INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Biosciences and Bioengineering

Subject Code: BEC-501 **Course Title:** Reaction engineering in bioprocesses

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Basics of reaction kinetics, enzyme kinetics, multi-substrate enzyme kinetics, immobilized enzyme kinetics, microbial growth kinetics, batch and continuous growth kinetics, maintenance coefficient, metabolic flux analysis, metabolic control analysis, batch and continuous sterilization kinetics.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Biosciences and Bioengineering

Subject Code: BEC-503 **Course Title:** Unit operations in Biomanufacturing

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Fundamentals of biomanufacturing, Understanding of bioproducts, cell culture, and fermentation as the foundation of bioprocesses. Understanding types of unit operations, Bioreactor selection, Scale-up consideration, computational fluid dynamics (CFD) modeling and simulation as tool for scale-up, downstream operations

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Biosciences and Bioengineering

Subject Code: BEC-505 **Course Title**: Plant Design and Technoeconomic Analysis

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Introduction to plant design concepts and methodologies. General design considerations, Process Flow sheeting and Material Balances, Principles of process flow diagram (PFD), Energy Balances and Process Integration, Plant Layout and Piping Design, Equipment Selection and Sizing, Introduction to Technoeconomic Analysis

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Biosciences and Bioengineering

Subject Code: BEC-507 **Course Title:** Biomanufacturing Laboratory

L-T-P: 0-0-6 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Microbiology and cell biology experiments, biochemistry and molecular biology techniques, Biochemical engineering experiments for reactor operation, downstream processing experiments for isolation and recovery of products.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPT./CENTRE/SCHOOL: Department of Biosciences and Bioengineering

Subject Code: BEC-511 **Course Title:** Essentials of Biosciences and Mathematics

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Explore life's fundamental principles, biomolecules, cellular structure, and function. Probability, linear algebra, calculus, applications in genomics, transcriptomics, proteomics, metabolism and statistical analysis in biological research.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPT./CENTRE/SCHOOL: Department of Biosciences and Bioengineering

Subject Code: BEC-513 **Course Title:** Computer Programming

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Linux, Python, and R essentials for computational biology. Linux commands, shell scripting for automation, Python programming for data analysis and module creation, R for statistical analysis and visualization, Final project applying programming skills in structural or computational biology.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPT./CENTRE/SCHOOL: Department of Biosciences and Bioengineering

Subject Code: BEC-515 **Course Title:** Structural Biology

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Intricacies of Structural Biology, covering X-ray Crystallography, NMR Spectroscopy, Cryo-EM, and Integrative Structural Biology. Principles of protein structure determination, data collection, analysis, and integration; Structure-function relationships in biological processes and drug design.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPT./CENTRE/SCHOOL: Department of Biosciences and Bioengineering

Subject Code: BEC-517 **Course Title:** Bioanalytical Techniques

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Advanced biophysical and biochemical analysis techniques, including light-matter interaction, microscopy, mass spectrometry, and structural biology. Electrophoresis, chromatography, spectroscopy, and gene editing techniques. System biology concepts: network analysis, stochasticity, and gene regulation networks.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPT./CENTRE/SCHOOL: Department of Biosciences and Bioengineering

Subject Code: BEC-519 **Course Title:** SCB Laboratory-I

L-T-P: 0-0-6 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Techniques in biochemistry and structural biology through practical experiments including various chromatography methods, spectroscopy, NMR, electron microscopy, crystallization, and computational analysis.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTER/SCHOOL: Department of Biosciences and Bioengineering

Subject code: BEC-521 **Course Title:** Advanced Biochemistry

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outline: Concepts in biochemistry, biological systems, basic principles of physics and thermodynamics; primary building blocks of life and biological macromolecules, structure of proteins and their correlation to biological functions; biological catalysis, catalytic mechanisms, metabolic pathways, and signaling processes.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTER/SCHOOL: Department of Biosciences and Bioengineering

Subject code: BEC-523 **Course Title:** Cell and Molecular Biology

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outline: Introduction to Cell, Functional Structural and components of Cell, Cellular Processes, Chromatin structure and dynamics, DNA Replication and DNA Repair, Gene Expression in Prokaryotes & Eukaryotes, Manipulating and studying cells, Genome instability and cell transformation, Oncogenes.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTER/SCHOOL: Department of Biosciences and Bioengineering

Subject code: BEC-525 **Course Title:** Applied Microbiology

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outline: Introduction to microbiology and microbes, history & scope of microbiology, Sterilization, disinfection and antisepsis, control of microorganisms, Microbial taxonomy and evolution of diversity, Virus and bacteriophages, Microbial interactions and infection, host-pathogen interactions, antibiotic resistance.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTER/SCHOOL: Department of Biosciences and Bioengineering

Subject code: BEC-527 **Course Title:** Genetics

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outline: Classical and molecular genetics, advanced Mendelian genetics, human pedigree analysis, inheritance, gene mapping, mutation, repair mechanisms for mutations, alteration of chromosomes, population genetics, mobile genetic elements and genetics of cancer, genetics in human diseases.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTER/SCHOOL: Department of Biosciences and Bioengineering

Subject code: BEC-529 **Course Title:** Developmental Biology

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outline: Basic concepts of development, Production of gametes, embryogenesis, Cell aggregation, development and regeneration in vertebrates, Characteristics of plant growth and development, cellular differentiation, de-differentiation and regeneration, Shoot and root development, Vascular development, Cell-cell communication during plant development.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTER/SCHOOL: Department of Biosciences and Bioengineering

Subject code: BEC-531 **Course Title:** BSBE Laboratory-I

L-T-P: 0-0-8 **Credits:** 4 **Subject Area:** PCC

Course Outline: Basic and advanced techniques and methods in microbiology, cell culture, molecular biology and recombinant DNA technology, gene cloning and expression in bacteria.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Biosciences and Bioengineering

Subject Code: BEL-503 **Course Title:** Mass and Heat Transfer Operations

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Definition and classification of mass and heat transfer operations. Distinction between steady-state and transient processes. Introduction to diffusion, convection, and radiation mechanisms. Applications of mass and heat transfer in various industries, Fundamentals of Mass Transfer and Heat Transfer, Types of mass transfer operations, Design of heat exchange equipment.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Biosciences and Bioengineering

Subject Code: BEL-510 **Course Title**: Microbiology and Biochemistry

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Organization of prokaryotic and eukaryotic cells. structure and functions of cell organelles, microbial nutrition and cell growth principles, energy transduction in microbial systems, Non-covalent interactions in biological systems. Structure and characteristics of carbohydrate, protein, lipid and nucleic acid, Protein purification techniques, introduction to enzymes, vitamins and coenzymes. Lipid and biological membranes, Transport across cell membranes, design of metabolism, metabolic pathways, electron transport chain, gluconeogenesis and control of glycogen metabolism, signal transduction

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject code: BEC-522 **Course Title:** Immunology

L-T-P: 3-0-0 **Credits:** 3 **Subject area:** PCC

Course Outlines: Introduction to immune cells and tissues, inflammation, Hematopoiesis, B, and T cell activation. Complement factors, hypersensitivity, autoimmunity, cancer immunology, transplantation immunology, vaccines, monoclonal antibodies, and immunotechniques.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject code: BEC-524 **Course Title:** Genetic Engineering

L-T-P: 3-0-0 **Credits:** 3 **Subject area:** PCC

Course Outlines: Molecular tools and techniques of recombinant DNA technology; Gene cloning and expression vectors; Restriction and modification enzymes; Gene expression analysis; Gateway cloning technology; Approaches and applications of genetic manipulation; Functional characterization of genes; Genetic, physical and regulatory interaction studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject code: BEC-526 **Course Title:** Animal Biotechnology

L-T-P: 3-0-0 **Credits:** 3 **Subject area:** PCC

Course Outlines: Introduction to animal cell culture; Various methods of animal cell cultures; Introduction to transgenic animals; Various methods of making transgenic animals; Applications of transgenic animals for wellbeing of human.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject code: BEL-507 **Course Title:** Enzyme Production and Industrial Fermentation

L-T-P: 3-1-0 **Credits:** 4 **Subject area:** PEC

Course Outlines: Overview of industrial fermentation process, upstream processing, downstream processing, various classes of enzymes, submerged fermentation, solid state fermentation, process flowsheet for specific products, regulatory requirements of different class of fermentation products, use of recombinant culture for various products, process economics, sensitivity analysis.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject code: BEL-508 **Course Title:** Biorefinery for Energy and Value-added Products

L-T-P: 3-1-0 **Credits:** 4 **Subject area:** PEC

Course Outlines: Introduction to Biorefinery synthesis and design, Types of biorefinery platforms- Biochemical, thermochemical, and hybrid approaches, Economic and environmental analysis of biorefineries cycle assessment of biorefinery products, challenges and opportunities in biomass supply chain management, Sustainability and environmental impact of biomass sourcing, Emerging technologies in biorefinery (algae-based biorefineries), Policy and regulatory frameworks for biorefineries.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject Code: BEL-514 **Course Title:** Computational Biology

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Introduction to computational biology, genome assembly, pairwise sequence alignment, multiple sequence alignment, phylogenetic trees, protein-DNA binding motifs, RNA structure analysis, Markov chains, hidden Markov models, sequence alignment algorithms, dynamic programming, phylogeny construction, RNA structure prediction, transformational grammars, Systems biology, transcriptomics, gene expression analysis, single-cell RNA-seq, medical imaging informatics, image segmentation, pathway analysis, Bayesian networks.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject code: BEL-516 **Course Title:** Advanced Cell and Tissue Engineering

L-T-P: 2-0-0 **Credits:** 2 **Subject area:** PEC

Course Outlines: Introduction to various plant growth regulators; Various plant hormones and tissue culture techniques; Various methods of animal stem cell cultures; Applications of stem cells and therapeutics; Stem cell differentiation and functions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject code: BEL- 517 **Course Title:** Genomics, Proteomics and Metabolomics

L-T-P: 3-0-0 **Credits:** 3 **Subject area:** PEC

Course Outlines: Genomics, proteomics, and metabolomics: principles, techniques, applications, mass spectrometry, identification of genes, proteins and metabolites, multivariate analyses, prediction models and biomarker discovery.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject code: BEL- 518 **Course Title:** Neuroscience

L-T-P: 3-0-0 **Credits:** 3 **Subject area:** PEC

Course Outlines: Introduction to basic understanding of neuron structure and its function, neurochemistry, brain functions at cellular level and classical studies, neurological conditions, Technologies relevant to unravelling and manipulating CNS functions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject Code: BEL-511 **Course Title:** Protein Design and Engineering

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Review of protein structure and function; Principles of Protein Stability and Engineering; Protein Engineering Techniques: Direct evolution, Random mutagenesis, focused mutagenesis, site saturation mutagenesis, Homologous and non-homologous recombination, Screening and selection techniques; Computational Protein Design: Rational designing of proteins, Multiple sequence alignment, Co-evolutionary analysis of protein surfaces, Structure-based designing of novel proteins using ab-initio methods, fragment-based methods, homology modeling and protein threading; De Novo Protein Design; Biotechnological Applications of Engineered Proteins.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject Code: BEL-512 **Course Title:** Molecular Dynamics Simulations

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Principles of classical mechanics, potential energy functions, thermostat algorithms, integration methods, software utilization (e.g., GROMACS, AMBER), system setup, simulation running, data analysis, advanced topics like free energy calculations, enhanced sampling techniques, coarse-grained simulations, and QM/MM simulations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject Code: BEL-513 **Course Title:** Structural and Translational Bioinformatics

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Basic Concepts of Bioinformatics; Fundamentals of protein, DNA and RNA structure; Study of macromolecular structures; Structural comparison and alignment; Protein-Protein and Protein-DNA interactions; Structure: function and application; Sequence analysis; Structural informatics; Health informatics.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject Code: BEL-515 **Course Title:** Probabilistic Machine Learning

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Introduction to Machine Learning; Development environment; Visualization libraries; Exploratory Data analysis; Supervised learning algorithms: Linear and Logistic regression, SVMs, Decision Trees and Random Forests, k-NN, and more; Unsupervised learning algorithms: k-means clustering, Gaussian Mixture Models, PCA; Evaluation metrics; Building machine learning models with examples.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biosciences and Bioengineering

Subject code: BEL-523 **Course Title:** Drug Discovery and Development

L-T-P: 3-0-0 **Credits:** 3 **Subject area:** PEC

Course Outlines: Attributes of a drug, Mode of action of drugs, Target identification for drug action, Lead drug optimization strategies, High throughput screening, Pharmacokinetics and pharmacodynamics of drugs, Pre-clinical studies and development, Drug manufacturing, Clinical trial design, Fundamentals of regulatory aspects and bioethics.