Integral University, Lucknow

Effective from Session: 2020-21							
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	The students will be acquainted to different aspects of environment and environment monitoring.
CO2	Graduates will be familiar with modern techniques and equipments related to solid waste management.
CO3	Graduates will be familiar with modern techniques and equipments used for efficient waste water treatment.
CO4	The students will get the knowledge of various eco-friendly techniques to solve various environment-related issues.

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	1
2	**Solid Waste Management**	Classification and Characterization of Solid Waste: Management and treatment of solid waste. Thermal and biological processes. Vermicomposting Sustainable fuels from waste: biogas, bioethanol and biohydrogen.	8	2
3	**Waste Water Treatment Methods**	Waste water treatment methods with advanced bioreactor configuration: activated sludge process, trickling filter, fluidized expanded bed reactor, upflow anaerobic sludge blanket reactor,contact process, fixed/packed bed reactor, hybrid reactors, sequential batch reactors.	8	3
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	4

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

	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
CO1	3	3	2	2	2	2	3	2	1			1	2	2	3
CO2	3	3	3	2	3	2	3	1	1			1	3	3	3
CO3	3	3	3	2	3	3	3	1	1			1	3	3	3
CO4	3	3	3	2	3	2	3	1	1			1	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: 2021-2022							
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	Understand the real industrial scale production of various valued bioproducts.
CO2	Determine internal and overall effectiveness factors for zero and first order reactions.
CO3	Understand the effect of catalyst porosity, size, and fluid properties on rate of reactions controlled by mass transfer.
CO4	Chose unit operations for isolation and purification of metabolites.
CO5	Scale-up bioreactors based on rule of thumbs.

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 and CO3
3	Product Extraction and Purification	Cell disruption: Physical, chemical methods, Filtration: batch and continuous, Centrifugation: batch and continuous, Reverse osmosis, Dialysis, Electrodialysis; Lyophilization	8	CO4
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	CO5

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	3	1	1						2	3	3	2	3			
CO2	3	3	3	3	2	1						2	3	3	2	3			
CO3	3	3	3	3	2	3						2	3	3	3	3			
CO4	3	3	3	3	2	3						2	3	3	3	3			
CO5	3	3	3	3	2	3						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: 2021-2022							
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	The course has an emphasis on the exploration of proteins and nucleic acids that includes analyses of sequences, structure prediction, validation, visualization, and phylogenetic analyses allowing students to advance their understanding of complex biological systems in silico along with the learning of high-throughput computational tools in light of the student's knowledge of basic bioinformatics.						

Course Outcomes	
CO1	Understand protein informatics and in silico tools required to explain molecular interaction with other molecular targets.
CO2	Explain secondary and tertiary structure prediction to advance the understanding of protein interaction mechanisms.
CO3	Understand DNA microarray technology and in silico gene prediction analyzing expression and functional annotation of genes and genomes.
CO4	Apply molecular phylogeny to explain the evolutionary relatedness of biomolecules.

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.

Structural Bioinformatics, Philip E. Bourne, Wiley-Liss, 2003, ISBN 9780471202004, 0471202002, 047120199.

Bioinformatics: Sequence and Genome Analysis, David W. mount, CSH Laboratory Press, 2001, ISBN 9780879695972.

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	PO12	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO6
CO1	1	1	1	2	2	2	2	1	1	1	2	3	2	2	2				
CO2	2	2	2	2	3	1	1	2	1	2	2	3	2	2	2				
CO3	1	3	2	3	3	1	1	1	1	2	2	3	2	2	2				
CO4	1	3	2	2	3	1	1	1	2	2	2	3	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: 2020-21							
Course Code	BE404	**Title of the Course**	Nanobiotechnology	**L**	**T**	**P**	**C**
Year	4	**Semester**	7	2	1	0	3
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To gain an understanding of the principles of Nanobiotechnology, characterization of nanostructure materials and equipment towards the cutting-edge areas of Nanobiotechnology, foster innovations and promote translational research to address various issues in the areas of health, agriculture, food and environment through basic and applied Nanobiotechnological research interventions.						

Course Outcomes	
CO1	To equip interdisciplinary knowledge of physics, chemistry and biology in the field of nanotechnology at a single platform.
CO2	To acquire the knowledge of different types of nanomaterials, their synthesis and characterization for various applications.
CO3	To utilize biomolecules for the creation of nanomaterials & their applications for the welfare for society.
CO4	To develop the understanding of utilizing biomolecules for designing tools and equipment (diagnostic tool, biosensors, smart drug delivery systems) for various applications in food, medicine and health science. To aware about the potential risks and ethical regulations associated with the nanobiotechnology.

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- Polysacharides–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- Carbonbased nanomaterials (buckyballs, nanotubes, graphene)– Metal-based nanomaterials (nanogold, nanosilver and metal oxides) -Nanocomposites-Nanopolymers – Nanoglasses –Nano ceramics, Surface and Bulk Properties of Bio materials – 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, and 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). 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 mortors – 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. Nano particle 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.
3. Our Molecular Future: How Nanotechnology, Robotics, Genetics and Artificial Intelligence will transform the World, Prometheus ISBN 1573929921.
4. Niemeyer C. M., "Nanobiotechnology: Concepts, Applications and Perspectives", Wiley – VCH, 2006.
5. David S Goodsell, "Bionanotechnology", John Wiley & Sons, 2004.
6. Debasis Bagchi et al. "Bio-Nanotechnology: A Revolution in Food, Biomedical & Health Sciences" Wiley-Blackwell, 2013.
7. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, "Biomaterials Science: An Introduction to Materials in Medicine", Academic Press, 2012.
8. Balaji Sitharaman "Nanobiomaterials Handbook", Taylor & Francis Group, 2011.

e-Learning Source:

1. https://nptel.ac.in/courses/102107058
2. Malik, Parth, et al. "Nanobiosensors: concepts and variations." International Scholarly Research Notices 2013 (2013).
3. Cavalli, Roberta, Marco Soster, and Monica Argenziano. "Nanobubbles: A promising efficienft tool for therapeutic delivery." Therapeutic delivery 7.2 (2016): 117-138.
4. Yu, H., and Q. Huang. "Bioavailability and delivery of nutraceuticals and functional foods using nanotechnology. Bio-Nanotechnology." (2013): 593-604.

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
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		2	3	3	3			
CO4	2	3	3	2	2	3	2	3	1	1	1	2	2	2	2			

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

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

Integral University, Lucknow

Effective from Session: 2020-2021							
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 collect water samples and do preliminary screening of collected samples
CO2	They will be acquainted with various methods of chemical analysis of waste samples.
CO3	The will be able to learn different methods of nitrogen estimation in water samples.
CO4	They will be able to perform BOD and COD to assess the level of pollution.
CO5	The studentds will be able toestimate the viable numbers of bacteria in the given water sample.

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	1
2	**Heavy metal determination**	Determination of heavy metal concentration in soil.	4	2
3	**Nitrogen Estimation**	Determination of Kjeldahl nitrogen, nitrate and nitrite nitrogen	4	3
4	**Assessment of Pollution level**	Determination of BOD AND COD of wastewater samples.	4	4
5	**Evaluation of Biological pollution**	Enumeration of contaminating pathogenic organisms by MPN method	4	5

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	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	2	3	2	3		3				3	3	3
CO2	3	3	1	2	3	2	3		3				3	3	3
CO3	3	3	1	2	3	2	3		3				3	3	3
CO4	3	3	1	2	3	2	3		3				3	3	3
CO5	3	3	1	2	3	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: 2020-21							
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	Perform experiment to obtain data for microbial growth, product formation and substrate utilization.
CO2	Perform data analysis and determine kinetic parameters for microbial growth, product formation and substrate utilization.
CO3	Understand the effect of mixing on microbial growth.

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 and CO2
2	Product formation in ideal mixing condition	A study of kinetic modeling of a batch reactor: Determination of kinetic equation explaining product formation.	6	CO1 and 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	CO1 and CO2
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	CO3

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 CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	1	2	1	1	1	2			3	3	3	3			
CO2	3	2	1	1	2	1	1	1	2			3	3	3	3			
CO3	3	2	1	1	2	1	1	1	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: 2021-2022							
Course Code	BE 407	**Title of the Course**	Bioinformatics Project	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VII	**0**	**0**	**4**	**2**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	This course deals with the students to create and execute projects related to Bioinformatics and its allied applications.						

Course Outcomes	
CO1	Student can effectively use his/her knowledge to think and create new projects and get involved in problem solving process
CO2	Student can exploit the knowledge of bioinformatics to solve real life scientific problems
CO3	Student will learn new tools and softwares related to bioinformatics
CO4	Student gets to learn the process of project writing and implementation process at small scale.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**

Reference Books:

e-Learning Source:
National Center for Biotechnology Information, www.ncbi.nlm.nih.gov
Webinar recording: a sequel for beginners: ligand-based drug design — the basics https://www.youtube.com/watch?v=ef5EaooBYUU

	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
CO1	3	2	1	1	2	2	1	2	2	1	2	2	3	3	3
CO2	2	1	2	1	2	1	1	1	2	2	2	2	3	2	3
CO3	3	2	3	2	2	1	1	1	2	1	2	2	1	2	3
CO4	2	2	2	1	1	1	1	1	2	2	2	2	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: 2021-2022							
Course Code	BE408	**Title of the Course**	Food Biotechnology	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VII	**2**	**1**	**0**	**3**
Pre-Requisite	BE-101, BE-213, BE312 & BE313	**Co-requisite**	None				
Course Objectives	To acquaint with the basic knowledge of foods and their various food laws (National and International), handling of food for maintaining the proper preservation techniques including impart knowledge which would be useful to the students for industrial job and PSUs job and Government job like Food Safety Officer (FSO) as UPPSC.						

Course Outcomes	
CO1	The student will gain basic knowledge of Applications of GMO/GMC in agriculture and industrial sector.
CO2	Students also will gain the fundamental aspects of food spoilage and acquired basic knowledge of fermentation of foods its mechanism concepts, parameter as well as their preservation methods.
CO3	Learners would have acquired basic knowledge of pre and pro biotic food and its major applications
CO4	Learners will gain the fundamental knowledge of various food laws and its applications as well as implementation and certification of food license.
CO5	Learners will also gain the fundamental and practical knowledge of food analysis and their testing methods in details as quality assurance.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Introduction Food Biotechnology	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 foods and their applications	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:

Potter N and Hotchikiss "Food Science" CBS Publ.

Frazier WC and Westhoff DC "Food microbiology", TATA McGraw Hill Publishing Company Ltd, New Delhi

Andrews AT, Varley J "Biochemistry of milk products", Royal Society of Chemistry.

e-Learning Source:

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	2	1	1	3	3	1	2	1	3	3	2	3
CO2	2	3	2	2	2	1	1	2	1	1	1	3	3	2	2
CO3	1	3	2	2	2	1	1	2	2	1	1	3	3	2	2
CO4	3	3	3	3	2	2	2	1	2	1	1	3	3	3	3
CO5	1	2	2	1	2	2	2	1	1	1	1	3	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: 2020-21							
Course Code	BE409	**Title of the Course**	Pharmaceutical Biotechnology	**L**	**T**	**P**	**C**
Year	4	**Semester**	7	3	1	0	4
Pre-Requisite	BE201	**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	The broad subject base core covering the major elements of biotechnology, together with specialized an in-depth study in pharmaceutical biotechnology.
CO2	To know about the methods of synthesis, advantages and challenges associated with the protein and peptide formulations.
CO3	To acquire knowledge about the proteins and phospholipids drug formulations used for the treatment of various diseases.
CO4	To gain more specialized knowledge of pulmonary drug delivery systems for biomacromolecules.
CO5	To develop the concept of different polymeric systems used for controlled drug delivery.

Unit No.	**Title of the Unit**	**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**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO4**	**PSO6**
CO1	3	3	3	3	3	3	2	2	2		1	3	3	3	2			
CO2	3	3	3	2	2	3	2	1				2	3	2	2			
CO3	3	3	3	2	2	3	2	1				2	3	3	2			
CO4	3	3	3	2	3	3	2	1				3	3	3	2			
CO5	3	3	3	3	3	3	2	1				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: 2020-2021							
Course Code	BE410	**Title of the Course**	BIOENERGETICS & METABOLIC ENGINEERING	**L**	**T**	**P**	**C**
Year	**FOURTH**	**Semester**	SEVENTH	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	This course deals with the basic energy harvesting processes which govern the self-assembly of biomolecules and their utilization to generate energy to run the biological machinery of evolution and also how this machinery can be utilised at its best for beneficial purposes.						

Course Outcomes	
CO1	Gain knowledge about the energy dynamics in the cells.
CO2	Analyze and evaluate the energy requirements in various biological processes.
CO3	Understand the energy dynamics of the cellular metabolic pathways and their intricacies.
CO4	Understand the regulation and modulation of the flux within the cellular machinery.
CO5	Design efficient metabolic pathways, in pursuit of developing high yielding biocatalysts.

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: Stochiometry of cellular reactions, Reaction rates, Dynamic mass balance.	8	CO3, CO5
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, CO5
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	CO4, 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	PO12	PSO1	PSO2	PSO3	PSO5	PSO6	PSO7
CO1	**3**	**2**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**2**	**0**	-	-	-
CO2	**3**	**3**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**0**	-	-	-
CO3	**1**	**1**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**1**	-	-	-
CO4	**1**	**2**	**2**	**2**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**2**	**3**	**2**	**1**	-	-	-
CO5	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**0**	**0**	**0**	**0**	**3**	**3**	**3**	**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: 2021-2022							
Course Code	BE411	**Title of the Course**	Agricultural Biotechnology	**L**	**T**	**P**	**C**
Year	IV	**Semester**	VII	**3**	**1**	**0**	**4**
Pre-Requisite	BE312	**Co-requisite**	None				
Course Objectives	This course deals with the basic knowledge of Agricultural Biotechnology. As an agricultural biotechnologist, it is necessary to know about the new varieties of plants and crops being developed. It is also necessary to know how to improve the quality of food grains products and their significance.						

Course Outcomes	
CO1	Students learn about the plant based genetic engineering and various techniques used for crop improvement.
CO2	Students acquire knowledge about the plant based industrial products and its application in pharmaceutical industry.
CO3	Students learn about the different molecular markers used in plant biotechnology and techniques.
CO4	To know about the methods used for plant transformation and hybridization methods.
CO5	Students acquire knowledge about the application of **Agri-Biotech**

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: somaclonal and gametoclonal 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	**Tools and techniques**	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	**Vectors**	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	**Applications of Agri-Biotech**	Brief overview of Bioremediation, Biodegradable plastics, Bio 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. Dixon RA, Gonzales RA, "Plant Cell Culture: A Practical Approach".
4. Mantell SH, Matthews JA, McKee RA, "Principles of Plant Biotechnology: An Introduction to Genetic Engineering in Plants".
5. Brown TA, "Gene cloning: An Introduction".

e-Learning Source:

https://www.youtube.com/watch?v=EDReGW95EGk

	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
CO1	3	2	3	1	2	3	2	2	1			2	3	3	2
CO2	3	1	3	3	2	2	1	1	2			2	3	3	2
CO3	3	2	3	2	3	1	1	1				2	3	3	3
CO4	3	3	3	2	2	2	1	1				2	3	3	3
CO5	3	3	3	3	2	3	3	2	2		2	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: 2021-2022							
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 deals with the students to provide comprehensive learning platform to students where they can enhance their employ ability skills and become job ready along with real corporate exposure.						

Course Outcomes	
CO1	Industrial training teaches and gives one the requisite skills using which students can effectively use his/her knowledge to achieve the pre-defined goals of the company or firm where he would .
CO2	Industrial training provides them with the required exposure to the real working condition and workplace, they get some sort of experience from. The newly acquired experience proves to be quite helpful for them when they get employed at some place after their training is complete.
CO3	Industrial training ensure students to interact with industrial personnel and follow engineering practices and discipline prescribed in industry.
CO4	Develop awareness about general workplace behavior and build interpersonal and team skills. Prepare professional work reports and presentations.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**

Reference Books:

e-Learning Source:

https://in.indeed.com/career-advice/career-development/internship-report

https://www.youtube.com/watch?v=nXmrI2A8Rv8

	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
CO1	3	2	1	1	2	2	1	2	2	1	2	2	3	3	3
CO2	2	1	2	1	2	1	1	1	2	2	2	2	3	2	3
CO3	3	2	3	2	2	1	1	1	2	1	2	2	1	2	3
CO4	2	2	2	1	1	1	1	1	2	2	2	2	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: 2021-2022							
Course Code	**BE499**	**Title of the Course**	**B.Tech Project**	**L**	**T**	**P**	**C**
Year	4th	**Semester**	8th	**0**	**0**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To enable students to work as a team to develop the methodology for the project. To develop the capability to apply the engineering principles to carry out the project work. To define the conclusion of the project undertaken with in depth understanding of the topic. .						

Course Outcomes	
CO1	Ability to work as a team of plan the execution of the undertaken project.
CO2	Capability to use the engineering knowledge and principles on an undertaken project.
CO3	Capacity to complete the undertaken project on time with effective communication to deliver the project successfully.

	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
CO1	0	0	0	3	3	2	1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	2	1	3	3	3	3	3	3	1	3
CO3	3	3	3	3	3	2	1	3	3	3	3	3	1	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: 2021-2022							
Course Code	**BE451**	**Title of the Course**	**Seminar**	**L**	**T**	**P**	**C**
Year	4th	**Semester**	8th	**0**	**0**	**0**	**3**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To develop the Communication & Research Comprehension. To developed leadership skills. To develop the ability to seek knowledge and defend the idea.						

Course Outcomes	
CO1	Learner should be able review available literature and extract idea from them.
CO2	Learner should be able to work in a team as leader or effective team member
CO3	Learner should be able to write technical reports and to present their work.

	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
CO1	0	0	0	3	3	0	0	3	3	3	0	3	3	3	3
CO2	0	0	0	3	3	0	0	3	3	3	0	3	3	1	3
CO3	0	0	0	3	3	0	0	0	3	0	0	3	1	2	2

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

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