Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	**401**	**Title of the Course**	**Environmental Biotechnology**	**L**	**T**	**P**	**C**
Year	**4**	**Semester**	7	**2**	**1**	**0**	**3**
Pre-Requisite	ES101	**Co-requisite**	NIL				
Course Objectives	To introduce students to modern techniques and equipments for solving problems related to environmental pollution and waste management and to make them aware of various eco-friendly techniques to solve various environment-related problems**.**						

Course Outcomes	
CO1	Graduates will be able to recognize and assess the structural and functional aspects of ecosystems, environmental pollution, emission and effluent characterization, and the standards for ambient air, noise, emissions, and effluents.
CO2	Graduates will be able to outline the use of GIS and remote sensing in environmental monitoring and clarify the processes involved in Environmental Impact Assessment (EIA) and Environmental Audits.
CO3	Graduates will be able to categorize solid waste types and apply and design appropriate management and treatment strategies, including thermal and biological processes, vermicomposting, and sustainable fuel production from waste.
CO4	Students will be able to analyze wastewater treatment methods using advanced bioreactor configurations, including activated sludge processes, trickling filters, and hybrid reactors, evaluate their effectiveness, and design and develop an appropriate wastewater treatment plan.
CO5	Graduates will be able to critique the structural and functional dynamics of microbes, including diversity, activity, growth, and community profiling, and assess and develop the biosensors and bioreporters in environmental monitoring.
CO6	They will be able to formulate and execute bioremediation strategies through microbes and plants, using microbial metabolism for the treatment of organic contaminants, heavy metals, and nitrogenous wastes, integrating various bioremediation techniques.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Ecology and Environment**	Ecosystem: Structural and functional aspects; Environment and environmental pollution; Characterization of emission and effluents; Standards for ambient air, noise, emission and effluents, use of GIS and remote sensing in environmental monitoring, Environmental Impact Assessment (EIA). Environmental Audit.	8	CO1,2
2	**Solid Waste Management**	Classification and Characterization of Solid Waste: Management and treatment of waste. Thermal and biological processes. Vermicomposting Sustainable fuels from waste: biogas, bioethanol and biohydrogen.	8	CO 1,3, 5,6
3	**Waste Water Treatment Methods**	Waste water treatment methods with advanced bioreactor configuration: activated sludge process, trickling filter, fluidized expanded bed reactor, up-flow anaerobic sludge blanket reactor, contact process, fixed/packed bed reactor, hybrid reactors, sequential batch reactors.	8	CO1, 4,5,6
4	**Microbes in Environmental Protection**	Structural and Functional dynamics of microbes: diversity, activity and growth, community profiling, biosensors, bioreporters, Microchips. Process strategies for bioremediation through microbes and plants; exploiting microbial metabolism for bioremediation of organic contaminants, heavy metal sand nitrogenous wastes.	8	CO3,4,5,6

Reference Books:

1. Environmental Biotechnology – Concepts and Applications, Hans-Joachim Jordening and Jesef Winter
2. Environmental Biotechnology, B.C. Bhattacharya &Ritu Banerjee, Oxford Press, 2007.
3. Agarwal S.K. (1998), Environmental Biotechnology, APH Publishing Corporation, New Delhi.
4. Essentials of Ecology & Environmental Science, S.V.S. Rana, Prentic-Hall India, 2006.

e-Learning Source:

https://drive.google.com/drive/u/0/folders/1bvphdzpz2xIr7ZY-o0D9nFyaoNc7Q0wR

https://drive.google.com/drive/u/0/folders/1bvphdzpz2xIr7ZY-o0D9nFyaoNc7Q0wR

https://drive.google.com/drive/u/0/folders/1bvphdzpz2xIr7ZY-o0D9nFyaoNc7Q0wR

https://drive.google.com/drive/u/0/folders/1bvphdzpz2xIr7ZY-o0D9nFyaoNc7Q0wR

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO / **CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2					3	2	2	3
CO2	3	3	3	2	3	2					3	3	3	3
CO3	3	3	3	2	3	3				2	2	3	3	3
CO4	3	3	3	2	3	2				2	2	3	3	3
CO5	3	3	3	2	3	3				2	2	3	3	2
CO6	3	3	3	2	3	3				2	2	3	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-2025							
Course Code	BE402	**Title of the Course**	Fermentation Engineering	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VII	**2**	**1**	**0**	**3**
Pre-Requisite	BE313	**Co-requisite**	None				
Course Objectives	To introduce students to the complexity of heterogeneous reaction system, give a brief overview of fermentative production of metabolites and downstream processing. Make students understand basic concepts of scale-up of bioreactors..						

Course Outcomes	
CO1	Analyze the fermentative production processes of organic acids (e.g., acetic acid), enzymes (e.g., proteases, amylases), antibiotics (e.g., penicillin, streptomycin), and organic solvents (e.g., ethanol) by comparing process parameters, and industrial methodologies.
CO2	Evaluate concentration profiles, effectiveness factors, and mass transfer limitations (external/internal) in heterogeneous reaction systems with spherical and non-spherical geometries using zero- and first-order kinetics.
CO3	Design strategies for cell disruption, filtration, centrifugation, dialysis, and lyophilization by selecting physical/chemical methods and justifying their suitability for specific bioproduct recovery applications
CO4	Critically assess bioreactor scale-up methodologies (e.g., regime analysis, constant P/V, KLa) and predict operational challenges such as mass transfer inefficiencies (impeller speed) and process variability.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Fermentative Production of Metabolites	Fermentative production of organic acids: Acetic acid; Fermentative production of enzymes: Proteases and amylases; Fermentative production of antibiotics: penicillin, streptomycin; Fermentative production organic solvent: ethanol.	8	CO1
2	Heterogeneous Reaction	Heterogeneous reaction systems: Zero order and First order kinetics of concentration profile with reference to spherical geometry and other shapes, Effectiveness factor, External and internal mass transfer, General comments on heterogeneous reactions in bioprocessing.	8	CO2
3	Product Extraction and Purification	Cell disruption: Physical, chemical methods, Filtration: batch and continuous, Centrifugation: batch and continuous, Reverse osmosis, Dialysis, Electrodialysis; Lyophilization	8	CO3
4	Bioreactor scale-up	Scale-up of microbial bioreactors: Various approaches to scale-up including regime analysis and scale-down; Scale-up by rules-of-thumb viz. constant P/V, KLa etc. Problems associated with scale-up.	8	CO4

Reference Books:

Levenspiel, O., Chemical Reaction Engineering, John Wiley. 2008

Fogler, H. S. Elements of Chemical Reaction Engineering, Prentice Hall India. 2015.

Doran P.M., Principle of Bioprocess Engineering. Elsevier. 2013

Shuler & Kargi, Bioprocess Engineering, Prentice Hall. 2001.

e-Learning Source:

https://archive.nptel.ac.in/courses/102/106/102106086/

https://youtu.be/BrpxAq9KVy0

https://youtu.be/QBFP2MEHtuk

https://youtu.be/prmNu7b7KYc

https://youtu.be/oxHLdNQrGhw

https://youtu.be/nN3ZL-Hqbsc

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO6
CO1	3	3	3			2					2		3	3	2	3			
CO2	3	3	3	2		1					2		3	3	2	3			
CO3	3	3	3	2		3					1		3	3	3	3			
CO4	3	3	3	3		1					1		3	3	3	3			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-2025							
Course Code	BE403	**Title of the Course**	Structural Bioinformatics & Phylogenetics	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VII	**2**	**1**	**0**	**3**
Pre-Requisite	BE311	**Co-requisite**	None				
Course Objectives	This course aims to develop a comprehensive understanding of protein structure, classification, and prediction methods while introducing the principles and applications of DNA microarray technology. It also equips students with knowledge of gene identification and prediction techniques, along with molecular phylogenetic analysis and phylogenetic tree construction methods, fostering analytical thinking and problem-solving skills in bioinformatics and phylogenetics.						

Course Outcomes	
CO1	Explain key concepts of proteins, identify structural features, apply classification systems, utilize relevant databases, and analyze relationships within biological structures.
CO2	Describe methods for secondary and tertiary protein structure prediction, apply Chou-Fasman and GOR methods, utilize knowledge-based and ab initio approaches, employ online tools for structure validation, and analyze predicted protein structures for accuracy and reliability.
CO3	Describe the principles and applications of DNA microarray technology, explain gene prediction methods, differentiate gene identification approaches in prokaryotes and eukaryotes, utilize online tools for in silico gene prediction, and compare their effectiveness.
CO4	Outline the principles of molecular phylogenetics, explain key assumptions and terminology, apply methods and tools for phylogenetic tree construction, evaluate phylogenetic trees, and interpret evolutionary relationships based on molecular data.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Structural elements of protein and databases	Protein classification: Structural elements and terminology- phi & psi bonds, Ramachandran Plot, Letter code for amino acids, Helix, Sheet, Strand, Loop and coil, Active site, Architecture, Classes and Domains, Fold, Motif, CATH-Classification by Class, Architecture, Topology, Homology, SCOP-Structural Classification of Protein, MMDB-Molecular Modeling Database.	8	CO1
2	2D and 3D structure prediction of proteins	Secondary structure prediction of proteins: Chou-Fasman and GOR methods. Tertiary structure prediction of Proteins: Knowledge-based and Ab initio-based methods, Various online tools for validating predicted protein structures.	8	CO2
3	Basics of DNA microarray and gene prediction	DNA microarray technology: Brief overview, types, and their applications. Gene identification and prediction: Basis of gene prediction, gene prediction methods, Gene finding in prokaryotes and eukaryotes, various online tools of in silico gene prediction and their comparison.	8	CO3
4	Molecular phylogenetic analysis	Molecular phylogenetics: Brief overview of molecular evolution and molecular phylogenetics, major assumptions and terminology used in phylogenetics, Procedure, methods, and programs of phylogenetic tree construction, Phylogenetic tree evaluation, and various tools of phylogenetic tree construction.	8	CO4

Reference Books:

Essential Bioinformatics, Jin Xiong, Cambridge University Press, 2006, ISBN 113945062X, 9781139450621.

Protein Bioinformatics: From Sequence to Function, M. Michael Gromiha, Academic Press, 2011, ISBN 0123884241.

Introduction to Bioinformatics, Arthur M. Lesk, Benjamin Cummings, 2001, ISBN 0582327881, 9780582327887.

e-Learning Source:

http://nptel.ac.in/courses/102107028/

http://nptel.ac.in/courses/102103044/

https://onlinecourses.nptel.ac.in/noc16-bt07

https://onlinecourses.nptel.ac.in/noc18-bt01

https://www.sib.swiss/bioinformatics-for-all/

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1		3	1		1	1		3	3	1	
CO2	3	2		1	3	1		1	1		3	3		1
CO3	1	2			3	1		1	1		3	1	3	
CO4	3	2		1	3	3		2	2		3	1		3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-2025							
Course Code	BE404	**Title of the Course**	Nanobiotechnology	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VII	**2**	**1**	**0**	**3**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The course provides fundamental knowledge of nanobiotechnology, including nanoscale materials, their synthesis, characterization, and applications in drug delivery, biosensors, and healthcare.						

Course Outcomes	
CO1	Understand, and analyze the fundamentals of nanobiotechnology, including nanoscale materials, dimensionality effects, surface properties, and biomolecular interactions at the nanoscale.
CO2	Understand and analyze the classification, synthesis, and characterization of nanomaterials, including chemical and physical synthesis methods and techniques such as spectroscopy, microscopy, and surface analysis.
CO3	Assess, comprehend, and interpret protein- and DNA-based nanostructures, including nanocircuitry, engineered nanopores, biomolecular motors, and DNA-templated nanomaterials.
CO4	Investigate, analyze, and determine the applications of nanotechnology in food, medicine, and health sciences, focusing on drug delivery systems, biosensors, food packaging, and the toxicity of nanomaterials.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Introduction to Nanobiotechnology	Introduction to nanotechnology and overview of nanoscale materials, effect of length scale on properties, Definition of a nanosystem, Dimensionality and size dependent phenomena, Surface to volume ratio, Fraction of surface atoms, Surface energy and surface stress, Surface defects, Properties at nanoscale (optical, mechanical, electronic, and magnetic). Introduction to Bionanotechnology, Structural & Functional Principles of Bionanotechnology: Lipid Bilayers, liposomes, neosomes, Polysaccharides, Peptides, limitations of natural biomolecules, challenges and opportunities associated with biology on the Nanoscale.	8	CO1
2	Classification and Synthesis of Nanomaterials & Characterization Techniques	Classification based on dimensionality-Quantum Dots, Wells and Wires, Carbon-based nanomaterials (buckyballs, nanotubes, graphene), Metal-based nanomaterials (nanogold, nanosilver and metal oxides), Nanocomposites, Nanopolymers, Nanoglasses, Nano ceramics, Surface and Bulk Properties of Biomaterials, Nanobiomaterials, NanoCeramics, Nanopolymers, Nano Silica, Hydroxy apatite, Carbon Based nanomaterials, Surface modification, Textured and Porous Materials, Surface immobilized biomolecules. Chemical Methods: Metal Nanocrystals by Reduction, Microemulsions or reverse micelles, micelle formation, Chemical Reduction, Emulsions, Dendrimers, Solvothermal Synthesis, Photochemical Synthesis, Sonochemical Routes, Chemical Vapor Deposition (CVD), Metal Oxide - Chemical Vapor Deposition (MOCVD).Physical Methods: Ball Milling, Electrodeposition, Spray Pyrolysis, Flame Pyrolysis, DC/RF Magnetron Sputtering, Molecular Beam Epitaxy (MBE). Characterization techniques: Optical (UV-Vis/Fluorescence), X-ray diffraction, Imaging and size (Electron microscopy, light scattering, Zetapotential), Surface and composition (ECSA, EDAX, AFM/STM etc.), Vibrational (FT-IR and RAMAN).	8	CO2
3	Protein and DNA based Nanostructures	Nanocircuitry, S-layer proteins: structure, chemistry and assembly, lipid chips, S-Layers as Templates, engineered nanopores, DNA-Protein Nanostructures, DNA-templated Electronics, DNA-based Metallic Nanowires and Networks, DNA-Gold-Nanoparticle Conjugates, DNA-templated Electronics, DNA, Biomolecular motors: linear, rotary motors, Immunotoxins, Membrane transporters and pumps.	8	CO3
4	Nanotechnology in Food, Medicine and Health Science	Cell-biomaterial interactions, immune response, In Vitro and In Vivo assessment of tissue compatibility, Nanoparticle Based Drug delivery systems, Ultra sound triggered Nano/Microbubbles, Regenerative Medicine, Nanoimmuno conjugates, Biosensors, Optical Biosensors Based on Nanoplasmonics, Nanobiosesors, Nano-Biosensors for Mimicking Gustatory and Olfactory Senses, Cyclodextrin in Nanomedicinal Foods and Cosmetics, Bioavailability and Delivery of Nutraceuticals and Functional Foods Using Nanotechnology, Polymer-Based Nanocomposites for Food Packaging, Toxicity and Environmental Risks of Nanomaterials.	8	CO4

Reference Books:

1.Engines of Creation, KE Drexler, Oxford Paperbacks, New York ISBN 0192861492

2.Nanosystems: Molecular Machinery, Manufacturing and Computation, K E Drexler, Wiley, ISBN 0471575186

e-Learning Source:

1. https:/nptel.ac.in/courses/102107058

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

CO\PO/PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	2	1	1			3	3	3	2
CO2	3	3	3	2	3	3	2	2			2	3	3	3
CO3	3	3	3	3	3	3	2	2	1		1	3	3	3
CO4	2	3	3	2	2	3	2	3	1		2	2	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-2025							
Course Code	**BE405**	**Title of the Course**	**Environmental Biotechnology Lab**	**L**	**T**	**P**	**C**
Year	**4**	**Semester**	**7**	**0**	**0**	**2**	**1**
Pre-Requisite	**ES101**	**Co-requisite**	**BE401**				
Course Objectives	To learn techniques to design and conduct experiments, interpret and analyze data and report results in order to solve problems related to waste water treatment.						

Course Outcomes	
CO1	The students will be able to recognize the key parameters and techniques involved in the preliminary screening and physico-chemical characterization of wastewater.
CO2	They will be able to clarify the procedure for determining the concentration of heavy metals in wastewater and soil, along with the analytical methods used.
CO3	They will be able to demonstrate the use of the Kjeldahl method and other techniques for quantifying nitrogen (Kjeldahl nitrogen, nitrate, and nitrite nitrogen) in wastewater and soil samples.
CO4	They will be able to investigate the pollution level of wastewater samples by determining the BOD (Biochemical Oxygen Demand) and COD
CO5	The students will be able to appraise the biological contamination of wastewater by enumerating pathogenic organisms through the MPN (Most Probable Number) method.
CO6	They will be able to construct and interpret experimental protocols to assess the pollution load and biological contamination in wastewater, combining multiple methods for a thorough water quality analysis.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Preliminary screening of waste water**	Physico-chemical characterization of waste water.	4	CO1,6
2	**Heavy metal determination**	Determination of heavy metal concentration in soil.	4	CO2,6
3	**Nitrogen Estimation**	Determination of Kjeldahl nitrogen, nitrate and nitrite nitrogen	4	CO3,6
4	**Assessment of Pollution level**	Determination of BOD and COD of wastewater samples.	4	CO4,6
5	**Evaluation of Biological pollution**	Enumeration of contaminating pathogenic organisms by MPN method	4	CO5,6

Reference Books:

1. Winter J, Environmental Processes series, Wiley Publications.
2. Metcalf and Fuddy, Waste Water Engineering, TMH publications.
3. Sharma PD, Ecology and Environment.
4. Ramalho RS, Introduction to waste water treatment, Academic Press

e-Learning Source:

https://www.pdfdrive.com/apha-standard-methods-for-the-examination-of-water-and-wastewater-d184521100.html

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	2		3	2		2	3	2	1
CO2	3	3	2	2	3	2		3	2		2	3	2	1
CO3	3	3	2	2	3	2		3	2		2	3	2	1
CO4	3	3	2	2	3	2		3	2		2	3	2	1
CO5	3	3	2	2	3	2		3	2		2	3	2	1
CO6	3	3	2	2	3	2		3	2		2	3	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	**BE406**	**Title of the Course**	**Fermentation Engineering Lab**	**L**	**T**	**P**	**C**
Year	**IV**	**Semester**	VII	**0**	**0**	**4**	**2**
Pre-Requisite	BE306	**Co-requisite**	None				
Course Objectives	To learn techniques of kinetic analysis of biomass, product and substrate in ideal and non-ideal mixing.						

Course Outcomes	
CO1	Analyze the kinetic models of batch reactors by determining the rate equations governing biomass formation under ideal conditions.
CO2	Evaluate the kinetic models for product formation in batch reactors using experimental data and apply appropriate modeling techniques.
CO3	Interpret the substrate consumption kinetics in batch reactors and derive the equations governing substrate depletion.
CO4	Compare the kinetic behavior of biomass and product formation in batch reactors under ideal and non-ideal mixing conditions, and assess the impact of deviations from ideality.

Unit No.	**Title of the Experiment**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Biomass formation in ideal mixing condition	A study of kinetic modeling of a batch reactor: Determination of kinetic equation explaining biomass formation.	6	CO1
2	Product formation in ideal mixing condition	A study of kinetic modeling of a batch reactor: Determination of kinetic equation explaining product formation.	6	CO2
3	Substrate consumption in ideal mixing condition	A study of kinetic modeling of a batch reactor: Determination of kinetic equation explaining substrate consumption.	6	CO3
4	Biomass and product formation in non-ideal mixing condition	A study of kinetic modeling of a batch reactor: Determination of kinetic equation explaining Biomass formation and Product formation considering non-ideal mixing.	8	CO4

Reference Books:

1. Moo-Young, M. (Ed.). (1985). Comprehensive Biotechnology: The Principles of Biotechnology (Vol. 1).
3. Pirt, S. J. (1975). Principles of Microbe and Cell Cultivation. Blackwell Scientific Publications.
4. Doran, P. M. (1995). Bioprocess Engineering Principles. Academic Press.

e-Learning Source:

http://38.100.110.143/model/bmc/theory.html

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	2			2	2		2	3	3	3
CO2	3	3	3	3	2			2	2		2	3	3	3
CO3	3	3	3	3	2			2	2		2	3	3	3
CO4	3	3	3	3	2			2	2		2			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-2025							
Course Code	BE407	**Title of the Course**	Bioinformatics Project	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VIII	0	0	0	2
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	This course aims to enable students to apply theoretical knowledge in practical domains of bioinformatics and its allied sciences. Students will analyze biological data, design computational models, and present findings through comprehensive reports and presentations, fostering critical thinking, technical writing, and communication skills.						

Course Outcomes	
CO1	Demonstrate the ability to apply bioinformatics tools and techniques to analyze biological data, interpret results, and provide meaningful insights.
CO2	Design and develop computational models or bioinformatics-based solutions to address biological challenges, incorporating innovative approaches.
CO3	Prepare a well-structured and scientifically sound report documenting the project's objectives, methodology, findings, and conclusions with clarity and precision.
CO4	Deliver an effective and professional PowerPoint presentation summarizing the project outcomes, demonstrating communication skills, teamwork, and the ability to address technical questions confidently.

Unit No.	**Skill Set**	**Content of Unit**	**Mapped CO**
1	Bioinformatics Tools Application, Biological Data Analysis	Application of bioinformatics tools for data retrieval (genomic, proteomic, transcriptomic databases), sequence alignment, structure prediction, molecular docking (CADD), homology modeling, molecular dynamics, functional genomics, systems biology, cheminformatics, and other allied bioinformatics areas.	CO1
2	Computational Model Design, Problem Solving Strategies	Design and development of computational models, simulation frameworks, algorithm development, predictive modeling, database creation, tool/software development in areas like drug discovery, genetic analysis, and personalized medicine.	CO2
3	Scientific Writing, Technical Documentation	Preparation of structured project reports including formulation of objectives, literature review, methodology design, results analysis, discussion of findings, conclusion writing, references formatting (as per scientific standards).	CO3
4	Presentation Skills, Professional Communication, Teamwork	Preparing and delivering professional PowerPoint presentations, demonstrating teamwork, answering viva questions effectively, and communicating complex technical concepts clearly.	CO4

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	2	1	1	2	2	2	3	2	2
CO2	3	3	3	2	3	2	1	1	2	2	2	3	3	2
CO3	2	2	2	1	2	2	1	2	3	3	2	2	2	1
CO4	2	2	1	1	2	2	1	2	3	3	2	2	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-2025							
Course Code	BE408	**Title of the Course**	Food Biotechnology	**L**	**T**	**P**	**C**
Year	4	**Semester**	7	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To impart applied knowledge of food biotechnology, emphasizing microbial roles, food safety laws, quality control techniques, and biotechnological applications in food preservation, fermentation, and functional foods.						

Course Outcomes	
CO1	Explain food biotechnology concepts and evaluate GMOs' applications using biotechnological tools and ethical considerations.
CO2	Analyze food spoilage mechanisms and apply preservation techniques to ensure safety, quality, and public health.
CO3	Understand fermentation principles and evaluate applications of probiotic foods for health, nutrition, and functional benefits.
CO4	Interpret food safety laws and apply quality control systems to ensure compliance with national and international standards.
CO5	Apply microbial techniques and biochemical tests to analyze food quality, safety, and starter culture effectiveness.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction**	Introduction to Food Biotechnology: definition and scope, Signification of DNA and RNA in GMO/GMC, Role of microorganism in food biotechnology. Merits and demerits and Applications of GMOs/GMCs.	8	CO1
2	**Spoilage and Preservation**	General principles underlying spoilage of foods, Basic concept of spoilage and source of contamination: Meat, Poultry, Fruits and vegetables, Microbial food poisoning and its prevention or control and food toxins. Different methods of preservation of foods	8	CO2
3	**Fermented Products**	Fermented foods and beverages, Pre and pro-biotic food, Applications of fermented foods	8	CO3
4	**Food Laws**	Relevant Food laws: FSSA 2006, ISO, AgMark, BIS: standard with Laboratory Services and Certification by BIS. HACCP system, NABL and quality control and quality assurance.	8	CO4
5	**Food Analysis**	Starter culture, pure culture technique: steak plate, pour plate, maintenance of culture. Microscope colony counts, most probable numbers (MPN). MBRT test, Saponification value, Iodine Value, RM value, Polanski Value, Rancidity	8	CO5

Reference Books:

1. Potter N and Hotchikiss "Food Science" CBS Publ.
2. Frazier WC and Westhoff DC "Food microbiology", TATA McGraw Hill Publishing Company Ltd, New Delhi.
3. Andrews AT, Varley J "Biochemistry of milk products", Royal Society of Chemistry.

e-Learning Source:

1. https://www.coursera.org/search?query=food
2. https://onlinecourses.nptel.ac.in/noc25_ag04/preview

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	1	2	2	3	1	1	1	3	3	2	2
CO2	3	2	2	1	2	2	3	1	1	1	3	3	3	2
CO3	3	2	2	1	2	2	1	1	1	1	2	3	2	2
CO4	3	2	2	2	2	3	3	1	2	1	2	3	3	3
CO5	3	3	2	3	3	2	1	1	1	1	2	3	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	BE 409	**Title of the Course**	Pharmaceutical Biotechnology	**L**	**T**	**P**	**C**
Year	4	**Semester**	7	**2**	**1**	**0**	**3**
Pre-Requisite	BE 201	**Co-requisite**	None				
Course Objectives	To equip students with the knowledge of various pharmaceutical products and processes, and with the applications of biotechnology in the pharmaceutical sector						

Course Outcomes	
CO1	**Understand** the core concepts of biotechnology and **analyze** major components through a broad subject base, while also engaging in **specialized and in-depth evaluation** of pharmaceutical biotechnology.
CO2	**Explain** various methods of protein and peptide synthesis, and **evaluate** the advantages and challenges associated with their pharmaceutical formulations.
CO3	**Identify and evaluate** key proteins and phospholipid-based drug formulations and **apply** this knowledge to understand their roles in the **treatment of various diseases**.
CO4	**Gain a comprehensive understanding** of pulmonary drug delivery systems and **analyze** their application in delivering biomacromolecules effectively.
CO5	**Develop and apply** conceptual knowledge of different polymeric systems used in **controlled drug delivery**, and **propose** novel strategies for effective therapeutic applications.

Unit No.	**Title**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Monoclonal Antibodies	Monoclonal antibodies: applications, generation, recombinant antibodies, production methods, Pharmaceutical, regulatory and commercial aspects.	8	CO1
2	Formulation of Proteins and Peptides	Formulation of proteins and peptides: making small protein particles, precipitation of proteins, quality control issues, multi-phase drug delivery system; Preparation of collagen, gelatin particles, albumin microparticles.	8	CO2
3	Proteins and Phospholipids	Proteins and phospholipids: structural properties of phospholipids, injectable lipid emulsions, liposomes, cochleal phospholipids structures; Polymeric systems for oral protein and peptide delivery.	8	CO3
4	Pulmonary Drug Delivery Systems for Biomacromolecules	Pulmonary drug delivery systems for biomacromolecules; Lipid based pulmonary delivery; Solid colloidal particles; Polycyanoacrylates; Poly (ether-anhydrides); Diketopiperazine derivatives; Polyethylene glycol conjugates; Factors affecting pulmonary dosing	8	CO4
5	Polymers used for Controlled Drug Delivery	Polymers used for controlled drug delivery: Hydrophilic polymers poly(esters), poly(cyanoacrylate), poly (ortho esters), poly (phosphazenes), Hydrophobic polymers poly (alkyl methacrylates), poly (methacrylates), poly (acrylates)], alginates, chitosan, polyethylene glycol. Gene therapy: the current viral and non-viral vectors.	8	CO5

Reference Books:

1. Gareth Thomas. Medicinal Chemistry. An introduction. John Wiley. 2000.
2. Katzung B.G. Basic and Clinical Pharmacology, Prentice Hall of Intl. 1995
3. Groves MJ Pharmaceutical Biotechnology, Taylor and Francis Group, 2013.
4. Crommelin DJA, Robert D, Sindelar Pharmaceutical Biotechnology 2008.
5. Kayser O, Muller R Pharmaceutical Biotechnology, 2010. 6. Banga AK Therapeutic peptides and proteins, 2005.

e-Learning Source:

1. Sahoo, Niharika, and Padmavati Manchikanti. "Recombinant drug development, regulation, & commercialization." BioDrugs 25.2 (2011): 105-113.
2. Bhosale, Rohit Rajendra, et al. "Nanocochleates: A novel carrier for drug transfer." J. Sci. Ind. Res 2 (2013): 964-969.
3. Sahithi, B., et al. "A review on collagen based drug delivery systems." Indian Journal of Research in Pharmacy and Biotechnology 1.3 (2013): 461.

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2	1			1	1	3	3	1
CO2	3	3	1	2	2	1	3	1			1	3	2	1
CO3	1	1	1	2	1	1	1				1	3	3	1
CO4	1	2	2	2	2	2	2	1			1	3	2	1
CO5	3	3	3	2	3	2	3	2		1	1	2	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-2025							
Course Code	BE410	**Title of the Course**	BIOENERGETICS & METABOLIC ENGINEERING	**L**	**T**	**P**	**C**
Year	4	**Semester**	7	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To provide an in-depth understanding of cellular bioenergetics, metabolic regulation, and pathway engineering through quantitative analysis, enabling students to model, analyze, and design metabolic systems using modern biotechnological tools.						

Course Outcomes	
CO1	Analyze bioenergetic pathways and energy transformations in cellular processes using scientific principles and engineering tools.
CO2	Apply principles of bioenergetics to analyze membrane transport and energy transduction using quantitative and computational tools.
CO3	Evaluate central metabolic networks and characterize cellular functions using omics data and dynamic computational modeling tools.
CO4	Analyze metabolic regulation and perform flux analysis to interpret enzyme-level and cellular control in metabolic networks.
CO5	Apply metabolic control analysis and design strategies to evaluate and engineer pathways for targeted strain development.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Bioenergetics: Introduction**	Introduction to bioenergetics, Chemosynthesis and energy dynamics, Photosynthesis and photosynthetic electron transfer, Mitochondrial electron transport chain and ATP synthesis.	8	CO1
2	**Bioenergetics: Basics**	Chemiosmotic energy transduction. Ion transport across energy conserving membranes. Quantitative bioenergetics. Cellular bioenergetics.	8	CO2
3	**Metabolic Engineering: Introduction**	Central Metabolism: Fueling metabolism, Supply of biomass precursors, Anabolism, Anaplerosis. Coordination of metabolic reactions: Feedback inhibition, Energy charge, Multigene networks. Methods for metabolic characterization: Genome, Transcriptome, Proteome, Metabolome, Fluxome. Comprehensive models for cellular reactions: Stoichiometry of cellular reactions, Reaction rates, Dynamic mass balance.	8	CO3
4	**Metabolic pathway analysis**	Regulation of metabolic pathways: Regulation of Enzymatic Activity, Regulation of Enzyme concentration, Regulation at whole cell level, Regulation of Metabolic networks. Metabolic flux analysis: Overdetermined and undetermined systems, Sensitivity analysis.	8	CO4
5	**Metabolic Control Analysis**	Metabolic control analysis (MCA): Determination of Flux control coefficients, MCA of Linear and Branched pathways. Metabolic design: Gene amplification, Gene-disruption, Randomized and targeted strain development.	8	CO5

Reference Books:

1. David G Nicholls, Stuart J Ferguson. Bioenergetics4, Academic Press, Elsevier 2013, Ed 4, ISBN: 978-0-12-388425-1.
2. David L Nelson, Michael M Cox. Lehninger Principles of Biochemistry, W. H. Freeman 2017, 7th edition, ISBN-13: 978-1-4641-2611-6.
3. Christina D Smolke. The Metabolic Pathway Engineering Handbook: Fundamentals, CRC Press 2010, ISBN-13: 978-1-4398-0296-0.

e-Learning Source:

1. https://nptel.ac.in/courses/102105086
2. https://nptel.ac.in/courses/102104063

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	1	2	2	1	1	1	1	1	2	3	2	1
CO2	3	2	1	2	3	1	1	1	1	1	2	3	3	1
CO3	3	3	2	3	3	1	1	1	2	1	3	3	3	2
CO4	3	3	1	3	3	1	1	1	1	1	2	3	3	2
CO5	3	3	3	3	3	1	1	1	1	1	3	3	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-2025							
Course Code	BE411	**Title of the Course**	Agricultural Biotechnology	**L**	**T**	**P**	**C**
Year	4	**Semester**	7	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To equip students with theoretical knowledge and practical skills in molecular markers, gene transfer techniques, blotting methods, and emerging biotechnological applications for sustainable and innovative life science solutions.						

Course Outcomes	
CO1	Analyze and apply plant tissue culture techniques to develop disease-free and genetically improved crop varieties.
CO2	Evaluate and apply plant cell culture techniques to select mutants, produce valuable chemicals, and perform biotransformation processes.
CO3	Apply and analyze molecular marker techniques and genome projects for genetic analysis, screening, and trait mapping.
CO4	Apply and evaluate plant transformation techniques and recombinant screening methods for effective genetic modification and analysis.
CO5	Analyze and apply biotechnological innovations like bioremediation, biofuels, and edible vaccines for sustainable development solutions.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction**	Brief overview of in vitro regeneration methods of plants; Production of disease free plants: shoot - tip and meristem cultures; Protoplast isolation, culture and fusion, selection of hybrid cells and regeneration of hybrid plants, somatic hybridization, cybrids; Tissue culture as a source of genetic variability: soma-clonal and gameto-clonal variant selection, sources and causes of variation, application in crop improvement.	8	CO1
2	**Plant Cell Culture**	In vitro selection of mutants; Plant cell cultures for the production of useful chemicals: pigments perfumes, flavors, insecticides, anticancer agents and pharmacologically important compounds; Biotransformation using plant cell cultures; Hairy root culture and cell suspension.	8	CO2
3	**Molecular Biology**	Molecular Markers: RAPD, RFLP, AFLP, ARDRA, SCAR, STS, ESTs, Microsatellites, ISSR, SSCP, QTL; Brief overview of Arabidopsis and Rice Genome Projects. Dot blot, Northern blotting, Immunological screening, Western blotting, HART, HAT.	8	CO3
4	**Genetic Engineering**	Ti, Ri and viral vectors for plant transformation; Brief overview of the methods for introduction of DNA into living cells with details of transformation mediated by Agrobacterium, microprojectile bombardment, electroporation and microinjection; Techniques for recombinant selection and screening: Functional (genetic) complementation, Nutritional complementation, Colony hybridization, Plaque hybridization, Southern hybridization.	8	CO4
5	**Application**	Brief overview of Bioremediation, Biodegradable plastics, Biofuels/Biodiesel, Bioinsecticides/Biopesticides, Biofertilizers; Edible vaccines.	8	CO5

Reference Books:

1. Chawla HS, "Plant Biotechnology: A Practical Approach".
2. Slater A, Scott NW, Fowler MR "Plant Biotechnology: The Genetic Manipulation of Plants".
3. Mantell SH, Matthews JA, McKee RA, "Principles of Plant Biotechnology: An Introduction to Genetic Engineering in Plants".

e-Learning Source:

1. https://onlinecourses.nptel.ac.in/noc24_ag08/preview
2. https://onlinecourses.nptel.ac.in/noc25_bt36/preview

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	3	3	1	1	1	2	1	2	3	3	2
CO2	3	3	3	3	3	2	1	1	2	1	2	3	3	2
CO3	3	3	2	3	3	1	1	1	2	1	2	3	2	2
CO4	3	3	3	3	3	2	1	1	2	1	2	3	3	2
CO5	3	3	3	2	2	3	2	1	2	2	3	3	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	BE418	**Title of the Course**	Plant Growth and Development	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VII	2	1	0	3
Pre-Requisite	BE213	**Co-requisite**	None				
Course Objectives	To understand and analyze plant light perception, circadian control, and environmental signaling mechanisms, enabling the design of innovative strategies for sustainable plant growth and development.						

Course Outcomes	
CO1	Analyze molecular genetics of plant development, elucidating angiosperm life cycle and growth characteristics to design innovative sustainable solutions
CO2	Apply analysis and design principles to elucidate molecular mechanisms governing root branching, organogenesis, and flowering while ensuring sustainability.
CO3	Apply integrated frameworks to analyze, design, and evaluate cell-cell communication, hormone signal transduction, and transport in plant development.
CO4	Analyze plant light perception, circadian regulation, and environmental signaling mechanisms using research-based approaches to enhance sustainable plant growth.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Growth in plants	Life cycle of an angiosperm, characteristics of plant growth and development. Molecular Genetics of Plant Development.	8	CO1
2	Organogenesis	Root development: Root branching, lateral root development, shoot development: SAM maintenance, organogenesis, leaf development, flowering.	8	CO2
3	Cell-Cell Communication	Cell-Cell Communication during plant development, transport and signal transduction of plant hormones and its importance for growth and development in plants.	8	CO3
4	Signaling and development	Light perception and signaling as well as circadian control and its importance for growth and development in plants, environmental perception and signaling and its importance for growth and development in plants.	8	CO4

Reference Books:

1. Leyser, O. and Day, S. Mechanisms in plant development. John Wiley & Sons. 2009.
2. Howell, S.H.Molecular genetics of plant development. Cambridge University Press. 1998.
3. Taiz, L. and Zeiger, E. Plant Physiology. Sinauer Associates. 2010 5th Eds.
4. Raven, P.H. Evert, R.F. and Eichhorn, S.E. Biology of plants. Macmillan. 2005 8th Eds

e-Learning Source:

1. https://www.youtube.com/watch?v=PwrADWcoyTs&list=PLLy_2iUCG87CTiGgwV-TU0zWDBOGm_9l1
2. https://www.youtube.com/watch?v=FKQOU79GrNk&list=PLLy_2iUCG87CTiGgwV-TU0zWDBOGm_9l1&index=12
3. https://www.youtube.com/watch?v=tP8syIY57mY&list=PLLy_2iUCG87CTiGgwV-TU0zWDBOGm_9l1&index=20

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	1	1	1	1	2	3	2	1
CO2	3	3	3	2	2	2	1	1	1	1	2	3	2	1
CO3	3	3	3	3	2	2	1	1	1	1	2	3	3	1
CO4	3	3	3	2	2	3	1	1	1	1	2	3	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	BE419	**Title of the Course**	Industrial Economics, Principles of Management and IPR	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VII	**2**	**1**	**0**	**3**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	This course aims to develop an understanding of industrial economics, management principles, intellectual property rights, and biosafety regulations, enabling students to analyze economic trends, legal frameworks, and ethical considerations in biotechnology and related industries.						

Course Outcomes	
CO1	Analyze the principles of industrial economics, demand-supply dynamics, consumer behavior, monetary policies, inflation, and banking systems to assess economic impacts on engineering and industry
CO2	Demonstrate an understanding of management principles, evaluate management theories, and analyze human behavior in organizations to enhance interpersonal relationships and effective leadership in engineering environments
CO3	Understand intellectual property rights (IPR), patent laws, and global treaties, and analyze their impact on innovation, industry, and ethical considerations in engineering and biotechnology
CO4	Analyze infringement issues, legal remedies, and biosafety regulations, ensuring compliance with national and global frameworks for GMO safety, food security, and environmental sustainability

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Industrial Economics**	Industrial Economics: Concept, Nature and significance; Demand and supply: Concept, Law; Elasticity of demand and supply; Theory of consumer behavior, Indifference curve analysis. Money: Concepts, inflation and Deflation; Banking system in India: Commercial and Central banking-Structure and types.	8	1
2	**Principles of Management**	Management: introduction, functions; Evaluation of Management thoughts; Human Behavior in organization: Perception, Personality development and interpersonal relationship	8	2
3	**IPRs**	Definition and concept of IPR, types of IPRs (patent, design, copyright and Geographical indication/trademark/trade secrets), Requirement and criteria of patent, Obtaining patent procedure (Invention step and prior art and state of art procedure), Indian Patent Act 1970 (amendment 2000); Major changes in Indian patent system as post TRIPS effects, PCT (patent cooperation treaty). Issues related to life forms and others.	8	3
4	**IPR infringement & Biosafety**	Infringement or violation, remedies against infringement: civil and criminal. Biosafety: Biosafety levels, safety guideline in India, Regulatory framework for GMOs Food safety and Environmental assessment of GE Plants.	8	4

Reference Books:

1. Biotechnology, B. D. Singh, Kalyani Publishers.
2. WIPO Handbook, WIPO.
3. Industrial Economics And Principles Of Management, Chabra. T.N; Dhanpat Rai and Co., New Delhi

e-Learning Source:

1. https://onlinecourses.swayam2.ac.in/aic21_ge20/preview
2. https://onlinecourses.nptel.ac.in/noc23_mg68/preview

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	1	2	2	1	2	3	2	2	1	3
CO2	2	2	3	2	1	2	1	3	3	3	3	3	2	3
CO3	2	3	2	2	2	3	2	3	2	3	2	3	2	3
CO4	2	3	2	2	1	3	3	3	2	3	2	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	BE420	**Title of the Course**	Genomics and Proteomics	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VII	**2**	**1**	**0**	**3**
Pre-Requisite	BE403	**Co-requisite**	None				
Course Objectives	To provide fundamental knowledge of genomics and proteomics, including genome organization, sequencing, gene mapping, protein separation, identification techniques, and their biomedical, clinical, and industrial applications.						

Course Outcomes	
CO1	Analyze prokaryotic and eukaryotic genomes, genetic and physical mapping techniques, and their applications in genomics research and biotechnology
CO2	Evaluate DNA sequencing methods, genome annotation, and databases, analyzing the impact of large-scale genomic projects on biomedical research and biotechnology applications
CO3	Apply proteomic techniques, including chromatography, electrophoresis, and mass spectrometry, for protein separation, characterization, and analysis in biomedical and biotechnological research
CO4	Analyze protein identification, sequencing, modifications, and interactions for applications in drug discovery, biomedical research, and industrial proteomics using advanced computational and experimental approaches

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction to Genomics and Mapping**	Introduction to Genome (Prokaryotic and Eukaryotic genomes– bacteria, yeast, Caenorhabditis, Homo sapiens, Arabidopsis, etc.), Genomics and importance, C-value paradox;Genetic mapping -Mapping by transformation, conjugation, and transduction;Physical mapping -DNA markers - RFLPs, AFLPs, RAPDs, SSLPs, SNPs,Restriction mapping, Fluorescent in situ hybridization, Radiation hybrid mapping and Sequence tagged site mapping.	8	CO1
2	**High-throughput Techniques of Genomics**	DNA sequencing methods: Maxam-Gilbert sequencing and Frederick Sanger sequencing, Human Genome Project (HGP): Goals of the HGP, salient findings of the HGP, potential applications of the HGP and post-HGP challenges,The 1000 Genomes Project; Gene prediction rules and softwares; Gene identification; Genomic databases; Annotation of genome;DNA Microarray.	8	CO2
3	**Fundamentals and High-throughput Techniques of Proteomics**	Introduction and scope of proteomics; Protein separation techniques: ion-exchange, size-exclusion and affinity chromatography techniques; Polyacrylamide gel electrophoresis; Isoelectric focusing (IEF); Two dimensional PAGE for proteome analysis; Image analysis of 2D gels; Introduction to mass spectrometry (MALDI-TOF).	8	CO3
4	**Protein sequencing and industrial applications of Proteomics**	Strategies for protein identification; Protein sequencing; Protein modifications and proteomics; Applications of proteome analysis to drug; Protein-protein interaction (Two hybrid interaction screening); Protein engineering; Protein chips and functional proteomics; Clinical and biomedical application of proteomics; Proteome database; Proteomics industry.	8	CO4

Reference Books:

1. Brown T. A. 2007, Genomes 3. Garland Science Publishing, NewYork.
2. Dunham, I., 2003. Genome Mapping and sequencing. HorizonScientific.
3. Graur, D and W H Li, 2000. Fundamentals of molecular evolution. SinauerAssociates.

e-Learning Source:

1. http://nptel.ac.in/courses/102101040.
2. https://www.takarabio.com/learning-centers/next-generation-sequencing.
3. https://www.genome.gov/27552686/nhgri-lecture-videos.

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	1	1	1	1	2	2	3	2	1
CO2	3	3	2	3	3	1	1	1	1	2	2	3	3	2
CO3	3	3	3	3	3	1	1	1	1	2	2	3	3	2
CO4	3	3	3	3	3	2	2	2	2	3	3	3	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-2025							
Course Code	BE300	**Title of the Course**	Industrial Training	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VII	0	0	0	0
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	This course aims to help students understand real-world biotechnology industry operations and workplace culture, apply theoretical biotechnology knowledge to practical industrial applications and processes, analyze industrial processes, techniques, and quality systems through direct exposure and training, and prepare a structured technical report based on their industrial training experience, which will be assessed through a brief viva voce.						

Course Outcomes	
CO1	Understand the structure, functioning, and workflow of biotechnology and associated industries.
CO2	Apply biotechnological concepts and techniques learned in academics to real industrial settings and practical tasks.
CO3	Industrial training ensures students to interact with industrial personnel and follow engineering practices and discipline prescribed in industry.
CO4	Create a detailed training report based on the industrial visit and participate in a viva voce examination to demonstrate the knowledge and skills acquired.

Unit No.	**Skill Set**	**Content of Unit**	**Mapped CO**
1	Industry Orientation	Understand the organizational structure, manufacturing processes, and workflow in biotech industries.	CO1
2	Practical Application	Apply theoretical biotechnology knowledge in real-life processes and operational environments.	CO2
3	Analytical Skills Development	Analyze and critically evaluate processes, equipment, and workflows observed during industrial training.	CO3
4	Communication and Reporting	Prepare structured reports and professional presentations based on industrial experience.	CO4

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	1	1	2	2	1	2	3	3	2
CO2	2	3	3	2	3	2	1	2	2	2	2	3	2	3
CO3	3	3	3	3	2	1	1	1	2	2	2	3	2	3
CO4	2	2	2	2	1	2	1	2	3	3	3	2	2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective Session: 2024-25							
Course Code	BE 499	**Title of the Course**	B.Tech Project	**L**	**T**	**P**	**C**
Year	4th	**Semester**	8th	**0**	**0**	**8**	**4**
Pre-Requisite		**Co-requisite**	None				
Course Objectives	The B.Tech Project aims to equip students with the ability to integrate interdisciplinary engineering knowledge (mathematics, sciences, domain fundamentals) to solve complex problems in biotechnology, food technology, or biomedical engineering. It fosters skills in critical problem analysis, research design, and sustainable innovation, emphasizing ethical practices, societal-environmental impact, and resource efficiency. Students develop proficiency in experimental investigations, modern tools, and project management, while cultivating teamwork, communication, and lifelong learning to address real-world challenges responsibly and adaptively.						

Course Outcomes	
CO1	Apply knowledge of mathematics, science, and engineering fundamentals to solve complex problems in biotechnology, food technology, or biomedical engineering.
CO2	Identify and analyze research problems by critically reviewing literature, aligning with sustainable development goals.
CO3	Design and develop effective engineering solutions or systems with considerations of health, safety, societal, and environmental aspects.
CO4	Use research-based knowledge and methods including experiments, data analysis, and interpretation to investigate complex problems.
CO5	Utilize modern tools, digital technologies, and project management principles to model, simulate, and manage engineering solutions.
CO6	Demonstrate ethical behavior, communication skills, teamwork, and commitment to lifelong learning in professional and societal contexts.

PO/ PSO	**Course Articulation Matrix: (Mapping of COs with POs and PSOs)**													
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3		2		2							3	2	
CO2	2	3		2		2					1	2	1	
CO3	2	1	3		1	3						2	3	1
CO4	1			3	2							2	3	2
CO5				1	3					3	2	1	3	2
CO6						2	3	3	3	2	3	1	1	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-2025							
Course Code	BE451	**Title of the Course**	Seminar	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VIII	0	0	0	3
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	This course is designed to develop students' abilities to independently explore recent developments in biotechnology and allied fields, critically review and analyze scientific literature, synthesize and organize technical information, prepare a structured review report, and deliver an effective oral presentation.						

Course Outcomes	
CO1	Understand recent trends, research advancements, and technological developments in biotechnology and allied areas.
CO2	Apply knowledge of biotechnology to identify, gather, and review relevant scientific literature on a chosen topic.
CO3	Analyze scientific findings, critically evaluate published work, and organize information logically.
CO4	Prepare a well-structured review report and deliver an effective oral presentation to communicate findings.

Unit No.	**Skill Set**	**Content of Unit**	**Mapped CO**
1	Research Orientation	Understand research areas, recent developments, and advancements in biotechnology and allied fields.	CO1
2	Application of Knowledge	Apply academic learning to identify and review current research topics and trends.	CO2
3	Critical Thinking and Analysis	Analyze and critically evaluate scientific papers, methods, and results.	CO3
4	Communication Skills	Prepare a technical report and deliver an oral presentation to effectively convey key findings.	CO4

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	1	1	1	2	1	2	3	3	2
CO2	2	3	2	3	2	2	1	2	2	2	2	3	3	3
CO3	3	3	3	2	2	1	1	1	2	2	2	2	2	3
CO4	2	2	1	1	1	2	1	2	3	3	3	2	2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-2025							
Course Code	BE412	**Title of the Course**	Educational Tour	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VIII	0	0	0	2
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	This course is designed to help students understand the structure and functioning of biotechnology and associated industries, apply theoretical biotechnology concepts in real-world industrial and academic environments, analyze techniques, systems, and workflows observed during the educational tour, and prepare a structured technical report based on the visit, assessed through a viva voce.						

Course Outcomes	
CO1	Understand the structure, operations, and research environment of biotechnology industries, pharmaceutical companies, and academic institutes.
CO2	Apply theoretical concepts of biotechnology to practical observations made during the educational tour.
CO3	Analyze industrial processes, research methodologies, and laboratory practices observed during the visit.
CO4	Prepare a detailed educational tour report and participate in a viva voce examination to demonstrate learning outcomes and skills acquired.

Unit No.	**Skill Set**	**Content of Unit**	**Mapped CO**
1	Industry and Institute Orientation	Understand the organizational setup, research focus, manufacturing processes, and workflows in biotech industries and academic institutes.	CO1
2	Practical Application of Knowledge	Apply academic knowledge of biotechnology in real-world industrial and research environments.	CO2
3	Analytical and Critical Thinking	Analyze techniques, methodologies, and operational systems encountered during the tour.	CO3
4	Technical Communication	Prepare a structured report and participate in a viva voce to effectively communicate observations and learning	CO4

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	2	2	1	2	3	3	2
CO2	2	3	2	2	2	2	1	2	2	2	2	3	2	3
CO3	3	3	2	2	2	1	1	1	2	2	2	3	2	3
CO4	2	2	1	1	1	2	1	2	3	3	3	2	2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**