Integral University, Lucknow

Effective from Session: 2020-2021							
Course Code	BE301	**Title of the Course**	BIOPHYSICAL TECHNIQUES	**L**	**T**	**P**	**C**
Year	**THIRD**	**Semester**	FIFTH	**2**	**1**	**0**	**3**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To equip students with the know-how of various analytical methods for the analysis of products and processes in biotechnology.						

Course Outcomes	
CO1	Design and analyze chromatographic techniques and evaluate the test result of samples.
CO2	Design centrifugation and electrophoretic processes for separation and analysis.
CO3	Analyze and evaluate the results obtained from various spectroscopic techniques.
CO4	Gain knowledge about radiochemical, microscopic and cell sorting methods for analysis and lyophilization for preservation of samples.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Chromatography**	Principle and Instrumentation of different chromatographic techniques (LC, GC, affinity, ion exchange, reverse phase, HIC, gel permeation, Chromatofocussing) and interpretation of their results.	8	CO1
2	**Centrifugation and Electrophoresis**	Centrifugation: principle and instrumentation/constituents of isopycnic centrifugation and density gradient centrifugation, ultracentrifugation, molecular weight determination. Electrophoresis: principle and instrumentation/constituents of electrophoresis (Agarose Gel electrophoresis, SDSPAGE, Isoelectric focusing) and interpretation of their results. 2D Electrophoresis: Peptide mapping.	8	CO2
3	**Spectroscopy**	Principle and Instrumentation of Spectroscopic methods UV, Visible, IR, FTIR, Fluorescence, ORD, CD, NMR, ESR, mass spectrometry and interpretation of their results. Analysis using Hybrid technologies: GC-MS and LC-MS. Principle and Instrumentation of X-ray diffraction, Atomic Absorption Spectroscopy and Plasma emission spectroscopy and interpretation of their results.	8	CO3
4	**Advanced Techniques**	Radiotracer technique. Introduction to principle and working of light and electron microscopes. Theory of lyophilization and its applications to biological systems; Cell sorter: Principle, working and applications.	8	CO4

Reference Books:

1. Principles and Techniques of Biochemistry and Molecular Biology, Keith Wilson, John Walker, John M. Walker, Cambridge University Press, 2008.
2. Practical Handbook of Microbiology, William M., O'Leary Robert, Dony Wu, CRC Press, Third Edition, 2015.

e-Learning Source:

1. **https://onlinecourses.swayam2.ac.in/cec21_bt06/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	PO12	PSO1	PSO2	PSO3	PSO5	PSO6	PSO7
CO1	**3**	**2**	**2**	**2**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**3**	**1**	-	-	-
CO2	**2**	**2**	**2**	**2**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**3**	**1**	-	-	-
CO3	**2**	**2**	**2**	**2**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**3**	**1**	-	-	-
CO4	**2**	**2**	**2**	**2**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**3**	**1**	-	-	-
CO5																		

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	BE302	**Title of the Course**	Bioprocess Engineering	**L**	**T**	**P**	**C**
Year	III	**Semester**	V	**3**	**1**	**0**	**4**
Pre-Requisite	BE-202, BE-221, BE-208, ME-222	**Co-requisite**	None				
Course Objectives	Students should be able to design and optimize media for production of various bioproducts, study its kinetic behavior, perform material and energy balances for any biochemical process decide upon control strategies for process control.						

Course Outcomes	
CO1	Understand the principles of microbial nutrition and design an efficient industrial media for large scale production of microbial metabolites.
CO2	Understand the concept of thermal death kinetics of microbes and design an efficient sterilizer for removal of microbial contamination.
CO3	Analyze kinetics of microbial growth in different culture system and evaluate the best one for scale up.
CO4	Apply mass and energy balances to analyze and interpret key elements of fermentation to design media and operate bioreactor accordingly.
CO5	Design reactors which is the heart of any fermentation process. Specifying aspects of the reactor and its operation and apply this knowledge during the lab course.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Media design and optimization	Principles of microbial nutrition, formulation of culture media, factors influencing the choice of various carbon and nitrogen sources, minerals, vitamins, precursors & antifoam agents; Importance of pH; Types of media. Storage and maintenance of microbial cultures. Media design and optimization.	8	CO1
2	Sterilization	Sterilization: Concept and methods; Sterilization of medium; Kinetics of thermal death of microorganisms; Batch sterilization; Continuous sterilization; Sterilization of air: Filters and design of depth filters.	8	CO2
3	Microbial Kinetics	Microbial kinetics of growth and substrate utilization in closed, semi-open and Fed batch cultivation systems; Product formation in batch, and continuous culture and Fed batch; Maintenance energy and yield concepts; Estimation of biomass. Microbial pellet formation; Kinetics and dynamics of pellet formation.	8	CO3
4	Material and Energy Balances	Steady state and unsteady state Material and Energy Balance calculations of different bioprocesses such as fermentation, sterilization, filtration etc.	8	CO4
5	Fermenters and their Control	Fermenters and their types; Control of physical, chemical and biological environment of the bioreactor and Advanced control strategies viz Proportional, Derivative, integral controllers and their combinations.	8	CO5

Reference Books:

1. Bioprocess Engineering Principles, P.M. Doran, Elsevier, Second Edition, 2014.
2. Biochemical Engineering Fundamentals, Bailey & Ollis, McGraw-Hill Book Company, 1986.
3. Principles of Fermentation Technology, Stanbury, Whitaker and Hall, Butterworth-Heinemann, second edition, 1995.

e-Learning Source:

	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	3	3	1	1	2						3	3	2
CO2	3	3	3	3	1	1	3		3				3	3	2
CO3	2	3	3	3	1	1	3		1				2	2	2
CO4	3	3	3	3	2	2	3	1	3	1			3	3	2
CO5	3	3	3	3	2	2	2	1	1	1	1	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: 2020-21							
Course Code	BE303	**Title of the Course**	GENETIC ENGINERING	**L**	**T**	**P**	**C**
Year	**3**	**Semester**	5	**3**	**1**	**0**	**4**
Pre-Requisite	MOLECULAR BIOLOGY	**Co-requisite**	NULL				
Course Objectives	**1. Develop the understanding of Genetic Manipulations.** **2. Introduce the concepts of different Enzymes, concept of Transformation, Gene Cloning and its expression.** **3. Introduce students with the concepts of Transgenic plants, animal, GMOs creation.**						

Course Outcomes	
CO1	To study different vectors and their characteristics
CO2	Learn about different enzymes used in genetic engineering for DNA manipulations
CO3	Transformation methods and their use in Genetic Engineering.
CO4	Determine the selection parameters of r-DNA, creation of different gene libraries
CO5	Using genetic engineering for mutagenesis, gene silencing, and amplification of DNA

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Basic Concepts and Vectors**	Concept and basic steps in gene cloning; Cloning vectors: Plasmid (pBR322, pUC series, pGEM); Phage λ, Phage M13, Cosmids, Phagemids, Phasmids, pTi based vectors, Plant and animal viruses, Yeast vectors, Artificial chromosomes, Expression vector.	8	1
2	**Enzymes used in Genetic Engineering**	Enzymes used in recombinant DNA technology: Restriction endonucleases, ligases, DNA polymerases, Nucleases, Ligases, Alkaline phosphatase, Polynucleotide kinase, Reverse transcriptase, Terminal deoxynucleotidyl transferase.	8	2
3	**Methods used for Genetic Transformation**	Transferring DNA into *E. coli*: chemical induction and electroporation; Use of *Agrobacterium* for genetic engineering in plants; Direct methods of gene transfer: Microprojectile bombardment, electroporation, microinjection.	8	3
4	**cDNA and Genomic Libraries**	Construction of cDNA library and genomic library, Screening of gene libraries: screening by hybridization (Southern, Northern), Preparation of probes, Immunoscreening, Western blotting; Use of marker gene, selectable markers and screenable markers, non-antibiotic marker.	8	4
5	**PCR-based Techniques and Gene silencing**	PCR technology, Variants of PCR, Real-Time PCR; Site-directed mutagenesis; Antisense RNA technology, RNA interference	8	5

Reference Books:

1. Glick, B.R. and Pasternak, J.J. "Molecular Biotechnology" ASM Press, USA.
2. Glover, D.M. and Hames, B.D. "DNA cloning" IRL Press.
3. Sambrook J., Fritsch, E.F., Maniatis "Molecular Cloning, A laboratory Manual" Cold Spring Harbor Laboratory, USA.
4. Watson "Recombinant DNA".
5. Rastogi and Pathak "Genetic Engineering", Oxford Press
6. Lodish, Berk, Matsudaira, Kaiser, Krieger, Scott, Zipersky and Darnell "Molecular Cell Biology".

e-Learning Source:

1. PCR, https://www.youtube.com/watch?v=nHi
2. Southern & Northern Blotting, https://www.youtube.com/watch?v=EoTq

	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	3	2	3	3	3	1	1	2	1	1	3	3	3	1			
CO2	2	2	1	2	1	1	1	1	2	1	1	3	3	3	2			
CO3	2	1	1	2	3	1	1	1	1	1	1	2	3	2	1			
CO4	3	3	3	3	3	1	1	1	1	1	2	2	3	3	3			
CO5	3	3	3	3	3	2	1	1	1	1	3	3	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: 20-21							
Course Code	BE304	**Title of the Course**	Mass Transfer Operations I	**L**	**T**	**P**	**C**
Year	**3**	**Semester**	5	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objective is to expose biotechnologists to various mass transfer operations like diffusion, adsorption, distillation, crystallization, drying, liquid-liquid extraction, solid-liquid extraction etc so as to enable them to improve the design and operations of the bioprocesses plant. It will also improve the interaction of biotechnologists with chemical engineers who will assist them in the design of the process plant.						

Course Outcomes	
CO1	The students will be introduced to different modes of mass transfer operations. They will be able to understand the Mass transfer in fluidized beds, Flow past solids and boundary layers, Simultaneous heat and mass transfer.
CO2	The unit will help the students to understand the Absorption and stripping operations and its importance in unit operations.
CO3	The students will learn about the concepts of humidification and dehumidification and water cooling.
CO4	The students will learn about Different modes of drying operations and its importance in biological processes.
CO5	To make students understand about the process of crystallization, crystal growth rates, control growth of crystal, and different types of crystallizer. This course will help the students to gain knowledge about different modes of mass transfer operations and its application in biotechnological, biochemical and industrial fields in downstream

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Diffusion	Molecular and turbulent diffusion, diffusion coefficient, Fick's law of diffusion. Dependence of diffusion coefficient on temperature, pressure and composition. Diffusion in multi-component gas mixtures. Diffusion in solids: Molecular, Knudsen & Surface diffusion. Inter-phase mass transfer: Mass transfer coefficients, Diffusion between phases. Equilibrium solubility of gases in liquids, Mass transfer theories, Mass transfer in fluidized beds, Flow past solids and boundary layers, Simultaneous heat and mass transfer.	8	1
2	Absorption and Stripping	Equipments, Gas-Liquid equilibria, Henry's Law, Selection of solvent, Absorption in tray column. Graphical and analytical methods, Absorption in packed columns. HTU, NTU & HETP concepts, Design equations for packed column.	8	1
3	Humidification and Dehumidification	Vapour-liquid equilibrium and enthalpy for a pure substance, vapour pressure temperature curve, vapour gas mixtures, Definition and derivations of relationships related with humidity. Fundamental concept of humidification, dehumidification and water cooling, Wet bulb temperature, Adiabatic and non-adiabatic operations. Evaporative cooling, Classification of cooling towers.	8	3
4	Drying	Solid-gas equilibria, Different modes of drying operations, Definition of moisture contents, Types of batch and continuous dryers, Rate of batch drying, Time of drying, Mechanism of batch drying, continuous drying.	8	4
5	Crystallization	Equilibrium yield of crystallization, Heat and mass transfer rates in crystallization, Theories of crystallization, Factor governing nucleation and crystal growth rates, Control growth of crystal, Classification of crystallizer.	8	5

Reference Books:

1. Treybal, R "Mass Transfer Operations", 3rded. New York: McGraw-Hill, (1980).
2. Sherwood T.K., Pigford R.L. and Wilke P. "Mass Transfer" McGraw Hill (1975).
3. Foust A.S. et.al., "Principles of Unit Operations" John Wiley (1980).
4. Geankoplis, C.J., "Transport Processes and Unit Operations", 3rd ed. Prentice Hall (1983).

e-Learning Source:

	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	3	3	2				2			3	3	3	1
CO2	3	3	2	3	2				2		2	3	3	3	1
CO3	3	3	2	2	1	1	1	2	2	1	1	3	3	3	1
CO4	3	3	2	3	2	1			2	1	1	3	3	3	1
CO5	3	3	3	3	1	1	1	1	2	1	1	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: 2020-21							
Course Code	BE305	**Title of the Course**	Cell Biology	**L**	**T**	**P**	**C**
Year	3rd	**Semester**	5th	2	1	0	3
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objective of this course is to provide knowledge on the fundamentals of Cell Biology and to make students understand the mechanisms of membrane transport, cell division and cell signaling.						

Course Outcomes	
CO1	Students will understand the ultra-structure and functions of Eukaryotic Cell Organelles.
CO2	Students will understand the principles of membrane transport.
CO3	Students will learn the process of Cell division i.e. Mitosis and Meiosis, Cell cycle, its check points, role of cyclin and cyclin dependent kinases in its regulation.
CO4	It will give the basics of Cell Signaling, signal transduction and Protein targeting, sorting and trafficking.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Ultra-structure and functions of Eukaryotic Cell Organelles**	Cell classification, cell variability (size, shape, complexity, functions). Structural organization of prokaryotic and eukaryotic cells. The ultra-structure and functions of Cell Wall, Nucleus, Mitochondria, Chloroplast, Endoplasmic Reticulum, Microsomes, Golgi Apparatus, Lysosomes and Peroxisomes, Cytoskeleton; Microtubules and Microfilaments.	8	CO1
2	**Principles of membrane transport**	Structure and functions of cell membrane, Principles of membrane transport, Ion channels and Transport across cell membrane: Diffusion, Facilitated diffusion, Active membrane transport and carrier proteins, Co-transport by Symporters and Antiporters	8	CO2
3	**Cell division**	Cell division: Mitosis and Meiosis; Cell cycle: check points, role of cyclin and cyclin dependent kinases in its regulation.	8	CO3
4	**Cell Signaling**	The interaction and communication between the cells, Cell-cell adhesion, cell junctions, Plasmodesmata, Gap junction, Tight junction. Basics of signal transduction: Role of calcium, cAMP, G-protein, inositol phosphates, phospholipases and protein kinases in signal transduction. Protein targeting, sorting and trafficking.	8	CO4

Reference Books:

Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter, Molecular Biology of Cell, Garland publications, 6th edition.

Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin, Molecular Biology of cell, Garland publications, 8th edition

Ambrose & Dorouthy M Easty, Cell Biology, ELBS Publications.

e-Learning Source:

https://drive.google.com/file/d/1wpgPeio3vTm7xfVlmJlQ0nkr47aOPVkz/view?usp=sharing

	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	2	3	1	2		1	1					3	3	1	2
CO2	2	3	1	2		1	1					3	2	2	3
CO3	2	3	1	2		1	1					3	2	2	2
CO4	2	3	1	2		1	1					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: 2020-2021							
Course Code	BE306	**Title of the Course**	BIOPROCESS ENGINEERING LAB	**L**	**T**	**P**	**C**
Year	**THIRD**	**Semester**	FIFTH	**0**	**0**	**6**	**3**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To learn the different techniques used in a bioprocess engineering lab.						

Course Outcomes	
CO1	Understand to evaluate the kinetics of batch cell culture reactor and appreciate the aeration and agitation effects.
CO2	Understand the principle and design of sterilization processes and cell death kinetics.
CO3	Develop a know-how of the immobilization process for cells and enzymes.
CO4	Designing fermentative processes for production of biomass and metabolites.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Experiment No. 1**	Determination of kinetic parameters for batch cultivation of Yeast under stationary and shake flask conditions.	5	CO1
2	**Experiment No. 2**	Determination of volumetric oxygen transfer coefficient (K_La) and effect of aeration and agitation speed etc.	5	CO1
3	**Experiment No. 3**	Determination of specific thermal death rate constant (K_d) and activation energy for microbial strains.	5	CO2
4	**Experiment No. 4**	Preparation of immobilized enzymes/cells and evaluation of their kinetic parameters.	5	CO3
5	**Experiment No. 5**	Fermentative production of Penicillin antibiotics using *Penicillium chrysogenum*.	5	CO4
6	**Experiment No. 6**	Citric acid production by (a) solid state and (b) submerged fermentation.	5	CO4
7	**Experiment No. 7**	Microbial production of enzymes by (a) solid state and (b) submerged fermentation.	5	CO4
8	**Experiment No. 8**	Fermentative production of ethanol using *Saccharomyces cerevisiae*.	5	CO4

Reference Books:

1. Doran, Pauline M. *Bioprocess engineering principles*. Elsevier, 1995..
2. Stanbury, Peter F., Allan Whitaker, and Stephen J. Hall. *Principles of fermentation technology*. Elsevier, 2013..

e-Learning Source:

1. http://38.100.110.143/model/index.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	PSO5	PSO6	PSO7
CO1	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**3**	**3**	**3**	**1**	**3**	**3**	**1**	-	-	-
CO2	**2**	**2**	**1**	**3**	**1**	**2**	**2**	**3**	**3**	**3**	**2**	**1**	**3**	**3**	**1**	-	-	-
CO3	**3**	**2**	**1**	**1**	**3**	**3**	**1**	**3**	**3**	**3**	**3**	**1**	**3**	**3**	**1**	-	-	-
CO4	**3**	**2**	**3**	**3**	**2**	**2**	**2**	**3**	**2**	**3**	**3**	**1**	**3**	**3**	**1**	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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	BE307	**Title of the Course**	GENETIC ENGINERING LAB.	**L**	**T**	**P**	**C**
Year	**3**	**Semester**	5	**0**	**0**	**4**	**2**
Pre-Requisite	MOLECULAR BIOLOGY	**Co-requisite**	GENETIC ENGINEERING				
Course Objectives	**1. Learn about the DNA isolation techniques (Genomic, Plasmid).** **2. Learning estimation of DNA and RNA along with visualization of DNA.** **3. Introduction to hybridization technique.**						

Course Outcomes	
CO1	Isolation of DNA.
CO2	Visualization of DNA
CO3	Estimation of Nucleic Acids
CO4	Competent Cell Preparation
CO5	Ampplification and Hybridization technique

Unit No.	**Title of the Unit**	**Name of the Experiment**	**Contact Hrs.**	**Mapped CO**
1		Isolation of plasmid DNA.	4	1
2		Visualization of DNA by gel electrophoresis.	4	2
3		Estimation of RNA content in the given sample by Orcinol method.	4	3
4		Restriction digestion.	4	1
5		Amplification of DNA.	4	5
6		Competent cell preparation, transformation, and selection of transformants.	4	4
7		Western Blotting.	4	5

Reference Books:

1. "Molecular Cloning: A Laboratory Manual"; Sambrook and Russel, 4th Edition; Cold Spring Harbor University Press
2. "Gene Cloning and DNA Analysis"; T. A. Brown, 7th Edition; Wiley-Blackwell Publishers

e-Learning Source:

1.
2.

	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	3	2	3	3	3	1	1	2	1	1	3	3	3	1			
CO2	2	2	1	2	1	1	1	1	2	1	1	3	3	3	2			
CO3	2	1	1	2	3	1	1	1	1	1	1	2	3	2	1			
CO4	3	3	3	3	3	1	1	1	1	1	2	2	3	3	3			
CO5	3	3	3	3	3	2	1	1	1	1	3	3	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: 2020-21							
Course Code	BE308	**Title of the Course**	PLANT MOLECULAR BIOLOGY	**L**	**T**	**P**	**C**
Year	**3**	**Semester**	5	**2**	**1**	**0**	**3**
Pre-Requisite	MOLECULAR BIOLOGY	**Co-requisite**	NULL				
Course Objectives	**The student will learn about different pathways of signal transduction along with cell cycle and its regulation.**						

Course Outcomes	
CO1	The students will get proper knowledge about the genome its organization, expression level and factors that affect its expression.
CO2	The students will learn the role of proteins, its synthesis, degradation and modifications in a plant cell.
CO3	The students will learn about the cell division its mechanism; control and factors that regulate cell division in plant and animal cell.
CO4	The students will learn about the signal transduction and communication of cell, with-in the cell and with respective environment, role of phytochromes its regulation and control, and factors that regulate stomata aperture.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Genome Structure and Organization**	Introduction, Genome structure, Genome organization, Transposable elements, Gene expression, Chromatin and the epigenetic regulation of gene expression	8	1
2	**Protein Synthesis, Folding, and Degradation**	Introduction, Organellar compartmentalization of protein synthesis, From RNA to protein, Mechanisms of plant viral translation, Protein synthesis in plastids, Post -translational modification of proteins, Protein degradation	8	2
3	**Cell Division**	Introduction, Animal and plant cell cycles, Historical perspective on cell cycle research, Mechanisms of cell cycle control, Cell cycle control during development	8	3
4	**Signal Transduction**	Introduction, Characteristics of signal perception, transduction, and integration in plants, Overview of signal perception at the plasma membrane, Intracellular signal transduction, amplification, and integration via second messengers and MAPK cascades, Ethylene signal transduction, Cytokinin signal transduction, Integration of auxin signaling and transport, Signal transduction from phytochromes, Gibberellin signal transduction and its integration with phytochrome signaling during seedling development, Integration of light, ABA, and CO_2 signals in the regulation of stomatal aperture	8	4

Reference Books:

1. "Biochemistry and Molecular Biology of Plants" by Bob B. Buchanan
2. "Lewin's Genes XI" by Jocelyn Krebs
3. "The Handbook of Plant Genome Mapping" by K. Meksem and G. Kahl. Publisher: Wiley-VCH

e-Learning Source:

1. http://www.arabidopsis.org/portals/education/teach.jsp

	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	1	1	1	1	2	1	1	1	1	1	1	2	3	1	1			
CO2	1	1	1	1	2	1	1	2	2	1	1	3	3	3	2			
CO3	2	1	2	1	2	2	1	2	2	1	1	3	3	3	1			
CO4	3	3	2	1	1	1	2	1	1	1	2	2	3	1	1			
CO5	1	1	1	1	2	1	1	1	1	1	1	2	3	1	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: 2020-21							
Course Code	BE309	**Title of the Course**	Animal Biotechnology	**L**	**T**	**P**	**C**
Year	3	**Semester**	5	2	1	0	3
Pre-Requisite	None	**Co-requisite**	BE305				
Course Objectives	The course has been designed to make students aware of basic animal tissue culture techniques and their applications in tissue engineering, pharmaceutical industry and regenerative medicine.						

Course Outcomes	
CO1	The students will able to understand the origin and current technical advances of animal tissue culture.
CO2	To understand the cell culture, scale up and preservation techniques.
CO3	They are equipped with the ability for application of their knowledge in further research in basic or applied immunology for human welfare.
CO4	Having a proper understanding of the technical aspects of existing technologies helps them to address the existing biological and medical challenges faced by the common man and try to find a solution by further applying their knowledge for the welfare of mankind.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Animal Tissue Culture	History of animal cell culture and development, Basic techniques in mammalian cell culture; Cell culture media; Serum free media; maintenance of the culture and cell lines; Development of primary culture, Development of cell line methods for primary cell & organ culture (from explants by enzymatic disaggregation, mechanical disaggregation, EDTA treatment), organ culture.	8	CO1
2	Permanent Cell Lines	Cell strains (Monolayer culture, suspension culture, stationary suspension culture, agar culture and agitated micro carrier suspension culture, hollow fiber systems). Measurement of growth and viability, cell synchronization, cell transformation, cryo-preservation, application of cell cultures, Animal Tissue Engineering.	8	CO2
3	Immunity to Virus, Bacteria and Parasites, Infectious Diseases	Tuberculosis, AIDS. Dysfunctions of immune system and their modulation, Approaches for correcting immune dysfunction. Principles and strategy for developing vaccines, Hybridoma techniques and monoclonal antibody production Applications of monoclonal antibodies in biomedical research and in clinical diagnosis and treatment.	8	CO3
4	Stem Cell Culture	Stem cell culture, Embryonic and adult stem cells and their applications. Animal virus vectors; cloning in mammalian cells, Integration of DNA into mammalian genome, Methods of transformation: (Microinjection, Electroporation, Microprojectile bombardment, Liposomal packaging). Gene knockout technology, gene transfers, transgenic animals and embryo transfer technology. Gene therapy, DNA Microarray Technology.	8	CO4
5				

Reference Books:

1. "Culture of Animal cell: A Manual of Techniques" by Ian Freshney; Publisher: New Jersey: John Wiley; Year: 2005; Edition: 5th.

2. "Basic Cell Culture" Edited by JM Davis; Publisher: Oxford University Press; Year: 2008; Edition: 2nd.

3. "Gene Cloning and DNA Analysis" by TA Brown, Publisher: Oxford Balckwell Science; Year: 2008, 2011; Edition: 4th, 5th.

4. "Immunology" by Roitt, Publisher: Edinburg Mosby; Year: 2002; Edition: 6th.

e-Learning Source:

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	3	2	3	3	2	1				3	3	3	2			
CO2	3	2	3	2	3	3	2	1				3	3	3	2			
CO3	3	3	3	3	3	3	2	2				3	3	3	2			
CO4	3	3	3	3	3	3	2	2				3	3	2	2			
CO5																		

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	BE310	**Title of the Course**	Principles of Biochemical Engineering	**L**	**T**	**P**	**C**
Year	III	**Semester**	V	**2**	**1**	**0**	**3**
Pre-Requisite	None	**Co-requisite**	BE302				
Course Objectives	To develop the understanding of reaction kinetics in biochemical reactions. To introduce the concepts of different bioreactor designs, concept of residence time distribution, conversion and sizing. To introduce the students with the concepts of reactor modeling and mass transfer in bioreactors.						

CourseOutcomes	
CO1	Size isothermal reactors for homogeneous reactions
CO2	Analyze multiple reactions carried out isothermally in continuous, batch and semi batch reactors to determine selectivity.
CO3	Determine the reaction order and specific reaction rate from experimental data.
CO4	Determine the mean residence time and standard deviation using residence time distribution (RTD) data
CO5	Understand the different factors affecting the oxygen mass transfer in bioreactors.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Introduction to Biochemical Engineering	Reaction kinetics, laws of mass action, rate equation, elementary and non-elementary chemical and biochemical reaction, chemical and biochemical reaction rate.	8	CO3
2	Conventional and Unconventional Reactors	Ideal reactors: batch, stirred tank and tubular flow reactor design, concept of RTD and bioreactor, conversion and reactor sizing. Unconventional bioreactors: Hollow fiber reactor, membrane reactor, perfusion reactor for animal and plant cell culture.	8	CO1 and CO4
3	Reactor Modelling	Multiple reactions, mole balance, maximization of desired product for a reactant, reactor choice; Factors affecting choice of chemical reactor and bioreactor. Models of non-ideal reactors: plug flow with axial dispersion, tanks-n-series model.	8	CO2
4	Mass Transfer in Bioreactors	Aeration and agitation: bubble aeration and mechanical agitation, calculation of power consumption, correlation between oxygen transfer coefficient and operating variables, comparison between aerobic and anaerobic bioconversion process; estimation of KLa in fermentation process, factors affecting volumetric oxygen transfer, rheology of fermentation fluids.	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/F5hXo1fU0hg

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	3	2			
CO2	3	3	3	3	2	1						2	3	3	3	2			
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	2						2	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: w.e.f 2017							
Course Code	CS335	**Title of the Course**	Basics of Database Management System	**L**	**T**	**P**	**C**
Year	3rd	**Semester**	5th				
Pre-Requisite	None	**Co-requisite**	None	2	1	0	0
Course Objectives	To describe a sound introduction to the discipline of Database Management Systems. To give a formal foundation of entity-relationship model, relational model, and usage of relational algebra. To introduce the concepts of basic SQL as a universal database language. To demonstrate the principles behind systematic database design approaches by covering conceptual design, logical design through normalization. To provide an overview of transactions, concept of serializability, concurrency control, and deadlock handling.						

Course Outcomes	
CO1	Acquire knowledge on concepts of Database Management Systems and overall database architecture & components
CO2	Acquire Knowledge on concepts on ER-model, database keys and conversion of ER into relational tables
CO3	Retrieve any type of information from a database by formulating SQL queries Analyze the existing design of a database schema and apply concepts of normalization to design an efficient database
CO4	Have knowledge of database transactions and concurrency control techniques

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**An overview of Database Management System**	An Overview of Database Management System: Database Vs. File System; Database System Concepts and Architecture; Data Models, Schemas and Instances; Data Independence and Data Base Languages and Interfaces; Data Definitions Language; DML; Overall Database Structure.	7	CO1
2	**Entity Relationship Model Concepts**	Entity Relationship Model Concepts: Notation for ER Diagram; Mapping Constraints; Keys; Concepts of Super Key; Candidate Key; Primary Key; Generalization; Aggregation; Reduction of ER Diagrams to Tables; Extended ER Model; Relational Data Model Concepts; Integrity Constraints, Relational Algebra.	8	CO2
3	**SQL; Data Base Design & Normalization**	SQL: Characteristics of SQL; Advantages of SQL; Data Types and Literals; Types of SQL Commands; SQL Operators and their Procedure; Tables; Views; Queries and Sub Queries; Aggregate Functions; Insert; Update and Delete Operations; Joint; Unions; Intersections; Minus. Data Base Design & Normalization: Functional Dependencies; Normal Forms; First , Second, Third Normal Forms; BCNF; Normalization Using FD.	9	CO3
4	**Transaction Processing Concepts; Concurrency Control Techniques**	Transaction Processing Concepts: Transaction System; Testing of Serializability; Serializability of Schedules: Conflict serializable Schedule; Recoverability; Recovery from Transaction Failures; Deadlock Handling. Concurrency Control Techniques: Concurrency Control; Locking from Concurrency Control; Two-Phase Locking Protocol.	8	CO4

Reference Books:

1. Date C J, “An Introduction to Database System”, Addision Wesley
2. Korth, Silbertz, Sudarshan, “Database Concepts”, McGraw Hill
3. Elmasri, Navathe, “Fundamentals of Database System”, Addision Wesley
4. Leon & Leon, “Database Management Systems”, Vikas Publishing House.
5. Bipin C. Desai, “An Introduction to Database System”, TMH
6. RamakrishnanGehrke, “Database management System”, McGraw Hill
7. Maheshwari Jain, “DBMS: Complete Practical Approach” Firewall Media, New Delhi

e-Learning Source:

https://onlinecourses.nptel.ac.in/noc22_cs51/preview

PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO3**
CO1	3	1	1	1	1	2		2	2	1		3	2	1		1
CO2	2	2	3	3	2	1		1	2			3	3	1		
CO3	3	2	1	1	2	2	3	1	2			3	3	1	2	1
CO4	3	2	2	2	3	3				1			2	1	3	
CO5	3	1	1	1	1	2	1					2	1	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: 2020 -21							
Course Code	BE 311	**Title of the Course**	Advanced Bioinformatics	**L**	**T**	**P**	**C**
Year	III	**Semester**	VI	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The course helps in learning and understanding various applications of bioinformatics in allied areas of scientific research. The course specifically draws out its implications in the field of genomics, data mining, algorithmic approaches and drug design.						

Course Outcomes	
CO1	Explain the basics of genome annotation, routes of gene finding, significance of Human genome project.
CO2	Understand the concept of biological data and its data mining, protocols to data mining.
CO3	Understand the concept and applications of Genetic algorithms and Artificial neural networks in biological sciences.
CO4	Explain the details of molecular modeling studies and its application in the field of bioinformatics.
CO5	Understand the details of modern era drug designing strategies and specific application of bioinformatics in computer aided drug development studies.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Bioinformatics in Genomics**	Gene and genome; Open Reading Frames; Gene Prediction studies in case of Eukaryotes and Prokaryotes; software for finding genes, Human genome projects: goals and applications.	8	CO1
2	**Data Mining**	Introduction to data mining, Data mining in Bioinformatics; Tasks in data Mining; Application of data mining; Data mining methods, Application of data mining in bioinformatics.	8	CO2
3	**Algorithms in Molecular Biology**	Introduction to Genetic Algorithm, Genetic Operators and Parameters, Application of Genetic Algorithms. Artificial Neural Networks: Neural Model, Firing rules, Network Architectures, feed forward and feed backward networks, application of neural networks.	8	CO3
4	**Molecular Modeling Studies**	Molecular modeling and simulations: Force fields, non-bonded interactions. Electrostatic Interactions. Van der Waals Interactions. Hydrogen Bonding. Molecular modeling softwares.	8	CO4
5	**Bioinformatics in Drug Designing**	Drug Designing: Drug and Targets, Targets identification, target validation, lead compounds, lead optimization: Molecular Docking and QSAR studies.	8	CO5

Reference Books:

Mike Starkey, Ramnath Elaswarapu. Genomics Protocols, Humana Press, 2008, Ed 2, ISBN: 978-1-58829-871-3.

Anthony J.F. Griffiths, Susan R. Wessler, Sean B. Carroll, John Doebley. Introduction to Genetic Analysis, W. H. Freeman; 10th edition (December 24, 2010).

Harren Jhoti Stephen Misener, Stephen A. Krawetz. Bioinformatics Methods and Protocols, Humana Press, 1999, ISBN 978-0-89603-732-8

Andrew Leach; Molecular Modelling: Principles and Applications (2nd Edition), Prentice Hall, 2001, ISBN 13: 9780582382107

e-Learning Source:

Computational chemistry in drug discovery. European Bioinformatics Institute - EMBL-EBIhttps://www.youtube.com/watch?v=9DESulCWbRQ

National Center for Biotechnology Information, www.ncbi.nlm.nih.gov

Auto Dock, autodock.scripps.edu

Computational chemistry in drug discovery. European Bioinformatics Institute-EMBL-EBI https://www.youtube.com/watch?v=9DESulCWbRQ.

	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	2	2	3	3	2	2	1	1	1	1	3	2	2
CO2	2	3	2	2	3	2	1	1	1	2	2	1	2	2	1
CO3	2	3	3	3	3	1	1	2	2	2	1	3	3	2	2
CO4	3	3	3	3	2	3	1	1	1	1	2	2	3	2	1
CO5	3	2	2	2	3	3	2	3	3	1	1	1	2	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:							
Course Code	**BE 312**	**Title of the Course**	**Plant Biotechnology**	**L**	**T**	**P**	**C**
Year	**III**	**Semester**	VI	2	1	0	3
Pre-Requisite	Plant Physiology	**Co-requisite**	None				
Course Objectives	The students would be acquainted with principles, technical requirement, scientific and commercial applications in plant biotechnology support methodologies in plant tissue/cell culture for plant improvement, as well as with PCR-based detection diagnostic tools..						

Course Outcomes	
CO1	Students are acquainted with knowledge and concept of sterilization and various culture techniques for plant tissue culture.
CO2	Students will gain knowledge of classical and modern plant biotechnology processes.
CO3	Acquaintance with principles, technical requirement, scientific and commercial applications of somaclonal variations and in vitro secondary metabolite production.
CO4	Students will aquainted with knowledge of apllied plant tissue/cell culture techniques used for plant improvement.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Basics of Plant Tissue Culture**	Introductory history: Laboratory organization; Media composition – solid and liquid: Sterilization techniques; Types of culture; Establishment and maintenance of callus and suspension cultures; Totipotency of plant cells- dedifferentiation and redifferentiation. Organogenesis and somatic embryogenesis, synthetic seeds.	8	CO1
2	**Micro Propagation and Haploid Production**	Plant micro propagation: Application of micro propagation in forestry and horticultural crops, Haploid plant production – Androgenesis; anther and microspore culture; Gynogenesis; Embryo culture and rescue in agricultural and horticultural crop; Protoplast isolation; fusion and regeneration; Somatic hybrids – cybrids; in vitro screening and selection of hybrids for various stress conditions.	8	CO2
3	**Somaclonal Variations and Secondary Metabolite Production**	Somaclonal variation in vitro cultures- Causes- stability and utilization – genetic and epigenetic basis; Establishment of cell lines and evaluation of secondary metabolite in cell culture; Hairy root culture, Applications of tissue culture for crop improvement in agriculture, horticulture and forestry.	8	CO3
4	**Plant Transformation Techniques**	Methods of plant transformation: Binary and Cointegrate vectors derived from Ti plasmid of Agrobacterium; Plant transformation with Ti plasmid of Agrobacterium, Direct methods of transferring genes to plants: Microprojectile bombardment, Electroporation, Manipulation of gene expression in plants; Production of marker free transgenic plants. Application of plant genetic engineering: insect resistance, disease resistance, herbicide resistance; delayed fruit ripening, FlavrSavr, Golden rice.	8	CO4

Reference Books:

1. An introduction to Plant Tissue culture by MK Razdan. M.K. Oxford & IBH Publishing Co, New Delhi, 2003.
2. Plant Biotechnology: An Introduction to Genetic Engineering by Adrian Slater, Nigel W. Scott, Mark R. Fowler. Oxford University Press, 2008.
3. Molecular Biotechnology by Glick, B.R. and J.J. Pasternak. Second Edition, ASM Press, Washington, 1998.
4. Plant tissue culture by Bhojwani. S.S and Razdan. M.K 2004.
5. Plant Propagation by Tissue Culture: Volume 1 & 2. EF George. Exegetics Limited, 1999.

e-Learning Source:

https://nptel.ac.in/courses/102103016

	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	1	2	2	3	3	1	1	3	2	2	3
CO2	3	3	3	2	3	2	2	2	2	1	1	3	3	2	3
CO3	3	3	3	2	3	3	2	2	3	1	1	3	3	2	1
CO4	3	3	2	2	3	2	2	3	3	1	1	3	3	3	1
CO5	3	3	2	2	1	2	2	3	3	1	1	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: 2020-21							
Course Code	BE313	**Title of the Course**	Fermentation Biotechnology	**L**	**T**	**P**	**C**
Year	III	**Semester**	VI	**3**	**1**	**0**	**4**
Pre-Requisite	BE-202, BE-302, BE-208, ME-222	**Co-requisite**	None				
Course Objectives	This course is designed for B.Tech Biotech students to make them aware and specialized in bioprocess/Fermentation technology so that they can use complete living cells or their components (e.g., bacteria, enzymes, chloroplasts) to obtain desired products. Main objective of the course is to make students capable of designing protocols for industrial scale production of medicinally and commercially important metabolites. Well acclaimed engineering benefits of Fermentation based industries over synthetic chemical processes have resulted in the acute requirement of specialized personnel's in this area. Technically and academically strong students can develop better understanding and perform more efficiently in commercial as well as research areas associated with medical research, food processing, agriculture, pharmaceutical development, waste management, and numerous other fields of science and industry.						

Course Outcomes	
CO1	Apply biological and engineering principles for cultivating microorganisms in fermentors.
CO2	Students are capable to create mutants and genetically engineered cells for industrial scale production of medicinally and commercially important metabolites.
CO3	Apply the bioprocess and key aspect of fermentation to produce variety of bio-products
CO4	Apply knowledge for gene cloning for over production of desired metabolites, trouble shoot problems including environmental, ethical issues related to fermentation of recombinant microbial cells for large scale production of genetically engineered primary and secondary metabolites
CO5	Understand the concept of metabolic pathway reconstruction for production of industrially relevant bioproducts and analyze omics data with the help of computational tools, implement genome- scale metabolic modeling for design and evaluation of metabolic engineering strategies.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	History and Introduction to Fermentation technology	History and development of fermentation industry: Introduction to submerged and solid state fermentation, primary and secondary metabolite. Raw material availability, quality, processes and pretreatment of raw materials.	8	CO1
2	Overproduction of industrially important metabolites	Creation/procedures for developing mutants of the desired microbes with the stable capacity of producing desired metabolites. Isolation and preservation of different types of mutants- induction resistant, feedback inhibition resistant. Concepts for overproduction of metabolites.	8	CO2
3	Fermentative production of products and metabolites	Fermentation of SCP producing organism; mushroom, Baker's yeast, algal proteins. Food additives like coloring agents, flavoring agents and vitamins. Large scale production and commercial application of enzymes: amylases and antibiotics: penicillin	8	CO3
4	Applications of gene cloning in metabolite production and fermentation of recombinant products	Application of gene cloning in redirecting cellular metabolism for over- production of desired metabolites, metabolic pathway synthesis, Fermentations of recombinant microbial cells for large- scale production of genetically engineered primary and secondary metabolites	8	CO4
5	Metabolic pathway reconstruction	Metabolic pathway reconstruction: Genome-scale metabolic network reconstruction, strategies for finding feasible metabolic pathways of commercially and medicinally metabolites.	8	CO5

Reference Books:

1. Comprehensive Biotechnology, Murray Moo-Young, Vol. 1& III- latest ed.
2. Microbes& Fermentation, A. Lel and Kotlers Richard J. Mickey, Oriffin publication
3. Industrial Fermentations- Leland, N.Y. Chemical publishers.

e-Learning Source:

http://www.biologydiscussion.com/vitamins/microbial-production-of-vitamins-an-overview/10372

	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	3	3	1	1	2						3	3	2
CO2	3	3	3	3	1	1	3		3				3	3	2
CO3	2	3	3	3	1	1	3		1				2	2	2
CO4	3	3	3	3	2	2	3	1	3	1			3	3	2
CO5	3	3	3	3	2	2	2	1	1	1	1	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: 2020-21							
Course Code	BE 314	**Title of the Course**	Mass Transfer Operations II	**L**	**T**	**P**	**C**
Year	3rd	**Semester**	6th	**3**	**1**	**0**	**4**
Pre-Requisite	BE 304	**Co-requisite**	None				
Course Objectives	The objective is to expose biotechnologists to various mass transfer operations like diffusion, adsorption, distillation, crystallization, liquid-liquid extraction, solid-liquid extraction etc so as to enable them to improve the design and operations of the bioprocesses plant. It will also improve the interaction of biotechnologists with chemical engineers who will assist them in the design of the process plant.						

Course Outcomes	
CO1	The students will be introduced to different modes of mass transfer operations in Distillation processes. They will be able to understand the single stage distillation and multistage distillation.
CO2	The unit will help the students to understand the Continuous Distillation of Binary Mixtures and Principles of azeotropic and extractive distillation, Introduction to multicomponent distillation system.
CO3	The students will learn about the concepts of Liquid-Liquid Extractionusing concept of Triangular graphical representation concept of theoretical or ideal stage
CO4	The students will learn about concept of Solid/Liquid extraction using technique of single and multistage cross current contact and counter operations.
CO5	To make students understand about the process of absorption and its type, nature of adsorbents adsorption equilibria and adsorption hysterises.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Distillation**	Pressure-composition, Temperature-concentration, Enthalpy-concentration diagrams for ideal and non-ideal solutions, Raoult's law and its application, Maximum and minimum boiling mixtures, concept of relative volatility. Single stage Distillation, Differential distillation, Flash vaporization Vacuum, molecular and steam distillation.	8	CO1
2	**Continuous Distillation of Binary Mixtures**	Multistage contact operations, Characteristics of multistage tower, McCabe Thiele method, Ponchon Savarit method, Reflux, maximum, min. and optimum reflux, Use of open steam. Tray efficiency, Determination of height and column diameter, Multistage batch distillation. Principles of azeotropic and extractive distillation, Introduction to multicomponent distillation system.	8	CO2
3	**Liquid-Liquid Extraction**	Ternary liquid equilibria. Triangular graphical representation concept of theoretical or ideal stage. Equipment used for single stage and multistage continuous operation. Analytical and graphical solution of single and multistage operation Super critical fluid extraction.	8	CO3
4	**Solid/Liquid Extraction**	Leaching, Solid liquid equilibrium, equipment used in solid-liquid extraction, Single and multistage cross current contact and counter operations. Concept of an ideal stage, Overall stage efficiency, determination of number of stages.	8	CO4
5	**Adsorption**	Description of adsorption processes and their application, Types of adsorption, nature of adsorbents adsorption equilibria and adsorption hysterises, Stage wise and continuous contact adsorption operations, Determination of number of stages, Equipments. Ion Exchange Equilibrium relationship, Principle of ion-exchange, techniques and applications, Principles and application of dialysis, osmosis reverse osmosis, thermal diffusion, sweep diffusion.	8	CO5

Reference Books:

1. Treybal, R "Mass Transfer Operations", 3rd ed. New York: McGraw-Hill.
2. Sherwood T.K., Pigford R.L. and Wilke P. "Mass Transfer" McGraw Hill
3. Geankoplis, C.J., "Transport Processes and Unit Operations", 3rd ed. Prentice Hall.

e-Learning Source:

	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		1	2	1	1			3	3	2	1
CO2	3	2	1	2		1	2	1	1			3	3	2	1
CO3	3	2	1	1		1	2	1	1			3	2	2	1
CO4	3	2	1	1		1	2	1	1			3	3	2	1
CO5	3	2	1	1		1	2	1	1			3	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: 2020-21							
Course Code	BE315	**Title of the Course**	Genetics	**L**	**T**	**P**	**C**
Year	3rd	**Semester**	6th	**2**	**1**	**0**	**3**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To understand the basics of genetic inheritance and Mendelian laws of inheritance. To learn the modern cytogenetics and molecular mapping techniques for eukaryotic chromosomes. To know the mechanism involved in chromosome segregation, different genetic disorders and use of statistics in advanced genetics.						

Course Outcomes	
CO1	To understand the basics of genetic inheritance and Mendelian laws of inheritance, Extra chromosomal inheritance like inheritance of mitochondrial and chloroplast genes, maternal inheritance.
CO2	To learn the modern cytogenetics and molecular mapping techniques for eukaryotic chromosomes like Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids.
CO3	To know the mechanism involved in chromosome segregation, different genetic disorders and understanding of Euphenics, Eugenics and Genetic counseling.
CO4	Students will learn the use of statistics in advanced genetics and in Population genetics.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Mendelian principles, Extra-Chromosomal Inheritance**	Chromosome morphology, chemical composition structure and function. Mendelian principles: Dominance, segregation, independent assortment, deviation from Mendelian inheritance. Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, Extra chromosomal inheritance: Inheritance of mitochondrial and chloroplast genes, maternal inheritance.	8	CO1
2	**Gene Mapping Methods**	Linkage and crossing over, sex linkage, sex limited and sex influenced characters; Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids.	8	CO2
3	**Cytogenetics**	Chromosome banding, Chromosome aberration, genetic studies: genetic diseases, blood group, disputed parentage, animal and crop improvement, Euphenics, Eugenics and Genetic counseling.	8	CO3
4	**Use of Statistics in Genetics**	Pedigree analysis, Karyotypes, Population genetics: Gene frequency, genotype frequency, gene pool, Hardy-Wienberg law and equllibrium, t-test; analysis off variance; $\chi 2$ test	8	CO4

Reference Books:

1. Gardner, M. J. Simmons, D. P. Snustad, Principles of Genetics, John Wiley & Sons, (8th Edition).
2. Tom Strachan, T. Strachan, Andrew Read, Andrew P. Read "Human Molecular Genetics" William S. Klug Michael R. Cummings "Concepts of Genetics (7th Edition)".
3. B.D.Singh, Genetics, Kalyani Publications (4th Edition).
4. P.S.Verma and V.K.Agarwal, Cell Biology, Molecular Biology, Genetics, Evolution and Ecology, S.Chand Publications (4th Edition).

e-Learning Source:

https://drive.google.com/file/d/1MqwWCB_OZjWiaq_u3_nUaeRZo-1ckN0b/view?usp=sharing

	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	2	2	1	1		1	2	1	1			3	3	2	1
CO2	2	2	1	1		1	2	1	1			3	3	2	1
CO3	2	2	1	1		1	2	1	1			3	3	2	1
CO4	2	2	1	1		1	2	1	1			3	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: 2020-21							
Course Code	BE 316	**Title of the Course**	Bioinformatics Lab	**L**	**T**	**P**	**C**
Year	III	**Semester**	VI	**0**	**0**	**4**	**2**
Pre-Requisite	BE 210	**Co-requisite**	BE 311				
Course Objectives	To provide students with a practical and hands-on experience with common bioinformatics tools and databases. Students will be trained in the basic theory and application of programs used for database searching, protein and nucleic acid sequence analysis, prediction of protein function, and building phylogenetic trees. Through practical exercises, the course aims to give students basic competences in the use of computational tools. The course emphasizes the learning of *in silico* tools in the context of the student's acquaintance with biological macromolecular sequences and structures.						

Course Outcomes	
CO1	Able to carry out the pairwise similarity studies between two biological sequences.
CO2	Predict the coding areas among nucleotide sequences.
CO3	Understand and analyse the important areas in protein sequences
CO4	Understand the prediction study and applications of secondary structure of proteins
CO5	Able to work on basic bioinformatics tools in analysis of nucleotide and protein sequences..

Unit No.	**Title of the Experiment**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Sequence alignment**	Creation of an optimal global alignment of protein and nucleotide sequences	2	1
2	**Sequence alignment - II**	Calculation of local alignment of protein and nucleotide sequences.	2	1
3	**Gene prediction**	Identification of complete gene structures in genomic DNA.	2	2
4	**ORF prediction**	Finding Open Reading Frames (ORFs) of a given sequence.	2	2
5	**Domain identification**	Search for conserved domains within a protein or coding nucleotide sequence.	2	3
6	**Secondary structure prediction**	Secondary structure prediction for amino acid sequences of a given protein.	2	4
7	**Translation of nucleic acid sequences**	Translation of nucleic acid sequences to the corresponding peptide sequences.	2	5
8	**Display of ORFs**	Display of DNA sequences with 6-frame translation and ORFs	2	5
9	**Back-translation of protein sequences**	Back-translation of protein sequences to nucleotide sequences	2	5
10	**Back-translation of protein sequences-II**	Back-translation of protein sequences to ambiguous nucleotide sequences.	2	5
11	**Creation of characteristic plots of amino acids**	Creation of various plots displaying different amino acid properties, such as hydropathy or charged residues, and their position in the sequence.	2	5
12	**Identification of CpG islands**	Identification of CpG islands in given nucleotide sequence (s).	2	5
13	**Isochores plotting**	Plotting of isochores in given DNA sequences.	2	5
14	**Format conversion of biosequences**	Reformatting of protein and nucleic acid sequences used in various biological databases.	2	5
15	**PDB structure searching**	Retrieval of biological macromolecular structures**.**	2	5

Reference Books:

Bioinformatics: A Practical Approach; Chapman & Hall/CRC Mathematical and Computational Biology; 2007; ISBN 9781584888109.

Practical Bioinformatics; Garland Science; 2012; ISBN 9780815344568

e-Learning Source:

European Molecular Biology Open Software Suite (EMBOSS) http://www.ebi.ac.uk/Tools/emboss/

Bioanalytical Techniques and Bioinformatics by Dr. Vishal Trivedi and Dr. Nitin Chaudhary http://nptel.ac.in/courses/102103044/

	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	1	2	2	1	3	1	2	2	2	2	3	2	2	1	3
CO2	3	2	1	1	3	2	1	1	1	2	1	1	1	1	3
CO3	3	2	1	2	2	1	1	1	2	2	1	2	2	2	2
CO4	3	1	1	2	2	2	2	1	2	2	1	2	2	1	1
CO5	3	1	2	1	2	1	1	2	2	2	2	2	3	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:							
Course Code	**BE 317**	**Title of the Course**	**Plant Tissue Culture & Genetics Lab**	**L**	**T**	**P**	**C**
Year	**III**	**Semester**	VI	3	1	0	4
Pre-Requisite	None	**Co-requisite**	Plant Biotechnology				
Course Objectives	To acquaint the students of different techniques of plant tissue culture and genetics.						

Course Outcomes	
CO1	Students are acquainted with practical knowledge and concept of sterilization techniques and media preparation for plant tissue culture.
CO2	Students will be able to determine the factors influencing plant cell differentiation and thereby execute proper techniques/ procedures for the maintenance of sterile condition and proper plant growth.
CO3	Students are equipped in handling of classical and modern plant biotechnology processes.
CO4	Acquaintance with the techniques of isolation of chromosome and karyotyping.
CO5	They are able to learn different stages of cell division.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Sterilization of media and explant**	1. Preparation and sterilization of Plant Tissue Culture media. 2. Surface sterilization of the explants	8	CO1
2	**In vitro Propagation**	1. In vitro germination of seeds for the initiation of culture 2. Initiation and proliferation of multiple shoots	8	CO2
3	**Callus and Suspension Culture**	1. Initiation and maintenance of callus culture 2. Initiation and maintenance of suspension culture.	8	CO3
4	**Gene Isolation Techniques**	1. Isolate polytene chromosomes from salivary gland of chironomid larva Chironomus sp.) or Drosophila melanogaster. 2. Prepare karyotype of plant (e.g. onion) and animal (human blood)	8	CO4
5	**Cell Division**	1. Mitotic studies in onion root tip. 2. Meiotic studies in flower bud	8	CO5

Reference Books:

1. Plant Propagation by Tissue Culture, E.F. George, M.A. Hall, G.D. Klerk, Edition 2008, Springer Publisher.
2. Plant Tissue Culture, V. Sharma, A. Alam, Edition 2015, I.K. International Publishing House.
3. Plant Tissue Culture: Techniques and Experiment; R.H. Smith, Edition 2012; Academy Press.

e-Learning Source:

https://www.youtube.com/watch?v=HHYDmfj4ojk

	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	1	2	2	3	3	1		2	2	2	2
CO2	3	3	3	2	3	3	2	2	2	1		2	3	3	2
CO3	3	3	3	2	3	3	2	2	3	1		2	3	3	1
CO4	2	3	2	2	3	2			3	1		2	3	3	1
CO5	2	2	2	2	3	2			3	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: 2020-21							
Course Code	BE318	**Title of the Course**	Plant Genomics	**L**	**T**	**P**	**C**
Year	III	**Semester**	VI	**2**	**1**	**0**	**3**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To make the students aware of the plant genomes, their sequencing and analysis. The students will also acquire knowledge about the plant proteomics and data bases.						

Course Outcomes	
CO1	The students will learn about genome structures in plants and their sequencing.
CO2	The students will learn about the methods of genome mapping.
CO3	The students will be able to analyse plant proteomics and its potential application in plant improvement.
CO4	The students will gain knowledge about the plant bioinformatics which would be helpful in future bioinformatics studies. The students will be able to identify the genomic and proteomic approaches and their role in plant function, and the use of genomics in producing better crop cultivars.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Genome Structure	Genetic architecture of plant genomes in nucleus, mitochondria and chloroplast. Whole genome sequencing- methods and perspectives. Arabidopsis and rice as a model genome.	8	CO1
2	Genome analysis	Importance of mapping-genetic and physical maps. Breeding requirements for maps. Methods of molecular mapping, Map based cloning, T-DNA and transposon tagging, TILLING, Differential display, Microarray in functional genomics.	8	CO2
3	Proteomics	Proteomic data bases, proteins as drugs, Protein chips-interactions and detection techniques. Two dimensional PAGE for proteasome analysis. Proteomics as a tool in plant improvement.	8	CO3
4	Plant Bioinformatics	Introduction to Data Mining, Sequence Comparison and Alignment Techniques, Primer design. Databases for functional information and Biological pathway resources and Plant Promoter Database.	8	CO4

Reference Books:

1. Brown, TA. Genomes 2, Wiley-Liss, 2006.
2. Durbin, R, Eddy, SR, Krogh, A and Mitchison, G. Biological Sequence Analysis, Probabilistic Models of Proteins and Nucleic Acids, Cambridge University Press, 2000.
3. Edwards, D. Plant Bioinformatics: Methods and Protocols (Methods in Molecular Biology), Humana Press, 2010.
4. Hartl, DL and Jones, EW. Genetics: Principles and Analysis (4th Ed), Jones and Bartlett Publishers, Inc., 1998.
5. Lankenau, D-H and Volff, J-N. Transposons and the Dynamic Genome, Springer, Dordrecht, 2009.
6. Meksem, K and Kahl, G. The Handbook of Plant Genome Mapping, Wiley-VCH, Weinheim, 2005.
7. Twyman, RM and Primrose, SB. Principle of Genome Analysis, Blackwell Publisher, 2003.

e-Learning Source:

https://drive.google.com/file/d/1FCycAsHpBx42KNs2UhELf0NZEhPBbhGp/view?usp=sharing

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	1	2	1	2	2				3	3	2	
CO2	1	2	3	2	2	3	2	2				3	3	2	
CO3	3	2	3	3	3	3	3	3				3	3	3	2
CO4	3	2	3	3	3	3	3	2				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	BE 319	**Title of the Course**	Medical Biotechnology	**L**	**T**	**P**	**C**
Year	3rd	**Semester**	6th	**2**	**1**	**0**	**3**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To acquaint the students about the basics and advanced applications of biotechnology in the field of medical sciences.						

Course Outcomes	
CO1	Students will learn about gene therapy, hormone therapy, replacement therapy as well as about blood and blood preservation techniques
CO2	To give knowledge about different molecular diagnostic techniques
CO3	To understand different biomedical devices used in health care
CO4	Students will learn about the nature of pharmaceutical products and their preservations in pharmaceutical industries

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction to Medical Biotechnology**	Cell renewal by stem cells, stem cell therapy and its applications; genesis, modulation and regeneration of skeletal muscle, marrow transplantation. Basics of gene therapy, replacement therapy, hormone therapy. Hemopheresis procedures, Hematopoietic stem cell disorders: classification and manifestations; Immunological principles, preservation and clinical use of blood and blood components.	8	CO1
2	**Clinical diagnosis**	Techniques in clinical and laboratory diagnosis: hematology, biochemistry, microbiology and serology. Molecular diagnostic techniques.	8	CO2
3	**Advanced Techniques**	Principles, working and applications of Electrical Impedence Cephalography; Biotelemetry; CT scan, Magnetic Resonance Imaging assisting the heart and kidney; Electrocardiogram; Ultrasonography, X-Ray.	8	CO3
4	**Pharmaceutical Products**	Types of spoilage of pharmaceutical products: factors responsible, assessment of spoilage, means of preservation, evaluation of microbial stability of formulations.	8	CO4

Reference Books:

1. Chaechter M. Medoff G. and Eisenstein BC. (1993) Mechanism of Microbial Diseases 2nd edition. Williams and Wilkins, Baltimore

2. Collee, JG. Duguid JP, Fraser AG, Marimon BP. (1989) Mackie and Mc Cartney Practical Medical Microbiology, 13th Edition. CIHUrchill Livingstone.

3. David Greenwood, Richard CD, Slack, John Forrest Peutherer. (1992) Medical Microbiology. 14th edition. ELBS with CIHUrchill Livingstone.

e-Learning Source:

	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	1	1	1	2	2	2	1	2	1	1	2	2	2	3	3
CO2	1	1	1	1	3	1	1	2	1	1	1	1	2	2	3
CO3	2	2	1	2	3	1	1	1	1	1	2	1	3	3	3
CO4	1	2	3	2	2	1	3	2	2	1	2	3	3	3	2
CO5	1	1	1	2	2	2	1	2	1	1	2	2	2	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:							
Course Code	**BE 320**	**Title of the Course**	**Downstream Processing**	**L**	**T**	**P**	**C**
Year	**III**	**Semester**	VI	2	1	0	3
Pre-Requisite	Biophysical Techniques	**Co-requisite**	None				
Course Objectives	The students will learn the basic techniques of product purification and polishing.						

Course Outcomes	
CO1	The students will acquaint with basic principle, procedure and applications of centrifugation.
CO2	Students will become familiar with the principle, procedure and applications of various electrophoresis and chromatography techniques. This will enable the students to implement the use of these techniques in biological research and in discovering new products/compounds.
CO3	The students will be acquainted with basic instrumentation, principle and procedure of various sophisticated spectroscopy and microscopy instruments.
CO4	The students will get the knowledge of Radiotracer Technology and their practical implications.
CO5	Students will become familiar with the principle, procedure and applications of various analytical techniques required for environmental monitoring.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction of DSP**	Properties of Biomolecules, Characteristics of fermentation broth. Cell disruption methods for intracellular products: Physical, chemical and mechanical methods; Removal of in soluble components: Biomass and particulate debris separation techniques – flocculation, sedimentation, centrifugation and filtration methods. Membrane based separations: Micro and ultrafiltration, theory, design and configuration of membrane separation equipment and their applications.	8	CO1
2	**Basic Techniques**	Adsorption: Principles and isotherms; Extraction: Basics of Batch and continuous,aqueous two-phase extraction, supercritical extraction; Precipitation:Methods of precipitation with salts, organic solvents and polymers.	8	CO2
3	**High Throughput Techniques**	Basic principles and designing of Chromatographic separation methods, Electrophoretic separation techniques.	8	CO3
4	**Product Polishing**	Crystallization: Principles, Nucleation, Crystal growth Kinetics, Batch crystallizers: Scale-up anddesign, Drying: Principles, Heat and mass transfer, Drying equipments:description, designing and operation of Vacuum shelf, rotary dryer, Freeze dryer, Spray dryer.Process economics: Capital and operatingcost analysis.	8	CO4

Reference Books:

1. Bio separation Science and Engineering; Roger G. Harrison, Paul Todd, Scott R. Rudge,
2. Demetri P. Petrides; Oxford University Press; Edition Year: 2003
3. Bioseparations; Belter PA and Cussler E, Wiley Publishers; Edition Year: 1985
4. Principles and Techniques of Biochemistry and Molecular Biology, Keith Wilson and John
5. Walker; Cambridge University Press; Edition Year: 2008.

e-Learning Source:

https://nptel.ac.in/courses/102106022

	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	3	3	3	3	2	2	1	1	1	1	1	1	1
CO2	3	3	3	3	3	3	2	2	2	1	2	1	2	2	2
CO3	3	3	3	3	3	2	2	1	2	1	3	2	3	3	3
CO4	3	3	3	3	3	2	3	1	3	1	3	2	3	3	3
CO5	3	3	3	3	3	3	3	2	3	3	3	2	3	3	3

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

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