	High	High	High	High	Medium

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Course Title: **Biotechnology Practicals**

Course Code: **253010303**

CO 1	Perform various staining techniques to visualize bacterial flagella, endospores, and plant chloroplasts, enhancing the understanding of microbial structures and plant organelles.
CO 2	Identify and analyze the stages of mitosis through microscopy, developing proficiency in understanding cell division and structural organization within plant and microbial cells.
CO 3	Demonstrate skills in isolating and purifying DNA and RNA from plant tissues using appropriate techniques, contributing to molecular biology studies such as gene expression and plant genetics.
CO 4	Understand bacterial motility by performing flagella staining, linking cellular structures to function through laboratory observations.
CO 5	Investigate Lac mutants to comprehend the principles of bacterial gene regulation, particularly the lac operon, and its role in controlling metabolic pathways.
CO 6	Integrate various staining and isolation techniques to enhance understanding of both structural and functional aspects of cells and genetic material in microorganisms and plants.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	High	Low	Medium	Medium	High	Medium	Low
CO 2	High	Medium	Medium	High	Low	Medium	Low	High	Medium	Low
CO 3	High	High	High	High	Low	Medium	Medium	High	Medium	Medium
CO 4	High	Medium	Medium	High	Low	Medium	Medium	High	Medium	Low
CO 5	High	High	High	High	Medium	Medium	High	High	High	Medium
CO 6	High	High	Medium	High	Medium	High	Medium	High	High	Medium

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B.Sc. Semester IV

Course Title: **Immunology-l**

Course Code: **253010401**

CO 1	Understand the structure and components of the immune system, including the process of hematopoiesis and the roles of key immune cells such as T cells, B cells, NK cells, and antigen-presenting cells (APCs).
CO 2	Differentiate between the types of immunity, including innate vs. acquired, active vs. passive, and humoral vs. cell-mediated immunity, and explain the concepts of primary and secondary immune responses.
CO 3	Define and classify antigens based on their properties, and understand the concepts of epitopes and haptens.
CO 4	Understand the structure, types, and functions of antibodies, including their role in blood typing and the ABO and Rh blood group systems.
CO 5	Explain the basic principles of antigen-antibody interactions, including the mechanisms of precipitation, agglutination, and cross-reactivity.
CO 6	Describe the techniques used to detect antigen-antibody interactions, including ELISA, RIA, and Western blotting, and understand their applications in immunological assays.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	High	Medium	Medium	Medium	High	Medium	Low
CO 2	High	High	Medium	Medium	Low	Medium	Medium	Medium	Medium	Medium
CO 3	High	Medium	Medium	High	Low	Medium	Medium	Medium	Medium	Low
CO 4	High	Medium	Medium	High	Low	Medium	Medium	High	Medium	Medium
CO 5	High	High	Medium	High	Low	Medium	Medium	High	Medium	Medium
CO 6	High	High	High	High	Medium	High	Medium	High	Medium	Medium

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Course Title: **Bioinstrumentation**

Course Code: **253010402**

CO 1	Understand the principles, instrumentation, and applications of UV-Visible spectroscopy, Atomic Absorption Spectroscopy, Flame Photometry, Nephlometry, Infra-Red Spectroscopy, and Mass Spectroscopy for protein characterization and identification.
CO 2	Explain the principles and types of electrophoresis, including its applications in protein and nucleic acid separation techniques such as PAGE, SDS-PAGE, Agarose Gel Electrophoresis, and Isoelectric Focusing (IEF).
CO 3	Understand the basic principles of sedimentation, and the types and applications of density gradient centrifugation (Rate Zonal and Isopycnic) and ultracentrifugation in biological sample analysis.
CO 4	Understand the principles, types, and applications of various chromatographic techniques, including Paper Chromatography, Thin Layer Chromatography, Adsorption Chromatography, Ion Exchange Chromatography, Gas Liquid Chromatography, HPLC, and Affinity Chromatography.
CO 5	Understand the definition, branches, aims, and scope of bioinformatics, and its relevance in biological research.
CO 6	Understand the types of bioinformatics databases (primary, secondary, tertiary, and composite) and database retrieval systems, and apply basic bioinformatics tools such as BLAST, sequence alignment, protein structure analysis, and utilize resources like NCBI and EBI.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	High	Low	Medium	Medium	High	Medium	Medium
CO 2	High	High	Medium	High	Low	Medium	Medium	High	Medium	Low
CO 3	High	Medium	Medium	High	Low	Medium	Medium	High	Medium	Low
CO 4	High	High	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 5	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High	Medium
CO 6	High	High	High	Medium	Medium	High	Medium	High	High	Medium

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Course Title: **Biotechnology Practicals**

Course Code: **253010403**

CO 1	Understand the effects of heavy metals, temperature, pH, and osmotic pressure on bacterial growth, analyzing microbial adaptability and survival mechanisms under various stress conditions.
CO 2	Examine the metabolic activity of E. coli and other bacteria, evaluating how environmental factors such as nutrients and stress affect microbial metabolism and energy production.
CO 3	Assess the effectiveness of antibiotics against Gram-positive and Gram-negative bacteria, understanding antibiotic resistance and sensitivity patterns.
CO 4	Cultivate anaerobic bacteria using the candle jar method, exploring the growth conditions and metabolic processes of anaerobes in the absence of oxygen.
CO 5	Isolate, cultivate, and study moulds, understanding their growth patterns, morphological characteristics, and environmental significance.
CO 6	Master essential microbiological techniques for bacterial and fungal cultivation, including antibiotic sensitivity testing, anaerobic cultivation, and environmental impact studies on microbial growth.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	High	High	Medium	Medium	Medium	High	Medium	High
CO 2	High	High	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 4	High	Medium	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 5	High	Medium	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 6	High	High	High	High	Medium	High	Medium	High	Medium	Medium

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B.Sc. Semester V

Course Title: **Fermentation Technology-I**

Course Code: **253010501**

CO 1	Understand the fundamental concepts of fermentation, the historical development of industrial microbiology, and the various components and range of fermentation processes.
CO 2	Describe the characteristics of industrially important microorganisms and apply techniques for primary and secondary screening for organic acid, antibiotic, enzyme, and growth factor producers.
CO 3	Understand the strategies for strain improvement, including the selection of induced mutants and recombinants, and apply preservation techniques and quality control for strain maintenance.
CO 4	Explain the design and functions of a stirred-tank bioreactor, including its structural components, and describe devices used for aeration, agitation, and monitoring of pH, temperature, foam, and dissolved oxygen.
CO 5	Differentiate between types of fermentation processes, including submerged (batch, fed-batch, continuous) and solid-state fermentation.
CO 6	Understand the principles of fermentation media formulation, including the role of media ingredients, and explain the methods of sterilization and the principles for developing inoculum for bacterial, yeast, and fungal processes.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	Medium
CO 2	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	Medium	High	High	Low	Medium	High	High	Medium	Medium
CO 4	High	Medium	Medium	High	Low	Medium	Medium	High	Medium	Medium
CO 5	High	High	High	Medium	Medium	Medium	Medium	High	Medium	Medium
CO 6	High	Medium	High	High	Low	Medium	Medium	High	Medium	Medium

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Course Title: **Molecular Techniques**

Course Code: **253010502**

CO 1	Understand the concepts and applications of genomic and cDNA libraries, and explain the principles, types, and uses of PCR techniques, including basic PCR and RT-PCR.
CO 2	Explain various nucleic acid hybridization techniques, including colony and plaque hybridization, and techniques like Southern, Northern, and Western blotting, dot-blotting, and differential screening.
CO 3	Understand in situ hybridization and FISH, with both radioactive and non-radioactive detection methods, and the principles and applications of autoradiography.
CO 4	Describe molecular markers such as RFLP, RAPD, AFLP, SNP, and satellite DNA, and understand the DNA fingerprinting process and its applications.
CO 5	Explain the principles and methods of DNA sequencing, including chain termination, chemical cleavage, and automated sequencing techniques.
CO 6	Understand the process of DNA foot printing, in vitro transcription and translation systems, and their applications in molecular biology research.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	High	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 2	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	High	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 4	High	High	High	Medium	Medium	Medium	Medium	High	Medium	Medium
CO 5	High	High	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 6	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium

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Course Title: **Environmental Biotechnology**

Course Code: **253010503**

CO 1	Understand the principles, strategies, and techniques of bioremediation, including both in situ and ex situ approaches, and explain the role of GMOs in enhancing bioremediation processes.
CO 2	Explain the processes involved in the bioremediation of metals and the use of phytoremediation in environmental cleanup.
CO 3	Understand the principles and mechanisms of biodegradation and detoxification, and explain the biodegradation of detergents, pesticides, lignin, hydrocarbons, and dyes.
CO 4	Explain the principles, mechanisms, and methods used to assess biodeterioration, and discuss the prevention and control strategies for biodeterioration of selected materials.
CO 5	Understand the principles and applications of biosensors, including their types, limitations, and use in environmental monitoring.
CO 6	Explain the concepts and technology behind bioplastics and bio transducers, and discuss their applications in solving environmental problems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	High	High	High	Medium	Medium	Medium	High	Medium	High
CO 2	High	High	Medium	High	Medium	Medium	Medium	High	Medium	High
CO 3	High	High	High	High	Medium	Medium	Medium	High	Medium	High
CO 4	High	High	Medium	High	Medium	Medium	Medium	High	Medium	High
CO 5	High	Medium	Medium	Medium	Medium	Medium	Medium	High	High	High
CO 6	High	High	High	Medium	Medium	Medium	Medium	High	High	High

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Course Title: **Environmental Biotechnology**

Course Code: **253010504**

CO 1	Understand the characteristics of ideal vectors and explain the use of various vectors like plasmids (pBR322, pUC), bacteriophage lambda, and cosmids in recombinant DNA construction and transformation, including techniques such as antibiotic and blue-white selection.
CO 2	Explain the basic concepts of genetic engineering and describe the molecular tools used, including restriction endonucleases, DNA cutting and ligation techniques, and DNA modifying enzymes, as well as gene transfer methods.
CO 3	Understand the fundamentals of tissue culture, with a focus on plant tissue culture (PTC), its methods, significance, and various applications in biotechnology.
CO 4	Explain the principles of animal tissue culture, including the differences between primary cultures and established cell lines, and the importance of equipment and materials in animal cell technology.
CO 5	Describe the basic media formulations and techniques used in mammalian cell culture and their role in cell growth and maintenance.
CO 6	Understand the manipulation and practical applications of animal and plant tissue culture techniques in research and biotechnology, including their potential uses in genetic modification and therapeutic applications.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 2	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	High	Medium	Medium	Medium	Medium	Medium	High	Medium	High
CO 4	High	High	Medium	Medium	Medium	Medium	Medium	High	Medium	Medium
CO 5	High	Medium	Medium	Medium	Medium	Medium	Medium	High	Medium	Medium
CO 6	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium

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Course Title: **Biotechnology Practicals**
Course Code: **253010505**

CO 1	Understand the principles and techniques of alcohol estimation and production using baker's yeast, and their applications in industrial microbiology.
CO 2	Apply methods for the primary screening of microbial producers, including amylase enzymes, antibiotics, and organic acids, and understand their significance in biotechnology.
CO 3	Gain practical skills in utilizing bioinformatics databases like NCBI, DDBJ, and GenBank for sequence retrieval and analysis, and understand the basics of sequence alignment.
CO 4	Understand and demonstrate the principles and applications of advanced molecular techniques such as RT-PCR and primer designing from cDNA libraries.
CO 5	Analyze microbial biodeterioration and biodegradation processes, focusing on the breakdown of dyes by microorganisms and the impact of microorganisms on material degradation.
CO 6	Perform and understand environmental and plant tissue culture techniques, including the analysis of total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), and callus culture in plant tissue culture.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	High	Medium	Medium	Medium	Medium	High	Medium	Medium
CO 2	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	High	Medium	High	Medium	Medium	Medium	High	High	Medium
CO 4	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 5	High	High	High	Medium	Medium	Medium	Medium	High	Medium	High
CO 6	High	High	High	Medium	Medium	Medium	Medium	High	Medium	High

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B.Sc. Semester VI

Course Title: **Fermentation Technology-II**

Course Code: **253010601**

CO 1	Understand the principles of downstream processing, including methods for the removal of microbial cells and suspended solids such as foam separation, precipitation, filtration, and centrifugation, as well as cell disruption techniques.
CO 2	Explain the processes involved in product concentration, purification, and finishing stages like liquid-liquid extraction, membrane processes, drying, crystallization, and effluent treatment.
CO 3	Understand the methods for detecting and assaying fermentation products, including physical assays (titration, gravimetric analysis), chemical assays (chromatography, spectrophotometry), and biological assays (microbial assays).
CO 4	Explain the microbial quality assurance methods used in fermentation, including sterility testing, the Limulus Amebocyte Lysate (LAL) test, and fermentation economics.
CO 5	Understand the fermentation processes involved in the production of industrial products such as alcohol, cheese, baker's yeast, glutamic acid, and citric acid.
CO 6	Explain the fermentative production of pharmaceuticals and industrial enzymes, including penicillin (and its conversion to semisynthetic derivatives), cyanocobalamin, steroids, amylase, and carotenoids.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 2	High	Medium	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 4	High	High	Medium	High	Medium	Medium	High	High	Medium	Medium
CO 5	High	High	High	Medium	Medium	Medium	Medium	High	Medium	High
CO 6	High	High	High	High	Medium	Medium	Medium	High	Medium	High

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Course Title: **Enzymology**

Course Code: **253010602**

CO 1	Understand the general characteristics, classification, and terminology related to enzymes, including holoenzymes, coenzymes, apoenzymes, cofactors, activators, inhibitors, and isoenzymes, as well as the concepts of turnover number and specific activity.
CO 2	Explain the structure of enzyme active sites, the specificity of enzyme actions, and factors affecting enzyme activity, with a brief introduction to allosteric enzymes.
CO 3	Derive and explain the Michaelis-Menten equation and its modifications, including various graphical methods like Lineweaver-Burk, Eadie-Hofstee, and Hanes-Woolf plots.
CO 4	Understand the different types of enzyme inhibition, such as competitive, non-competitive, uncompetitive, mixed, and substrate inhibition, and their effects on enzyme kinetics.
CO 5	Describe the types, methods, applications, advantages, and limitations of enzyme immobilization, with an introduction to reverse micelles.
CO 6	Understand the sources and industrial applications of enzymes such as amylase, protease, and lipase in industries like detergent, leather, food, dairy, textile, and medical fields, including the industrial production of enzymes.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Medium	Medium	Medium	Medium	High	Medium	Medium
CO 2	High	High	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 4	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 5	High	Medium	High	Medium	Medium	Medium	Medium	High	Medium	High
CO 6	High	Medium	High	Medium	Medium	Medium	Medium	High	Medium	High

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Course Title: **Molecular Biology-II**

Course Code: **253010603**

CO 1	Understand the organization of the eukaryotic genome, DNA packaging, and the problems associated with eukaryotic replication, and explain the roles of various enzymes and proteins involved in the replication process.
CO 2	Explain the central dogma of molecular biology, and describe the process of transcription in eukaryotes, including the roles of RNA polymerases, promoters, enhancers, and silencers in transcription initiation, elongation, and termination.
CO 3	Understand post-transcriptional modifications, including the types of introns, RNA splicing, and the modification of 5' and 3' ends of tRNA and rRNA.
CO 4	Explain the process of translation in eukaryotes, including the roles of ribosomes, initiation, elongation, termination, and the importance of post-translational modifications and protein targeting.
CO 5	Understand the different types of mutations (spontaneous and induced), and describe their effects on protein-coding genes, including forward, reverse, and suppressor mutations.
CO 6	Describe the various DNA repair mechanisms, including direct and indirect repair systems, SOS repair, and the structure and properties of transposable elements, as well as their application in transposon mutagenesis.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 2	High	High	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	Medium	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 4	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 5	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 6	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium

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Course Title: **Biosafety, Bioethics & IPR**

Course Code: **253010604**

CO 1	Understand the fundamental concepts of biosafety, including standard laboratory practices, containment strategies, biosafety levels, biosafety guidelines in India, laboratory biosecurity, and risk assessment.
CO 2	Explain the principles of Good Laboratory Practices (GLP), Good Manufacturing Practices (GMP), and the basic concepts of Quality Control (QC) and Quality Assurance (QA), including guidelines for raw materials, sterilization, media, and product validation.
CO 3	Understand the role of culture collection centers, public health laboratories, and regulatory agencies in ensuring quality and safety in biological practices.
CO 4	Comprehend the basics and principles of bioethics, regulatory concerns, international codes and guidelines in India, and the role of non-governmental organizations (NGOs) in biological regulations.
CO 5	Understand the different types of intellectual property rights (IPR) and their management, including the benefits and challenges associated with IPR in biotechnology.
CO 6	Explain the patenting process, international harmonization of patent law, biotechnological process patents, and their protection, with a focus on the Indian scenario and case studies related to infringement.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	High	Medium	Medium	High	High	Medium	High
CO 2	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	Medium	Medium	High	Medium	Medium	High	Medium	Medium	Medium
CO 4	High	High	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 5	High	Medium	Medium	Medium	High	Medium	Medium	Medium	High	Medium
CO 6	High	Medium	Medium	High	Medium	Medium	Medium	Medium	High	Medium

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Course Title: **Biotechnology Practicals**

Course Code: **253010605**

CO 1	Understand and apply sterility testing protocols for pharmaceutical products, ensuring compliance with safety and quality standards in microbiological assays.
CO 2	Demonstrate knowledge and skills in fermentation processes for the production of food products like cheese and sauerkraut, understanding the role of microbes in food biotechnology.
CO 3	Perform isolation and analysis of biomolecules such as chloroplasts and eukaryotic DNA, gaining proficiency in essential cell biology and molecular biology techniques.
CO 4	Apply immobilization techniques for cells and enzymes, including encapsulation, and understand their significance in industrial bioprocesses.
CO 5	Analyze and quantify biomolecules such as streptomycin and paracetamol using chemical methods like sodium nitroprusside and colorimetry, and employ chromatography for purification.
CO 6	Demonstrate the use of advanced molecular biology techniques, such as agarose gel electrophoresis and the study of yeast artificial chromosomes, for DNA analysis and qualification.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	High	Medium	Medium	High	High	Medium	High
CO2	High	Medium	High	Medium	High	Medium	Medium	High	Medium	High
CO3	High	Medium	High	High	Medium	Medium	Medium	High	Medium	Medium
CO4	High	Medium	High	Medium	Medium	Medium	High	High	Medium	High
CO5	High	Medium	High	High	Medium	Medium	Medium	High	Low	Medium
CO6	High	Medium	High	High	Medium	Medium	Medium	High	Medium	Medium

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Department of Chemistry

B.Sc. Semester I

Course Title: **Basic Chemistry-I**

Course Code: **253020101**

CO 1	Identify the position of lanthanides and actinides in the periodic table and recall their electronic configurations.
CO 2	Describe the general mechanisms of organic reactions, including nucleophilic substitution, elimination, and addition reactions.
CO 3	Demonstrate the ability to write and balance chemical equations involving the combustion of alkanes
CO 4	Analyze experimental data to identify the presence and quantity of elements in a compound.
CO 5	Apply the rules of Markovnikov and anti-Markovnikov additions to predict the products of addition reactions involving alkenes and alkynes.
CO 6	Design an experiment to measure the rate of a reaction and interpret the data to determine the reaction order and rate constant.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Low	Medium	Low	Low	Medium	Low	Medium	Low
CO 2	High	High	High	Medium	Low	Medium	Low	Medium	Low	Medium
CO 3	High	Medium	Low	High	Low	Low	Medium	Low	High	Low
CO 4	Low	High	High	High	Medium	Low	High	High	Medium	Low
CO 5	High	High	High	High	Low	High	Medium	Low	High	High
CO 6	Medium	Low	Low	High	Medium	High	Low	Medium	High	Medium

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Course Title: **Chemistry Practicals**

Course Code: **253020102**

CO 1	List the cations belonging to each analytical group and recall the reagents used for their separation.
CO 2	Describe the concept of titration and the role of indicators in acid-base volumetric analysis.
CO 3	Perform systematic qualitative analysis to identify two unknown cations/anions in a given inorganic salt sample.
CO 4	Carry out acid-base titrations accurately, using appropriate indicators to determine the concentration of unknown solutions.
CO 5	Differentiate between similar cations based on their unique chemical behavior during group separation and confirmatory tests.
CO 6	Design a flow chart for the systematic identification of two unknown radicals in an inorganic salt.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Low	Medium	Low	Low	Medium	Low	High	Low
CO 2	High	High	High	Medium	High	Medium	Low	Medium	High	Medium
CO 3	Low	Low	Mediu m	High	Low	Low	Medium	Low	High	Low
CO 4	High	High	High	High	Medium	Low	High	High	High	Low
CO 5	High	High	High	Low	Low	High	Medium	Low	Medium	High
CO 6	Medium	Low	High	High	Medium	High	Low	Medium	High	Medium

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B.Sc. Semester II

Course Title: **Basic Chemistry-II**

Course Code: **253020201**

CO 1	Identify different types of chemical bonds (ionic, covalent, metallic, etc.) and recall the basic principles governing bond formation.
CO 2	Describe the basic principles of wave-particle duality and the Schrödinger equation in quantum chemistry.
CO 3	Apply crystal field theory and ligand field theory to predict the geometry and magnetic properties of complex compounds.
CO 4	Analyze the stability and reactivity of coordination complexes based on their ligand and metal center interactions.
CO 5	Compare the stability of different conformations of simple organic molecules (e.g., ethane, butane) using Newman projections.
CO 6	Evaluate the energy barriers for conformational changes and predict the most stable conformer.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Low	High	Low	High	Medium	Low	High	Low
CO 2	Low	High	High	Low	High	Medium	Low	Medium	Low	Medium
CO 3	Medium	Medium	Low	Mediu m	Medium	Low	Medium	Low	Medium	Low
CO 4	Low	Medium	Medium	Low	High	Low	High	Medium	Medium	Low
CO 5	High	High	High	Mediu m	Low	High	Medium	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: **Chemistry Practicals**

Course Code: **253020202**

CO 1	Identify common organic compounds based on their physical properties such as color, odor, and texture.
CO 2	Explain the role of indicators in acid-base titrations and the concept of end-point determination.
CO 3	Perform spot tests to identify the presence of specific functional groups in an unknown organic sample.
CO 4	Carry out accurate volumetric titrations to determine the concentration of unknown acid or base solutions.
CO 5	Evaluate the accuracy and reliability of different organic spotting techniques based on experimental outcomes.
CO 6	Develop a protocol for a new volumetric analysis experiment, including the preparation of reagents, execution, and calculation of results.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Low	Medium	Low	High	Medium	Low	High	Low
CO 2	Low	High	High	Medium	Low	Medium	Low	Medium	Low	High
CO 3	High	Medium	High	High	Medium	Low	Medium	Low	High	Low
CO 4	Low	High	Mediu m	Low	High	Low	High	High	Medium	Low
CO 5	High	High	High	High	Low	High	Medium	Low	Low	High
CO 6	Medium	Low	Low	High	Medium	High	Low	High	High	Medium

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B.Sc. Semester III

Course Title: **Fundamentals of Organic chemistry**

Course Code: **253020301**

CO 1	Differentiate between various poly-nuclear hydrocarbons based on their chemical reactivity.
CO 2	Explain the atomicity and electronic properties of five- and six-membered hetero cycles.
CO 3	Evaluate the synthesis methods for hetero cyclic compounds and their practical applications.
CO 4	Design synthetic routes for complex hetero cyclic compounds used in pharmaceuticals.
CO 5	Analyze the reactivity of β–di carbonyl compounds in different chemical environments.
CO 6	Identify and classify acids and bases according to the Bronsted-Lowry and Lewis definitions.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	Medium	Low	Low	Medium	Low	High	Medium	Low	High	Low
CO 2	Low	High	High	Low	Low	Medium	Low	Medium	Low	Medium
CO 3	High	Medium	Low	Medium	Medium	Low	Medium	Low	High	Low
CO 4	Low	High	Mediu m	Low	High	Low	High	Medium	Medium	Low
CO 5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	High	Low	High	High	High

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Course Title: **Fundamentals of Analytic chemistry**

Course Code: **253020302**

CO 1	Explain the process of osazone formation and the role of carbohydrates in biological systems.
CO 2	Differentiate between different types of carbohydrates based on their structure and function.
CO 3	Describe the zwitter ionic nature of amino acids and explain the concept of the iso electric point.
CO 4	Predict the products of EAS reactions given different aromatic substrates and electrophiles.
CO 5	Analyze the reactivity of β–dicarbonyl compounds in different chemical environments
CO 6	Evaluate the synthesis methods for heterocyclic compounds and their practical applications.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Low	High	Low	Low	Medium	Low	High	Low	Medium
CO 2	Medium	Medium	Low	Medium	Low	Low	Medium	Low	Medium	Low
CO 3	Low	Low	High	Low	Medium	Medium	Low	High	Low	Medium
CO 4	Low	Medium	Mediu m	Low	High	Low	Medium	Medium	Low	Low
CO 5	High	Low	Low	High	Low	Medium	Low	Low	High	Medium
CO 6	High	High	High	High	Medium	High	High	High	High	High

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Course Title: **Chemistry Practicals**

Course Code: **253020303**

CO 1	Explain the principles behind various organic separation techniques, such as distillation and extraction.
CO 2	Perform the separation and identification of compounds in an organic mixture using standard laboratory techniques.
CO 3	Interpret titration data to calculate the concentrations of calcium and magnesium ions in water.
CO 4	Analyze the factors affecting the completeness and accuracy of the precipitation reaction.
CO 5	Compare the results obtained from Mohr's and Volhard methods and discuss any discrepancies
CO 6	Describe the principles behind argentometric titration and the role of indicators in these methods.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Low	High	Low	High	Medium	Low	High	Low
CO 2	Low	High	High	Low	High	Medium	Low	Medium	Low	Medium
CO 3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO 4	Low	Medium	Medium	Low	High	Low	High	Medium	Medium	Low
CO 5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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B.Sc. Semester IV

Course Title: **Fundamentals of Inorganic chemistry**

Course Code: **253020401**

CO 1	Solve basic quantum mechanical problems using the Schrödinger equation for simple systems like the particle in a box.
CO 2	Analyze the behavior of quantum particles in different potential fields using wave mechanics.
CO 3	Predict the magnetic and spectral properties of coordination compounds using Crystal Field Theory.
CO 4	Evaluate the role of non-aqueous solvents in industrial applications, such as in organic synthesis and electrochemistry.
CO 5	Apply bonding theories to predict molecular geometries and physical properties of molecules.
CO 6	Evaluate the suitability of different bonding models for explaining the behavior of complex molecules.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	Medium	Medium	Low	Medium	Low	High	Medium	Low	Medium	Low
CO 2	Low	High	High	Low	High	Medium	Low	Medium	Low	High
CO 3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO 4	Low	Low	Medium	Low	High	Low	Medium	Medium	Medium	Low
CO 5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: **Fundamentals of Physical chemistry**

Course Code: **253020402**

CO 1	Use qualitative and quantitative analysis methods to identify and quantify the components in various chemical samples.
CO 2	Analyze data from qualitative and quantitative analysis to interpret the composition and concentration of substances.
CO 3	Describe the process of redox titration, including the selection of appropriate indicators and the calculation of oxidation states.
CO 4	Analyze the environmental benefits and economic implications of adopting green chemistry practices in industrial and laboratory settings.
CO 5	Evaluate the suitability of precipitation titration and gravimetric analysis methods for different types of samples and compare their effectiveness with other quantitative analysis techniques.
CO 6	Conduct precipitation titrations and gravimetric analysis to quantitatively determine the concentration of analytes such as chloride or sulfate ions in a solution.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Low	Low	Medium	Low	High	Medium	Low	Medium	Low
CO 2	Low	High	High	Low	High	High	Low	Medium	High	High
CO 3	High	Medium	High	Medium	Medium	Low	Medium	Low	Medium	Low
CO 4	Low	Low	Medium	Low	High	Low	Medium	Medium	Medium	Medium
CO 5	High	High	High	Medium	Low	High	High	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: **: Chemistry Practical**

Course Code: **253020403**

CO 1	Explain the principles behind the systematic separation and identification of ions in an inorganic mixture.
CO 2	Measure the viscosity of different liquids using an Ostwald viscometer and calculate the viscosity coefficient.
CO 3	Explain how the concentration of water and methanol in a mixture influences its viscosity and how this can be measured
CO 4	Analyze viscosity data to assess the proportional relationship between waterconcentration and the measured viscosity.
CO 5	Perform experiments to determine the reaction order for the hydrolysis of methyl acetate (first-order kinetics) and alkaline hydrolysis of ethyl acetate (second-order kinetics).
CO 6	Evaluate the advantages and limitations of conductometric titration compared to other titration methods, such as pH-based titration, in determining the concentration of strong acids and bases.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	Medium	Low	Medium	Medium	Low	High	Medium	Low	Low	Low
CO 2	High	High	High	Low	High	Medium	Low	Medium	High	High
CO 3	High	Medium	High	Medium	Medium	Low	Medium	Low	Medium	Low
CO 4	Low	Low	Medium	Low	High	Low	Medium	Medium	High	Medium
CO 5	High	High	High	High	Low	High	High	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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B.Sc. Semester V

Course Title: **Organic chemistry - C- l**

Course Code: **253020501**

CO 1	List the different classes of carbohydrates
CO 2	Explain the structural differences between glucose and fructose.
CO 3	Demonstrate the formation of glycosidic bonds in the synthesis of disaccharides.
CO 4	Compare the chemical reactivity of aldoses and ketoses in various organic reactions.
CO 5	Evaluate the role of carbohydrates in biological processes like energy storage and cell signaling.
CO 6	Synthesize a carbohydrate derivative with potential applications in drug development.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	Low	Low	Medium	High	Low	High	Medium	Low	Medium	Low
CO 2	High	High	High	Low	High	Medium	Low	Medium	High	High
CO 3	High	Medium	High	Medium	Medium	Low	High	Low	Medium	Low
CO 4	Low	Low	Medium	Low	High	Low	Medium	Medium	High	Medium
CO 5	Medium	High	High	High	Low	High	High	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	Medium

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Course Title: **Inorganic chemistry - C- l**

Course Code: **253020502**

CO 1	Identify the different symmetry elements and symmetry operations in molecules.
CO 2	Explain the significance of molecular symmetry in determining the physical and chemical properties of molecules.
CO 3	Use symmetry elements to classify molecules into different point groups.
CO 4	Analyze the relationship between molecular symmetry and spectroscopic selection rules.
CO 5	Evaluate the role of symmetry in predicting molecular vibrations and their infrared/Raman activity.
CO 6	Design a molecule with specific symmetry properties that could serve as a model for studying symmetry-related phenomena.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	Medium	Medium	Low	Medium	Low	High	Medium	Low	Medium	Low
CO 2	Low	High	High	Low	High	Medium	Low	Medium	Low	High
CO 3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO 4	Low	Low	Medium	Low	High	Low	Medium	Medium	Medium	Low
CO 5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: **Physical chemistry - C- l**

Course Code: **253020503**

CO 1	List the laws of thermodynamics and key thermodynamic terms
CO 2	Explain the concept of entropy and how it relates to the spontaneity of a process.
CO 3	Calculate the change in Gibbs free energy for a chemical reaction and predict whether it will occur spontaneously.
CO 4	Analyze a phase diagram to determine the conditions under which different phases of a substance exist.
CO 5	Evaluate the efficiency of a heat engine or refrigeration cycle using thermodynamic principles.
CO 6	Develop a new thermodynamic cycle that maximizes efficiency for a specific industrial process.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	Medium	Medium	Low	Medium	Low	High	Medium	Low	Medium	Low
CO 2	Low	High	High	Low	High	Medium	Low	Medium	Low	High
CO 3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO 4	Low	Low	Medium	Low	High	Low	Medium	Medium	Medium	Low
CO 5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: **Analytical chemistry - C- l**

Course Code: **253020504**

CO 1	List the types of electronic transitions commonly observed in UV spectroscopy
CO 2	Explain how the Beer-Lambert Law relates absorbance to concentration and path length in UV spectroscopy.
CO 3	Use UV spectra to determine the concentration of a compound in solution by applying the Beer-Lambert Law
CO 4	Analyze the UV spectra of different conjugated systems to understand the effect of conjugation on absorption maxima.
CO 5	Evaluate the limitations of UV spectroscopy in determining the structure of complex molecules.
CO 6	Design an experiment using UV spectroscopy to monitor the progress of a photochemical reaction.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Low	High	Low	Low	Medium	Low	High	Low	Medium
CO 2	Medium	Medium	Low	Medium	Low	Low	Medium	Low	Medium	Low
CO 3	Low	Low	High	Low	Medium	Medium	Low	High	Low	Medium
CO 4	Low	Medium	Medium	Low	High	Low	Medium	Medium	Low	Low
CO 5	High	Low	Low	High	Low	Medium	Low	Low	High	Medium
CO 6	High	High	High	High	Medium	High	High	High	High	High

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Course Title: **Chemistry Practicals**

Course Code: **253020505**

CO 1	Analyze kinetics data using various methods and interpret solubility equilibrium data to assess factors affecting solubility in inorganic compounds.
CO 2	Explain the impact of factors like temperature, catalysts, and concentration on reaction rates, and the role of solubility equilibria in solutions.
CO 3	Use integrated rate laws and solubility principles to solve problems involving reaction kinetics and solubility equilibria.
CO 4	Apply solubility rules, precipitation methods, and flame tests to distinguish between different cations and anions in inorganic mixtures.
CO 5	Analyze and interpret qualitative tests and separate ions based on chemical properties in complex inorganic mixtures.
CO 6	Recall principles of cation and anion analysis, along with reagents and general procedures in inorganic qualitative analysis.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Low	High	Low	High	Medium	Low	High	Low
CO 2	Low	High	High	Low	High	Medium	Low	Medium	Low	Medium
CO 3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO 4	Low	Medium	Medium	Low	High	Low	High	Medium	Medium	Low
CO 5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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B.Sc. Semester VI

Course Title: **Organic chemistry - C- II**

Course Code: **253020601**

CO 1	Identify the key types of synthetic dyes
CO 2	Explain the chemical processes involved in dye synthesis and application.
CO 3	Demonstrate the process of dyeing a textile with a synthetic dye.
CO 4	Compare and contrast synthetic dyes with natural dyes in terms of environmental impact and colorfastness.
CO 5	Assess the environmental impact of synthetic dye production.
CO 6	Design a more sustainable synthetic dye with reduced toxicity.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	Medium	Medium	Low	Medium	Low	High	Medium	Low	Medium	Low
CO 2	Low	High	High	Low	High	Medium	Low	Medium	Low	High
CO 3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO 4	Low	Low	Medium	Low	High	Low	Medium	Medium	Medium	Low
CO 5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: **Inorganic chemistry - C- II**

Course Code: **253020602**

CO 1	List the different types of chemical bonds
CO 2	Explain the concept of hybridization and how it influences molecular geometry.
CO 3	Predict the molecular structure and bond angles of a given molecule using VSEPR theory.
CO 4	Compare the strengths and properties of different types of bonds in various compounds.
CO 5	Assess the impact of chemical bonding on the physical and chemical properties of substances.
CO 6	Design a molecule with specific properties by manipulating chemical bonds

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Low	High	Low	High	Medium	Low	High	Low
CO 2	Low	High	High	Low	High	Medium	Low	Medium	Low	Medium
CO 3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO 4	Low	Medium	Medium	Low	High	Low	High	Medium	Medium	Low
CO 5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: **Physical chemistry - C- II**

Course Code: **253020603**

CO 1	List the laws of thermodynamics and key terms
CO 2	Explain how the first and second laws of thermodynamics govern energy changes in chemical reactions.
CO 3	Calculate the Gibbs free energy change for a chemical reaction under standard conditions.
CO 4	Compare endothermic and exothermic reactions in terms of enthalpy and entropy changes.
CO 5	Assess the spontaneity of a chemical reaction by evaluating the signs of enthalpy, entropy, and Gibbs free energy.
CO 6	Design an experiment to measure the heat capacity of a substance and interpret the results using thermodynamic principles.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	Medium	Medium	Low	Medium	Low	High	Medium	Low	Medium	Low
CO 2	Low	High	High	Low	High	Medium	Low	Medium	Low	High
CO 3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO 4	Low	Low	Medium	Low	High	Low	Medium	Medium	Medium	Low
CO 5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: **Analytical chemistry - C- II**

Course Code: **253020604**

CO 1	List the different types of errors in analytical chemistry
CO 2	Explain the significance of accuracy, precision, and sensitivity in analytical measurements.
CO 3	Calculate the standard deviation and confidence interval for a set of analytical data.
CO 4	Analyze a data set to identify possible sources of error and suggest ways to minimize them.
CO 5	Evaluate the reliability and validity of analytical data by comparing it with known standards.
CO 6	Develop a protocol for the systematic treatment of errors in a new analytical method.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Low	High	Low	Low	Medium	Low	High	Low	Medium
CO 2	Medium	Medium	Low	Medium	Low	Low	Medium	Low	Medium	Low
CO 3	Low	Low	High	Low	Medium	Medium	Low	High	Low	Medium
CO 4	Low	Medium	Medium	Low	High	Low	Medium	Medium	Low	Low
CO 5	High	Low	Low	High	Low	Medium	Low	Low	High	Medium
CO 6	High	High	High	High	Medium	High	High	High	High	High

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Course Title: **Chemistry Practicals**

Course Code: **253020605**

CO 1	Explain the steps involved in gravimetric analysis, including precipitation, filtration, drying, and weighing to determine the amount of radicals.
CO 2	Analyze the gravimetric data obtained during experiments and interpret the results to evaluate the concentration of radicals in the sample.
CO 3	Apply separation and identification techniques to organic mixtures such as acid-base, acid-phenol, and neutral-neutral using practical laboratory methods.
CO 4	Analyze titration curves and stoichiometric relationships to interpret the amount of analyte present in a solution based on volumetric data. |
CO 5	Evaluate the efficiency of separation and identification techniques by comparing the physical and chemical properties of the separated compounds with known standards.
CO 6	Explain the principles behind EDTA titrations and Mohr's method for the quantitative analysis of metal ions and chloride ions.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	Low	Low	Medium	High	Low	High	Medium	Low	Medium	Low
CO 2	High	High	High	Low	High	Medium	Low	Medium	High	High
CO 3	High	Medium	High	Medium	Medium	Low	High	Low	Medium	Low
CO 4	Low	Low	Medium	Low	High	Low	Medium	Medium	High	Medium
CO 5	Medium	High	High	High	Low	High	High	Low	Low	High
CO 6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	Medium

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Department of Mathematics

B.Sc. Semester I

Course Title: **Calculus and Algebra**
Course Code: **253030101**

CO 1	Recall standard results for the nth derivative and Leibniz's Theorem. Define the limit of a sequence and understand the convergence and divergence of infinite series.
CO 2	State Rolle's Theorem, Lagrange's Mean Value Theorem, Cauchy's Mean Value Theorem, Taylor's and Maclaurin's Theorems.
CO 3	Analyze indeterminate forms and apply L'Hôpital's Rules to resolve them.
CO 4	Identify different types of matrices and recall basic operations and theorems related to matrices.
CO 5	Apply theorems and concepts of matrices to solve systems of simultaneous linear equations using Cramer's rule and matrix methods.
CO 6	Analyze the consistency of a system of simultaneous linear equations using relevant theorems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	Medium	Low	Low	Low	Low	Low	Medium	Low	Low
CO2	High	High	High	Medium	Low	Low	Medium	Low	Low	High
CO3	High	High	Medium	High	Low	Medium	Low	Medium	Low	High
CO4	High	Medium	Medium	Low	Low	Low	Medium	High	Low	Low
CO5	High	High	Low	Low	Medium	Low	High	High	Low	Low
CO6	Low	Low	Medium	High	Medium	Low	Low	High	Medium	Low

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Course Title: **Mathematics Practical**

Course Code: **253030102**

CO 1	Practicals based on Integral and successive differentiation.
CO 2	Practicals based on convergence of infinite series, Mean value theorems, Expansions of functions, and L′Hospital's Rule.
CO 3	Practicals based on Matrices and its applications.
CO 4	Practicals based on tracing of curves.
CO 5	Find some solutions using the Leibniz theorems
CO 6	Practicals based on integral and derivatives

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	High	High	High	Medium	Low	Low	Low	Medium	Medium	Medium
CO2	High	High	High	Low	Medium	Low	Low	Medium	Medium	Medium
CO3	High	High	Medium	Medium	Low	Low	Low	Medium	Medium	Low
CO4	High	High	Medium	Medium	Low	Low	Low	Medium	Medium	High
CO5	High	High	High	Medium	Low	Low	Medium	Medium	Low	Low
CO6	High	High	High	Medium	Low	Low	Medium	Medium	Low	Low

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B.Sc. Semester II

Course Title: **Differential Equation and Coordinate Geometry**

Course Code: **253030201**

CO 1	Determine the suitability of a particular method for solving a given differential equation of the first order and first degree.
CO 2	Assess the general and singular solutions of first-order higher-degree differential equations, including Clairaut's and Lagrange's differential equations.
CO 3	Identify and define linear differential equations of higher order and degree one with constant coefficients.
CO 4	Describe the Cartesian and general equations of a sphere, and the properties of tangency and normality in relation to spheres.
CO 5	Evaluate the conditions for orthogonality of spheres and the tangency of planes to spheres.
CO 6	Analyze the different types of cones and cylinders and their equations, particularly the right circular cone and cylinder.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Medium	Low	Low	Medium	Medium	Medium	Low
CO2	High	Low	High	Low	High	Low	Medium	Low	Low	High
CO3	High	High	Medium	Low	High	Medium	Low	Medium	Low	High
CO4	High	Medium	Medium	Low	Low	High	Low	Medium	Low	High
CO5	High	Low	High	Low	High	Low	Medium	Low	Low	High
CO6	High	High	Medium	Low	High	Medium	Low	Medium	Low	High

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Course Title: **Mathematics Practical**

Course Code: **253030202**

CO 1	**Apply the methods of solving first-order differential equations:** Students will be able to apply various techniques, including variable separation, integrating factors, and the Bernoulli method, to solve first-order differential equations effectively.
CO 2	**Solve higher-degree differential equations:** Students will develop the ability to solve first-order differential equations of higher degrees, including those solvable for y, x, or p, and apply methods to find both general and singular solutions for Clairaut's and Lagrange's differential equations.
CO 3	**Analyze and solve linear differential equations of higher order:** Students will gain proficiency in solving linear differential equations of higher order with constant and variable coefficients using methods such as complementary functions, inverse operators, and the Euler form.
CO 4	**Perform geometric operations in R3 involving spheres:** Students will be able to calculate the equations of spheres, including intersections with lines, planes, and other spheres, as well as determine tangent planes and normal lines to spheres.
CO 5	**Classify and analyze conicoids in R3**: Students will acquire the skills to classify various types of conicoids, understand their geometric properties, and solve related problems.
CO 6	**Convert and apply polar coordinates in R2 and R3:** Students will demonstrate the ability to convert between Cartesian and polar coordinates and solve problems involving cones and cylinders in R3, including right circular cones and cylinders.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Medium	Low	Low	Low	Medium	Medium	Medium
CO2	High	High	High	Low	Medium	Low	Low	Medium	Medium	Medium
CO3	High	High	Medium	Medium	Low	Low	Low	Medium	Medium	Low
CO4	High	High	Medium	Medium	Low	Low	Low	Medium	Medium	High
CO5	High	High	High	Medium	Low	Low	Medium	Medium	Low	Low
CO6	High	High	High	Medium	Low	Low	Medium	Medium	Low	Low

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B.Sc. Semester III

Course Title: **Linear Algebra**

Course Code: **253030301**

CO 1	Explain the concept of a limit and the process of differentiation, including the chain rule, derivatives of inverse functions, implicit functions, parametric functions, exponential, and logarithmic functions.
CO 2	Assess the correctness of derivative calculations for different functions, including implicit and parametric functions.
CO 3	Explain the process of integration and how it applies to various types of functions, including trigonometric substitutions.
CO 4	Calculate definite integrals using the fundamental theorem of calculus and apply it to solve real-world problems.
CO 5	Explain the concept of differential equations and the specific methods used to solve first-order and first-degree equations.
CO 6	Evaluate the solutions to differential equations, ensuring they meet the initial conditions and are mathematically sound.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	High	Low	Medium	Low	Medium	Medium	Medium
CO2	High	High	High	High	Medium	Low	Medium	Medium	Medium	Low
CO3	High	High	High	Medium	Low	Low	Low	Medium	Medium	Medium
CO4	High	High	Medium	High	Low	Medium	Low	Medium	Medium	Medium
CO5	High	High	High	High	Medium	Low	Medium	Medium	Medium	Low
CO6	High	High	High	Medium	Low	Low	Low	Medium	Medium	Medium

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Course Title: **Numerical Analysis**

Course Code: **253030302**

CO 1	Explain the concepts of repeated or iterated integrals and the transformation of double and triple integrals, including the introduction to the Jacobian.
CO 2	Evaluate the effectiveness of using multiple integrals in solving complex geometric and physical problems.
CO 3	Explain the properties of Beta and Gamma functions and how they can be used to evaluate definite integrals.
CO 4	Analyze complex vector fields using the integral theorems and apply them to solve real-world problems.
CO 5	Explain the concepts of complete and particular integrals in first-order PDEs and Lagrange's method for solving linear equations.
CO 6	Evaluate different solution methods for PDEs and assess their effectiveness in solving complex mathematical problems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Medium	Low	Medium	Low	Medium	High	Medium
CO2	High	High	High	Medium	Low	Medium	High	Medium	High	Medium
CO3	High	High	High	Medium	Low	Medium	Low	Medium	High	Low
CO4	High	High	High	Low	Medium	Low	Low	High	Medium	High
CO5	Low	Low	High	Medium	Low	High	Medium	Low	Low	Low
CO6	High	High	High	Medium	Low	Medium	Low	Medium	High	Low

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Course Title: **Mathematics Practical**

Course Code: **253030303**

CO 1	Apply the concept of limits to determine the continuity and behavior of polynomial, rational, and trigonometric functions.
CO 2	Solve integration problems using standard methods such as substitution, including trigonometric substitution, and integration by parts.
CO 3	Classify and solve first-order and first-degree differential equations using methods like variable separation and understand their applications in modeling real-world phenomena.
CO 4	Evaluate double and triple integrals and interpret their geometric significance, applying these concepts to solve practical problems in multiple dimensions.
CO 5	Utilize Beta and Gamma functions to evaluate definite integrals and understand their properties.
CO 6	Apply and verify Green's, Gauss's divergence, and Stokes's theorems to solve line, surface, and volume integrals, interpreting the physical implications of these results.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Medium	Low	Low	Low	Medium	Medium	Medium
CO2	High	High	High	Low	Medium	Low	Low	Medium	Medium	Medium
CO3	High	High	Medium	Medium	Low	Low	Low	Medium	Medium	Low
CO4	High	High	Medium	Medium	Low	Low	Low	Medium	Medium	High
CO5	High	High	High	Medium	Low	Low	Medium	Medium	Low	Low
CO6	High	High	High	Medium	Low	Low	Medium	Medium	Low	Low

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B.Sc. Semester IV

Course Title: **Advanced Calculus**

Course Code: **253030401**

CO 1	Apply numerical methods such as the Bisection Method, Iteration Method, Aitken's Δ^2 Process, and Method of False Position to find roots of algebraic and transcendental equations.
CO 2	Utilize the Newton-Raphson method to solve nonlinear equations and understand its application in various scientific and engineering problems.
CO 3	Perform interpolation using forward, central, and backward differences, and utilize symbolic relations of operators to detect and correct errors in difference tables.
CO 4	Compute differences of polynomials and apply Newton's forward and backward formulae for interpolation in uniformly spaced data.
CO 5	Use advanced interpolation techniques such as Gauss forward and backward formulae, Bessel's, Stirling's, and Everett's formulae to handle complex interpolation problems.
CO 6	Apply Lagrange's interpolation method to solve problems involving unequally spaced data points, and understand its significance in real-world applications where data may not be uniformly spaced.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Medium	Low	Medium	High	Medium	High	Medium
CO2	High	High	High	Medium	Low	Medium	High	Medium	High	Medium
CO3	High	High	High	Medium	Low	Medium	High	Medium	High	Medium
CO4	Low	Medium	High	Medium	High	Medium	High	Low	High	Low
CO5	High	High	Low	Medium	Low	High	Low	Low	Medium	High
CO6	Low	Medium	High	Low	Medium	Low	Medium	High	Medium	Low

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Course Title: **Algebra and Statistical mathematics**

Course Code: **253030402**

CO 1	Students will be able to apply numerical methods such as Newton's forward and backward differences, Gauss's method, and determine the maximum and minimum values of a tabulated function.
CO 2	Students will be able to implement numerical integration techniques, including the Trapezoidal rule and Simpson's 1/3 and 3/8 rules, to approximate definite integrals.
CO 3	Students will be able to solve ordinary differential equations using methods such as Romberg integration, Taylor's series, Picard's method, Euler's method, modified Euler's method, and the Runge-Kutta method up to second order.
CO 4	Students will comprehend the definition and properties of linear transformations and apply them in various mathematical contexts.
CO 5	Students will be able to analyze the relationship between matrices and linear maps, including constructing matrices associated with linear maps and vice versa, through practical examples.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Low	High	Medium	High	Low	High	High
CO2	Medium	Low	Low	Low	Medium	Low	Low	Low	High	Low
CO3	High	Low	High	Low	Low	Low	High	Low	High	High
CO4	High	High	High	High	Low	High	High	High	Low	High
CO5	High	High	Low	Medium	Medium	High	Low	Medium	High	Low
CO6	Low	Medium	Medium	Low	High	Medium	Medium	Low	Medium	Medium

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Course Title: **Mathematics Practical**

Course Code:**253030403**

CO 1	Students will be able to apply numerical differentiation methods such as Newton's forward and backward differences and Gauss's method, as well as numerical integration techniques like the Trapezoidal rule and Simpson's 1/3 and 3/8 rules.
CO 2	Students will be able to solve ordinary differential equations using Romberg integration, Taylor's series, Picard's method, Euler's method, Modified Euler's method, and the Runge-Kutta method up to the second order.
CO 3	Students will comprehend the definition and properties of linear transformations and apply them in various mathematical contexts.
CO 4	Students will be able to analyze the relationship between matrices and linear maps, including constructing matrices associated with linear maps and vice versa, through practical examples.
CO 5	Students will be able to apply the Newton-Raphson method for finding roots and perform interpolation using forward, central, and backward differences, while also understanding symbolic relations of operators and detecting errors using difference tables.
CO 6	Students will be able to perform interpolation with unequally spaced points using Lagrange's formula, divided differences, Newton's general formula, and solve problems using inverse interpolation and the method of successive approximations.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Low	Low	Medium	Medium	Medium	High	High	High	Medium	Low
CO2	Low	Low	Medium	Medium	Medium	High	High	High	Low	Medium
CO3	Low	Low	Medium	Medium	Low	High	High	Medium	Medium	Low
CO4	Low	Low	Medium	Medium	High	High	High	Medium	Medium	Low
CO5	Low	Medium	Medium	Low	Low	High	High	High	Medium	Low
CO6	Low	Medium	Medium	Low	Low	High	High	High	Medium	Low

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B.Sc. Semester V

Course Title: **Complex Analysis**

Course Code: **253030501**

CO 1	Understand and apply the basic properties of complex numbers, including their moduli, conjugates, and polar coordinates.
CO 2	Analyze and apply De Moivre's theorem to find the roots of complex numbers and perform operations in exponential form.
CO 3	Evaluate the convergence of sequences and series in the context of complex numbers, including trigonometric and hyperbolic functions.
CO 4	Apply theorems related to limits, continuity, and differentiation in complex functions, including the use of Cauchy-Riemann equations.
CO 5	Understand and analyze the concept of analytic and harmonic functions, and apply the principles of mapping and conformal mapping using elementary functions.
CO 6	Evaluate and compute line integrals in the complex plane, and apply Cauchy's integral formula and Liouville's theorem in practical contexts.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Low	Medium	Low	Medium	High	Low	Medium
CO2	High	High	High	Medium	High	High	High	Medium	High	Low
CO3	Low	Low	Medium	High	Low	Medium	Low	Low	Low	High
CO4	Medium	High	Low	Medium	Low	Low	High	Low	High	Low
CO5	High	Low	High	Low	High	High	High	High	Medium	Medium
CO6	Medium	High	High	Low	Low	Low	Low	Medium	High	High

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Course Title: **Operation Research**

Course Code: **253030502**

CO 1	Understand the concepts of convex sets and linear programming problems, including the identification of extreme points, convex combinations, and theorems on convexity.
CO 2	Apply formulation techniques to linear programming (LP) problems and solve them using the Simplex method, Big-M (Penalty) method , and Two-Phase method.
CO 3	Analyze the duality concept in linear programming, including the formulation of dual problems, and evaluate the relationship between primal and dual solutions.
CO 4	Apply the dual simplex method to solve linear programming problems, including the mathematical procedure and interpretation of results.
CO 5	Understand and apply the concepts of transportation and assignment problems, including mathematical formulation, initial feasible solutions, and optimality tests using methods such as MODI and Hungarian Method.
CO 6	Solve unbalanced transportation and assignment problems using appropriate methods, and evaluate the efficiency of solutions.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	Medium	High	High	Low	Low	Medium	Low	Medium	Low	Medium
CO2	High	High	High	Low	Low	Medium	Low	Medium	Medium	Medium
CO3	Medium	High	High	Low	Low	Medium	Low	High	High	Low
CO4	High	High	High	Low	Low	Medium	High	Low	Medium	Low
CO5	High	High	High	Low	Low	Medium	Low	Medium	Medium	Medium
CO6	Medium	High	High	Low	Low	Medium	Low	High	High	Low

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Course Title: **Discrete Mathematics**

Course Code: **253030503**

CO 1	Identify relations and functions, including binary operations and their significance in algebraic structures.
CO 2	Illustrate the structure of different graphs (simple graphs, digraphs, etc.) and apply graph theory concepts such as paths, trails, walks, circuits, and cycles.
CO 3	Apply lattice theory to understand the meet and join operations, and explore concepts like sublattices, order-preserving functions, and isomorphisms.
CO 4	Explain the properties of Boolean algebra and its role in the analysis of switching circuits.
CO 5	Explore advanced topics like Boolean homomorphisms, isomorphisms, and the Stone Representation Theorem for practical and theoretical purposes.
CO 6	Construct and analyze subgraphs and multiple paths in practical scenarios.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Low	Low	Medium	Low	Medium	Low	Medium
CO2	High	High	High	Low	Medium	Medium	Low	Medium	High	Low
CO3	High	Low	Low	High	Medium	Low	Low	Medium	High	Low
CO4	Low	Medium	Low	High	Medium	High	High	Low	Low	High
CO5	Medium	Medium	Low	High	High	High	Low	Medium	Low	Low
CO6	Medium	Low	Low	High	Low	Low	Medium	Medium	Low	Medium

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Course Title: **Abstract Algebra**

Course Code: **253030504**

CO 1	Explain binary operations, the division algorithm, and congruence modulo relation in the set of integers.
CO 2	Analyze the structure and properties of subgroups, including normalizers, centralizers, cyclic groups, and lattice diagrams of finite groups.
CO 3	Apply Lagrange's theorem, Euler's theorem, and Fermat's theorem to solve problems related to group theory.
CO 4	Define and work with permutations, including cycles, transpositions, and the distinction between even and odd permutations.
CO 5	Understand the structure of symmetric and alternating groups, and analyze quotient groups and normal subgroups.
CO 6	Apply the concepts of isomorphism and homomorphism in groups, understanding their definitions and properties.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	High	High	High	Medium	Low	Medium	Low	Medium	Low	Medium
CO2	High	High	High	Medium	Low	Medium	High	Medium	Low	High
CO3	High	Low	Medium	Low	High	Medium	High	Low	High	Low
CO4	Medium	Low	Medium	High	High	High	High	High	High	Low
CO5	Medium	High	Medium	High	High	High	High	High	High	Medium
CO6	Medium	High	Low	High	Low	Medium	High	Low	Medium	High

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Course Title: **Mathematics Practical**

Course Code:**253030505**

CO 1	Solve Linear Programming Problems (LPP) using the Simplex, Big-M, and Two-Phase methods.
CO 2	Solve dual problems using the Dual Simplex method and interpret the relationship between primal and dual solutions.
CO 3	Solve balanced and unbalanced assignment problems using the Hungarian method.
CO 4	Perform operations such as sum, product, and roots of complex numbers in polar and exponential forms.
CO 5	Solve problems involving differentiability, continuity, and harmonic functions.
CO 6	Solve conformal mapping problems using elementary and Möbius transformations.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	Low	High	Medium	Medium	High	Medium	High	Low	Medium	High
CO2	Medium	Low	Low	Low	Low	Low	Medium	Medium	Low	Low
CO3	High	Low	Low	High	Low	Low	Low	Low	High	Low
CO4	Low	Medium	High	Low	High	High	Low	Low	Low	Medium
CO5	Low	Low	Medium	Medium	Medium	Low	Medium	High	Medium	Low
CO6	Medium	Low	Low	Low	Low	Low	Low	Medium	Low	High

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B.Sc. Semester VI

Course Title: **Analysis -II**

Course Code:**253030601**

CO 1	Formulate Linear Programming (LP) problems and recognize different problem-solving techniques, including the Simplex, Big-M, and Two-Phase methods.
CO 2	Solve LP problems using the Simplex method, Big-M (Penalty) method, and Two-Phase method.
CO 3	Compare and interpret the solutions of primal and dual problems, and solve them using the Dual Simplex method.
CO 4	Formulate and solve transportation problems using methods such as North-West Corner Rule, Least Cost Method, and Vogel's Approximation Method.
CO 5	Conduct an optimality test using the MODI method and address issues like degeneracy and unbalanced problems.
CO 6	Analyze simple game theory models and apply appropriate strategies for two-person zero-sum games.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Low	Medium	Low	Medium	Low	High	Low	Medium
CO2	High	High	High	Medium	Low	Medium	Low	Medium	Medium	Low
CO3	Low	Medium	High	Medium	Low	Low	Medium	High	Low	Low
CO4	High	Medium	Low	Low	Medium	High	Medium	Low	High	Low
CO5	Medium	Medium	Low	High	Medium	Low	Low	High	Low	High
CO6	Low	Low	High	Low	Low	High	Medium	Low	Medium	Low

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Course Title: **Abstract Algebra -II**

Course Code: **253030602**

CO 1	Define and apply binary operations and algebraic structures, and understand their operations on functions.
CO 2	Define different types of graphs such as simple graphs, digraphs, and random graphs, and analyze their properties.
CO 3	Apply concepts such as paths, subgraphs, circuits, cycles, and equivalence relations in solving graph theory problems.
CO 4	Define and explore properties of relations, including reflexive, symmetric, antisymmetric, transitive, and equivalence relations.
CO 5	Analyze partially ordered sets (posets), Hasse diagrams, and lattice structures, including meet and join operations, lattice homomorphism, and isomorphism.
CO 6	Apply concepts such as sub-Boolean algebra, Boolean rings, homomorphism, isomorphism, and the Stone representation theorem in solving Boolean algebra problems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Medium	Low	Medium	High	Medium	Medium	Medium
CO2	High	Low	High	Medium	Low	Low	Medium	Low	High	Low
CO3	High	Low	High	Medium	High	Low	High	Low	Low	Medium
CO4	High	High	Medium	High	Low	Medium	Low	Medium	Medium	Low
CO5	Low	Low	High	Low	High	High	Low	Low	High	Medium
CO6	Medium	Medium	Low	Medium	Low	Medium	Medium	Low	High	Low

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Course Title: **Analysis-III**

Course Code: **253030603**

CO 1	Explain congruence modulo relation in integers and describe groups with examples.
CO 2	Distinguish between commutative and non-commutative groups and create group tables for finite groups.
CO 3	Apply Lagrange's theorem and Euler's theorem in solving group-related problems, and understand Fermat's theorem.
CO 4	Define and work with permutations, cycles, and transpositions, and differentiate between even and odd permutations.
CO 5	Calculate the order of a permutation and work with symmetric and alternating groups.
CO 6	Understand the kernel of a homomorphism and apply the fundamental theorem of homomorphisms.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Low	Medium	Low	Medium	Medium	Low	High
CO2	Medium	Low	High	Low	Low	Medium	High	Low	Medium	Low
CO3	Medium	High	Low	Low	Medium	Low	High	Low	Medium	High
CO4	Low	Medium	Medium	High	Low	High	Low	Low	Medium	Low
CO5	High	Low	Low	High	High	Low	Low	Medium	Low	Medium
CO6	Low	High	Low	Low	Low	Low	High	Medium	Low	High

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Course Title: **Graph Theory**

Course Code: **253030604**

CO 1	Apply the Fundamental Theorem of Calculus, integration by parts, and change of variable in solving problems.
CO 2	Use advanced tests such as Condensation Test and Pringsheim's Test for series with positive terms.
CO 3	Analyze and apply the ratio and root tests using lim sup and lim inf for absolute convergence.
CO 4	Apply Merten's theorem in the context of series and study power series expansions.
CO 5	State and apply Taylor's theorem with Lagrange and Cauchy forms of the remainder.
CO 6	Expand functions like exponential, logarithmic, and trigonometric using Taylor and Binomial series.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	High	Medium	Low	Medium	High	Low	Medium	Low	Low	High
CO2	Low	Medium	High	Low	Medium	Low	High	Low	Medium	High
CO3	High	Low	Medium	Low	High	Low	Low	Low	High	Low
CO4	High	Medium	Low	High	Low	Low	Low	Medium	Low	Medium
CO5	Low	Medium	High	Low	Medium	Low	High	Low	High	Low
CO6	High	Low	Medium	Low	High	Low	Low	Low	Low	High

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Course Title: **Mathematics Practical**

Course Code: **253030605**

CO 1	Compute and interpret Riemann sums for various functions and intervals.
CO 2	Use comparison tests, condensation tests, and Pringsheim's test to analyze the convergence of series with positive terms.
CO 3	Understand and use advanced concepts such as Cauchy product and Merten's theorem in series analysis.
CO 4	Expand functions like exponential, logarithmic, and trigonometric functions into Taylor series.
CO 5	Simplify Boolean expressions and design switching circuits based on Boolean algebra principles.
CO 6	Solve problems involving permutations, normal subgroups, and homomorphisms using practical examples.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	Low	High	Medium	Medium	High	Medium	High	Low	Medium	High
CO2	Medium	Low	Low	Low	Low	Low	Medium	Medium	Low	Low
CO3	High	Low	Low	High	Low	Low	Low	Low	High	Low
CO4	Low	Medium	High	Low	High	High	Low	Low	Low	Medium
CO5	Low	Low	Medium	Medium	Medium	Low	Medium	High	Medium	Low
CO6	Medium	Low	Low	Low	Low	Low	Low	Medium	Low	High

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Department of Microbiology

B.Sc. Semester I

Course Title: **Introduction to Microbial world**

Course Code: **253040101**

CO 1	Explain the historical developments in microbiology, including the discovery of microbes, theory of biogenesis, and key advances in pure culture techniques, germ theory, and vaccination.
CO 2	Compare the characteristics and habitats of prokaryotic and eukaryotic organisms, and evaluate the significance and applications of microbiology in various fields.
CO 3	Demonstrate understanding of pure culture techniques, including methods of isolation, preservation, and the role of culture collections in microbiological research.
CO 4	Apply various microscopy techniques, such as light, dark field, phase contrast, fluorescence, and electron microscopy, to study microbial structures and characteristics.
CO 5	Analyze the chemistry and mechanism of dyes and stains, and their role in microbiological staining techniques for observing microorganisms.
CO 6	Evaluate the practical uses of microbiological techniques in applied microbiology, genetic engineering, and biotechnology.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Medium	Low	Low	Low	Medium	High	Low
CO2	High	High	High	Medium	Low	Medium	Low	Medium	High	Medium
CO3	High	High	High	Medium	Low	Medium	Medium	High	Medium	Medium
CO4	High	High	Medium	High	Low	Low	Low	High	Medium	Low
CO5	High	High	Medium	Medium	High	Low	Low	High	Medium	Low
CO6	High	High	High	High	Medium	High	Medium	High	High	Medium

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Course Title: **Microbiology Practicals**

Course Code: **253040102**

CO 1	Demonstrate the correct use of microbiological instruments such as autoclave, laminar air flow, hot air oven, colony counter, and shaker in laboratory experiments.
CO 2	Perform proper cleaning and sterilization of glassware to ensure contamination-free experiments.
CO 3	Apply standard protocols for the safe disposal of laboratory waste and microbial cultures, maintaining biosafety standards.
CO 4	Develop basic microbial handling skills, including aseptic techniques and inoculation methods, to work safely with microorganisms.
CO 5	Prepare various types of microbiological media and broth, understanding their composition and role in microbial growth.
CO 6	Conduct negative staining techniques to observe microbial cell morphology and differentiate bacterial structures.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	Low	Medium	Low	High	Medium	Low
CO2	Medium	Medium	High	Medium	Low	Medium	Medium	High	Low	Medium
CO3	Medium	High	High	Medium	Medium	Low	High	High	Low	High
CO4	High	High	Medium	High	Medium	Low	Medium	High	Medium	Low
CO5	High	Medium	High	Medium	Medium	Low	Low	High	Low	Low

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B.Sc. Semester II

Course Title: **Basic Bacteriology**

Course Code: **253040201**

CO 1	Explain the principles of bacterial taxonomy, including the binomial system of nomenclature and various classification systems for typical prokaryotes.
CO 2	Analyze the cellular organization of bacteria, including their size, shape, arrangement, and structures involved in spore formation, sporulation, and germination.
CO 3	Describe the structural components of a bacterial cell, including surface appendages (flagella, pili, fimbriae, prosthecae, and stalks), surface layers (capsule, slime layer, cell wall), and internal organelles (cytoplasmic membrane, ribosome, plasmids).
CO 4	Evaluate the nutritional requirements and diversities in bacteria, and explain the formulation, ingredients, and types of culture media used for bacterial cultivation.
CO 5	Identify and compare the various methods of microbial control, including the use of physical agents (heat, radiation, filtration) and chemical agents (phenols, halogens, surfactants, alcohols, heavy metals, and gaseous agents).
CO 6	Apply the principles of microbial control and understand the significance of killing, inhibition, and removal methods in preventing microbial growth.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Low	Low	Low	Medium	High	Low
CO2	High	High	Medium	Medium	Low	Low	Low	Medium	High	Low
CO3	High	Medium	Medium	Medium	Low	Low	Low	Medium	High	Low
CO4	Medium	High	Medium	High	Medium	Low	Low	High	High	Low
CO5	Medium	High	Medium	Medium	High	Low	Low	Medium	High	Low
CO6	Medium	High	Medium	High	High	Low	Low	Medium	High	Low

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Course Title: **Microbiology Practicals**

Course Code: **253040202**

CO 1	Explain the techniques of microbial staining, including fixation and smear preparation.
CO 2	Perform Gram staining to differentiate between Gram-positive and Gram-negative bacteria.
CO 3	Apply the streak plate method to isolate pure bacterial colonies.
CO 4	Utilize the spread plate technique for the enumeration of microbial cells.
CO 5	Implement the pour plate technique to culture and quantify microbial populations.
CO 6	Identify bacterial species based on staining and morphological characteristics.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Low	Low	Low	High	Medium	Low
CO2	High	High	High	Medium	Low	Low	Low	High	Medium	Low
CO3	High	Medium	High	Medium	Low	Low	Low	High	Medium	Low
CO4	Medium	Medium	High	Medium	Low	Low	Low	High	Medium	Low
CO5	Medium	Medium	High	Medium	Low	Low	Low	High	Medium	Low
CO6	High	Medium	Medium	Medium	Low	Low	Low	High	Medium	Low

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B.Sc. Semester III

Course Title: **MICROBIAL PHYSIOLOGY**

Course Code: **253040301**

CO 1	Describe the chemical structure, properties, classification, and biological significance of biomolecules including carbohydrates, proteins, lipids, and nucleic acids.
CO 2	Explain the structure, function, and classification of enzymes, including their physical and chemical properties, and mechanisms of enzyme action.
CO 3	Analyze the factors affecting enzyme activity and differentiate between competitive and non-competitive enzyme inhibition.
CO 4	Classify bacteria based on environmental growth requirements and compare different modes of nutrient uptake in bacteria.
CO 5	Explain the processes of microbial metabolism, including anabolism, catabolism, and the role of reducing power, precursor metabolites, and energy-rich compounds.
CO 6	Analyze bacterial growth, reproduction, and evaluate the effects of chemotherapeutic agents, including antibiotics, on bacterial growth and metabolism.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Low	Medium	Low	High	Medium	Low
CO2	High	High	High	Medium	Low	Medium	Low	High	Medium	Low
CO3	High	High	High	Medium	Low	Medium	Low	High	Medium	Low
CO4	Medium	Medium	Medium	Medium	Medium	Low	Low	High	High	Medium
CO5	High	High	Medium	Medium	Medium	Low	Low	High	Medium	Medium
CO6	High	High	Medium	High	Medium	Low	Low	High	Medium	Medium

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Course Title: **Soil & Water Microbiology**

Course Code: **253040302**

CO 1	Describe the physicochemical characteristics of soil, methods for studying soil microflora, and the microbial interactions in soil, including neutral, positive, and negative associations.
CO 2	Explain the role of microorganisms as biogeochemical agents, including their involvement in the nitrogen, sulfur, carbon, iron, and phosphorus cycles.
CO 3	Analyze the significance of the rhizosphere, mycorrhiza, and microbial interactions with plant roots in enhancing soil fertility and biofertilizer production.
CO 4	Evaluate the sources of contamination in natural water, microbial indicators of fecal pollution, and the methods used for bacteriological examination of drinking water.
CO 5	Interpret the microbiological and chemical characteristics of wastewater, including the role of BOD, COD, and TOD in assessing water quality.
CO 6	Apply methods of wastewater treatment, including primary, secondary, and advanced treatment processes, and explain the role of microorganisms in solid waste processing such as anaerobic sludge digestion and composting.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Low	Medium	Low	High	Medium	Medium
CO2	High	High	Medium	Medium	Low	Medium	Low	High	High	High
CO3	High	High	Medium	Medium	Low	Medium	Low	High	High	High
CO4	High	High	Medium	Medium	Medium	Medium	Low	High	Medium	High
CO5	High	Medium	Medium	Medium	Medium	Medium	Low	High	Medium	High
CO6	High	High	High	High	Medium	Medium	Low	High	Medium	High

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Course Title: **Microbiology Practicals**

Course Code: **253040303**

CO 1	Perform microbial diversity analysis in soil using the Winogradsky column and analyze the results to understand different microbial niches.
CO 2	Demonstrate the buried slide method to study soil microflora and interpret the microbial interactions and diversity present in the soil sample.
CO 3	Conduct microbiological analysis of soil and water, including Standard Plate Count (SPC) and Most Probable Number (MPN) methods, to evaluate bacterial abundance and quality.
CO 4	Measure the moisture content in soil samples and estimate macromolecules such as carbohydrates (using the DNSA method) and proteins (using the Folin-Lowry method) in biological samples.
CO 5	Analyze bacterial growth curves through laboratory experiments and interpret the effects of various factors on bacterial growth dynamics.
CO 6	Evaluate the effect of antibiotics on bacterial growth and assess their efficiency in inhibiting microbial proliferation by performing susceptibility tests.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	Low	Medium	Low	High	High	High
CO2	High	Medium	Medium	Medium	Low	Medium	Low	High	High	Medium
CO3	High	High	Medium	High	Low	Medium	Low	High	High	Medium
CO4	High	Medium	Medium	Medium	Medium	Low	Low	High	Medium	Medium
CO5	High	High	Medium	Medium	Medium	Medium	Low	High	Medium	Low
CO6	High	High	Medium	High	Medium	Medium	Low	High	Medium	Medium

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B.Sc. Semester IV

Course Title: **Bacterial Diversity**

Course Code: **253040401**

CO 1	Explain the phylogeny and general properties of Archaebacteria, including their cell wall, cell membrane, chromosome, and ribosome structures. Describe the salient features of Methanogens, Halophiles, and Thermophilic S0 metabolizers.
CO 2	Identify and differentiate between photosynthetic and chemolithotrophic bacteria, including Oxygenic and Anoxygenic photosynthetic bacteria, and various types of Chemolithotrophic bacteria such as Nitrifying, Colorless Sulphur, Iron, Hydrogen, and Magnetotactic bacteria.
CO 3	Classify Gram-negative spiral and curved rods (Spirocheatales, Spiral bacteria, Curved rods), aerobic rods and cocci (Pseudomonadaceae, Neisseriaceae), and anaerobic and facultative rods and cocci (Enterobacteriaceae, Vibrionaceae, Veillonellaceae), along with obligatory parasites (Rickettsiaceae, Chlamydiaceae, Mollicutes). Analyze their distinguishing features and implications.
CO 4	Characterize Gram-positive rods and cocci, including Micrococcaceae, Deinococcaceae, Streptococcus, Leuconostoc, Peptococcus, endospore formers, and non-spore forming rods. Describe Gram-positive irregular rods, filamentous bacteria with complex morphology, and bacteria with unusual morphology such as prosthecate and nonprosthecate budding/non-budding bacteria.
CO 5	Compare and contrast different types of Gram-positive and Gram-negative bacteria based on their morphological and physiological characteristics. Assess their roles and significance in various environments and processes.
CO 6	Evaluate the diversity and functional roles of various bacterial types in ecological and industrial contexts. Apply knowledge of bacterial classification to analyze their applications and implications in biotechnology and environmental science.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Low	Medium	Low	High	Medium	Low
CO2	High	High	Medium	Medium	Low	Medium	Low	High	High	Medium
CO3	High	High	Medium	High	Low	Medium	Low	High	Medium	Medium
CO4	High	Medium	Medium	Medium	Medium	Low	Low	High	Medium	Medium
CO5	High	High	Medium	Medium	Medium	Low	Low	High	Medium	Medium
CO6	High	High	Medium	High	Medium	Medium	Low	High	Medium	High

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Course Title: **Food & Dairy Microbiology**

Course Code: **253040402**

CO 1	Identify the microbial flora present in various food sources such as fruits, vegetables, meat, eggs, and milk, and explain how food serves as a substrate for microorganisms.
CO 2	Analyze the intrinsic and extrinsic factors that influence the types and numbers of microorganisms in food.
CO 3	Differentiate between foodborne infections caused by bacteria, viruses, and protozoa, and describe their sources, incubation periods, and clinical characteristics.
CO 4	Examine the role of microorganisms like Staphylococcus aureus, Clostridium botulinum, and Salmonella spp. in food poisoning, and discuss the role of molds in food toxicity, including agents like Aspergillus and *Claviceps purpurea*.
CO 5	Evaluate methods of microbial food spoilage and preservation, including pasteurization, sterilization, refrigeration, and the use of preservatives, assessing their effectiveness in preventing spoilage in various foods.
CO 6	Discuss the role of microbes in the production of fermented foods, probiotics, and prebiotics, and apply microbiological techniques to the examination and analysis of food and milk products, following food safety standards and certification practices in India.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Low	Low	Medium	Low	High	Medium	Medium
CO2	High	High	Medium	Medium	Low	Medium	Low	High	Medium	Medium
CO3	High	High	Medium	Medium	Low	Medium	Low	High	Medium	Medium
CO4	High	Medium	Medium	Medium	Low	Medium	Low	High	Medium	Medium
CO5	High	Medium	Medium	Medium	Low	Medium	Low	High	Medium	High
CO6	High	Medium	Medium	Medium	Medium	Medium	Low	High	Medium	High

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Course Title: **Microbiology Practicals**

Course Code: **253040403**

CO 1	Isolate and identify fungi from environmental and clinical samples using appropriate techniques and demonstrate proficiency in fungal staining methods.
CO 2	Analyze the skin flora by isolating and identifying common microorganisms found on human skin and evaluate their significance in health and disease.
CO 3	Perform cell wall staining procedures to visualize and interpret the structural components of microbial cell walls.
CO 4	Apply acid-fast staining techniques to distinguish acid-fast bacteria from non-acid-fast organisms, and assess their role in microbial identification.
CO 5	Execute the Methylene Blue Reduction Test (MBRT) to determine the microbial quality and spoilage potential of milk samples.
CO 6	Conduct microbiological analysis of food and milk, including quantitative analysis using Standard Plate Count (SPC), and interpret results to assess food safety and quality.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Medium	Low	Medium	High	Medium	Medium
CO2	High	High	Medium	Medium	Low	Medium	Low	High	Medium	Medium
CO3	High	Medium	Medium	High	Medium	Low	Low	High	Medium	Medium
CO4	High	Medium	Medium	Medium	Medium	Low	Low	High	Medium	Medium
CO5	High	Medium	Medium	Medium	Medium	Low	Low	High	Medium	High
CO6	High	Medium	Medium	High	Medium	Medium	Low	High	Medium	High

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B.Sc. Semester V

Course Title: **Fermentation technology-I**

Course Code: **253040501**

CO 1	Understand the fundamental concepts of fermentation, the historical development of industrial microbiology, and the various components and range of fermentation processes.
CO 2	Describe the characteristics of industrially important microorganisms and apply techniques for primary and secondary screening for organic acid, antibiotic, enzyme, and growth factor producers.
CO 3	Understand the strategies for strain improvement, including the selection of induced mutants and recombinants, and apply preservation techniques and quality control for strain maintenance.
CO 4	Explain the design and functions of a stirred-tank bioreactor, including its structural components, and describe devices used for aeration, agitation, and monitoring of pH, temperature, foam, and dissolved oxygen.
CO 5	Differentiate between types of fermentation processes, including submerged (batch, fed-batch, continuous) and solid-state fermentation.
CO 6	Understand the principles of fermentation media formulation, including the role of media ingredients, and explain the methods of sterilization and the principles for developing inoculum for bacterial, yeast, and fungal processes.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	Medium
CO 2	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	Medium	High	High	Low	Medium	High	High	Medium	Medium
CO 4	High	Medium	Medium	High	Low	Medium	Medium	High	Medium	Medium
CO 5	High	High	High	Medium	Medium	Medium	Medium	High	Medium	Medium
CO 6	High	Medium	High	High	Low	Medium	Medium	High	Medium	Medium

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Course Title: **Bacterial Metabolism**

Course Code: **253040502**

CO 1	Explain enzyme kinetics by applying the Michaelis-Menten equation and analyze the significance of the Lineweaver-Burk plot in determining enzyme activity parameters.
CO 2	Evaluate the types and significance of metabolic regulation, and assess the various modes of ATP generation in biological systems.
CO 3	Demonstrate the catabolism of glucose, fatty acids, and proteins, and explain the steps of the TCA cycle and its role in energy production.
CO 4	Differentiate between chemoheterotrophic, chemoautotrophic, and phototrophic metabolism, and illustrate the process of cyclic and non-cyclic photophosphorylation in ATP generation.
CO 5	Describe the Calvin-Benson cycle for CO2 fixation and explain how chemoautotrophs generate ATP and reducing power.
CO 6	Summarize the principles governing biosynthesis, and analyze the pathways involved in the biosynthesis of fatty acids, phospholipids, and the assimilation of nitrogen and sulfur compounds.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Low	Medium	Low	High	Medium	Medium
CO2	High	High	Medium	Medium	Low	Medium	Low	Medium	Medium	Medium
CO3	High	Medium	Medium	Medium	Low	Medium	Low	High	Medium	Medium
CO4	High	Medium	Medium	Medium	Low	Medium	Low	High	Medium	Medium
CO5	High	Medium	Medium	Medium	Low	Medium	Low	Medium	Medium	Medium
CO6	High	Medium	Medium	Medium	Low	Medium	Low	Medium	Medium	Medium

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Course Title: **Enzymology**

Course Code: **253040503**

CO 1	Explain the general characteristics, classification, and terminology related to enzymes, including holoenzymes, coenzymes, apoenzymes, and inhibitors, and differentiate between first-order and zero-order reactions.
CO 2	Describe the structure and specificity of enzyme active sites, and analyze the factors affecting enzyme activity, including turnover number, specific activity, and allosteric regulation.
CO 3	Apply the Michaelis-Menten equation and its modifications (Lineweaver-Burk, Eadie-Hofstee, and Hanes-Woolf plots) to enzyme kinetics, and distinguish between types of enzyme inhibition (competitive, non-competitive, uncompetitive, mixed, and substrate inhibition).
CO 4	Evaluate different methods of enzyme immobilization, and assess their applications, advantages, and limitations in industrial and biochemical processes, including reverse micelles and whole-cell immobilization.
CO 5	Identify the industrial applications of key enzymes such as amylase, protease, and lipase in various sectors (detergent, leather, food, dairy, textile, and medical), and explain their roles in these industries.
CO 6	Demonstrate the methods for industrial production of enzymes and examine the relevance of enzyme sources in large-scale industrial applications.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Low	Medium	Low	Medium	Medium	Low
CO2	High	High	Medium	Medium	Low	Medium	Low	Medium	Medium	Medium
CO3	High	Medium	Medium	High	Low	Medium	Low	Medium	Medium	Medium
CO4	High	Medium	Medium	Medium	Low	Medium	Low	High	Medium	Medium
CO5	High	Medium	Medium	Medium	Low	Medium	Low	High	Medium	Medium
CO6	High	Medium	Medium	High	Low	Medium	Low	High	Medium	Medium

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Course Title: **BIOSAFETY, BIOETHICS & IPR**

Course Code: **253040504**

CO 1	Understand the fundamental concepts of biosafety, including standard laboratory practices, containment strategies, biosafety levels, biosafety guidelines in India, laboratory biosecurity, and risk assessment.
CO 2	Explain the principles of Good Laboratory Practices (GLP), Good Manufacturing Practices (GMP), and the basic concepts of Quality Control (QC) and Quality Assurance (QA), including guidelines for raw materials, sterilization, media, and product validation.
CO 3	Understand the role of culture collection centers, public health laboratories, and regulatory agencies in ensuring quality and safety in biological practices.
CO 4	Comprehend the basics and principles of bioethics, regulatory concerns, international codes and guidelines in India, and the role of non-governmental organizations (NGOs) in biological regulations.
CO 5	Understand the different types of intellectual property rights (IPR) and their management, including the benefits and challenges associated with IPR in biotechnology.
CO 6	Explain the patenting process, international harmonization of patent law, biotechnological process patents, and their protection, with a focus on the Indian scenario and case studies related to infringement.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	High	Medium	Medium	High	High	Medium	High
CO 2	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	Medium	Medium	High	Medium	Medium	High	Medium	Medium	Medium
CO 4	High	High	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO 5	High	Medium	Medium	Medium	High	Medium	Medium	Medium	High	Medium
CO 6	High	Medium	Medium	High	Medium	Medium	Medium	Medium	High	Medium

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Course Title: **Microbiology Practicals**

Course Code: **253040505**

CO 1	Demonstrate the process of alcohol production using baker's yeast and perform alcohol estimation through microbial fermentation techniques.
CO 2	Perform primary screening techniques for the identification of microbial producers of amylase, antibiotics, and organic acids, and evaluate their potential for industrial applications.
CO 3	Explain the structure and functionality of bioinformatics databases such as NCBI, DDBJ, and GenBank, and apply these tools for biological data retrieval and analysis.
CO 4	Conduct enzyme immobilization experiments and analyze the factors affecting enzyme activity, including temperature, pH, and substrate concentration, to determine optimal conditions for enzymatic reactions.
CO 5	Investigate the effect of temperature and pH on bacterial growth, and apply these concepts in microbial growth regulation for biotechnological processes.
CO 6	Evaluate the procedures for sterility testing in pharmaceutical products, and analyze case studies of patent law, including patent infringement and its implications in biotechnology.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Low	Medium	Low	Medium	Medium	Medium
CO2	High	Medium	Medium	Medium	Low	Medium	Low	Medium	Medium	Medium
CO3	High	Medium	Medium	Medium	Low	Medium	Low	High	Medium	Medium
CO4	High	Medium	Medium	High	Low	Medium	Low	High	Medium	Medium
CO5	High	Medium	Medium	Medium	Low	Medium	Low	Medium	Medium	Medium
CO6	High	Medium	Medium	High	Low	Medium	High	Medium	Medium	High

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B.Sc. Semester VI

Course Title: **Fermentation Technology-II**

Course Code: **253040601**

CO 1	Understand the principles of downstream processing, including methods for the removal of microbial cells and suspended solids such as foam separation, precipitation, filtration, and centrifugation, as well as cell disruption techniques.
CO 2	Explain the processes involved in product concentration, purification, and finishing stages like liquid-liquid extraction, membrane processes, drying, crystallization, and effluent treatment.
CO 3	Understand the methods for detecting and assaying fermentation products, including physical assays (titration, gravimetric analysis), chemical assays (chromatography, spectrophotometry), and biological assays (microbial assays).
CO 4	Explain the microbial quality assurance methods used in fermentation, including sterility testing, the Limulus Amebocyte Lysate (LAL) test, and fermentation economics.
CO 5	Understand the fermentation processes involved in the production of industrial products such as alcohol, cheese, baker's yeast, glutamic acid, and citric acid.
CO 6	Explain the fermentative production of pharmaceuticals and industrial enzymes, including penicillin (and its conversion to semisynthetic derivatives), cyanocobalamin, steroids, amylase, and carotenoids.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 2	High	Medium	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 3	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO 4	High	High	Medium	High	Medium	Medium	High	High	Medium	Medium
CO 5	High	High	High	Medium	Medium	Medium	Medium	High	Medium	High
CO 6	High	High	High	High	Medium	Medium	Medium	High	Medium	High

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Course Title: **MEDICAL MICROBIOLOGY**

Course Code: **253040602**

CO 1	Describe the normal microflora of the human body, nosocomial infections, and the role of carriers, pathogenicity, and virulence factors in disease, and explain the concept of septicemia, septic shock, and biosafety levels in microbiological practices.
CO 2	Identify the morphology, pathogenesis, symptoms, and laboratory diagnosis of infections caused by gram-positive bacteria (e.g., S. aureus, S. pyogenes, B. anthracis, C. perfringens, C. tetani), and evaluate preventive measures and chemotherapy options for treatment.
CO 3	Explain the principles of bioethics and biosafety guidelines related to contamination, decontamination, disposal, and safety from infectious sources in clinical and laboratory settings.
CO 4	Analyze the morphology, pathogenesis, symptoms, and laboratory diagnosis of diseases caused by gram-negative bacteria (e.g., E. coli, N. gonorrhoeae, N. meningitidis, P. aeruginosa, S. typhi, S. dysenteriae, Y. pestis, B. abortus, H. influenzae, V. cholera), and propose effective preventive measures and chemotherapy treatments.
CO 5	Understand the properties of antigens and antibodies, including antigen processing, presentation, antigenicity, and recognition by MHC molecules, and apply knowledge of monoclonal antibodies and their clinical applications.
CO 6	Classify and explain the bacterial diseases affecting different systems of the body, such as the skin, eyes, digestive system, nervous system, and respiratory tract, and describe their respective diagnostic and treatment protocols.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Low	High	Medium	Medium	Medium	High
CO2	High	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium
CO3	High	Medium	High	Medium	Low	High	Medium	High	Medium	High
CO4	High	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium
CO5	High	Medium	Medium	Medium	Medium	High	Low	Medium	Medium	Medium
CO6	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	High

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Course Title: **IMMUNOLOGY-II**

Course Code: **253040603**

CO 1	Explain the key components of the innate immune system, including phagocytosis, the complement system, inflammation, cytokines, and acute phase proteins, and describe the cells, tissues, and organs involved in immune defense.
CO 2	Understand the role of antigens, haptens, and cluster of differentiation (CD) molecules in immune recognition and distinguish between humoral and cell-mediated immunity.
CO 3	Analyze the biology of T cells, including T cell receptors, types of T cells, and T cell activation, and evaluate their role in immune responses.
CO 4	Describe the structure, function, and classes of immunoglobulins (antibodies), and demonstrate the mechanisms and measurement of antigen-antibody reactions, including precipitation and agglutination tests.
CO 5	Understand immune disorders such as immunodeficiency, hypersensitivity, and autoimmune diseases, and analyze their mechanisms and clinical implications.
CO 6	Explain the immunological aspects of transplantation, including the classification of transplants, allograft rejection, graft survival, and the immunological responses to malignancy and graft-versus-host reactions.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Low	High	Medium	Medium	Medium	Medium
CO2	High	Medium	Medium	Medium	Low	High	Medium	Medium	Medium	Medium
CO3	High	Medium	High	Medium	Low	High	Medium	Medium	Medium	Medium
CO4	High	Medium	Medium	High	Low	High	Medium	Medium	Medium	Medium
CO5	High	Medium	Medium	Medium	High	High	Medium	Medium	Medium	Medium
CO6	High	Medium	Medium	Medium	High	High	Medium	Medium	Medium	Medium

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Course Title: **Environmental Microbiology**

Course Code: **253040604**

CO 1	Explain the processes of symbiotic and asymbiotic nitrogen fixation, describe the structure and mechanism of nitrogenase, and understand the role of biofertilizers, including Azotobacter and Rhizobia, in agricultural practices.
CO 2	Describe the concept of biodeterioration, including the degradation of wood, paint, and metal, and explain the principles and applications of bioremediation, focusing on the treatment of petroleum hydrocarbons, chlorinated compounds, and microbial enhanced oil recovery.
CO 3	Understand the concept of xenobiotics and recalcitrance, analyze biomagnification, and evaluate the biodegradation of environmental pollutants such as ABS, chlorinated hydrocarbons, oil pollutants, and biodegradable polymers.
CO 4	Explain the importance of biofuels as renewable energy resources, describe various types of biofuels including biogas, hydrogen, and alcohol, and evaluate the advantages and disadvantages of biogas production, including its substrates and microorganisms.
CO 5	Understand the role of microbial insecticides in agriculture and pest control, analyze their mechanisms, and evaluate their effectiveness in reducing pest populations.
CO 6	Describe the general principles of bioremediation, demonstrate methods for the remediation of specific pollutants, and evaluate the effectiveness of bioremediation strategies in environmental clean-up.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Low	Medium	Medium	Medium	Medium	Medium
CO2	High	High	High	Medium	Medium	High	Medium	Medium	Medium	High
CO3	High	High	Medium	Medium	Medium	High	Medium	Medium	Medium	High
CO4	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
CO5	High	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium
CO6	High	High	Medium	Medium	Medium	High	Medium	Medium	Medium	High

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Course Title: **Microbiology Practicals**

Course Code: **253040605**

CO 1	Demonstrate key laboratory techniques such as ammonium sulfate precipitation, Widal test, and RPR test for diagnostic and analytical purposes.
CO 2	Analyze sterility testing in pharmaceutical products and interpret results to ensure compliance with safety standards.
CO 3	Understand the microbial processes involved in the production of food products like cheese and sauerkraut, and their industrial significance.
CO 4	Perform agarose gel electrophoresis and evaluate nucleic acid separation techniques based on molecular weight.
CO 5	Isolate industrially important microorganisms like Bacillus thuringiensis from soil and assess their potential applications.
CO 6	Investigate microbial biodegradation, including dye decolorization and biodeterioration, and apply findings to environmental issues.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	High	Medium	High	Low	Medium	Medium	Medium	Medium	Medium
CO3	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO4	High	Medium	Medium	High	Medium	Medium	Medium	High	Medium	Medium
CO5	High	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium	High
CO6	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	High

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Department of Physics

B.Sc. Semester I

Course Title: **Basic Physics-I**
Course Code: **253050101**

CO 1	Analyze wave propagation in various media
CO 2	Perform vector algebra and analysis operations.
CO 3	Study optical phenomena using Fermat's principle and thin film interference.
CO 4	Evaluate ultrasonic wave generation, detection, and applications.
CO 5	Apply matrix methods to optics problems.
CO 6	Explain laser principles and their applications.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Medium	Low	Medium	Low	Medium	Medium	Medium
CO2	High	High	High	Medium	Low	Medium	Low	Medium	Low	Low
CO3	High	Medium	Medium	Medium	Low	Medium	Low	Medium	Low	Low
CO4	High	Medium	High	High	Medium	Medium	Medium	High	Medium	Low
CO5	High	High	Medium	Medium	Medium	Medium	Low	Medium	Medium	Low
CO6	High	Medium	Medium	Medium	Medium	High	Low	Medium	Low	Medium

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Course Title: **Physics Practicals**
Course Code: **253050102**

CO 1	Perform experimental procedures to measure and analyze physical quantities such aswavelength, capacitance, and inductance.
CO 2	Apply theoretical principles to verify experimental relationships and constants, such as P/Land T/l², in various practical setups.
CO 3	Utilize resonance and rectification techniques to determine frequencies, efficiencies, andload characteristics in electrical circuits.
CO 4	Conduct experiments to understand the behavior of materials under stress, including measuring Young's Modulus and analyzing transformer performance.
CO 5	Demonstrate proficiency in digital electronics by constructing and testing logic gates andinterpreting their truth tables and voltage levels.
CO 6	Analyze and determine the efficiency of solar cells and other electronic componentsthrough practical experiments and data analysis.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	High	Medium	Medium	Low	High	Medium	Low
CO2	High	High	High	High	Medium	Medium	Low	High	Medium	Low
CO3	High	Medium	High	High	Medium	Medium	Low	High	Low	Low
CO4	High	High	High	High	Medium	Medium	Low	High	Medium	Low
CO5	High	Medium	Medium	Medium	Medium	Medium	Low	High	Medium	Low
CO6	High	High	High	High	Medium	Medium	Low	High	Medium	High

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B.Sc. Semester II

Course Title: **Basic Physics-II**
Course Code: **253050201**

CO 1	Analyze and determine the electrostatic potential and field due to various charge distributions, including spherical shells and rings.
CO 2	Apply Gauss's law, Poisson's and Laplace's equations to solve electrostatic field and potential problems.
CO 3	Evaluate diode circuits, including rectifiers and filter circuits, using load line analysis and performance metrics.
CO 4	Understand and describe the characteristics, behaviors, and diagnostic methods of plasmas, including their applications and instabilities.
CO 5	Solve problems involving RL, RC, and L-C-R circuits in both DC and AC conditions, including bridge circuits.
CO 6	Apply radioactive decay laws and dating techniques to determine age, equilibrium states, and the characteristics of radioactive materials.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Medium	Medium	Low	Low	High	Medium	Low
CO2	High	High	High	Medium	Medium	Low	Low	High	Medium	Low
CO3	High	Medium	High	Medium	Medium	Medium	Low	High	Low	Low
CO4	High	Medium	High	Medium	Medium	Medium	Medium	High	Medium	Medium
CO5	High	High	High	High	Medium	Medium	Low	High	Medium	Low
CO6	High	High	Medium	Medium	Medium	Medium	Low	High	Medium	Medium

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Course Title: **Physics Practicals**
Course Code: **253050202**

CO 1	Perform experimental procedures to measure and analyze physical quantities such as wavelength, capacitance, and inductance.
CO 2	Apply theoretical principles to verify experimental relationships and constants, such as P/L and T/l², in various practical setups.
CO 3	Utilize resonance and rectification techniques to determine frequencies, efficiencies, and load characteristics in electrical circuits.
CO 4	Conduct experiments to understand the behavior of materials under stress, including measuring Young's Modulus and analyzing transformer performance.
CO 5	Demonstrate proficiency in digital electronics by constructing and testing logic gates and interpreting their truth tables and voltage levels.
CO 6	Analyze and determine the efficiency of solar cells and other electronic components through practical experiments and data analysis.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Medium	Medium	Low	Low	High	Medium	Low
CO2	High	High	High	Medium	Medium	Low	Low	High	Medium	Low
CO3	High	Medium	High	Medium	Medium	Medium	Low	High	Low	Low
CO4	High	Medium	High	Medium	Medium	Medium	Medium	High	Medium	Medium
CO5	High	High	High	High	Medium	Medium	Low	High	Medium	Low
CO6	High	High	Medium	Medium	Medium	Medium	Low	High	Medium	Medium

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B.Sc. Semester III

Course Title: **Physics-301**
Course Code:**253050301**

CO 1	Recall the fundamental characteristics of transistors and semiconductor devices.
CO 2	Explain the underlying principles of transistor operation and quantum mechanics concepts.
CO 3	Apply transistor principles to design basic amplifier circuits and voltage regulator circuits.
CO 4	Analyze the performance characteristics of transistor amplifiers and voltage regulator circuits under different conditions.
CO 5	Critically evaluate the limitations of classical models and assess the suitability of different semiconductor devices for specific applications.
CO 6	Design innovative transistor amplifier configurations and propose experimental setups to explore advanced topics in wave optics.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Medium	Low	Low	Low	High	Medium	Low
CO2	High	High	High	Medium	Low	Low	Low	High	Medium	Low
CO3	High	High	High	Medium	Medium	Medium	Low	High	Medium	Medium
CO4	High	High	High	Medium	Medium	Medium	Low	High	Low	Low
CO5	High	Medium	High	High	Medium	Medium	Medium	High	Medium	Medium
CO6	High	High	High	High	High	Medium	Low	High	Medium	Medium

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Course Title: **Physics-302**
Course Code: **253050302**

CO 1	Recall the fundamental concepts of dielectrics, including polarization and types of dielectric materials.
CO 2	Explain the laws of electrostatics in the presence of dielectrics and analyze the behavior of electric fields and energies.
CO 3	Apply the principles of magnetostatics to analyze the behavior of magnetic fields in different materials and media.
CO 4	Analyze the motion of particles in central force fields and collisions, including elastic and inelastic scattering phenomena.
CO 5	Evaluate the effectiveness of different nuclear particle detectors and particle accelerators in experimental setups.
CO 6	Design experimental setups utilizing nuclear magnetic resonance (NMR) techniques and propose experiments to explore various nuclear physics phenomena.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Medium	Low	Low	Low	Medium	Medium	Low
CO2	High	High	High	Medium	Medium	Low	Low	High	Medium	Low
CO3	High	High	High	Medium	Medium	Medium	Low	High	Medium	Low
CO4	High	High	High	Medium	Medium	Medium	Medium	High	Medium	Low
CO5	High	Medium	High	High	Medium	Medium	Medium	High	Medium	Medium
CO6	High	High	High	High	High	Medium	Low	High	Medium	Medium

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Course Title: **Physics Practicals**
Course Code: **253050303**

CO 1	Recall the fundamental principles and techniques involved in experimental methods such as Koening's method, Newton's ring, Hartmann formula, and Desauty's method.
CO 2	Understand the concepts behind resolving power, figure of merit, absorption coefficient, electron diffraction, resonance, and Fourier analysis as applied in experimental setups.
CO 3	Apply numerical methods to analyze oscillatory motion and determine parameters such as C1/C2 for electrical circuits and h-parameters for transistor configurations.
CO 4	Analyze the performance characteristics of devices and systems, such as telescope resolving power, load line determination for BJTs, and resonance in pendulum experiments.
CO 5	Evaluate the effectiveness of different experimental techniques and methods in achieving desired outcomes, such as the use of Zener diodes as voltage regulators or liquid lenses in optical systems.
CO 6	Design and conduct experiments utilizing various techniques learned in the course, and propose innovative applications or modifications to existing setups to achieve specific experimental goals.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Medium	Low	Medium	Low	High	Medium	Low
CO2	High	High	High	Medium	Medium	Medium	Medium	High	Medium	Low
CO3	High	High	High	Medium	Medium	Medium	Low	High	Medium	Low
CO4	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO5	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium
CO6	High	High	High	High	High	Medium	Low	High	Medium	Medium

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B.Sc. Semester IV

Course Title: **Physics-401**
Course Code: **253050401**

CO 1	Explain lattice vibrations and phonon quantization in solids.
CO 2	Apply classical and quantum theories to analyze thermal properties of solids.
CO 3	Analyze entropy and thermodynamic principles in pure substances.
CO 4	Evaluate transistor biasing techniques and their impact on circuit stability.
CO 5	Convert and compare different number systems used in digital electronics.
CO 6	Analyze atomic spectra and explain phenomena like Zeeman and Stark effects.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Medium	Low	Medium	Low	Medium	Medium	Low
CO2	High	High	High	Medium	Medium	Medium	Low	High	Medium	Low
CO3	High	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO4	High	High	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO5	High	High	High	Medium	Medium	Medium	Low	High	Medium	Low
CO6	High	High	High	High	Medium	Medium	Medium	High	Medium	Medium

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Course Title: **Physics-402**
Course Code: **253050402**

CO 1	Calculate reverberation time and analyze acoustics in architectural spaces.
CO 2	Explain the principles of polarization, double refraction, and analyze polarized light.
CO 3	Analyze macroscopic and microscopic states, and apply principles of statistical mechanics.
CO 4	Apply the special theory of relativity to explain relativistic phenomena like time dilation and mass-energy equivalence.
CO 5	Solve the Schrödinger equation for various potential systems and interpret wave functions.
CO 6	Explain the general formalism of wave mechanics, including eigenvalues, eigenfunctions, and the uncertainty principle.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium	Low
CO2	High	High	Medium	Low	Medium	Low	Medium	High	Medium	Low
CO3	High	High	High	Medium	Medium	Low	Medium	Medium	Medium	Low
CO4	High	High	Medium	High	Medium	Medium	Low	Medium	Medium	Low
CO5	High	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO6	High	High	High	Medium	High	Medium	Medium	Medium	Medium	Medium

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Course Title: **Physics Practicals**
Course Code: **253050403**

CO 1	Apply Searl's goniometer to measure angles and analyze the properties of crystals.
CO 2	Evaluate the resolving power of telescopes using optical principles.
CO 3	Analyze diffraction patterns and determine the wavelength of light using different methods.
CO 4	Measure and analyze phonon dispersion in a monoatomic lattice.
CO 5	Study and interpret FET characteristics and their applications in circuits.
CO 6	Apply Thevenin's theorem to verify the maximum power transfer in electrical circuits.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Low	Medium	Low	Medium	Medium	Low	Low
CO2	High	High	Medium	Low	Medium	Low	Medium	High	Low	Low
CO3	High	High	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low
CO4	High	High	Medium	Medium	High	Low	Low	Medium	Medium	Low
CO5	High	High	High	Medium	Medium	High	Medium	Medium	Medium	Medium
CO6	High	Medium	High	Medium	High	High	Medium	Medium	Medium	Medium

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B.Sc. Semester V

Course Title: **Mathematical Physics, Quantum & Classical Mechanics-1**
Course Code: **253050501**

CO 1	Apply the method of separation of variables to solve partial differential equations in various coordinate systems.
CO 2	Analyze and solve second-order differential equations using series solutions and the Frobenius method.
CO 3	Formulate and solve problems in classical mechanics using Lagrangian methods and conservation laws.
CO 4	Explain and apply the principles of rigid body motion, including Euler's equations and nutational motion.
CO 5	Solve quantum mechanical problems using exactly soluble eigenvalue methods, including the harmonic oscillator.
CO 6	Analyze angular momentum in quantum systems with spherical symmetry and interpret spherical harmonics.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Medium	Low	Low	Medium	Low	Medium	Low
CO2	High	High	Medium	Medium	Low	Low	Medium	Low	Medium	Low
CO3	High	High	High	Medium	Medium	Low	Medium	Medium	High	Medium
CO4	High	Medium	High	Medium	Medium	Low	Medium	Medium	Medium	Medium
CO5	High	Medium	High	Medium	Medium	High	Medium	Medium	Medium	Medium
CO6	High	High	High	Medium	Medium	High	Medium	Medium	Medium	Medium

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Course Title: **Electronic Spectra-1, Solid State Physics & Stat. Mech-1**
Course Code: **253050502**

CO 1	Apply the Born-Oppenheimer approximation to explain molecular energy states and types of molecular spectra.
CO 2	Analyze the characteristics of rotational and vibrational-rotational spectra and their experimental setups.
CO 3	Explain the Raman effect using classical and quantum theories and compare it with infrared spectra.
CO 4	Evaluate the mechanisms of fluorescence and phosphorescence, distinguishing them from Raman spectra.
CO 5	Formulate and apply quantum statistics to Bose-Einstein and Fermi-Dirac distributions, including partition functions.
CO 6	Analyze the properties of free electron Fermi gas and the electrical and thermal conductivity in metals.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Medium	Low	Low	Medium	Low	Medium	Low
CO2	High	High	Medium	Medium	Low	Medium	Medium	Medium	Medium	Low
CO3	High	High	High	Medium	Medium	Low	Medium	Medium	Medium	Low
CO4	High	High	Medium	Medium	Medium	Low	Medium	Medium	High	Low
CO5	High	Medium	High	Medium	Medium	Low	Medium	Medium	Medium	Medium
CO6	High	Medium	High	Medium	Medium	High	Medium	Medium	Medium	Medium

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Course Title: **Nuclear physics-1 & Electrodynamics-1**

Course Code: **253050503**

CO 1	Explain the concepts of hysteresis and Maxwell's equations in electromagnetic induction.
CO 2	Analyze the propagation of electromagnetic waves in different media and evaluate the effects of polarization and skin effect.
CO 3	Apply the principles of electromagnetic radiation to determine the fields and potentials of moving charges.
CO 4	Explain the mechanisms of alpha and beta decay, including the Pauli's neutrino hypothesis and Fermi's theory.
CO 5	Evaluate the energy levels and decay processes in gamma-ray emission and internal conversion.
CO 6	Analyze the liquid drop model of the nucleus and its application to nuclear stability and decay processes.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Medium	Low	Low	Medium	Low	Medium	Low
CO2	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO3	High	Medium	High	Medium	Medium	Low	Medium	Medium	High	Low
CO4	High	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	Low
CO5	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO6	High	Medium	High	Medium	Medium	Low	Medium	Medium	Medium	Medium

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Course Title: **Linear Electronic Circuits-1**
Course Code: **253050504**

CO 1	Explain the fundamental concepts and characteristics of amplifiers, including gain, efficiency, and distortion.
CO 2	Analyze the frequency response of transistor amplifiers at both low and high frequencies, including the impact of various circuit components.
CO 3	Design and simplify digital circuits using Boolean algebra, Karnaugh maps, and understand the working principles of different flip-flops.
CO 4	Apply network theorems, including Thevenin's and Norton's theorems, to simplify and solve complex electrical networks.
CO 5	Evaluate the performance of resonant circuits by calculating Q factor, bandwidth, and analyzing resonance behavior in series and parallel circuits.
CO 6	Design transistor amplifier circuits and evaluate their performance through the analysis of harmonic distortion and frequency response.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Low	Low	Medium	Low	Medium	Low
CO2	High	Medium	High	Medium	Medium	Low	Medium	Medium	Medium	Low
CO3	High	High	High	Medium	High	Medium	Medium	Medium	High	Medium
CO4	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO5	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High	Low
CO6	High	Medium	High	Medium	Medium	Low	Medium	Medium	Medium	Medium

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Course Title: **Physics Practicals**
Course Code: **253050505**

CO 1	Demonstrate the ability to measure physical quantities such as gravity, temperature, and electrical properties using standard experimental techniques.
CO 2	Analyze experimental data to determine physical constants and properties, such as melting point, dielectric constant, and viscosity.
CO 3	Use various instruments and techniques to investigate and characterize properties of materials and electronic components.
CO 4	Evaluate the performance of electronic circuits and devices by measuring their characteristics and responses.
CO 5	Interpret experimental results to understand fundamental principles in physics, such as interference, resonance, and electromagnetic effects.
CO 6	Develop skills in using and calibrating scientific instruments for precise measurement and analysis in laboratory experiments.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Low	Low	Medium	Medium	Low	Medium	Low
CO2	High	High	Medium	Medium	Low	Medium	Low	Low	Medium	Low
CO3	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO4	High	Medium	High	High	Medium	Medium	Medium	Low	High	Low
CO5	High	High	Medium	Medium	Medium	Medium	Medium	Low	Medium	Low
CO6	High	High	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium

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B.Sc. Semester VI

Course Title: **Mathematical Physics, Quantum & Classical Mechanics-2**
Course Code: **253050601**

CO 1	Apply special functions (e.g., Bessel, Legendre, Hermite) to solve physical problems in various contexts.
CO 2	Analyze and utilize the variational principle and Lagrangian/Hamiltonian formulations in classical mechanics.
CO 3	Solve and interpret quantum mechanical problems using the three-dimensional square well potential model.
CO 4	Demonstrate an understanding of quantum states, representations, and symmetries in the context of quantum mechanics.
CO 5	Derive and apply solutions for special functions relevant to different physical systems and boundary conditions.
CO 6	Evaluate the impact of symmetries and transformations on physical systems and their conservation laws.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Low	Medium	Medium	Low	Low	Medium	Low
CO2	High	High	High	Medium	Medium	Medium	Medium	Low	Medium	Low
CO3	High	High	Medium	Medium	High	Medium	Medium	Low	Medium	Low
CO4	High	Medium	High	High	Medium	Medium	Medium	Low	High	Low
CO5	High	High	Medium	Medium	Medium	High	Medium	Low	Medium	Low
CO6	High	High	High	Medium	Medium	High	Medium	Low	Medium	Medium

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Course Title: **Electronic Spectra-2, Solid State Physics & Stat. Mech-2**
Course Code: **253050602**

CO 1	Analyze the formation and features of electronic spectra, including vibrational and rotational structures.
CO 2	Apply the Franck-Condon principle to explain intensity distributions in electronic band spectra for absorption and emission.
CO 3	Evaluate transport phenomena by analyzing mean collision time, scattering cross-section, and various transport properties.
CO 4	Describe and apply theories of dielectric polarization, including ionic, dipole, and optical polarizations.
CO 5	Analyze diamagnetism and paramagnetism theories, including Langevin's theory and quantum mechanical formulations.
CO 6	Explain the quantum mechanical aspects of magnetic susceptibility and its applications in materials and resonance phenomena.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	Medium	Medium	Low	Low	Medium	Low
CO2	High	High	Medium	Medium	High	Medium	Low	Low	Medium	Low
CO3	High	High	Medium	Medium	Medium	Medium	Medium	Low	Medium	Low
CO4	High	Medium	Medium	High	Medium	Medium	Low	Low	Medium	Low
CO5	High	High	Medium	Medium	High	Medium	Medium	Low	Medium	Low
CO6	High	High	Medium	Medium	Medium	High	Medium	Low	Medium	Medium

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Course Title: **Nuclear physics-2 & Electrodynamics-2**
Course Code: **253050603**

CO 1	Analyze the motion of charged particles in uniform and varying magnetic and electric fields, including drift and gyro relaxation effects.
CO 2	Evaluate the characteristics of plasma in a magnetic field, including the effects of diffusion, oscillations, and waves.
CO 3	Describe the processes involved in neutron-induced fission and the energy release in nuclear reactors.
CO 4	Apply the Boltzmann-Vlasov equation to analyze plasma behavior, including Debye screening and Landau damping.
CO 5	Explain the Mossbauer effect and its applications, as well as the principles of natural and controlled nuclear fusion.
CO 6	Analyze the properties of elementary particles, including their interactions, conservation laws, and the quark model.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	High	Medium	Medium	Low	Medium	Medium	Low
CO2	High	High	Medium	High	Medium	Medium	Low	Medium	Medium	Medium
CO3	High	Medium	Medium	High	Medium	Medium	Low	Low	Medium	Low
CO4	High	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
CO5	Medium	Medium	Medium	Medium	High	High	Low	Low	Medium	Medium
CO6	High	Medium	Medium	High	Medium	High	Medium	Low	Medium	Medium

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Course Title: **Linear Electronic Circuits-2**
Course Code: **253050604**

CO 1	Analyze the effects of negative feedback on transistor amplifier performance and describe various types of feedback circuits.
CO 2	Explain the principles and characteristics of Field Effect Transistors (FETs), including their operation and application in amplifiers.
CO 3	Design and implement arithmetic circuits for binary operations, including addition, subtraction, multiplication, and division.
CO 4	Evaluate the performance and limitations of different voltage regulation techniques in regulated power supplies.
CO 5	Describe the construction, operation, and applications of electronic instruments such as the Cathode Ray Oscilloscope (CRO).
CO 6	Analyze the functionality and design considerations of various transistor oscillators and their feedback mechanisms.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	High	Medium	Medium	Medium	Medium	Low	Medium	Medium	Low
CO3	Medium	Medium	High	Medium	Medium	Medium	High	Medium	Medium	Low
CO4	Medium	Medium	Medium	High	High	Medium	Low	Medium	Medium	Low
CO5	High	Medium	Medium	Medium	High	Medium	Medium	High	Medium	Medium
CO6	High	Medium	Medium	High	Medium	High	Medium	Low	Medium	Medium

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Course Title: **Physics Practicals**
Course Code: **253050605**

CO 1	Perform experiments to measure physical constants such as acceleration due to gravity and permeability of free space using various methods.
CO 2	Analyze electronic circuit behavior and component characteristics, including power transistors and operational amplifiers.
CO 3	Investigate the physical properties and applications of materials such as rubber tubing and ferromagnetic substances.
CO 4	Utilize optical instruments and techniques to calibrate spectrometers, determine interference patterns, and study absorption spectra.
CO 5	Execute and analyze experiments to determine fundamental quantities such as the charge on an electron and the dead time of a Geiger-Muller tube.
CO 6	Design and test various electronic circuits, including digital arithmetic units, multiplexers, and feedback amplifiers using operational amplifiers and transistors.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Medium	Low	Medium	Low	Medium	Low
CO2	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Low	Low
CO3	Medium	Medium	Medium	Low	High	Low	Low	Low	Medium	Low
CO4	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High	Low
CO5	High	Medium	Medium	Low	Medium	Low	Medium	Low	Low	Low
CO6	Medium	High	High	Medium	Medium	Medium	High	Medium	Medium	High

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Course Outcome for M.Sc. Courses

Department of Biotechnology

M.Sc. Semester I

Course Title: **Gene Structure and Function**

Course Code: **256010101**

CO 1	Understand the chemistry, structure, and forces stabilizing DNA, including Watson-Crick and Hoogsteen base pairing, and analyze the physical properties of dsDNA.
CO 2	Explain DNA topology, supercoiling, and the role of DNA topoisomerases in regulating DNA structure and gene expression in both prokaryotes and eukaryotes.
CO 3	Explore DNA-protein interactions, focusing on helix-turn-helix, B-sheet, and zinc finger motifs, and their roles in regulating genetic processes.
CO 4	Analyze the organization and packaging of DNA into chromosomes in prokaryotes and eukaryotes, including nucleosome assembly and chromatin modification.
CO 5	Describe the mechanisms of DNA replication, including the role of DNA polymerases, replisome assembly, telomerase function, and inhibitors of DNA replication.
CO 6	Evaluate the processes of transcription, translation, and gene regulation in prokaryotes and eukaryotes, focusing on operon models and posttranslational modifications.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	High	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO3	High	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO4	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	Medium
CO5	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO6	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	High

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Course Title: **Bioinstrumentation**

Course Code: **256010102**

CO 1	Understand the principles of electrochemistry, including pH, buffers, potentiometric and conductometric titrations, and their applications in biological systems.
CO 2	Explore the principles and applications of various microscopy techniques, such as light, electron, and fluorescence microscopy, along with sample preparation methods.
CO 3	Analyze the methodologies and applications of chromatography techniques, including gel-filtration, ion-exchange, affinity, thin layer, gas, and HPLC chromatography.
CO 4	Explain the principles and applications of electrophoresis techniques such as Native and SDS PAGE, agarose, and 2D gel electrophoresis for biomolecule separation.
CO 5	Evaluate the principles and applications of spectroscopy techniques (UV, IR, NMR, ESR) and their relevance in studying biomolecular structures and functions.
CO 6	Apply the principles of centrifugation, radioactive isotope techniques, and biosensors in biological research and biopolymer analysis, with emphasis on radiation dosimetry and tracer methods.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO3	High	High	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO4	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Medium
CO5	High	Medium	High	Medium	Medium	High	Medium	Medium	Medium	Medium
CO6	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	High

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Course Title: **Microbial Diversity**

Course Code: **256010103**

CO 1	Understand the principles and concepts of microbial diversity, including both culturable and non-culturable microbes and the methodologies to study them.
CO 2	Explore the principles of metagenomics and its role in understanding microbial diversity, as well as strategies for the conservation of microbial diversity.
CO 3	Analyze the metabolic diversity in bacteria and the systematics of various bacterial groups, with an emphasis on molecular and conventional approaches.
CO 4	Examine the diversity of actinomycetes, cyanobacteria, and fungi, focusing on their classification, reproduction, and ecological significance.
CO 5	Evaluate the systematics, occurrence, and adaptive features of different groups of archaea (Halophiles, Thermophiles, Alkalophiles, Acidophiles) and their applications.
CO 6	Assess the industrial and ecological roles of yeast, moulds, and mycorrhizal fungi, including their economic importance and contribution to various ecosystems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	High	High	High	Medium	Medium	Medium	Medium	Medium	High
CO3	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO4	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO5	High	Medium	High	Medium	High	Medium	Medium	Medium	Medium	High
CO6	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	High

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Course Title: **Biogeohydrotechnology and Biofuels**

Course Code: **256010104**

CO 1	Understand the classification and characterization of different types of waste and the principles and mechanisms involved in waste treatment.
CO 2	Analyze biological methods for treating liquid and solid waste, focusing on the principles and applications of these methods in waste management.
CO 3	Explore the marine environment, including bacterial diversity, and the cultivation and enumeration of marine bacteria for various applications.
CO 4	Apply indicators for marine microbial enzymes, polysaccharides, antimicrobial peptides, and carotenoids to assess their potential uses in marine biotechnology.
CO 5	Examine the processes of bioleaching, bio-oxidation, and biogeohydrotechnology for handling sulphidic minerals, including methods and factors affecting these processes.
CO 6	Evaluate fuel biotechnology concepts including types of energy resources, production of biofuels (biogas, bioethanol, biodiesel, bio-hydrogen), and their desirable and undesirable features, energy crops, and microbial enhanced oil recovery (MEOR).

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	High	High	Medium	Medium	Medium	Medium
CO2	High	High	High	High	High	High	High	Medium	Medium	Medium
CO3	Medium	High	High	Medium	Medium	High	Medium	Medium	Medium	Medium
CO4	Medium	Medium	Medium	High	Medium	High	Medium	Medium	Medium	Low
CO5	High	High	Medium	High	High	High	Medium	Medium	High	Medium
CO6	High	Medium	Medium	High	High	High	Medium	Medium	Medium	High

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Course Title: **Biotechnology Practicals**

Course Code: **256010105**

CO 1	**Manipulate** basic laboratory instruments and **perform** sterilization and decontamination of lab equipment and media with precision and adherence to safety protocols.
CO 2	**Execute** Gram staining procedures for bacterial identification and **apply** the Folin Lowry method for protein estimation, demonstrating accurate technique.
CO 3	**Carry out** carbohydrate quantification using the Coles method and **conduct** DNA quantification using the DPA method, ensuring careful sample handling and measurement.
CO 4	**Operate** Agarose Gel Electrophoresis for DNA analysis and **isolate** Actinomycetes and fungi from samples using appropriate culturing techniques.
CO 5	**Cultivate** yeast cultures and **demonstrate** the process of column chromatography packing, ensuring the correct setup for effective separation.
CO 6	**Assess** the physical characteristics of wastewater, **measure** phosphate levels, and **isolate** antibiotic-resistant mutants using the replica plate technique, applying experimental accuracy and precision.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	Low	High	Medium	Medium	Medium	Low
CO2	Medium	Medium	Medium	High	Low	Medium	Medium	Medium	Medium	Low
CO3	High	Medium	Medium	Medium	Low	High	Medium	Medium	Medium	Low
CO4	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Low
CO5	Medium	Medium	Medium	High	Low	High	Medium	Medium	Medium	Low
CO6	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Medium

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M.Sc. Semester II

Course Title: **Microbial Genetics**

Course Code: **256010201**

CO 1	Explain the types, mechanisms, and repair pathways of mutations, including spontaneous mutations, DNA damage, and repair systems.
CO 2	Describe plasmid biology, including types, replication, control of copy number, and plasmid segregation.
CO 3	Discuss the principles of recombination, including homologous and site-specific recombination, and their biological roles.
CO 4	Analyze bacterial conjugation, focusing on processes involving the F-factor, Hfr conjugation, and plasmid-based conjugation.
CO 5	Understand Agrobacterium genetics, including Ti-plasmid function and interkingdom gene transfer mechanisms.
CO 6	Explore transformation and transduction mechanisms in bacteria and viruses, including applications and measurement techniques.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO2	High	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Low
CO3	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO4	Medium	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Low
CO5	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO6	Medium	Medium	Medium	High	Medium	High	Medium	Medium	Medium	Low

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Course Title: **Immunology**

Course Code: **256010202**

CO 1	Understand the principles of innate and adaptive immunity, including inflammation, roles of cells, receptors, and proteins.
CO 2	Describe the cells and organs of the immune system, including hematopoiesis and the function of primary and secondary lymphoid organs.
CO 3	Explain the properties of antigens and antibodies, including their structure, classes, biological activities, and antibody diversity.
CO 4	Analyze antigen-antibody interactions and the complement system, including its components, activation, regulation, and related diseases.
CO 5	Discuss the Major Histocompatibility Complex (MHC) and its role in antigen presentation, including MHC organization, antigen processing, and disease susceptibility.
CO 6	Explore T-cell and B-cell maturation, activation, differentiation, cytokines, and the mechanisms of cell-mediated cytotoxicity, hypersensitivity, and immune tolerance.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO2	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO3	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO4	Medium	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO5	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO6	High	Medium	High	Medium	Medium	High	Medium	Medium	Medium	Low

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Course Title: **Bioprocess Technology**

Course Code: **256010203**

CO 1	Understand the principles of isolation, preservation, and improvement of industrially important microorganisms.
CO 2	Describe substrates for fermentation processes and methods for medium optimization.
CO 3	Explain bioreactor design, including laboratory, pilot, and large-scale reactors, as well as sterilization of media and air.
CO 4	Discuss mass transfer of oxygen in bioprocesses, including agitation, aeration, determination of KLa, and factors affecting it.
CO 5	Analyze bioprocess kinetics, focusing on growth and substrate utilization in batch, fed-batch, and continuous systems.
CO 6	Explore the control of process parameters, including instrumentation, sensors, controllers, fermentation control systems, and dynamic modeling of fermentation processes.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO2	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO3	High	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO4	Medium	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Low
CO5	Medium	Medium	High	Medium	High	Medium	Medium	Medium	Medium	Low
CO6	Medium	Medium	High	Medium	Medium	High	Medium	Medium	Medium	Low

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Course Title: **Tools and techniques in synthetic microbiology**

Course Code: **256010204**

CO 1	Understand the principles of light microscopy, including optical corrections, types of objectives, oculars, and illumination methods.
CO 2	Differentiate between types of light microscopes (bright field, dark field, fluorescence, phase contrast, polarizing, differential interference contrast) and understand micrometry.
CO 3	Describe the basic components of electron microscopes, including thermionic and field emission electron guns, and differentiate between TEM, SEM, STEM, ESEM, and HVEM.
CO 4	Explain fixation and storage techniques, including classification of fixatives, procedures, and factors affecting fixation for plant, animal, and microbial samples.
CO 5	Demonstrate preparation techniques for biological samples for light and electron microscopy, including sectioning, staining, and photomicrography.
CO 6	Apply histochemical and cytochemical techniques to localize metabolites, enzymes, and ultra-structural components in biological samples, including immunocytochemistry.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	High	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low	Low
CO2	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low
CO3	High	Medium	High	Medium	Medium	High	Medium	Medium	Medium	Low
CO4	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low
CO5	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium	Low	Low
CO6	Medium	Medium	High	High	Medium	High	Medium	Medium	Low	Low

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Course Title: **Biotechnology Practicals**

Course Code: **256010205**

CO 1	Perform cell wall and spirochete staining techniques with precision, and isolate and identify fungi and soil bacteria (actinomycetes).
CO 2	Skillfully conduct endospore staining and primary screening for amylase producers, and apply the encapsulation technique for yeast cell immobilization.
CO 3	Proficiently carry out fermentation processes for alcohol and amylase production, and determine amylase activity and ethanol concentration in samples.
CO 4	Demonstrate techniques such as agglutination, paper chromatography, and the serodiagnosis of diseases like syphilis (RPR test) and enteric fever (Widal test).
CO 5	Develop expertise in enzyme immobilization, sauerkraut production, double immunodiffusion (ring test), and studying biodeterioration of given samples.
CO 6	Execute advanced laboratory techniques such as HPLC, gas chromatography, and agarose gel electrophoresis with accuracy and precision.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	Low	High	Medium	Medium	Medium	Low
CO2	Medium	Medium	High	High	Low	High	Medium	Medium	Medium	Low
CO3	High	Medium	High	High	Low	High	Medium	Medium	Medium	Medium
CO4	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Low
CO5	High	Medium	High	Medium	Low	High	Medium	Medium	Medium	Low
CO6	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium

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M.Sc. Semester III

Course Title: **Microbial Biotechnology**

Course Code: **256010301**

CO 1	Understand the microbial production processes for primary metabolites such as amino acids (glutamic acid, lysine), enzymes (proteases, amylases), organic acids (citric acid, acetic acid), and industrial alcohol.
CO 2	Explain the production methods and applications of secondary metabolites, including antibiotics (penicillin, streptomycin), vitamins (B12, B2), ergot alkaloids, and carotenoid pigments (β-carotene, lycopene).
CO 3	Describe microbial production techniques for other products and biotransformation, including microbial polysaccharides (xanthan, alginate, dextran), beverages (beer, wine), polyhydroxyalkanoates (PHA, PHB), biosurfactants, and steroid transformation.
CO 4	Analyze the methods and applications of fungal biomass production, including baker's yeast and single cell oil, and evaluate their industrial uses.
CO 5	Discuss mushroom cultivation techniques and the use of algal biomass, including their applications in various industries.
CO 6	Identify the microbial production techniques for food and feed, emphasizing their benefits and challenges in industrial settings.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO2	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO3	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Medium
CO4	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO5	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO6	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium

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Course Title: **Enzymology**

Course Code: **256010302**

CO 1	Understand the historical developments in enzymology, protein structure (primary, secondary, tertiary, and quaternary), and the techniques used in enzyme characterization.
CO 2	Explain enzyme classification according to the IUB system, and describe the principles and techniques of enzymatic analysis, including factors affecting enzyme activity, extraction, and purification strategies.
CO 3	Analyze enzyme kinetics, including single substrate kinetics (equilibrium and steady-state kinetics, Km, Vmax, Kcat), multisubstrate kinetics (general rate equations, mechanisms), and thermal kinetics (temperature effects, Arrhenius equation).
CO 4	Discuss enzyme inhibition and its kinetics, covering reversible and irreversible inhibition, competitive, noncompetitive, uncompetitive, mixed, partial, substrate, and allosteric inhibition.
CO 5	Describe the mechanisms of enzyme action, including enzyme activators, coenzymes, cofactors, specificity, and experimental approaches to determining enzyme mechanisms. Analyze specific enzyme mechanisms and allosteric regulation.
CO 6	Explore enzyme engineering techniques, including chemical modification of enzymes, enzyme immobilization, the use of enzymes in non-conventional media, enzyme sensors, and their applications as analytical reagents.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO2	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO3	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO4	Medium	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO5	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Medium
CO6	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	Medium

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Course Title: **r-DNA technology**

Course Code: **256010303**

CO 1	Understand the concept and importance of genetic engineering, including general strategies, steps involved in gene cloning, and the extraction and purification of DNA from bacterial, plant, and animal cells.
CO 2	Describe the roles of restriction enzymes, DNA ligase, and other enzymes in gene cloning, and explain the processes of mRNA and cDNA preparation.
CO 3	Explain the chemical synthesis of genes and DNA cloning and expression vectors, including plasmids, bacteriophages, phagemids, cosmids, YACs, BACs, and MACs, and the expression of cloned genes in heterologous hosts.
CO 4	Outline the techniques for recombinant selection and screening, including Southern blotting, Northern analysis, Western blotting, various electrophoresis methods, and protein activity assays (e.g., yeast-one hybrid, yeast-two hybrid).
CO 5	Discuss advanced methods for gene characterization and mapping, such as restriction mapping, DNA sequencing, nucleic acid microarrays, metagenomics, and gene therapy, as well as molecular markers and genomic mapping techniques.
CO 6	Analyze recombinant products, including recombinant hormones, DNA vaccines, transgenic plants and animals, and understand the guidelines for genetic engineering, including physical and biological containment levels and Indian guidelines.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
CO3	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO4	Medium	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO5	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Medium
CO6	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	High

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Course Title: **Animal Tissue Culture and Pharmaceutical Biotechnology**

Course Code: **256010304**

CO 1	Understand the principles of animal tissue culture, including primary culture and established cell line cultures, equipment and material for cell technology, basic media and techniques, and manipulation and application of animal cell culture.
CO 2	Analyze bioprocess economics, including expenses for industrial materials, equipment, product recovery, effluent treatments, cost recovery from waste usage and recycling, and the principles of IPR and patent processes.
CO 3	Describe the benefits, problems, and management of IPR, international harmonization of patent law, and the protection of biotechnological processes, with a focus on the Indian scenario.
CO 4	Explain regulatory affairs related to pharmacopoeia, good microbiological techniques, good laboratory practice (GLP), quality control (QA) and quality assurance (QC), validation studies, and the roles of culture collection centres and regulatory agencies.
CO 5	Discuss biosafety and bioethics, including biosafety guidelines, risk assessment, biosafety levels, laboratory biosecurity concepts, drug design, pre-clinical and clinical trials, and bioethics principles, including international codes and guidelines in India.
CO 6	Evaluate the ethical considerations and guidelines in the post-genomic era, and understand the implications for biosafety and bioethics in modern research and applications.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO3	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO4	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
CO5	High	Medium	Medium	High	Medium	Medium	High	Medium	Medium	Medium
CO6	Medium	Medium	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium

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Course Title: **Biotechnology Practicals**

Course Code: **256010305**

CO 1	Understand the principles of animal tissue culture, including primary culture and established cell line cultures, equipment and material for cell technology, basic media and techniques, and manipulation and application of animal cell culture.
CO 2	Analyze bioprocess economics, including expenses for industrial materials, equipment, product recovery, effluent treatments, cost recovery from waste usage and recycling, and the principles of IPR and patent processes.
CO 3	Describe the benefits, problems, and management of IPR, international harmonization of patent law, and the protection of biotechnological processes, with a focus on the Indian scenario.
CO 4	Explain regulatory affairs related to pharmacopoeia, good microbiological techniques, good laboratory practice (GLP), quality control (QA) and quality assurance (QC), validation studies, and the roles of culture collection centres and regulatory agencies.
CO 5	Discuss biosafety and bioethics, including biosafety guidelines, risk assessment, biosafety levels, laboratory biosecurity concepts, drug design, pre-clinical and clinical trials, and bioethics principles, including international codes and guidelines in India.
CO 6	Evaluate the ethical considerations and guidelines in the post-genomic era, and understand the implications for biosafety and bioethics in modern research and applications.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO3	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO4	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
CO5	High	Medium	Medium	High	Medium	Medium	High	Medium	Medium	Medium
CO6	Medium	Medium	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium

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M.Sc. Semester IV

Course Title: **Plant Biotechnology**

Course Code: **256010401**

CO 1	Understand the principles and techniques of cell and tissue culture in plants, including callus cultures, in-vitro morphogenesis, organogenesis, embryogenesis, artificial seeds, micropropagation, and haploidy.
CO 2	Describe the methods for protoplast isolation, culture, fusion, somatic hybridization, and cybrids, and explain somaclonal variation, in-vitro mutation methods, virus elimination, pathogen indexing, and cryopreservation.
CO 3	Analyze the production of secondary metabolites in plants, including sources, criteria for cell selection, factors affecting culture, bioreactors used, biochemical pathways, and biotransformation processes.
CO 4	Explain the principles and methods of genetic engineering in agriculture, including genetic transformation techniques such as Agrobacterium tumefaciens, A. rhizogenes, PEG-mediated transformation, microinjection, particle bombardment, and electroporation.
CO 5	Discuss the importance of molecular markers in plant breeding, including Marker Assisted Selection (MAS) and the use of molecular markers for genetic transformation and transgenic plant production.
CO 6	Examine molecular plant pathology, focusing on mechanisms of disease resistance, signaling pathways, and molecular events during pathogen-plant interactions, and understand the implications of biotechnology and intellectual property rights (IPR) in plant genetic resources.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO2	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO3	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO4	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO5	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium
CO6	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High

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Course Title: **Environmental Biotechnology**

Course Code: **256010402**

CO 1	Understand environmental monitoring techniques, including the use of bio-indicators, biomarkers, biosensors, and toxicity testing, and analyze environmental impacts, conservation strategies, and environmental laws and policies in India.
CO 2	Explain the principles and strategies of bioremediation, including in situ and ex situ techniques, and discuss bioremediation of metals, phytoremediation, and the role and impact of GMOs in bioremediation processes.
CO 3	Describe the principles of biodegradation and mechanisms of detoxification, focusing on the biodegradation of detergents, pesticides, lignin, hydrocarbons, and dyes.
CO 4	Analyze the principles and mechanisms of biodeterioration, including methodologies for assessing biodeterioration and strategies for its prevention and control.
CO 5	Evaluate the environmental impacts of various pollutants and the effectiveness of different bioremediation and biodegradation techniques in mitigating these impacts.
CO 6	Discuss the integration of rDNA technology in environmental monitoring and bioremediation, and understand the role of conservation strategies and environmental policies in addressing environmental problems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High
CO2	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
CO3	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO4	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO5	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High
CO6	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High

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Course Title: **Biotechnology Practicals**

Course Code: **256010403**

CO 1	Demonstrate Polymerase Chain Reaction (PCR) and perform Agarose Gel Electrophoresis.
CO 2	Estimate sulfate, Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), and chloride in given samples.
CO 3	Study dye degradation and analyze the results.
CO 4	Isolate DNA and RNA from given samples.
CO 5	Perform Native SDS-PAGE for protein analysis.
CO 6	Apply and interpret techniques for nucleic acid and protein isolation and analysis.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Low	High	Medium	Medium	Medium	Low
CO2	Medium	Low	Medium	Medium	Low	Medium	Medium	Medium	Low	Low
CO3	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low	Low
CO4	Medium	Medium	Medium	High	Low	High	Medium	Medium	Medium	Low
CO5	Medium	Medium	Medium	High	Low	High	Medium	Medium	Medium	Low
CO6	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Low

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Department of Chemistry
M.Sc Semester-I

Course Title: **Organic Chemistry -I**
Course Code: **256020101**

CO 1	Understand the E1, E2, E1CB elimination reaction mechanisms, stereo chemistry, and factors affecting reactivity and orientation
CO 2	Analyze mixed SN1, SN2, SET mechanisms and nucleophilic substitution, focusing on substrate structures and stereochemistry.
CO 3	Explain the concept of aromaticity using resonance, Huckel's rule, and molecular orbitals, and distinguish between aromatic, anti-aromatic, and homoaromatic compounds
CO 4	Understand acid-base concepts, pKa, and the effect of structure on acidity and basicity.
CO 5	Examine the structure, stability, and fate of reactive intermediates such as carbocations, carbanions, carbenes, free radicals, and nitrenes
CO 6	Analyze carbon-carbon and carbon-nitrogen migration reactions, including pinacol-pinacolone, Curtius, Schmidt, and Baeyer-Villiger rearrangements

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Low	High	High	Low	High	High	Low	High	Medium
CO2	High	Low	Low	High	Low	Medium	High	Medium	High	Medium
CO3	High	Medium	Medium	Low	Medium	Medium	Low	High	Low	High
CO4	High	High	High	Low	High	High	Medium	Low	Low	High
CO5	High	Low	High	High	High	High	Medium	Low	Low	Low
CO6	High	Medium	Low	High	Low	Low	Low	Medium	Low	Low

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Course Title**: Inorganic Chemistry -I**
Course Code: **256020102**

CO 1	Understand and apply the principles of quantum mechanics to atomic structure, including solving Schrödinger wave equations and interpreting hydrogenic orbitals.
CO 2	Analyze and apply group theory to molecular symmetry, focusing on character tables and their relevance to physical and chemical properties.
CO 3	Evaluate the principles of magnetochemistry, understanding Curie and Curie-Weiss laws and analyzing diamagnetic and antiferromagnetic properties in materials.
CO 4	Apply the concept of metalloporphyrins and bio-inorganic chemistry to understand their role in biological systems, such as hemoglobin, myoglobin, and enzymes.
CO 5	Investigate coordination compounds used in medicine, focusing on chelation therapy, platinum-based anticancer drugs, and radiodiagnostic agents.
CO 6	Develop skills in the use of approximation methods in quantum mechanics, including the variation method and perturbation theory, applied to atomic systems.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	High	High	High	low	Medium	High	low	Low	medium	High
CO2	High	high	medium	Medium	Medium	High	low	high	medium	High
CO3	High	low	High	low	low	High	medium	High	low	medium
CO4	High	low	medium	high	High	Medium	high	low	High	medium
CO5	High	medium	Medium	low	low	low	medium	High	High	medium
CO6	High	High	low	High	low	medium	Low	Medium	medium	medium

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Course Title: **Physical Chemistry - I**
Course Code: **256020103**

CO 1	Understand and apply the principles of quantum mechanics to atomic structure, including solving Schrödinger wave equations and interpreting hydrogenic orbitals.
CO 2	Analyze and apply group theory to molecular symmetry, focusing on character tables and their relevance to physical and chemical properties.
CO 3	Evaluate the principles of magnetochemistry, understanding Curie and Curie-Weiss laws and analyzing diamagnetic and antiferromagnetic properties in materials.
CO 4	Apply the concept of metalloporphyrins and bio-inorganic chemistry to understand their role in biological systems, such as hemoglobin, myoglobin, and enzymes.
CO 5	Investigate coordination compounds used in medicine, focusing on chelation therapy, platinum-based anticancer drugs, and radiodiagnostic agents.
CO 6	Develop skills in the use of approximation methods in quantum mechanics, including the variation method and perturbation theory, applied to atomic systems.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	Medium	Medium	Low	Medium	Low	High	Medium	Low	Medium	Low
CO2	Low	High	High	Low	High	Medium	Low	Medium	Low	High
CO3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO4	Low	Low	Medium	Low	High	Low	Medium	Medium	Medium	Low
CO5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: **Analytical Chemistry - I**
Course Code: **256020104**

CO 1	Understand the scope of analytical science, qualitative/quantitative analysis, and data handling.
CO 2	Learn error analysis, significance testing, and precision/accuracy in experimental results.
CO 3	Develop competence in GLP, standard operating procedures, and quality control/assurance.
CO 4	Understand sampling, calibration methods, and calibration curve construction.
CO 5	Demonstrate mastery in spectrophotometry fundamentals, including Beer's law and photometric accuracy
CO 6	Apply advanced spectrophotometric techniques to real-world problems such as equilibrium constant measurement.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	High	Low	High	Low	Low	Medium	Low	High	Low	Medium
CO2	Medium	Medium	Low	Medium	Low	Low	Medium	Low	Medium	Low
CO3	Low	Low	High	Low	Medium	Medium	Low	High	Low	Medium
CO4	Low	Medium	Medium	Low	High	Low	Medium	Medium	Low	Low
CO5	High	Low	Low	High	Low	Medium	Low	Low	High	Medium
CO6	High	High	High	High	Medium	High	High	High	High	High

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Course Title: **Chemistry Practical**

Course Code: **256020105**

CO 1	Understand the mechanisms and applications of nitration, bromination, and acylation reactions.
CO 2	Demonstrate the reduction and oxidation reactions and analyze their role in organic synthesis
CO 3	Gain proficiency in condensation reactions (Aldol, Cannizzaro) and their synthetic importance.
CO 4	Conduct diazotization and Friedel-Crafts reactions, understanding their industrial and lab applications.
CO 5	Master experimental techniques for the synthesis of organic compounds through various methodologies.
CO 6	Develop innovative approaches to solving organic chemistry problems through reaction mechanism analysis

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Low	High	Low	High	Medium	Low	High	Low
CO2	Low	High	High	Low	High	Medium	Low	Medium	Low	Medium
CO3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO4	Low	Medium	Medium	Low	High	Low	High	Medium	Medium	Low
CO5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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M.Sc Semester-II

Course Title: **Organic Chemistry -II**

Course Code: **256020201**

CO 1	Demonstrate expertise in spectroscopy and heterocyclic chemistry, including detailed knowledge of structure determination and photochemistry.
CO 2	Perform independent research on mass spectrometry fragmentation patterns and advanced organic reactions.
CO 3	Analyze the reactivity of heterocycles and stereochemistry in organic compounds, focusing on specific reagents and reaction mechanisms.
CO 4	Solve complex reaction mechanisms related to photochemical and heterocyclic reactions, employing advanced problem-solving techniques.
CO 5	Utilize spectroscopy techniques (NMR, IR, UV) in structure determination, particularly with heterocyclic compounds and functional groups.
CO 6	Demonstrate effective communication of scientific results through written reports on spectroscopy and organic reactions, adhering to professional standards.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	Medium	Low	Medium	Low	High	Medium	Low	Medium	Low
CO2	Low	High	High	Low	High	Medium	Low	Medium	Low	High
CO3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO4	Low	Low	Medium	Low	High	Low	Medium	Medium	Medium	Low
CO5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: **Inorganic Chemistry -II**
Course Code: 256020202

CO 1	Demonstrate comprehensive understanding of chemical bonding theories.
CO 2	Apply symmetry principles to molecular orbitals, IR/Raman spectral data interpretation, and hybrid orbital formation.
CO 3	Understand the structure and reactivity of organometallic compounds, especially π-bonded and electron-ligand complexes.
CO 4	Analyze reaction mechanisms in square planar complexes and electron transfer processes in oxidation-reduction reactions.
CO 5	Demonstrate problem-solving skills in analyzing kinetic effects in substitution reactions and electron transfer mechanisms.
CO 6	Effectively communicate the applications of chemical bonding, organometallic chemistry, and reaction mechanisms in catalysis and materials science.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Low	High	Low	High	Medium	Low	High	Low
CO2	Low	High	High	Low	High	Medium	Low	Medium	Low	Medium
CO3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO4	Low	Medium	Medium	Low	High	Low	High	Medium	Medium	Low
CO5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: **Physical Chemistry -II**

Course Code: 256020203

CO 1	Understand the distribution of molecules and thermodynamic probability in statistical thermodynamics.
CO 2	Apply nuclear chemistry principles to nuclear models, radioactive decay, and nuclear reactions.
CO 3	Analyze the kinetics and mechanisms of polymerization processes, and the properties of polymers.
CO 4	Conduct experiments to determine dissociation constants and apply electrochemical principles to real-world problems
CO 5	Demonstrate proficiency in using laboratory tools for the characterization of polymers and electrochemical measurements.
CO 6	Effectively communicate the principles and findings in statistical thermodynamics, nuclear chemistry, polymer chemistry, and electrochemistry.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO 3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	Medium	Medium	Low	Medium	Low	High	Medium	Low	Medium	Low
CO2	Low	High	High	Low	High	Medium	Low	Medium	Low	High
CO3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO4	Low	Low	Medium	Low	High	Low	Medium	Medium	Medium	Low
CO5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: Analytic Chemistry-II
Course Code: 256020204

CO 1	focuses on the distribution of molecules and thermodynamic probability in statistical thermodynamics. This requires a strong understanding of theoretical principles and contributes to interdisciplinary knowledge
CO 2	Involves applying concepts from nuclear chemistry, such as nuclear models, radioactive decay, and nuclear reactions, which aligns well with advanced knowledge , critical analysis , and interdisciplinary integration
CO 3	Relates to the kinetics and mechanism of polymer processes in polymer chemistry, as well as the characterization of polymers. This outcome emphasizes problem-solving , critical analysis , and technical expertise .
CO 4	Involves electrochemical experiments, including the determination of dissociation constants through conductometry and potentiometry, which correlates strongly with research competency , technical expertise , and problem-solving.
CO 5	emphasizes the practical use of laboratory tools for polymer characterization and electrochemical measurements, focusing on technical skills , research competency , and problem-solving.
CO 6	ddresses the ability to communicate findings in statistical thermodynamics, nuclear chemistry, polymer chemistry, and electrochemistry. This relates to scientific communication and interdisciplinary integration

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	Medium	Low	Medium	Low	High	Medium	Low	Medium	Low
CO2	Low	High	High	Low	High	Medium	Low	Medium	Low	High
CO3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO4	Low	Low	Medium	Low	High	Low	Medium	Medium	Medium	Low
CO5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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Course Title: Chemistry Practical

Course Code: **256020205**

CO 1	Perform the analysis and separation of mixtures (solid) using physical and chemical methods.
CO 2	Conduct conductometric, potentiometric, and pH-metric titrations to verify theoretical principles like Ostwald's Law.
CO 3	Apply principles of adsorption, kinetics, and distribution methods to determine reaction orders and complex formulas.
CO 4	Perform the analysis and separation of mixtures (liquid) using physical and chemical methods.
CO 5	Estimate the saponification, iodine, and acid values of oils and perform EDTA titrations for simultaneous estimations
CO 6	Separate amino acids, drugs, and dyes using thin layer chromatography (TLC) and interpret results effectively.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	High	Medium	Low	High	Low	High	Medium	Low	High	Low
CO2	Low	High	High	Low	High	Medium	Low	Medium	Low	Medium
CO3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO4	Low	Medium	Medium	Low	High	Low	High	Medium	Medium	Low
CO5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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MSc Semester III

Course Title: **Natural Products and Bio molecules**

Course Code: 256020301

CO 1	Understand the general classification and biosynthesis of natural pigments like anthocyanins, flavones, and flavanols.
CO 2	Study the chemistry, synthesis, and biochemical role of alkaloids and vitamins like quinine, vitamin B, and vitamin C.
CO 3	Explore the structure, stereochemistry, and biochemical role of steroids and hormones, including cholesterol, androgens, estrogens, and gestrogens.
CO 4	Analyze the structure and synthesis of terpenoids and carotenoids, including compounds like abietic acid, farnesol, and squalene.
CO 5	Demonstrate the ability to apply general methods of structure determination in natural compounds and steroids.
CO 6	nvestigate biosynthetic pathways of terpenoids, steroids, and alkaloids through theoretical and experimental research, and develop methods for solving advanced biochemical problems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Low	Medium	High	Low	High	Low	Medium	High	High
CO2	Medium	High	Low	Low	Low	Medium	High	Low	Low	Low
CO3	Low	Medium	Medium	High	Medium	Low	Medium	Medium	High	High
CO4	Low	Medium	High	Low	High	Low	Medium	High	Low	Low
CO5	High	Low	Low	High	Medium	High	Low	Low	High	High
CO6	Medium	Medium	High	Low	Low	Medium	Medium	High	Low	Low

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Course Title: Medicinal Chemistry

Course Code: 256020304

CO 1	Understand the structures and mechanisms of antibiotics that interfere with bacterial cell wall biosynthesis, including β-lactam antibiotics (penicillin and cephalosporin) and non-lactam antibiotics.
CO 2	Analyze the SAR (structure-activity relationship) of penicillins and tetracyclines, and study antibiotics that interfere with protein biosynthesis like tetracycline and chloramphenicol.
CO 3	Study psychoactive drugs, including CNS depressants (general and local anesthetics, sedatives, and hypnotics), and explore the synthesis of thiopental, diazepam, lidocaine, and other relevant drugs.
CO 4	Investigate modern chemotherapy for malaria, including the synthesis and SAR of antimalarial drugs such as chloroquine, primaquine, and mefloquine, and explore their modes of action.
CO 5	Analyze the synthesis and biochemical roles of antituberculosis drugs like isoniazid, ethionamide, and ethambutol, as well as their pharmacological implications in tuberculosis treatment.
CO 6	Examine cardiovascular drugs, diuretics, and hypoglycemic agents, including the synthesis of atenolol, diltiazem, tolbutamide, and others, and understand their role in treating cardiovascular and metabolic diseases.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	High	Low	High	Low	Medium	Medium	High
CO2	High	Low	Medium	Medium	Medium	Low	Low	High	Low	Medium
CO3	Low	High	Low	Medium	High	Medium	High	High	High	Low
CO4	Medium	Low	Low	High	High	Low	Medium	Medium	Low	Low
CO5	Low	High	Low	Medium	Low	High	Low	Medium	High	Low
CO6	Medium	Low	Low	High	Medium	Low	Low	High	Low	Low

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Course Title: **Organic Spectroscopy**

Course Code: 256020305

CO 1	List the different types of errors in analytical chemistry
CO 2	Explain the significance of accuracy, precision, and sensitivity in analytical measurements.
CO 3	Calculate the standard deviation and confidence interval for a set of analytical data.
CO 4	Analyze a data set to identify possible sources of error and suggest ways to minimize them.
CO 5	Evaluate the reliability and validity of analytical data by comparing it with known standards.
CO 6	Develop a protocol for the systematic treatment of errors in a new analytical method.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Low	High	Low	Low	Medium	Low	High	Low	Medium
CO2	Medium	Medium	Low	Medium	Low	Low	Medium	Low	Medium	Low
CO3	Low	Low	High	Low	Medium	Medium	Low	High	Low	Medium
CO4	Low	Medium	Medium	Low	High	Low	Medium	Medium	Low	Low
CO5	High	Low	Low	High	Low	Medium	Low	Low	High	Medium
CO6	High	High	High	High	Medium	High	High	High	High	High

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Course Title**: Industrial Chemsitry**
Course Code: 256020304

CO 1	Understand basic chemical data, batch vs continuous operations, process design, and flow charts for chemical process selection and safety management.
CO 2	Apply the principles of nitration, sulfonation, halogenation, amination, and alkylation in industrial processes, especially for chemicals derived from benzene, naphthalene, and anthracene.
CO 3	Analyze and understand the 12 principles of Green Chemistry and apply them in the development of sustainable chemical processes.
CO 4	Explore the use of green solvents like ionic liquids in aqueous phase reactions and Wurtz, Wittig-Horner, and Michael reactions, and their industrial applications.
CO 5	Understand the role of green catalysts and reagents in promoting sustainable reactions such as hydrogenation, Diels-Alder, o-alkylation, and N-alkylation.
CO 6	Study the manufacture and uses of agrochemicals such as insecticides, fungicides, weedicides, pesticides, plant nutrients, and hormones, focusing on sustainability and environmental impact.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	High	Low	High	Low	Medium	Medium	High
CO2	High	Low	Medium	Medium	Medium	Low	Low	High	Low	Medium
CO3	Low	High	Low	Medium	High	Medium	High	High	High	Low
CO4	Medium	Low	Low	High	High	Low	Medium	Medium	Low	Low
CO5	Low	High	Low	Medium	Low	High	Low	Medium	High	Low
CO6	Medium	Low	Low	High	Medium	Low	Low	High	Low	Low

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Course Title :**Organic Chemistry Practicals**
Course Code: 256020305

CO 1	Analyze kinetics data using various methods and interpret solubility equilibrium data to assess factors affecting solubility in inorganic compounds.
CO 2	Explain the impact of factors like temperature, catalysts, and concentration on reaction rates, and the role of solubility equilibria in solutions.
CO 3	Use integrated rate laws and solubility principles to solve problems involving reaction kinetics and solubility equilibria.
CO 4	Apply solubility rules, precipitation methods, and flame tests to distinguish between different cations and anions in inorganic mixtures.
CO 5	Analyze and interpret qualitative tests and separate ions based on chemical properties in complex inorganic mixtures.
CO 6	Recall principles of cation and anion analysis, along with reagents and general procedures in inorganic qualitative analysis.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Low	High	Low	High	Medium	Low	High	Low
CO2	Low	High	High	Low	High	Medium	Low	Medium	Low	Medium
CO3	Medium	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low
CO4	Low	Medium	Medium	Low	High	Low	High	Medium	Medium	Low
CO5	High	High	High	Medium	Low	High	Medium	Low	Low	High
CO6	Medium	Medium	Low	High	Medium	Medium	Low	High	High	High

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M.Sc Semester-IV

Course Title: **Advanced Organic Chemistry**

Course Code: **256020401**

CO 1	Understand and apply the Sandmeyer reaction, including its mechanism, purification, and characterization of products.
CO 2	Study and apply the Pechmann reaction, Skraup synthesis, Riemer-Tiemann reaction, Kolbe-Smith reaction, and Claisen-Smith synthesis .
CO 3	Analyze and apply the Hofmann reaction, Diels-Alder reaction, and Green bromination, including their mechanisms and product characterization.
CO 4	Perform drug assays including the estimation of sulpha drugs, understanding its significance and methodology.
CO 5	Apply non-aqueous titration, nitrite value estimation, and drug dissolution techniques in pharmaceutical analysis
CO 6	Integrate preparation techniques and estimation methods to solve complex problems in industrial and pharmaceutical chemistry.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	High	Medium	High	Medium	Low	Low	High	Medium	High	Medium
CO2	High	Medium	High	Medium	High	Medium	High	Medium	Low	Low
CO3	Low	Low	Low	Low	High	Medium	High	Medium	Low	Low
CO4	Medium	High	High	Medium	High	Medium	Medium	Low	High	High
CO5	Low	High	Medium	High	Medium	High	Medium	High	Medium	High
CO6	High	Medium	High	Medium	High	High	Low	High	High	Low

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Course Title: **Advanced Organic Synthesis**

Course Code: **256020402**

CO 1	Understand the principle of protecting functional groups (hydroxyl, amino, carbonyl, carboxylic acid) and apply methods of protection and deprotection in complex syntheses.
CO 2	Apply synthetic equivalent groups and carry out synthetic analysis and planning, controlling stereochemistry in multi-step reactions.
CO 3	Use the disconnection approach to design synthesis pathways, including functional group inter-conversions, and plan selective disconnections of C-X bonds.
CO 4	Apply C-C disconnections to alcohol and carbonyl compounds, and explore regioselectivity and the use of aliphatic nitro compounds in organic synthesis.
CO 5	Synthesize saturated heterocycles (3-6 membered rings) and aromatic heterocycles, understanding the stereochemistry and regioselectivity of ring closure reactions.
CO 6	Integrate protection, disconnection, and ring synthesis strategies to plan and execute complex organic syntheses, controlling stereochemistry and functional group interactions.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	High	Low	Low	Medium	Low	High
CO2	High	Medium	High	Medium	Low	High	Medium	High	Medium	Medium
CO3	Low	High	Medium	High	Medium	Low	High	Low	High	Low
CO4	Low	High	Low	Low	High	Medium	Medium	High	Low	High
CO5	Low	Low	High	Medium	Medium	Low	High	Medium	Medium	Low
CO6	High	Medium	Medium	Low	High	Low	Low	Low	High	Medium

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Course Title: **Bio -Organic Chemistry**

Course Code: **256020403**

CO 1	Understand the role of water in biological systems, including interactions among biomolecules, buffering systems, and its participation in biological reactions.
CO 2	Explore the chemistry and biochemical functions of vitamins (A, D, E, K, C, B complex, H, and folic acid) in absorption, transport, and mobilization.
CO 3	Examine protein properties, stereochemistry, peptide formation, separation and sequencing of proteins, and the roles of oxygen-binding proteins (hemoglobin and myoglobin).
CO 4	Analyze enzyme activity, catalytic specificity, regulation, and inhibition through key examples like chymotrypsin, hexokinase, and lysozyme.
CO 5	Understand carbohydrate structure and classification, biologically important derivatives, and the roles of glucoconjugates in biological systems.
CO 6	Investigate the structure and properties of lipids, including fatty acids, triacylglycerols, membrane lipids, and bile acids, and their roles in biological systems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	High	Medium	Medium	Low	Medium	Medium
CO2	High	Medium	High	Medium	High	Medium	Medium	High	Medium	Medium
CO3	High	Medium	High	High	Medium	Medium	Low	High	Medium	Medium
CO4	High	Medium	High	Low	High	Low	Low	Medium	High	Low
CO5	High	Medium	High	Medium	Low	High	High	Medium	Medium	Low
CO6	Low	High	Low	Medium	High	Medium	Medium	High	High	High

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Course Title: **Selected topics in medicinal chemistry**

Course Code: **256020404**

CO 1	Understand the procedure of drug design, including lead compound modification, clinical trials, and SAR theories.
CO 2	Explore pharmacokinetics and the factors affecting drug absorption, distribution, metabolism, and elimination.
CO 3	Analyze pharmacodynamics, including enzyme stimulation/inhibition and the significance of drug metabolism.
CO 4	Understand dosage forms, routes of administration, and modern methods of pharmaceutical analysis and quality control.
CO 5	Investigate the application of computers in chemistry, including online resources, data search, and pharmaceutical applications.
CO 6	Study the medicinal use of nanomaterials for drug delivery, cancer treatment, and the application of nanotechnology in medical devices.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	High	High	Medium	Medium	Medium	Medium	Low
CO2	High	Medium	High	Medium	High	Medium	Medium	Low	Medium	High
CO3	High	Medium	High	Medium	High	High	Medium	Medium	Medium	Medium
CO4	High	Medium	High	Medium	High	High	Medium	Medium	Medium	Low
CO5	High	Medium	High	Medium	High	High	Medium	Medium	Medium	Low
CO6	High	High	High	High	Medium	High	Medium	Medium	Medium	High

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Course Title: **Dissertation Program**

Course Code: **256020405**

CO 1	Understand the disaster management strategies and their theoretical foundations.
CO 2	Conduct research and develop methodologies for assessing risks and vulnerabilities.
CO 3	Critically evaluate disaster scenarios and responses within the company's operations, interpreting complex data.
CO 4	Develop disaster preparedness and response plans to solve real-world issues encountered during company operations.
CO 5	Integrate interdisciplinary knowledge from fields like engineering, environmental science, and risk management.
CO 6	Collaborate with teams in designing emergency management protocols, while ensuring compliance with ethical standards.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	High	Medium	Medium	Medium	High	Medium
CO2	High	High	High	Medium	High	Medium	Medium	Medium	Medium	High
CO3	Medium	High	High	High	High	Medium	Medium	Medium	High	Medium
CO4	High	Medium	High	High	Medium	High	Medium	High	Medium	High
CO5	High	Medium	High	High	High	Medium	Medium	Medium	Medium	Medium
CO6	Medium	Medium	Medium	Medium	Medium	Medium	High	High	High	Medium

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Department of Microbiology

M.Sc. Semester I

Course Title: **Gene Structure and Function**

Course Code: **256030101**

CO 1	Understand the chemistry, structure, and forces stabilizing DNA, including Watson-Crick and Hoogsteen base pairing, and analyze the physical properties of dsDNA.
CO 2	Explain DNA topology, supercoiling, and the role of DNA topoisomerases in regulating DNA structure and gene expression in both prokaryotes and eukaryotes.
CO 3	Explore DNA-protein interactions, focusing on helix-turn-helix, B-sheet, and zinc finger motifs, and their roles in regulating genetic processes.
CO 4	Analyze the organization and packaging of DNA into chromosomes in prokaryotes and eukaryotes, including nucleosome assembly and chromatin modification.
CO 5	Describe the mechanisms of DNA replication, including the role of DNA polymerases, replisome assembly, telomerase function, and inhibitors of DNA replication.
CO 6	Evaluate the processes of transcription, translation, and gene regulation in prokaryotes and eukaryotes, focusing on operon models and posttranslational modifications.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	High	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO3	High	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO4	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	Medium
CO5	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium

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CO6	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	High

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Course Title: **Bioinstrumentation**

Course Code: **256030102**

CO 1	Understand the principles of electrochemistry, including pH, buffers, potentiometric and conductometric titrations, and their applications in biological systems.
CO 2	Explore the principles and applications of various microscopy techniques, such as light, electron, and fluorescence microscopy, along with sample preparation methods.
CO 3	Analyze the methodologies and applications of chromatography techniques, including gel-filtration, ion-exchange, affinity, thin layer, gas, and HPLC chromatography.
CO 4	Explain the principles and applications of electrophoresis techniques such as Native and SDS PAGE, agarose, and 2D gel electrophoresis for biomolecule separation.
CO 5	Evaluate the principles and applications of spectroscopy techniques (UV, IR, NMR, ESR) and their relevance in studying biomolecular structures and functions.
CO 6	Apply the principles of centrifugation, radioactive isotope techniques, and biosensors in biological research and biopolymer analysis, with emphasis on radiation dosimetry and tracer methods.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO3	High	High	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO4	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Medium
CO5	High	Medium	High	Medium	Medium	High	Medium	Medium	Medium	Medium
CO6	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	High

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Course Title: **Microbial Diversity**

Course Code: **256030103**

CO 1	Understand the principles and concepts of microbial diversity, including both culturable and non-culturable microbes and the methodologies to study them.
CO 2	Explore the principles of metagenomics and its role in understanding microbial diversity, as well as strategies for the conservation of microbial diversity.
CO 3	Analyze the metabolic diversity in bacteria and the systematics of various bacterial groups, with an emphasis on molecular and conventional approaches.
CO 4	Examine the diversity of actinomycetes, cyanobacteria, and fungi, focusing on their classification, reproduction, and ecological significance.
CO 5	Evaluate the systematics, occurrence, and adaptive features of different groups of archaea (Halophiles, Thermophiles, Alkalophiles, Acidophiles) and their applications.
CO 6	Assess the industrial and ecological roles of yeast, moulds, and mycorrhizal fungi, including their economic importance and contribution to various ecosystems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	High	High	High	Medium	Medium	Medium	Medium	Medium	High
CO3	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO4	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO5	High	Medium	High	Medium	High	Medium	Medium	Medium	Medium	High
CO6	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	High

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Course Title: **Biogeohydrotechnology and Biofuels**

Course Code: **256030104**

CO 1	Understand the classification and characterization of different types of waste and the principles and mechanisms involved in waste treatment.
CO 2	Analyze biological methods for treating liquid and solid waste, focusing on the principles and applications of these methods in waste management.
CO 3	Explore the marine environment, including bacterial diversity, and the cultivation and enumeration of marine bacteria for various applications.
CO 4	Apply indicators for marine microbial enzymes, polysaccharides, antimicrobial peptides, and carotenoids to assess their potential uses in marine biotechnology.
CO 5	Examine the processes of bioleaching, bio-oxidation, and biogeohydrotechnology for handling sulphidic minerals, including methods and factors affecting these processes.
CO 6	Evaluate fuel biotechnology concepts including types of energy resources, production of biofuels (biogas, bioethanol, biodiesel, bio-hydrogen), and their desirable and undesirable features, energy crops, and microbial enhanced oil recovery (MEOR).

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	High	High	Medium	Medium	Medium	Medium
CO2	High	High	High	High	High	High	High	Medium	Medium	Medium
CO3	Medium	High	High	Medium	Medium	High	Medium	Medium	Medium	Medium
CO4	Medium	Medium	Medium	High	Medium	High	Medium	Medium	Medium	Low
CO5	High	High	Medium	High	High	High	Medium	Medium	High	Medium
CO6	High	Medium	Medium	High	High	High	Medium	Medium	Medium	High

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Course Title: **Microbiology Practicals**

Course Code: **256030105**

CO 1	Demonstrate proper sterilization techniques for lab equipment and media, including autoclaving and chemical methods.
CO 2	Perform Gram staining on bacterial samples to distinguish between Gram-positive and Gram-negative bacteria.
CO 3	Use the Coles method to quantify carbohydrates, employing colorimetric assays or other techniques for concentration measurement.
CO 4	Apply the DPA (Diphenylamine) method to quantify DNA, understanding the principles and application of this technique.
CO 5	Perform the Biuret method to quantify protein concentrations, based on the formation of a colored complex.
CO 6	Demonstrate the isolation of Rhizobium bacteria from root nodules, emphasizing the symbiotic relationship with leguminous plants.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	Low	High	Medium	Medium	Medium	Low
CO2	Medium	Medium	Medium	High	Low	Medium	Medium	Medium	Medium	Low
CO3	High	Medium	Medium	Medium	Low	High	Medium	Medium	Medium	Low
CO4	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Low
CO5	Medium	Medium	Medium	High	Low	High	Medium	Medium	Medium	Low
CO6	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Medium

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M.Sc. Semester II

Course Title: **Microbial Genetics**

Course Code: **256030201**

CO 1	Explain the types, mechanisms, and repair pathways of mutations, including spontaneous mutations, DNA damage, and repair systems.
CO 2	Describe plasmid biology, including types, replication, control of copy number, and plasmid segregation.
CO 3	Discuss the principles of recombination, including homologous and site-specific recombination, and their biological roles.
CO 4	Analyze bacterial conjugation, focusing on processes involving the F-factor, Hfr conjugation, and plasmid-based conjugation.
CO 5	Understand Agrobacterium genetics, including Ti-plasmid function and interkingdom gene transfer mechanisms.
CO 6	Explore transformation and transduction mechanisms in bacteria and viruses, including applications and measurement techniques.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO2	High	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Low
CO3	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO4	Medium	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Low
CO5	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO6	Medium	Medium	Medium	High	Medium	High	Medium	Medium	Medium	Low

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Course Title: **Bioprocess Technology**

Course Code: **256030202**

CO 1	Understand the principles of innate and adaptive immunity, including inflammation, roles of cells, receptors, and proteins.
CO 2	Describe the cells and organs of the immune system, including hematopoiesis and the function of primary and secondary lymphoid organs.
CO 3	Explain the properties of antigens and antibodies, including their structure, classes, biological activities, and antibody diversity.
CO 4	Analyze antigen-antibody interactions and the complement system, including its components, activation, regulation, and related diseases.
CO 5	Discuss the Major Histocompatibility Complex (MHC) and its role in antigen presentation, including MHC organization, antigen processing, and disease susceptibility.
CO 6	Explore T-cell and B-cell maturation, activation, differentiation, cytokines, and the mechanisms of cell-mediated cytotoxicity, hypersensitivity, and immune tolerance.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO2	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO3	High	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO4	Medium	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO5	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO6	High	Medium	High	Medium	Medium	High	Medium	Medium	Medium	Low

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Course Title:

Course Code: **256030203**

CO 1	Understand the principles of isolation, preservation, and improvement of industrially important microorganisms.
CO 2	Describe substrates for fermentation processes and methods for medium optimization.
CO 3	Explain bioreactor design, including laboratory, pilot, and large-scale reactors, as well as sterilization of media and air.
CO 4	Discuss mass transfer of oxygen in bioprocesses, including agitation, aeration, determination of KLa, and factors affecting it.
CO 5	Analyze bioprocess kinetics, focusing on growth and substrate utilization in batch, fed-batch, and continuous systems.
CO 6	Explore the control of process parameters, including instrumentation, sensors, controllers, fermentation control systems, and dynamic modeling of fermentation processes.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO2	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low
CO3	High	High	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO4	Medium	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Low
CO5	Medium	Medium	High	Medium	High	Medium	Medium	Medium	Medium	Low
CO6	Medium	Medium	High	Medium	Medium	High	Medium	Medium	Medium	Low

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Course Title: Tools & Techniques In Microbiology

Course Code: **256030204**

CO 1	Understand the principles of light microscopy, including optical corrections, types of objectives, oculars, and illumination methods.
CO 2	Differentiate between types of light microscopes (bright field, dark field, fluorescence, phase contrast, polarizing, differential interference contrast) and understand micrometry.
CO 3	Describe the basic components of electron microscopes, including thermionic and field emission electron guns, and differentiate between TEM, SEM, STEM, ESEM, and HVEM.
CO 4	Explain fixation and storage techniques, including classification of fixatives, procedures, and factors affecting fixation for plant, animal, and microbial samples.
CO 5	Demonstrate preparation techniques for biological samples for light and electron microscopy, including sectioning, staining, and photomicrography.
CO 6	Apply histochemical and cytochemical techniques to localize metabolites, enzymes, and ultra-structural components in biological samples, including immunocytochemistry.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low	Low
CO2	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low
CO3	High	Medium	High	Medium	Medium	High	Medium	Medium	Medium	Low
CO4	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low
CO5	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium	Low	Low
CO6	Medium	Medium	High	High	Medium	High	Medium	Medium	Low	Low

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Course Title: Microbiology Practicals

Course Code: **256030205**

CO 1	Perform cell wall and spirochete staining techniques with precision, and isolate and identify fungi and soil bacteria (actinomycetes).
CO 2	Skillfully conduct endospore staining and primary screening for amylase producers, and apply the encapsulation technique for yeast cell immobilization.
CO 3	Proficiently carry out fermentation processes for alcohol and amylase production, and determine amylase activity and ethanol concentration in samples.
CO 4	Demonstrate techniques such as agglutination, paper chromatography, and the serodiagnosis of diseases like syphilis (RPR test) and enteric fever (Widal test).
CO 5	Develop expertise in enzyme immobilization, sauerkraut production, double immunodiffusion (ring test), and studying biodeterioration of given samples.
CO 6	Execute advanced laboratory techniques such as HPLC, gas chromatography, and agarose gel electrophoresis with accuracy and precision.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	Low	High	Medium	Medium	Medium	Low
CO2	Medium	Medium	High	High	Low	High	Medium	Medium	Medium	Low
CO3	High	Medium	High	High	Low	High	Medium	Medium	Medium	Medium
CO4	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Low
CO5	High	Medium	High	Medium	Low	High	Medium	Medium	Medium	Low
CO6	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium

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M.Sc. Semester III

Course Title: **Microbial Biotechnology**

Course Code: **256030301**

CO 1	Understand the microbial production processes for primary metabolites such as amino acids (glutamic acid, lysine), enzymes (proteases, amylases), organic acids (citric acid, acetic acid), and industrial alcohol.
CO 2	Explain the production methods and applications of secondary metabolites, including antibiotics (penicillin, streptomycin), vitamins (B12, B2), ergot alkaloids, and carotenoid pigments (β-carotene, lycopene).
CO 3	Describe microbial production techniques for other products and biotransformation, including microbial polysaccharides (xanthan, alginate, dextran), beverages (beer, wine), polyhydroxyalkanoates (PHA, PHB), biosurfactants, and steroid transformation.
CO 4	Analyze the methods and applications of fungal biomass production, including baker's yeast and single cell oil, and evaluate their industrial uses.
CO 5	Discuss mushroom cultivation techniques and the use of algal biomass, including their applications in various industries.
CO 6	Identify the microbial production techniques for food and feed, emphasizing their benefits and challenges in industrial settings.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO2	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO3	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Medium
CO4	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO5	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO6	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium

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Course Title: **Enzymology**

Course Code: **256030302**

CO 1	Understand the historical developments in enzymology, protein structure (primary, secondary, tertiary, and quaternary), and the techniques used in enzyme characterization.
CO 2	Explain enzyme classification according to the IUB system, and describe the principles and techniques of enzymatic analysis, including factors affecting enzyme activity, extraction, and purification strategies.
CO 3	Analyze enzyme kinetics, including single substrate kinetics (equilibrium and steady-state kinetics, Km, Vmax, Kcat), multisubstrate kinetics (general rate equations, mechanisms), and thermal kinetics (temperature effects, Arrhenius equation).
CO 4	Discuss enzyme inhibition and its kinetics, covering reversible and irreversible inhibition, competitive, noncompetitive, uncompetitive, mixed, partial, substrate, and allosteric inhibition.
CO 5	Describe the mechanisms of enzyme action, including enzyme activators, coenzymes, cofactors, specificity, and experimental approaches to determining enzyme mechanisms. Analyze specific enzyme mechanisms and allosteric regulation.
CO 6	Explore enzyme engineering techniques, including chemical modification of enzymes, enzyme immobilization, the use of enzymes in non-conventional media, enzyme sensors, and their applications as analytical reagents.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO2	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Low
CO3	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO4	Medium	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO5	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Medium
CO6	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	Medium

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Course Title: **Food & Dairy Microbiology**

Course Code: **256030303**

CO 1	Understand the scope of food microbiology and recognize microorganisms such as bacteria, yeast, and molds important in food microbiology, while analyzing the factors influencing microbial growth in food.
CO 2	Explain the general principles underlying food spoilage, including the spoilage of canned food, sugar products, vegetables, fruits, meat, milk, fish, seafood, and poultry, and assess the contamination risks involved.
CO 3	Analyze foodborne pathogens and the processes involved in bacterial foodborne infections and intoxications caused by Clostridium, Escherichia, Salmonella, and Shigella, while evaluating general diagnostic and preventive methods.
CO 4	Apply the principles of food preservation techniques such as asepsis, microbial removal, and temperature control, and evaluate the use of chemical and biological preservatives along with food additives.
CO 5	Evaluate the role of food packaging and labeling, genetically modified foods, and biosensors in food research, while comparing recent foodborne outbreaks and their impacts.
CO 6	Analyze food safety regulations, including HACCP, Codex Alimentarius, PFA, FPO, MFPO, BIS, and AGMARK, and assess microbiological testing procedures for water, milk, and food plant sanitation.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	Low	Medium	Medium	Medium	Low	Low
CO2	High	Medium	High	Medium	Low	Medium	Medium	Medium	Low	Low
CO3	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO4	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Low
CO5	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO6	High	High	High	High	Medium	High	High	High	Medium	High

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Course Title: **Agricultural Microbiology**

Course Code: **256030304**

CO 1	Understand the composition of the lithosphere and analyze the role of soil microbes, along with the factors influencing soil microbial populations.
CO 2	Explain the distribution, abundance, and nutritional groups of soil bacteria, actinomycetes, fungi, algae, protozoa, and viruses, and evaluate their ecological significance in the soil environment.
CO 3	Assess microbial transformations of minerals like phosphorus, sulfur, iron, and other elements, focusing on the processes of mineralization, immobilization, and oxidation/reduction.
CO 4	Analyze the types, production, and applications of biofertilizers, including nitrogen-fixing organisms (Azotobacter, Azospirillum, cyanobacteria), phosphate-solubilizing microbes, and their role in plant growth and integrated nutrient management.
CO 5	Evaluate plant pathogenic microorganisms, including their entry modes and factors affecting disease incidence, as well as plant disease resistance mechanisms and control measures.
CO 6	Understand the history and application of biopesticides (viral, bacterial, fungal, protozoan) and their interaction with plant pathogens, and assess the potential of biopesticides in sustainable agriculture.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Medium	Low	Medium	Medium	Medium	Low	Low
CO2	High	Medium	High	Medium	Medium	High	Medium	Medium	Medium	Low
CO3	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO4	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Low
CO5	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO6	High	High	High	High	Medium	High	High	High	Medium	High

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Course Title: **Microbiology Practicals**

Course Code: **256030305**

CO 1	Perform primary screening of amylase and organic acid-producing microorganisms, demonstrating proper microbial handling and culturing techniques.
CO 2	Execute experiments to measure the effect of temperature, pH, and substrate concentration on enzyme activity with precision and accuracy.
CO 3	Conduct the isolation of DNA from plant cells and demonstrate gel electrophoresis techniques, ensuring the correct handling of samples and equipment.
CO 4	Demonstrate the processes of PCR and animal tissue culture with adherence to procedural steps and safety protocols in a laboratory setting.
CO 5	Carry out sterility testing of pharmaceutical products and study protein structure using PDB, following standard laboratory practices.
CO 6	Operate bioinformatics databases (NCBI, DDBJ, GenBank) for sequence alignment and analysis, and design primers from a cDNA library, applying computational tools efficiently.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Medium	Low	Medium	Medium	Low	Medium	Low
CO2	High	Medium	High	High	Medium	Medium	Medium	Low	Medium	Medium
CO3	High	High	High	High	Medium	Medium	Medium	Medium	Medium	Low
CO4	High	High	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO5	High	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Low
CO6	High	High	High	High	High	Medium	High	High	Medium	Medium

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M.Sc. Semester IV

Course Title: **Environmental Microbiology**

Course Code: **256030401**

CO 1	Understand the global environmental problems, including global warming, ozone depletion, acid rain, and their impacts on ecosystems and infectious diseases.
CO 2	Explain the sources and types of water pollution, including microbial indicators, eutrophication, and control methods, along with the mechanisms of biodeterioration of wood and metals.
CO 3	Analyze the biogeochemical cycles of carbon, nitrogen, sulfur, iron, and phosphorus, along with the detrimental effects of biogeochemical cycle diversions, such as acid mine drainage and nitrate pollution.
CO 4	Discuss biological nitrogen fixation, including asymbiotic, symbiotic, and associative nitrogen fixation, with emphasis on the structure, function, and genetic regulation of nitrogenase.
CO 5	Evaluate the mechanisms and factors affecting the biodegradation of organic pollutants, and examine bioremediation techniques for oil spills, heavy metal pollution, and the use of GMOs in bioremediation.
CO 6	Describe bioleaching of metals, microbial insecticides, and biofertilizers, along with their industrial applications in biomining, pest management, and enhanced oil recovery processes.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low	Low
CO2	High	High	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium
CO3	High	High	High	High	Medium	Medium	Medium	Medium	Medium	Low
CO4	High	Medium	High	Medium	Medium	Medium	Low	Medium	Medium	Medium
CO5	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO6	High	High	High	High	Medium	High	High	High	Medium	Medium

Course Title: **r-DNA Technology**

Course Code: **256030402**

CO 1	Understand the concept and importance of genetic engineering, including general strategies, steps involved in gene cloning, and the extraction and purification of DNA from bacterial, plant, and animal cells.
CO 2	Describe the roles of restriction enzymes, DNA ligase, and other enzymes in gene cloning, and explain the processes of mRNA and cDNA preparation.
CO 3	Explain the chemical synthesis of genes and DNA cloning and expression vectors, including plasmids, bacteriophages, phagemids, cosmids, YACs, BACs, and MACs, and the expression of cloned genes in heterologous hosts.
CO 4	Outline the techniques for recombinant selection and screening, including Southern blotting, Northern analysis, Western blotting, various electrophoresis methods, and protein activity assays (e.g., yeast-one hybrid, yeast-two hybrid).
CO 5	Discuss advanced methods for gene characterization and mapping, such as restriction mapping, DNA sequencing, nucleic acid microarrays, metagenomics, and gene therapy, as well as molecular markers and genomic mapping techniques.
CO 6	Analyze recombinant products, including recombinant hormones, DNA vaccines, transgenic plants and animals, and understand the guidelines for genetic engineering, including physical and biological containment levels and Indian guidelines.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
CO2	High	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
CO3	High	High	High	High	Medium	High	Medium	Medium	Medium	Medium
CO4	Medium	Medium	High	High	Medium	Medium	Medium	Medium	Medium	Medium
CO5	High	Medium	High	High	Medium	High	Medium	Medium	Medium	Medium
CO6	High	Medium	Medium	High	Medium	High	Medium	Medium	Medium	High

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Course Title: **Microbiology Practicals**

Course Code: **256030403**

CO 1	Perform Polymerase Chain Reaction (PCR) technique, demonstrating the ability to accurately amplify specific DNA sequences.
CO 2	Operate Agarose Gel Electrophoresis for the separation and visualization of DNA fragments based on size.
CO 3	Execute the detection of Treponema pallidum antibodies for syphilis diagnosis through appropriate serological testing.
CO 4	Conduct the Widal test to diagnose malaria antibody, demonstrating precision in antigen-antibody reactions.
CO 5	Measure and estimate the concentration of sulfate, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), and chloride in given samples, following proper laboratory protocols.
CO 6	Isolate and purify DNA and RNA from biological samples and use Native SDS-PAGE for protein analysis, exhibiting accurate technique and analysis skills.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	High	Medium	Medium	Low	Low	Medium	Low	Low
CO2	High	High	Medium	High	Medium	Medium	Low	Medium	Medium	Low
CO3	High	Medium	Medium	Medium	Low	Medium	Medium	Low	Low	Low
CO4	High	Medium	Medium	Medium	Low	Medium	Low	Medium	Low	Low
CO5	High	High	High	Medium	Medium	High	Medium	Medium	Medium	Medium
CO6	High	High	High	High	Medium	Medium	Medium	Medium	Medium	Medium

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Department of Physics

M.Sc. Semester I

Course Title: **Quantum Mechanics-l and Mathematical Physics-l**

Course Code: **256040101**

CO 1	Apply the concepts of Laplace transforms to solve differential equations and model physical problems. (Application)
CO 2	Analyze group theory principles to understand group representations and their role in quantum mechanics. (Analysis)
CO 3	Evaluate the tensor algebra and its applications in transforming between different coordinate systems. (Evaluation)
CO 4	Apply approximation methods such as perturbation theory and the variational method to solve stationary state quantum systems. (Application)
CO 5	Develop solutions to quantum mechanical problems using the WKB approximation and time evolution techniques. (Synthesis)

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Low	High	Low	High	Medium	Low	Medium
CO2	High	High	Medium	Low	Medium	Low	Medium	High	High	Medium
CO3	Medium	High	High	Low	Medium	Low	High	Medium	Low	High
CO4	High	High	High	Medium	High	Medium	Medium	High	Medium	Low
CO5	High	High	Medium	Medium	Medium	Low	High	High	Medium	Medium

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Course Title: **Classical Mechanics-l and Statistical Mechanics**

Course Code: **256040102**

CO 1	Apply the theory of small oscillations to analyze coupled oscillations and normal modes in physical systems. (Application)
CO 2	Evaluate the principles of canonical transformations and Hamilton-Jacobi theory to solve advanced dynamical systems. (Evaluation)
CO 3	Analyze critical phenomena and phase transitions using mathematical models like the Ising Model and Curie-Weiss theory. (Analysis)
CO 4	Develop an understanding of fluctuations by applying Langevin theory and Wiener-Khinching theorem in the study of random motion. (Synthesis)
CO 5	Apply the concepts of Brownian motion and noise theories to explain time-dependent fluctuations and their effects in physical systems. (Application)

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	Medium	High	Low	Medium	High	Medium	High	Low	High
CO2	High	High	Medium	Medium	High	Low	Medium	Low	Medium	High
CO3	Low	High	High	Medium	Low	Medium	High	High	Medium	Low
CO4	High	Medium	High	Medium	Low	High	Medium	High	High	Low
CO5	High	Medium	Medium	High	High	Low	Medium	Medium	High	Low

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Course Title: **Electrodynamics-l and Programming in C-l**

Course Code: **256040103**

CO 1	Analyze the propagation, reflection, and transmission of electromagnetic waves in various media, including conducting and dielectric materials. (Analysis)
CO 2	Apply the principles of wave propagation in different types of waveguides, including rectangular and co-axial, to solve practical problems. (Application)
CO 3	Evaluate scattering phenomena and dispersion in different materials, and their frequency dependence on permittivity, permeability, and conductivity. (Evaluation)
CO 4	Understand and apply plasma physics concepts like moment equations, MHD, and thermonuclear reactions in controlled environments. (Understanding & Application)
CO 5	Analyze the challenges of plasma confinement, heating, and energy loss in thermonuclear fusion, including the Lawson criterion. (Analysis)

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	High	Medium	Low	High	High	Medium	Low	High	Medium
CO2	High	High	High	Low	Medium	Medium	High	Medium	Low	Low
CO3	Low	Medium	High	High	Medium	High	Low	High	Medium	High
CO4	High	Medium	High	High	Medium	Low	Medium	High	Low	Medium
CO5	High	High	Medium	Medium	Low	Medium	High	Low	High	Medium

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Course Title: **Solid State Physics and Plasma Physics**

Course Code: **256040104**

CO 1	Analyze the origin of energy gaps and apply models like the Nearly Free Electron Model and Kronig-Penney Model to understand energy bands in metals and insulators. (Analysis)
CO 2	Evaluate the construction of Fermi surfaces and understand electron, hole, and open orbits in various zone schemes. (Evaluation)
CO 3	Apply vacuum techniques, including different types of pumps and gauges, for practical measurement and handling of 3-vacuum systems. (Application)
CO 4	Understand and utilize experimental techniques such as X-ray diffraction and electron diffraction to study crystal structures and solid-state properties. (Understanding & Application)
CO 5	Analyze neutron scattering and its application in studying the properties of solids, including s1 neutron scattering and elastic scattering phenomena. (Analysis)

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	Low	High	Medium	High	High	Medium	Medium	Low	High
CO2	High	High	Medium	Low	Medium	High	Low	High	Medium	Medium
CO3	Medium	Medium	High	High	Low	High	High	Low	Medium	Medium
CO4	High	Low	Medium	High	High	Medium	Low	High	Medium	Medium
CO5	High	Medium	Medium	Medium	High	High	Low	Medium	High	Low

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M.Sc. Semester II

Course Title: **Quantum Mechanics-II and Mathematical Physics-II**

Course Code: **256040201**

CO 1	Apply complex variable techniques, including contour integrals and the residue theorem, to solve definite integrals and understand conformal mapping.
CO 2	Analyze integral equations and Green's functions to solve boundary value problems in one and 3er dimensions.
CO 3	Evaluate quantum dynamics using Schrödinger and Heisenberg pictures to understand the motion of atoms and molecules.
CO 4	Understand and apply the Pauli exclusion principle and spin functions to study multi-electron atoms, including the Helium atom.
CO 5	Analyse Einstein's quantum theory of radiation, including quantum electrodynamics, perturbation theory, and the interaction of radiation with matter.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	Medium	High	High	High	Low	High	Medium	Low	Medium
CO2	High	High	Medium	Medium	Low	Medium	High	Low	High	Medium
CO3	Medium	High	High	Medium	Low	High	Medium	Low	Medium	High
CO4	High	High	Low	High	Medium	Medium	Low	Medium	High	Medium
CO5	High	Medium	High	Low	High	Medium	High	Low	Medium	Medium

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Course Title: **Classical Mechanics-ll and Statistical Mechanics**

Course Code: **256040202**

CO 1	Analyze non-linear oscillations and the emergence of chaotic behavior using mathematical models and examples. (Analysis)
CO 2	Apply the principles of relativistic electrodynamics and classical field theory to understand the dynamics of continuous systems and field transformations.
CO 3	Evaluate various magnetic phenomena, including diamagnetism, paramagnetism, and ferromagnetic domains, using models like the Heisenberg and Neel models. (Evaluation)
CO 4	Understand and apply the BCS theory and other principles of superconductivity to explain phenomena like the Meissner effect, flux quantization, and Josephson effects.
CO 5	Analyze the thermodynamic and quantum mechanical aspects of superconductors, including the London equation and 3-TC superconductors.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	Medium	High	High	High	Low	High	Medium	Low	High
CO2	High	High	Medium	Medium	Medium	Medium	Low	High	Low	High
CO3	High	Medium	Medium	High	Low	Medium	High	Low	Medium	Medium
CO4	Medium	High	High	Medium	High	Medium	Low	Medium	High	Low
CO5	High	Medium	High	Medium	High	Medium	High	Low	Medium	Medium

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Course Title: **Semiconductor Physics and Devices**

Course Code: **256040203**

CO 1	Understand energy bands in metals, semiconductors, and insulators, and analyze carrier concentration under thermal equilibrium conditions. (Understanding & Analysis)
CO 2	Apply the principles of p-n junctions to explain equilibrium Fermi levels, depletion regions, and current-voltage characteristics. (Application)
CO 3	Evaluate the performance and characteristics of field-effect transistors (JFET and MOSFET) in various amplifier configurations. (Evaluation)
CO 4	Analyze the working principles and structures of optoelectronic devices such as LEDs, semiconductor lasers, and photodiodes. (Analysis)
CO 5	Understand the operation and characteristics of different digital IC families, including TTL, MOS, and CMOS, and their interfacing techniques. (Understanding & Application)

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Low	Medium	High	Medium	Medium	Low	High
CO2	High	Medium	High	Medium	Low	High	Medium	Medium	High	Low
CO3	Medium	High	Low	High	Medium	Medium	High	Low	High	Medium
CO4	High	Medium	Medium	High	Low	Medium	High	Medium	Low	High
CO5	High	High	Medium	Medium	Medium	Medium	Low	High	Low	Medium

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Course Title: **Analog Electronics**

Course Code: **256040204**

CO 1	Understand the working principles of IC voltage regulators, including 723, positive, negative, and 3/1 voltage regulators, and analyze current booster and fold-back current limiting circuits. (Understanding & Analysis)
CO 2	Apply operational amplifiers in various configurations such as active filters, sample and hold circuits, and logarithmic/antilogarithmic amplifiers. (Application)
CO 3	Analyze the performance of tuned and wide-band amplifiers, including single and double-tuned transformers, pulse response, and bandwidth requirements. (Analysis)
CO 4	Understand the basic operation of Phase-Locked Loop (PLL) circuits and apply them for AM and FM detection. (Understanding & Application)
CO 5	Evaluate the design and functionality of power amplifiers and multivibrators, including class A, class B, and Schmitt trigger circuits, with detailed analysis. (Evaluation)

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	High	Medium	High	Low	High	Medium	Medium	High	Low
CO2	High	Medium	High	Low	High	Medium	Medium	High	Low	High
CO3	High	High	Medium	Medium	Medium	Low	High	Medium	Low	High
CO4	Medium	Medium	High	High	High	Medium	Low	Medium	Low	High
CO5	High	Medium	Medium	Medium	Low	High	High	Medium	Medium	Low

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M.Sc. Semester III

Course Title: **Advanced Quantum Mechanics-I, Nuclear Physics-I**

Course Code: **256040301**

CO 1	Analyze the kinematics of scattering processes, including differential and total cross sections for elastic and inelastic scattering, and apply wave mechanical concepts such as scattering amplitude and phase shifts. (Analysis)
CO 2	Understand and apply the Born approximation and its validity in scattering theory, including the Born series and Eikonal approximation. (Understanding & Application)
CO 3	Evaluate nuclear properties such as nuclear spin, electric and magnetic moments, and the effects of external magnetic fields on hyperfine structures. (Evaluation)
CO 4	Analyze two-body nuclear forces and scattering phenomena, including the deuteron, neutron-proton scattering, effective range theory, and meson theory of nuclear forces. (Analysis)
CO 5	Understand and apply principles of transducers and measurement systems, including signal conditioning, noise reduction, impedance matching, and the use of phase-sensitive detectors and lock-in amplifiers. (Understanding & Application)

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	Medium	Medium	High	Low	Medium	High	Medium	Low	High
CO2	Medium	High	High	Medium	High	Medium	Medium	Low	High	Medium
CO3	High	Medium	Low	High	Medium	High	Medium	Low	Medium	High
CO4	Medium	High	High	Medium	Medium	Low	High	Medium	High	Medium
CO5	High	Medium	Medium	High	Low	Medium	Medium	Low	High	Medium

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Course Title: **Numerical Methods and Digital Eletcronics**

Course Code: **256040302**

CO 1	Apply numerical methods to solve ordinary differential equations using techniques such as Euler's method, Runge-Kutta method, and Predictor-Corrector method. (Application)
CO 2	Analyze and solve partial differential equations, including elliptic, parabolic, and hyperbolic equations, using appropriate numerical methods for Laplace, Poisson, heat, and wave equations. (Analysis)
CO 3	Understand and implement digital electronic components such as parity generators, ROM, PAL, and utilize clocks and timers including TTL clock and 555 Timer in various configurations. (Understanding & Application)
CO 4	Design and analyze shift registers and counters, including various types of serial and parallel registers and asynchronous and synchronous counters, with practical applications in digital electronics. (Design & Analysis)
CO 5	Evaluate and implement digital-to-analog (D/A) and analog-to-digital (A/D) converters, including accuracy, resolution, and applications, and analyze different display technologies such as LED, LCD, and plasma. (Evaluation)

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	High	High	Low	High	Medium	High	Medium	Low	High
CO2	High	High	Medium	Medium	Medium	Low	High	Medium	Low	High
CO3	Medium	Medium	High	High	Medium	High	Low	Medium	Low	Medium
CO4	High	Medium	Medium	High	Low	High	Medium	Low	High	Medium
CO5	High	High	Medium	Medium	High	Medium	Low	Medium	High	Low

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Course Title: **Fiber Optics, Satellite Communication & Microprocessor-I**

Course Code: **256040303**

CO 1	Understand and analyze the principles of radio wave propagation, including free space, tropospheric, and ionospheric propagation, as well as the fundamentals of satellite communication, including orbit types, power systems, and transponder operations. (Understanding & Analysis)
CO 2	Explain the principles of fiber optic communication, including light propagation in fibers, modal concepts, dispersion effects, and the design and functioning of optical components such as sources, detectors, and connectors. (Understanding & Application)
CO 3	Describe the architecture and interfacing of microprocessor-based systems, including the functioning of microcontrollers, memory types, input/output devices, and basic hardware and software components. (Understanding & Application)
CO 4	Demonstrate proficiency in 8085 Assembly language programming, including instruction sets, data formats, program execution, and the development of simple programs for arithmetic and data manipulation. (Application & Analysis)
CO 5	Analyze and implement microprocessor architectures, including memory interfacing, I/O device integration, and instruction decoding, with a focus on the 8085 microprocessor and its applications in microcomputer systems. (Analysis & Design)

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	High	Medium	Medium	Medium	Low	High	Low	Medium	High
CO2	High	Medium	High	Medium	Medium	High	Low	Medium	Low	High
CO3	Medium	High	High	Low	High	Medium	Medium	Low	High	Medium
CO4	High	Medium	Medium	High	Medium	Low	High	Medium	Low	High
CO5	Medium	High	Medium	Medium	High	Medium	High	Low	Medium	High

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Course Title: **Electronic Communication-I**

Course Code: **256040304**

CO 1	Understand and apply the lumped element circuit model for transmission lines, perform field analysis, and utilize the Smith chart for impedance matching and loss analysis in transmission lines. (Understanding & Application)
CO 2	Describe and analyze basic antenna parameters such as radiation pattern, radiation resistance, directivity, and gain, and understand the design and characteristics of different types of antennas, including dipole, Yagi, and parabolic reflector antennas. (Understanding & Analysis)
CO 3	Explain the principles of amplitude modulation (AM), single sideband modulation (SSB), and angle modulation, including the theory, spectrum, and modulation techniques, and analyze AM and FM modulator and detector circuits. (Understanding & Application)
CO 4	Analyze and design pulse modulation systems, including pulse amplitude modulation (PAM), pulse code modulation (PCM), pulse time modulation (PTM), and synchronization techniques, and understand digital carrier systems such as ASK, FSK, CPFSK, MSK, and PSK. (Analysis & Design)
CO 5	Understand and apply digital communication techniques, including bit error probability, matched filters, bit-timing recovery, and carrier recovery systems, and evaluate performance in baseband and carrier-modulated digital communication systems. (Understanding & Evaluation)

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	High	Medium	High	Medium	Medium	High	Low	Medium	High
CO2	High	Medium	High	Low	High	Medium	Medium	High	Medium	Low
CO3	High	High	Medium	Medium	Medium	Low	High	Low	High	Medium
CO4	Medium	High	High	Medium	High	Low	Medium	High	Low	High
CO5	High	Medium	Medium	Medium	Low	Medium	High	Low	High	Medium

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M.Sc. Semester IV

Course Title: **Advance Quantum Mechanics-II & Nuclear Physics-II**

Course Code: **256040401**

CO 1	Describe and explain the fundamental concepts of nuclear reactions, including resonance, compound nucleus theory, and direct reactions.
CO 2	Apply the Dirac equation to solve problems involving relativistic particles, including the calculation of energy spectra and spin properties.
CO 3	Analyze the implications of the CPT theorem, charge independence, and isospin invariance on particle physics theories.
CO 4	Evaluate the significance of nuclear isomerism and the predictions of the shell model in relation to experimental data.
CO 5	Design and solve problems involving angular momentum coupling and spherical tensor operators in quantum systems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	High	High	Low	High	Medium	Medium	High	Low	High
CO2	High	Medium	High	High	Low	Medium	High	Low	Medium	High
CO3	Medium	High	Low	Medium	High	Low	Medium	High	High	Medium
CO4	High	Medium	Medium	High	Low	High	Medium	Medium	Low	High
CO5	Medium	High	High	Medium	High	Medium	High	Low	Medium	High

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Course Title: **Numerical Techniques & Sophisticated Experimental and Characterization Techniques**

Course Code: **256040402**

CO 1	Describe and explain the fundamental numerical techniques used for solving complex scientific and engineering problems, including methods such as finite difference, finite element, and interpolation techniques.
CO 2	Apply numerical algorithms and methods to solve real-world problems in areas such as data analysis, optimization, and simulation, using appropriate software tools and programming languages.
CO 3	Analyze experimental data using sophisticated characterization techniques, such as spectroscopy, microscopy, and X-ray diffraction, to determine material properties and validate numerical models.
CO 4	Evaluate the effectiveness and limitations of various experimental and characterization techniques in achieving accurate and reliable results, and make recommendations for improvements.
CO 5	Design and conduct experiments using advanced techniques to characterize materials or phenomena, and integrate numerical methods to interpret experimental data and validate theoretical models.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	Low	High	Medium	High	Low	Medium	Medium
CO2	High	High	Medium	Medium	Low	Medium	High	Low	Medium	High
CO3	Medium	Medium	High	High	Medium	High	Low	Medium	High	Low
CO4	High	Medium	Medium	High	Medium	Low	High	Medium	Low	High
CO5	High	High	Medium	Medium	Medium	Medium	Low	High	High	Low

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Course Title: **Microwaves and Microprocessor-II**

Course Code: **256040403**

CO 1	Understand and apply 8085 microprocessor instructions for data handling and arithmetic operations.
CO 2	Design and implement counters and time delays using the 8085 microprocessor.
CO 3	Utilize stack operations and subroutines effectively in assembly programming.
CO 4	Perform code conversions and arithmetic operations involving BCD and 16-bit data.
CO 5	Describe the principles and applications of microwave devices and passive components.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Low	Medium	High	Low	Medium	High
CO2	High	High	Medium	Medium	High	Low	Medium	High	Low	Medium
CO3	Medium	Medium	High	High	Low	Medium	High	Medium	High	Low
CO4	High	Medium	Medium	High	Medium	Low	High	Medium	Low	High
CO5	Medium	High	Medium	Medium	High	Medium	High	Low	Medium	High

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Course Title: **Remote Sensing & Electronic Communication-II**

Course Code: **256040404**

CO 1	Apply transmission line theory to analyze and design electrical circuits involving lumped elements, field analysis, and impedance matching.
CO 2	Design and evaluate various antenna systems based on their fundamental parameters and operational characteristics.
CO 3	Demonstrate knowledge of radio receiver architecture and performance, including AM and FM receivers, their components, and noise management.
CO 4	Understand radar system principles and apply them to analyze radar performance, including pulsed radar, MTI, and Doppler systems.
CO 5	Integrate and apply knowledge from transmission lines, antennas, receivers, and radar systems to solve complex problems in communication and radar technology.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	High	Low	High	Medium	Medium	Low	High
CO2	High	High	Medium	Medium	Medium	Medium	High	Low	High	Low
CO3	Medium	Medium	High	High	High	Low	Medium	Medium	Low	High
CO4	High	Medium	Medium	High	Low	Medium	High	Low	High	Medium
CO5	High	High	Medium	Medium	Medium	Medium	Low	Medium	High	Low

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Department of Mathematics

M.Sc. Semester I

Course Title**: Abstract Algebra - I**
Course Code**: 253030101**

CO 1	Understand the definition and examples of groups, subgroups, normal subgroups, quotient groups, and cyclic groups.
CO 2	Apply the concept of group homomorphisms and understand the fundamental theorem of homomorphisms.
CO 3	Explain conjugacy relations and their applications within a group.
CO 4	Comprehend and apply Cauchy's theorem for both abelian and finite groups.
CO 5	Understand the structure of finite abelian groups through Sylow's theorems.
CO 6	Examine and construct composition series for solvable groups.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Low	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO2	High	Medium	High	High	Medium	Low	Low	Low	Medium	Low
CO3	High	Low	High	Medium	Medium	Low	Low	Low	Medium	Low
CO4	High	Medium	High	High	Medium	Low	Low	Low	Medium	Low
CO5	High	Medium	High	High	Medium	Low	Low	Low	Medium	Low
CO6	High	Medium	High	High	Medium	Low	Medium	Medium	High	Low

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Course Title**: Real Analysis**

Course Code**: 253030102**

CO 1	Understand the concept of Lebesgue outer measure, algebra, σ-algebra of sets, Borel sets, and measurable sets, along with the construction of the Lebesgue measure.
CO 2	Explain measurable functions, Littlewood's three principles, and Egoroff's theorem, and compare Riemann and Lebesgue integration methods.
CO 3	Apply the concept of the Lebesgue integral for bounded functions, understand the bounded convergence theorem, and differentiate it from Riemann integration.
CO 4	Analyze the integration of non-negative measurable functions using Fatou's lemma, monotone convergence theorem, and Lebesgue's convergence theorem.
CO 5	Evaluate the differentiation of measurable functions, monotone functions, and functions of bounded variation, and explore absolutely continuous functions and their properties.
CO 6	Understand the relationship between indefinite integrals and absolutely continuous functions through the differentiation of integrals.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Low	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO2	High	Medium	High	Medium	Medium	Low	Medium	Low	Medium	Low
CO3	High	Medium	High	High	Medium	Low	Medium	Low	Medium	Low
CO4	High	Medium	High	High	Medium	Low	Medium	Low	Medium	Low
CO5	High	Medium	High	High	Medium	Low	Medium	Medium	High	Low
CO6	High	Medium	High	High	Medium	Low	Medium	Medium	High	Medium

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Course Title**: Statistical Methods**
Course Code**: 253030103**

CO 1	Understand the fundamental concepts of statistics, including summarizing qualitative and quantitative data, and apply various measures of location, variability, and association between two variables in business and economics.
CO 2	Analyze data using descriptive statistical methods, such as the stem-and-leaf display, cross-tabulation, scatter diagrams, and detect outliers through measures of distribution shape and relative location.
CO 3	Apply basic probability concepts to determine the probability of events using classical, relative frequency, and subjective methods, and solve problems involving conditional probability and Bayes' theorem.
CO 4	Understand different types of probability distributions, including binomial, Poisson, and normal distributions, and compute expected value and variance for discrete and continuous random variables.
CO 5	Apply sampling methods, and understand sampling distribution, point and interval estimation, and hypothesis testing for population means and proportions, including tests about differences between two populations.
CO 6	Understand and apply simple linear regression models using the least squares method for estimation and prediction, and evaluate model assumptions, residual analysis, outliers, and influential observations to validate the regression model.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Low	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO2	High	Medium	High	Medium	Medium	Low	Medium	Low	Medium	Low
CO3	High	Medium	High	High	Medium	Low	Medium	Low	Medium	Low
CO4	High	Medium	High	High	Medium	Low	Medium	Low	Medium	Low
CO5	High	Medium	High	High	Medium	Low	Medium	Medium	High	Low
CO6	High	Medium	High	High	Medium	Low	Medium	Medium	High	Medium

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Course Title: Advanced Linear Algebra
Course Code: 256030104

CO 1	Understand the algebra of linear transformations, characteristic roots, and vectors, and apply the concept of diagonalization of matrices.
CO 2	Analyze triangular canonical forms and apply related theorems to solve problems involving nilpotent linear transformations.
CO 3	Comprehend and apply the decomposition theorem and understand the concept of Jordan canonical forms for linear transformations.
CO 4	Apply rational canonical forms in matrix theory and calculate determinants for solving various matrix-related problems.
CO 5	Comprehend and apply the decomposition theorem and understand the concept of Jordan canonical forms for linear transformations.
CO 6	Apply rational canonical forms in matrix theory and calculate determinants for solving various matrix-related problems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	High	High	Medium	Medium	Medium	Low	Medium	Medium
CO2	High	Medium	High	High	Medium	Medium	Medium	Low	Medium	Medium
CO3	High	Medium	High	High	Medium	Medium	Medium	Low	High	High
CO4	High	Medium	High	High	Medium	Medium	Medium	Low	High	High
CO5	High	Medium	High	High	Medium	Low	Medium	Low	Medium	Low
CO6	High	Medium	High	High	Medium	Low	Medium	Low	Medium	Low

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Course Title**: Mathematics Practical**
Course Code: 256030105

Sr. No.	Course Outcomes
CO 1	Demonstrate an understanding of key vocabulary from selected stories and effectively apply grammar concepts such as active/passive voice, tenses, prepositions, and determiners.
CO 2	Analyze the structure and usage of active and passive voice in different contexts and apply them in writing tasks.
CO 3	Apply the correct use of tenses, prepositions (place, time, direction), and determiners in both written and spoken communication.
CO 4	Develop letter-writing skills, adhering to proper format and tone for various formal communications.
CO 5	Write applications for different purposes, demonstrating clarity, coherence, and appropriate use of grammar and vocabulary.
CO 6	Synthesize the understanding of grammar rules and vocabulary from the stories to effectively communicate ideas in writing and speaking.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Low	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO2	High	Medium	High	Medium	Medium	Low	Medium	Low	Medium	Low
CO3	High	Medium	High	High	Medium	Low	Medium	Low	Medium	Low
CO4	High	Medium	High	High	Medium	Low	Medium	Low	Medium	Low
CO5	High	Medium	High	High	Medium	Low	Medium	Medium	High	Low
CO6	High	Medium	High	High	Medium	Low	Medium	Medium	High	Medium

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M.Sc. Semester II

Course Title: **Advanced Abstract Algebra – II**

Course Code: 256030201

CO 1	Understand the definitions and properties of fields, subfields, rings, and principal ideals, and apply conditions for subfields and the embedding of rings.
CO 2	Analyze the concepts of Euclidean rings and unique factorization domains (UFDs), and apply the unique factorization theorem and Eisenstein's criterion of irreducibility.
CO 3	Understand and apply the concepts of field extensions, simple extensions, and algebraic extensions, and explore algebraically closed fields.
CO 4	Comprehend the properties of root fields, splitting fields, and apply the concepts of normal and separable extensions in field theory.
CO 5	Understand the fundamental concepts of fields, subfields, rings, and principal ideals, and apply conditions for subfields, characteristics of rings and fields, and the embedding of rings.
CO 6	Analyze the properties of Euclidean rings, unique factorization domains (UFDs), algebraic extensions, and normal and separable extensions, and apply these concepts to solve related problems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Low
CO 2	High	High	High	Medium	Medium	Medium	Low	Low	Medium	Medium
CO 3	High	High	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium
CO 4	High	High	High	High	Medium	Medium	Low	Low	Medium	Medium
CO 5	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium
CO 6	High	High	High	High	Medium	Medium	Low	Low	Medium	Medium

Course Code: **253030204**

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Course Title**: Complex Analysis**

Course Code: 256030202

CO 1	Understand the properties of complex numbers, their polar and exponential forms, and analyze regions in the complex plane, continuity, differentiability, and analytic functions using Cauchy-Riemann equations.
CO 2	Apply the properties of elementary functions such as exponential, trigonometric, hyperbolic, and logarithmic functions, and solve complex line and contour integrals using Cauchy's theorem.
CO 3	Explore important theorems in complex analysis, including Cauchy's integral formula, Morera's theorem, Liouville's theorem, and apply Taylor and Laurent series expansions for analytic functions.
CO 4	Analyze singularities, poles, and zeros of analytic functions, and apply the residue theorem for the evaluation of improper integrals.
CO 5	Understand the harmonic functions of two variables and their relationship to analytic functions in complex analysis.
CO 6	Evaluate improper integrals using residues at poles and apply the residue theorem to solve complex integration problems in advanced mathematics.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Low
CO 2	High	High	High	Medium	Medium	Medium	Low	Low	Medium	Medium
CO 3	High	High	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium
CO 4	High	High	High	High	Medium	Medium	Low	Low	Medium	Medium
CO 5	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium
CO 6	High	High	High	High	Medium	Medium	Low	Low	Medium	Medium

Course Code: **253030204**

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CO 1	Understand the definition and general solution of Legendre's equation, and apply orthogonal properties, recurrence formulas, and generating functions of Legendre polynomials Pn(x) and Qn(x).
CO 2	Analyze hypergeometric functions, including their series definitions, particular cases, and solutions, and apply integral formulas and theorems such as Kummer's and Gauss's theorems.
CO 3	Explore confluent hypergeometric functions, their integral representations, and differentiation techniques, and understand their continuous nature.
CO 4	Solve boundary value problems using Hermite polynomials, including understanding Hermite's differential equation, generating functions, orthogonal properties, and recurrence formulas.
CO 5	Apply Chebyshev polynomials to solve differential equations, prove that Tn(x) and Un(x) are independent solutions, and use generating functions and recurrence formulas for these polynomials.
CO 6	Compute and analyze the first few Hermite and Chebyshev polynomials, and apply their orthogonal properties and recurrence relations in practical problems.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low
CO 2	High	High	High	Medium	Medium	Medium	Low	Low	Medium	Medium
CO 3	High	High	High	Medium	Medium	Medium	Low	Low	Medium	Medium
CO 4	High	High	High	High	Medium	Medium	Low	Low	Medium	Medium
CO 5	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium
CO 6	High	High	High	High	Medium	Medium	Low	Low	Medium	Medium

Course Title**: Ordinary Differential Equations**

Course Code: **253030204**

CO 1	Understand and apply the concepts of singular solutions and extraneous loci in ordinary differential equations (ODEs), and review simultaneous ODEs of the first order and linear differential equations of the second order.
CO 2	Solve non-linear differential equations of particular forms and apply techniques for total differential equations.
CO 3	Analyze ordinary and singular points of differential equations, and apply series solutions to Cauchy-Euler equations and regular singular points.
CO 4	Implement numerical methods for solving ordinary differential equations, including Euler's method for initial value problems.
CO 5	Apply the Runge-Kutta method (both one-stage and two-stage) to obtain numerical solutions for ordinary differential equations and analyze their accuracy.
CO 6	Compare and evaluate the effectiveness of different numerical methods, such as Euler's method and Runge-Kutta methods, in solving ordinary differential equations.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	High	Medium	Medium	Medium	Low	Low	Low	Low
CO 2	High	High	High	Medium	Medium	Medium	Low	Low	Medium	Medium
CO 3	High	Medium	High	High	Medium	Medium	Low	Low	Medium	Medium
CO 4	Medium	High	High	High	Medium	Medium	Low	Low	Medium	Medium
CO 5	Medium	High	High	High	Medium	Medium	Low	Low	Medium	Medium
CO 6	Medium	High	High	High	Medium	Medium	Low	Low	Medium	Medium

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Course Title**: Mathematics Practical**
Course Code**: 253030205**

Sr. No.	**Course Outcomes**
CO 1	Solve systems of linear equations, compute eigenvalues and eigenvectors, and apply the Cayley-Hamilton theorem in matrix analysis.
CO 2	Work with orthogonal and unitary matrices, compute matrix norms, and apply these concepts in matrix problem-solving.
CO 3	Analyze and solve problems involving bilinear, quadratic, and Hermitian forms, including their applications.
CO 4	Compute measures, work with measurable sets and functions, and apply these concepts in real-world scenarios.
CO 5	Apply Holder's and Minkowski's inequalities, compute derived numbers, and solve practical problems involving these concepts.
CO 6	Solve differential equations using various methods, including Lagrange's equation and Jacobi's methods, addressing initial and boundary value problems.

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO 1	High	High	High	Medium	Medium	Medium	Low	Low	Low	Low
CO 2	Medium	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low
CO 3	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Low	Low
CO 4	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Low
CO 5	Medium	Medium	Medium	Medium	High	Medium	Low	Low	Low	Low
CO 6	Medium	High	Medium	High	Medium	High	Low	Low	Low	Low

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M.Sc. Semester III

Course Title**: Functional Analysis**
Course Code: **253030301**

CO 1	Understand and apply the concepts of normed linear spaces, Banach spaces, and quotient spaces, including completeness and bounded linear transformations.
CO 2	Apply key theorems related to normed and Banach spaces, including the Hahn-Banach theorem, dual spaces, and the open mapping and closed graph theorems.
CO 3	Define and analyze inner product spaces and Hilbert spaces, including their properties, orthogonal complements, and orthonormal sets, and apply Bessel's inequality.
CO 4	Understand and use the concepts of conjugate spaces and Riesz representation theorem in the context of Hilbert spaces.
CO 5	Analyze operators on Hilbert spaces, including understanding the adjoint of an operator, and applying concepts of self-adjoint, normal, and unitary operators.
CO 6	Solve problems involving bounded linear transformations and operators on normed and Banach spaces, and apply theoretical results to practical scenarios.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low
CO 2	Medium	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low
CO 3	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Low	Low
CO 4	Medium	Medium	Medium	High	Medium	Medium	Low	Low	Low	Low
CO 5	Medium	Medium	Medium	High	High	Medium	Low	Low	Low	Low
CO 6	Medium	Medium	Medium	Medium	High	High	Low	Low	Low	Low

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Course Title: **Mathematical Modeling**

Course Code: **253030302**

CO 1	Understand the scope and limitations of mathematical modeling, classify different types of models, and apply techniques for dimensional homogeneity in various models such as gravity, population growth, and diffusion.
CO 2	Analyze and interpret two-species population models, including prey-predator dynamics, competition models, and various epidemic models (SI, SIS, ISI, and models with removal).
CO 3	Develop and analyze biological models including diffusion of glucose in the bloodstream, genetics models related to Hardy-Weinberg law and blood groups, and apply business models such as the EOQ model and even price adjustment models.
CO 4	Apply mathematical techniques to traffic models, including macroscopic and microscopic models, and analyze linear and non-linear car-following models to determine stopping distances.
CO 5	Evaluate the stability and geometric interpretations of population dynamics models and epidemic models, and apply these evaluations to practical scenarios in biology and epidemiology.
CO 6	Develop and solve mathematical models for various real-world applications, including biological processes, business optimization, and traffic flow, using appropriate modeling techniques and analysis methods.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Low
CO 2	Medium	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low
CO 3	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Low	Low
CO 4	Medium	Medium	Medium	High	Medium	Medium	Low	Low	Low	Low
CO 5	Medium	Medium	Medium	Medium	High	Medium	Low	Low	Low	Low
CO 6	Medium	Medium	Medium	Medium	Medium	High	Low	Low	Low	Low

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Course Title**: Partial Differential Equation**

Course Code**: 253030303**

CO 1	Understand the origin and formulation of second-order partial differential equations (PDEs), including linear PDEs with constant coefficients, and solve equations involving polynomial, exponential, and trigonometric functions.
CO 2	Classify second-order partial differential equations and convert them to canonical form. Apply Monge's method to solve nonlinear second-order PDEs and understand solutions for both special and general cases.
CO 3	Solve second-order partial differential equations with variable coefficients using methods such as changing variables and analyze solutions in the context of specific equations.
CO 4	Apply the separation of variables method to solve the Laplace, wave, and diffusion equations, and determine solutions in various coordinate systems.
CO 5	Analyze and solve boundary value problems including Dirichlet and Neumann problems, and apply principles such as the maximum and minimum principles, Harnack's theorem, and Green's function.
CO 6	Develop and solve partial differential equations using various methods and techniques, including classification, changing variables, separation of variables, and boundary value problem approaches.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Low	Low
CO 2	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Low	Low
CO 3	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Low
CO 4	Medium	Medium	Medium	High	Medium	Medium	Low	Low	Low	Low
CO 5	Medium	Medium	Medium	Medium	High	Medium	Low	Low	Low	Low
CO 6	Medium	Medium	Medium	Medium	Medium	High	Low	Low	Low	Low

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Course Title**: Topology – I**

Course Code**: 253030304**

CO 1	Understand the concepts of topological spaces, including basis and subbasis, order topology, subspace topology, and the properties of closed sets and limit points.
CO 2	Analyze continuous functions and homeomorphisms, apply the pasting lemma, understand mappings into product spaces, and explore the metric topology and the uniform limit theorem.
CO 3	Define and analyze connected spaces, path-connected spaces, and connected sets in the real line. Understand components, path components, and the relationship between local connectedness and path connectedness.
CO 4	Examine compact spaces and compact sets in the real line, including limit point compactness and locally compact spaces. Understand the concept of one-point compactification.
CO 5	Apply the sequence lemma to understand convergence in topological spaces and investigate the quotient topology in relation to continuous functions and homeomorphisms.
CO 6	Develop and apply techniques for analyzing topological properties such as connectedness and compactness, and use these concepts to solve problems in various topological spaces.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO 2	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO 3	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO 4	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO 5	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO 6	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low

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Course Title**: Mathematics Practicals**
Course Code**: 253030305**

CO	Course Coverage
CO 1	Implement examples to understand topological spaces, closed sets, limit points, and explore connected and compact spaces.
CO 2	Perform simulations for population models, epidemic models, and business models to analyze dynamics and outcomes.
CO 3	Solve second-order partial differential equations (PDEs) using methods such as separation of variables and analyze solutions for Laplace, Wave, and Diffusion equations.
CO 4	Investigate properties of continuous functions, including homeomorphisms and uniform limits, through practical examples.
CO 5	Perform hypothesis testing, regression analysis, and work with various probability distributions in statistical analysis.
CO 6	Analyze and implement deterministic inventory control models, queuing models, equipment replacement policies, and sequencing problems using optimization techniques.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low
CO 2	Medium	Medium	Medium	Medium	Low	High	Low	Low	Low	Medium
CO 3	High	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low
CO 4	High	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low
CO 5	Low	Medium	High	Medium	High	Low	Low	Low	Low	Low
CO 6	Medium	Medium	Medium	Medium	Low	High	Low	Low	Low	Medium

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MSc Semester IV

Course Title**: Number Theory**

Course Code**: 253030401**

CO 1	Understand and apply fundamental concepts of number theory, including the division algorithm, greatest common divisor, Euclidean algorithm, and Diophantine equations.
CO 2	Analyze properties of congruences, solve linear congruences, and apply the Chinese Remainder Theorem. Utilize number-theoretic functions and apply results such as Fermat's Little Theorem, Wilson's Theorem, and Mobius inversion.
CO 3	Explore Euler's Phi function and Euler's theorem, analyze properties of the Phi function, and determine primitive roots for primes and composite numbers. Understand the theory of indices, Euler's criterion, and the Legendre symbol.
CO 4	Apply the quadratic reciprocity law to solve quadratic congruences with composite moduli. Analyze and solve problems involving quadratic congruences and the equation x^2 + y^2 = z^2.
CO 5	Study Fermat's Last Theorem and understand its implications in number theory. Analyze the representation of numbers as sums of squares, including the sum of two and more than two squares.
CO 6	Develop and apply methods for solving various problems in number theory, including congruences, factorization methods, and the representation of numbers by sums of squares.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low
CO 2	Medium	High	Medium	Medium	Low	Medium	Low	Low	Low	Medium
CO 3	High	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low
CO 4	Medium	Medium	Medium	High	Low	Low	Low	Low	Low	Medium
CO 5	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low
CO 6	Medium	Medium	Medium	Medium	Low	Medium	Low	Low	Low	Medium

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Course Title: **Research Methodology**

Course Code: **253030402**

CO 1	Understand the definition, scope, and methods of data collection, classification, and tabulation. Present data graphically and diagrammatically and apply measures of central tendency, dispersion, and standard error.
CO 2	Analyze and apply probability distributions, including binomial, Poisson, and normal distributions, to various statistical problems.
CO 3	Conduct hypothesis testing, understand types of errors and levels of significance, and apply various statistical tests, including Chi-square goodness of fit.
CO 4	Perform simple linear regression and correlation analysis to determine relationships between variables and interpret results.
CO 5	Develop skills in scientific writing and research, including creating research proposals, papers, review papers, theses, and conference reports. Understand formatting and content requirements for research documentation.
CO 6	Prepare and deliver scientific presentations, including formatting research reports and theses, and include sections such as title pages, certificates, declarations, acknowledgements, lists of tables and figures, and references.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Low	Low	Low	Low	Low	Low	Low
CO 2	Medium	High	Medium	Low	Low	Low	Low	Low	Low	Medium
CO 3	Medium	Medium	High	Medium	Low	Low	Low	Low	Low	Low
CO 4	Medium	Medium	Medium	High	Low	Low	Low	Low	Low	Low
CO 5	Medium	Low	Medium	Low	High	Medium	Low	Low	Low	Low
CO 6	Medium	Low	Low	Low	High	High	Low	Low	Low	Low

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Course Title: **Integral Transforms**

Course Code: **253030403**

CO 1	Understand the definition and properties of the Laplace transform, including rules of shifting, Laplace transforms of derivatives and integrals, and the convolution theorem. Apply the complex inversion formula to solve problems.
CO 2	Analyze and apply Fourier transforms, including definitions and properties of Fourier sine, cosine, and complex transforms. Utilize convolution theorems, inversion theorems, and Fourier transforms of derivatives in practical applications.
CO 3	Study the definition and elementary properties of the Mellin transform. Apply Mellin transforms to derivatives and integrals and use the inversion and convolution theorems in solving problems.
CO 4	Explore the definition and properties of the Henkel transform, including transforms of derivatives and integrals. Apply the inversion and convolution theorems to various problems.
CO 5	Develop a comprehensive understanding of the interrelationships between different integral transforms (Laplace, Fourier, Mellin, and Henkel) and their applications in solving differential equations and other mathematical problems.
CO 6	Apply integral transforms to practical problems in engineering and applied mathematics, including the solution of boundary value problems and signal processing.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Low	Low	Low	Low	Low	Low	Low
CO 2	Medium	High	Medium	Low	Low	Low	Low	Low	Low	Medium
CO 3	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low	Low
CO 4	Medium	Medium	Low	Medium	Low	Low	Low	Low	Low	Low
CO 5	High	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low
CO 6	Medium	Low	Low	Low	High	Medium	Low	Low	Low	Low

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Course Title**: Topology – II**

Course Code**: 253030404**

CO 1	Understand and identify different separable axioms, including T0, T1, T2 spaces, and concepts of first countable, second countable, Lindelöf, and separable spaces.
CO 2	Analyze and characterize regular and normal spaces, including completely normal and completely regular spaces, and apply concepts such as one-point compactification in topological spaces.
CO 3	Explore product and quotient topologies, including weak topologies, product spaces, Tychonoff topology, and Tychonoff's theorem, and apply these concepts to solve problems in topology.
CO 4	Study sequences and nets in topological spaces, including direct sets, residual subsets, and convergence properties of nets and ultrasets. Understand filters, filter bases, and ultrafilters, and analyze convergence and cluster points of filters.
CO 5	Develop an understanding of advanced topological concepts such as compactification, separation properties, and convergence theories. Apply these concepts to solve complex problems in topology.
CO 6	Apply theoretical concepts of topological spaces to practical problems, including the use of filters and nets in analyzing convergence and clustering properties within various topological structures.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Low	Low	Low	Low	Low	Low	Low
CO 2	Medium	High	Medium	Medium	Low	Low	Low	Low	Low	Low
CO 3	Medium	Medium	High	Low	Medium	Low	Low	Low	Low	Low
CO 4	Medium	Low	Medium	Medium	Low	Low	Low	Low	Low	Low
CO 5	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO 6	Medium	Medium	Medium	Low	High	Low	Low	Low	Low	Low

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Course Title**: Mathematical Practicals**
Course Code**: 253030405**

CO	Course Outcome
CO 1	Apply the Laplace transform to solve ordinary differential equations and analyze systems with given initial conditions. Demonstrate understanding of the properties, rules, and convolution theorem.
CO 2	Utilize Fourier transforms to solve problems involving signal processing, differential equations, and boundary value problems. Apply Fourier sine, cosine, and complex transforms, as well as convolution and inversion theorems.
CO 3	Implement the Mellin transform in solving differential equations and analyzing functions, including applying the inversion and convolution theorems to practical problems.
CO 4	Use the Henkel transform to address problems in applied mathematics, including its definition, properties, and application of convolution and inversion theorems.
CO 5	Investigate separable and countable axioms in topological spaces, including practical problems involving T0, T1, T2 spaces, and separability properties.
CO 6	Analyze and apply concepts of regularity and normality in topological spaces, including one-point compactification. Solve problems involving product spaces, quotient topologies, and Tychonoff's theorem.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	High	Medium	Medium	Low	Low	Low	Low	Low	Low	Low
CO 2	Medium	High	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO 3	Medium	Medium	High	Low	Low	Low	Low	Low	Low	Low
CO 4	Medium	Low	Medium	Medium	Low	Low	Low	Low	Low	Low
CO 5	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low
CO 6	Medium	Medium	Medium	Medium	High	Low	Low	Low	Low	Low

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Course Title**: Environmental Issues and Impacts**

Course Code: **256060102**

M.Sc. Semester I

Department of Environment Science

Course Title**: Environmental Science and Ecology**

Course Code: **256060101**

CO 1	Explain the fundamental concepts of ecology, including species interactions, natural selection, species richness, ecological succession, and ecosystem stability.
CO 2	Analyze the structure and functioning of ecosystems, focusing on energy flow, primary and secondary production, food chains, food webs, and decomposition processes.
CO 3	Compare and contrast the characteristics of various terrestrial biomes, including tundra, taiga, temperate forests, grasslands, deserts, and tropical rainforests, with a focus on forest resources and their sustainable management.
CO 4	Evaluate the impact of human activities, such as deforestation, forest degradation, and dam construction, on forest ecosystems and indigenous communities, with particular attention to India's forest resources.
CO 5	Assess the environmental implications of mineral resource exploration and usage, and the challenges associated with global food production, including the use of pesticides and the impact of modern agriculture on the environment.
CO 6	Propose sustainable solutions for conserving natural resources, emphasizing the role of individuals in promoting sustainable agriculture, pollution prevention, and equitable resource management.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Low	Medium	Medium	Medium	Low	Low	Low	Low	Medium
CO2	Medium	Medium	High	Medium	High	Medium	Low	Low	Medium	Medium
CO3	Medium	Low	Medium	Medium	High	Low	Low	Low	Medium	Medium
CO4	Medium	Low	Medium	High	High	Low	Low	Medium	High	High
CO5	Medium	Medium	High	Medium	High	Low	Low	Medium	Medium	High
CO6	Low	High	Medium	High	High	Low	Medium	Medium	High	High

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Course Title**: Environmental Issues and Impacts**

Course Code: **256060102**

CO 1	Explain the composition and temperature profile of the atmosphere, including the evolution of the primitive atmosphere and the sources and sinks of atmospheric components, with a focus on the causes, impacts, and mitigation of acid rain.
CO 2	Analyze the chemical processes affecting the stratospheric ozone layer, including the role of chlorofluorocarbons (CFCs) and nitrogen oxides in ozone depletion, as well as the significance of international agreements like the Montreal Protocol for ozone protection.
CO 3	Examine the chemical reactions in the troposphere, focusing on photochemical smog, the role of the hydroxyl radical (OH), and the effects of atmospheric particles on climate, air quality, and human health, while exploring strategies for particle control.
CO 4	Discuss the greenhouse effect, global warming, and climate change, evaluating the impact of greenhouse gases, the consequences of rising CO_2 levels, and international policy responses like the Kyoto Protocol to mitigate climate-related environmental changes.
CO 5	Investigate the formation and consequences of the ozone hole and assess the worldwide trends in ozone concentration, along with strategies to address the environmental challenges induced by CO_2 rise and other greenhouse gases.
CO 6	Evaluate the risks associated with radiation hazards and environmental degradation, including radioactive pollution from anthropogenic sources, the concept of nuclear winter, and preventive measures to minimize the effects of ionizing radiation and radioactive waste.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	Low	Medium	Medium	Medium	Low	Low	Low	Low	Medium
CO2	Medium	High	Medium	Low	Medium	Low	Low	Medium	Low	Medium
CO3	Low	Medium	High	Medium	Medium	Medium	Low	Low	Medium	Medium
CO4	Medium	Low	Medium	High	Medium	Low	Low	Medium	High	High
CO5	Low	Medium	High	Medium	High	Low	Low	Medium	Medium	High
CO6	Low	Low	Medium	High	Medium	Medium	Low	Medium	High	High

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Course Title: **Energy and Environment**
Course Code: 256060103

CO 1	Understand the fundamental laws of energy flow, dynamic equilibrium, and the principles of chemical kinetics, including the structure of atoms, elements, molecules, and chemical reactions.
CO 2	Analyze the processes of energy production and consumption, identifying various energy sources such as renewable and conventional fuels, and evaluating energy conservation strategies and solar energy input.
CO 3	Evaluate the production and management of nuclear energy, including nuclear reactions, the role of uranium, and the risks associated with nuclear accidents.
CO 4	Explore non-conventional energy sources such as photovoltaics, solar heating, wind energy, and tidal power, emphasizing their potential as sustainable energy solutions.
CO 5	Examine the role of biomass and biofuels in energy production, focusing on the use of natural vegetation, energy tree plantations, and specific energy crops for sustainable energy development.
CO 6	Assess the environmental implications of biomass energy programs and the impact of various renewable energy sources on environmental sustainability.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Low
CO2	Medium	High	Medium	Medium	High	Medium	Low	Low	Medium	Medium
CO3	Medium	Medium	High	High	Medium	Medium	Low	Low	Medium	Medium
CO4	Medium	Medium	Medium	High	High	Medium	Low	Low	Medium	High
CO5	Medium	Medium	Medium	Medium	High	Medium	Low	Low	Medium	High
CO6	Low	Medium	High	High	High	Medium	Low	Medium	High	High

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Course Title: **Environment and Soil**

Course Code: 256060104

CO 1	Understand the processes of soil formation, weathering, and the factors influencing soil development, including land degradation, soil horizons, and the use of GIS and GPS in soil mapping and quality assessment.
CO 2	Analyze the physical properties of soil, such as texture, structure, density, porosity, permeability, and soil temperature, while evaluating their impact on soil health and plant growth.
CO 3	Evaluate the relationship between soil and water, focusing on soil water content, water flow, and plant water uptake, and explore techniques for improving water efficiency and reducing water loss in soils.
CO 4	Investigate the chemical properties of soil, including the behavior of soil clays, organic colloids, cation/anion exchange, and the reactions that influence soil acidity and buffering capacity.
CO 5	Examine the role of lime in soil management, focusing on the composition and reactions of lime, its impact on soil acidity, and the relationship between lime balance and crop productivity.
CO 6	Assess the ecological impact of soil acidity and acidification, and explore methods for managing acidic soils to improve soil fertility and environmental sustainability.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Medium
CO2	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Medium	Medium
CO3	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Medium	Medium
CO4	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium
CO5	Medium	Low	Medium	Medium	High	Medium	Low	Low	Medium	Medium
CO6	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	High

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MSc Semester 2

Course Title**: Water Quality and Wastewater Treatment Techniques**

Course Code: **256060201**

CO 1	Understand the hydrological cycle, surface water and groundwater systems, and evaluate natural conditions and human activities that influence water quality, including the classification and effects of different water pollutants.
CO 2	Analyze methods for managing water resources and the utilization of water, focusing on the origin and characteristics of wastewater from various sources.
CO 3	Develop skills in wastewater sampling and analysis, including the determination of organic and inorganic substances, physical characteristics, and bacteriological measurements for water quality assessment.
CO 4	Examine the stages of wastewater treatment processes, from primary and secondary (biological) treatment to advanced treatment techniques, and explore the recovery of valuable materials from industrial effluents.
CO 5	Investigate the impact of industrial chemical processes on water quality, focusing on sectors such as sugar, distillery, pharmaceuticals, pulp and paper, tanneries, fertilizers, and dairy industries.
CO 6	Assess water quality regulations and their implementation in various industries, emphasizing the importance of compliance to reduce environmental pollution and ensure sustainable water resource management.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	High
CO2	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	High
CO3	Medium	High	High	Medium	Medium	Medium	Low	Low	Medium	Medium
CO4	Medium	Medium	High	High	Medium	Medium	Low	Low	Medium	High
CO5	Medium	Medium	Medium	High	Medium	Medium	Low	Low	Medium	High
CO 6	High	High	High	High	Medium	Medium	High	High	High	High

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Course Title**: Integrated Solid Waste Management**

Course Code: **256060202**

CO 1	Understand the basic concepts of solid waste management, including types of solid waste, collection methods, volume reduction technologies, and the hierarchy of waste management, with a focus on cost and efficiency in environmental management.
CO 2	Analyze source reduction policies and methodologies, evaluate government programs and initiatives aimed at reducing garbage, and explore various concentrating methods such as vacuum filtration, rotary drum precoat filter, and incineration of municipal sludge.
CO 3	Evaluate recycling processes and technologies, including collection of recyclables, processing equipment like baling and magnetic separation, and the recycling of materials such as glass, plastics, and automotive batteries.
CO 4	Examine composting and landfilling processes, including the classification of compost systems and landfills, composting phases, environmental factors affecting composting, and the generation and management of landfill gases and leachate.
CO 5	Understand the management of hazardous waste, including definitions, transportation, treatment, storage, disposal, site remediation, and minimization strategies, with a focus on medical, hospital, and nuclear wastes.
CO 6	Assess the environmental impacts of various waste management techniques and regulations, and explore sustainable practices for reducing, recycling, composting, and safely managing hazardous and non-hazardous waste.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	High
CO2	Medium	High	Medium	Medium	Medium	Medium	Low	Low	Medium	High
CO3	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Medium	High
CO4	Medium	Medium	Medium	High	Medium	Medium	Low	Low	Medium	High
CO5	Medium	Medium	Medium	Medium	High	Medium	Low	Low	Medium	High
CO6	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High

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Course Title**: Aquatic and marine Environmental Chemistry**

Course Code: **256060203**

CO 1	Understand the fundamentals of aquatic and marine chemistry, including the properties of aquatic environments, water acidity, metal complexes, oxidation-reduction processes, and the significance of pharmaceuticals from the sea.
CO 2	Analyze the sources, nature, and effects of pollutants in the marine environment, with a focus on oil pollution, microbial degradation of petrochemicals, and metallic pollutants, and evaluate the status and mitigation strategies for coastal and estuarine pollution, particularly in India.
CO 3	Examine the role of oceans in climate regulation, including the chemical properties of seawater, spatial scales of oceanic change, the carbon cycle, oceanic gases, and their interaction with climate feedback processes.
CO 4	Explore the impact of oceanic chemical processes on climate, including feedback mechanisms involving marine chemistry and potential future changes in ocean-climate interactions.
CO 5	Understand the principles of remote sensing, including types of remote sensing systems, their overview, and applications, as well as the integration of Geographic Information Systems (GIS) and Global Positioning Systems (GPS) in environmental monitoring.
CO 6	Apply remote sensing, GIS, and GPS technologies to analyze and manage environmental data, with a focus on their applications in studying and mitigating marine and coastal pollution.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium
CO2	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Medium	High
CO3	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Medium	High
CO4	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Medium	High
CO5	Medium	Medium	Medium	Medium	High	Medium	Low	Low	Medium	High
CO6	Medium	Medium	Medium	Medium	High	High	High	Medium	Medium	High

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Course Title**: Air Pollution: Quality and Control Methods**

Course Code: **256060204**

CO 1	Understand the sources, classification, and properties of air pollutants, including their behavior, fate, and the formation of photochemical smog, and evaluate the effects of air pollution on human health, vegetation, and materials, as well as the Air (Prevention and Control of Pollution) Act of 1981.
CO 2	Analyze various methods for sampling and measuring air pollutants, including ambient air sampling, collection techniques for gaseous and particulate pollutants, and stack sampling, while understanding the principles of analysis for air pollutants.
CO 3	Examine air pollution control methods and equipment, focusing on source correction methods and the operation of control systems for particulate emissions (e.g., gravitational settling chambers, cyclone separators) and gaseous pollutants (e.g., sulfur dioxide, nitrogen oxides).
CO 4	Evaluate the effectiveness of different air pollution control technologies and equipment, including fabric filters, electrostatic precipitators, and wet collectors, in managing emissions from various sources.
CO 5	Understand indoor air quality issues, including the sources and toxicity of indoor air pollutants, and recognize syndromes related to poor indoor air quality, such as Sick Building Syndrome and Multiple Chemical Sensitivity.
CO 6	Assess the sources and sinks of pollutants in indoor environments and develop strategies to improve indoor air quality and mitigate health risks associated with indoor air pollution.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	High
CO2	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Medium	High
CO3	Medium	Medium	Medium	High	Medium	Medium	Low	Low	Medium	Medium
CO4	Medium	Medium	Medium	High	Medium	Medium	Low	Low	Medium	Medium
CO5	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium
CO6	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High

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M.Sc. Semester III

Course Title**: Environmental Biotechnology**

Course Code: **256060301**

CO 1	Evaluate the environmental impact of various processes and technologies, including the use of nitrogen fertilizers, impermeable barrier liners in landfills, and the control of submicron air toxin particles from coal combustion, with a focus on cleaner bioprocesses and sustainable development.
CO 2	Analyze advanced recycling and treatment methods for organic wastes, such as duckweed-based wastewater treatment, anaerobic treatment of tequila vinasse, and engineered reed bed systems, while exploring their effectiveness in resource recovery and reuse.
CO 3	Investigate methods for the removal of recalcitrant compounds from contaminated environments, including the use of immobilized non-viable cyanobacteria for heavy metal adsorption, bioremediation of soils and aquifers, and strategies for increasing the bioavailability of recalcitrant molecules.
CO 4	Examine bioremediation techniques for cleaning up contaminated soils and aquifers, focusing on the application of biotechnologies for environmental restoration and the role of environmental oil biocatalysis.
CO 5	Explore cleaner bioprocesses in industrial applications, including clean biological bleaching processes in the pulp and paper industry, and microbial processes that contribute to economic benefits and sustainability.
CO 6	Assess the implementation of cleaner technologies and production activities across various industries, emphasizing their role in enhancing environmental sustainability and reducing industrial impacts.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	High
CO2	Medium	High	Medium	Medium	Medium	Medium	Low	Low	Medium	High
CO3	Medium	Medium	High	Medium	Medium	Medium	Medium	Low	Medium	High
CO4	Medium	Medium	High	Medium	Medium	Medium	Medium	Low	Medium	High
CO5	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium	Medium	High
CO6	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High

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SWARNIM STARTUP & INNOVATION UNIVERSITY
BHOYAN RATHOD, KALOL, GANDHINAGAR.

Course Title**: Environmental Toxicology and Its Impact**
Course Code: **256060302**

CO 1	Understand the fundamentals of toxicology and toxicological chemistry, including dose-response relationships, relative toxicities, xenobiotic and endogenous substances, and the effects of toxins on teratogenesis, mutagenesis, carcinogenesis, immune, and reproductive systems.
CO 2	Analyze the toxicology of various chemical substances, including toxic elements, heavy metals (e.g., cadmium, lead, arsenic), and toxic inorganic and organic compounds, focusing on their health hazards and environmental impact.
CO 3	Examine the environmental presence and effects of heavy metals such as arsenic, cadmium, lead, mercury, and chromium, including their biochemical effects, emission sources, toxicity, transformation, and remedial measures.
CO 4	Evaluate the impact of toxic elements and compounds, including elemental halogens, organometallic compounds, and specific toxic inorganic compounds like cyanide and carbon monoxide, on human health and the environment.
CO 5	Assess the environmental impact of pesticides, including their historical use, classification, application potential, limitations, persistence, and issues related to bioaccumulation and biomagnification.
CO 6	Apply knowledge of toxicological principles to evaluate health hazards associated with various chemicals and develop strategies for mitigating their impact on the environment and human health.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium
CO2	Medium	High	Medium	Medium	Medium	Medium	Low	Low	Medium	High
CO3	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Medium	High
CO4	Medium	Medium	Medium	High	Medium	Medium	Low	Low	Medium	High
CO5	Medium	Medium	Medium	Medium	High	Medium	Low	Low	Medium	High
CO6	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High

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Course Title**: Environmental Rules & Regulations**
Course Code: **256060303**

CO 1	Understand the fundamentals of toxicology and toxicological chemistry, including dose-response relationships, relative toxicities, xenobiotic and endogenous substances, and the effects of toxins on teratogenesis, mutagenesis, carcinogenesis, immune, and reproductive systems.
CO 2	Analyze the toxicology of various chemical substances, including toxic elements, heavy metals (e.g., cadmium, lead, arsenic), and toxic inorganic and organic compounds, focusing on their health hazards and environmental impact.
CO 3	Examine the environmental presence and effects of heavy metals such as arsenic, cadmium, lead, mercury, and chromium, including their biochemical effects, emission sources, toxicity, transformation, and remedial measures.
CO 4	Evaluate the impact of toxic elements and compounds, including elemental halogens, organometallic compounds, and specific toxic inorganic compounds like cyanide and carbon monoxide, on human health and the environment.
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CO1	High	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	Medium
CO2	Medium	High	Medium	Medium	Medium	Medium	Low	Low	Medium	High
CO3	Medium	Medium	High	Medium	Medium	Medium	Low	Low	Medium	High
CO4	Medium	Medium	Medium	High	Medium	Medium	Low	Low	Medium	High
CO5	Medium	Medium	Medium	Medium	High	Medium	Low	Low	Medium	High
CO6	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High

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Course Title**: Environmental Impact Assessment**
Course Code: **256060304**

CO 1	Understand the fundamental concepts and methodologies of Environmental Impact Assessment (EIA), including its role as a planning tool, criteria for selecting EIA methodologies, and the use of predictive models for impact assessment.
CO 2	Assess and predict the impacts of major projects on various environmental aspects, including noise, transport, landscape, air quality, soil, water, ecology, and socio-economic factors.
CO 3	Analyze environmental risk assessment (ERA) concepts and methods, including key steps in performing an ERA, legislative and policy backgrounds, and the similarities and challenges between ERA and EIA.
CO 4	Evaluate the application of environmental remote sensing (RS) and geographical information systems (GIS) in EIA, including the use of RS data and software for impact prediction, mitigation, and monitoring.
CO 5	Develop skills in integrating GIS and remote sensing data into the EIA process, including their application in screening, scoping, baseline studies, impact prediction, and mitigation efforts.
CO 6	Apply knowledge of EIA methodologies, environmental risk assessment, and remote sensing technologies to real-world case studies, assessing their effectiveness in managing environmental impacts.

CO-PO Mapping

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CO1	High	Medium	Medium	Medium	Medium	Low	Medium	High	Medium	High
CO2	Medium	Medium	High	Medium	Medium	Medium	Medium	High	Medium	High
CO3	Medium	Medium	High	Medium	Medium	Medium	Low	Medium	Medium	High
CO4	Medium	Medium	Medium	High	Medium	Medium	High	Medium	Medium	High
CO5	Medium	Medium	Medium	High	Medium	Medium	High	Medium	Medium	High
CO6	Medium	Medium	Medium	High	Medium	Medium	High	Medium	Medium	High

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MSc. Semester IV

Course Title**: Remote Sensing and Geographic Information**

Course Code: **256060401**

CO 1	Understand the fundamentals of remote sensing, including definitions, scope, electromagnetic radiation, atmosphere windows, and the various platforms and sensors used in remote sensing systems, with a focus on LANDSAT, SPOT, and Indian remote sensing satellites.
CO 2	Analyze aerial photography techniques, including the use of vantage points, cameras, filters, and films, and comprehend the elements of visual image interpretation, as well as the principles of multispectral and microwave remote sensing and photogrammetry.
CO 3	Examine digital image processing techniques, including image restoration and enhancement, and apply image classification methods to various remote sensing applications in forestry, ecology, land use, agriculture, soils, geology, and disaster management.
CO 4	Explore the applications of remote sensing technologies in environmental science, including their use in monitoring and managing forestry, ecological systems, land use, and disaster response.
CO 5	Understand the principles and applications of Geographic Information Systems (GIS), including hardware and software requirements, and the conceptual models of spatial and non-spatial information.
CO 6	Apply GIS technology and GPS for environmental science applications, integrating spatial and non-spatial data to support environmental analysis and decision-making.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	High	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium
CO2	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium
CO3	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO4	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO5	Medium	Medium	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium
CO6	Medium	Medium	Medium	Medium	Medium	Medium	High	Medium	Medium	Medium

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Course Title**: Environmental Modelling and Biostastistics**
Course Code: **256060402**

CO 1	Apply statistical measures of central tendency (mean, median, mode) and dispersion (standard deviation, skewness, kurtosis) to analyze data, and use correlation and linear regression techniques to model relationships between variables.
CO 2	Understand and utilize probability concepts, random variables, and density functions, including the application of binomial and normal distributions in statistical analysis and hypothesis testing.
CO 3	Explore the role of modeling in environmental sciences, including the classification of deterministic and stochastic models, steady-state and dynamic models, and the stages involved in building and formulating these models.
CO 4	Apply microbial growth kinetics models, such as the Monod equation, and methods for formulating dynamic balance equations, including mass balance procedures, to environmental and biological systems.
CO 5	Analyze and apply various environmental models, including the Lotka-Volterra model for population interactions, Leslie's matrix model, point source stream pollution models, box models, and Gaussian plume models, for understanding and predicting environmental phenomena.
CO 6	Develop and validate regression models (linear, simple, and multiple) for environmental data analysis and forecasting, and apply these models to practical environmental scenarios for accurate prediction and decision-making.

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO2	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO3	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO4	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO5	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
CO6	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium

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