Integral University, Lucknow

Effective from Session: 2020-21							
Course Code	**BE501**	**Title of the Course**	**Biochemistry**	**L**	**T**	**P**	**C**
Year	1st	**Semester**	1st	**2**	**1**	**0**	**3**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	This course is designed to introduce the organic structure of living systems mainly dealing with biomolecules like carbohydrates, proteins, lipids, enzymes and their metabolism. This course will lay the foundation for other advanced courses like physiology, cell biology, molecular biology and metabolic engineering.						

Course Outcomes	
CO1	The students will learn about the carbohydrate metabolism, and its regulation; understand how the body meets the carbohydrate requirements, and how the carbohydrate metabolism is essential for synthetic pathways of other biomolecules.
CO2	The students will learn about structure and metabolism of lipids, and proteins in body.
CO3	The students will understand about the mechanism and regulation of nucleotide synthesis and degradation.
CO4	The course will aid the students in understanding other courses such as cell and molecular biology, immunology. This course will also lay the foundation for other advanced courses like metabolic engineering and bioprocess engineering.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Carbohydrates**	Structure and properties of mono, di, oligo and polysaccharides; complex carbohydrates, TCA cycle, glycolysis, gluconeogenesis, pentose phosphate shunt. Respiratory chain, ATP cycle, energy rich compounds.	8	CO1
2	**Lipids**	Structure and properties of fatty acids, Glycerolipids, phospholipids, sphingolipids, Glycolipids, steroids. Biosynthesis and degradation of fatty acids and cholesterol.	8	CO2
3	**Proteins**	Structure and properties of amino acids, peptides, proteins and conjugated proteins. Urea cycle. Biosynthesis and degradation of amino acids and proteins.	8	CO3
4	**Nucleic Acids**	Structure and properties of purines, pyrimidines, nucleosides, nucleotides, polynucleotides. Ribonuclic acid and deoxyribonucleic acids, nucleoprotrein complexes. Biosynthesis and degradation of purines, pyrimidines and nucleic acids.	8	CO4

Reference Books:

1. Nelson & Cox, Lehninger's Principles of Biochemistry, 5th Edition
2. Harpers Biochemistry, McGraw Hill
3. Stryer, Biochemisrty, Freeman.
4. Donald Voet, J.G.Voet, Biochemistry, John Willey. Voet & Voet, "Biochemistry".

e-Learning Source:

https://drive.google.com/file/d/1t-tMP3OZ03KCQDR1dxDgfxa2mOd6ZkOh/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	3	3	2	3		1	1	1				3	1	2	2
CO2	3	3	2	3		1	1	1				3	2	2	2
CO3	3	3	2	3		1	1	1				3	2	2	2
CO4	3	3	2	3		1	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:							
Course Code	**BE 502**	**Title of the Course**	**Bioanalytical Techniques**	**L**	**T**	**P**	**C**
Year	**I**	**Semester**	I	3	1	0	4
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The paper will help students to acquaint with basic instrumentation, principle and procedure of various sophisticated instruments like HPLC, FACS, GLC and NMR etc. This will enable the students to implement the use of these techniques in biological research and in discovering new products/compounds.						

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	**Centrifugation**	Centrifugation: types of rotors; principlesand application of differential, zonal, density gradient and ultra-centrifugation.	8	CO1
2	**Electrophoresis and Chromatography**	Electrophoresis: principles and applications of moving boundary and zone electrophoresis including gel electrophoresis (PAGE, starch, agarose and Pulse Field gel Electrophoresis),isoelectric focusing, isotachophoresis; Chromatography: Adsorption, partition, ion-exchange, reverse phase, covalent, gel filtration, affinity, gas chromatography, HPLC and FPLC.	8	CO2
3	**Spectroscopy and Microscopy**	Basic Principles of Spectroscopy: UV-visible, atomic absorption, ESR, NMR, IR, mass and plasma emission spectroscopy. Microscopy: Simple, compound, phase contrast, electron (transmission, scanning) and confocal microscopy.	8	CO3
4	**Radiotracer Technology**	Radiotracer technology, use of radioactive isotopes in biological system; autoradiography, Geiger-Muller counter, Liquid scintillation counter; CD;ORD;X-ray crystallography; Biosensors; Flow cytometer; Freeze drying; Amino acid analyzer.	8	CO4
5	**Environmental Analytical Techniques**	Analysis of Biomass; measurement of dry weight and biomass composition; Measurement of BOD and COD in Waste-Waters; Gas Analysis for O_2 and CO_2; Flow injection analysis	8	CO5

Reference Books:

1. Wilson K, Walker J, Walker JM,"Principles and Techniques of Practical Biochemistry".
2. Sambrook J, Russell DW, Sambrook J, "Molecular Cloning: A Laboratory Manual".
3. Cantor CR, Schimme IPR, "*Biophysical Chemistry"*.
4. Lehninger A, *"Principles of Biochemistry*

e-Learning Source:

https://drive.google.com/drive/u/0/folders/181gGJZiE1hkxsIGZiHyUBhX3AYhFs4DG

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	2	3	2	2	1	1	1	1	2	3	2	3
CO2	3	3	3	2	3	2	2	1	1	1	1	2	3	3	3
CO3	3	3	3	2	3	2	2	1	1	1	1	2	3	3	2
CO4	3	3	3	3	3	2	2	1	1	1	1	2	3	3	2
CO5	3	3	3	3	3	2	2	2	1	1	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:							
Course Code	**BE503**	**Title of the Course**	**Microbial Genetics & Technology**	**L**	**T**	**P**	**C**
Year	I	**Semester**	I	**2**	**1**	**0**	**3**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The course is designed to understand the basics of microbial growth, reproduction, methods of genetic exchange. It will also focus on the media design, modes of operation of fermenter for large scale biomass and product formation and industrial applications of microbes.						

Course Outcomes	
CO1	Students are able to design media, sterilization procedure for the growth of micro-organisms for industrial applications
CO2	Large scale production of valuable microbial metabolites and abilty to decide the best culture system.
CO3	Students are capable of explaining process involved in genetic exchange in prokaryotes.
CO4	An ability to isolate, maintain, preserve and genetically modify microorganisms for various applications

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Microbial Nutrition and Growth**	Principle of microbial nutrition, formulation of culture media, selective media, factors influencing the choice of various carbon and nitrogen sources, vitamins, minerals, precursors & antifoam agents; Importance of pH; Starter culture; Principles of media and air sterilization; kinetics of thermal death of cells & spores, design of batch and continuous thermal sterilizer, sterilization of air, design of filter; Radiation, chemical and steam sterilization.	8	CO1
2	**Microbial growth kinetics under different culture systems**	Kinetics of microbial growth, substrate utilization and product formation: growth phases of a batch culture, synchronous culture, determination of kinetic parameters by batch, fed batch and continuous culture; Analysis of chemostat performance. Kinetics of growth & product formation by filamentous organisms; Role of maintenance and endogenous metabolism in substrate utilization & growth; structured models: Compartmental models; Gaden's and Deindoerfer's classifications	8	CO2
3	**Applied Microbial Genetics**	Horizontal gene transfer (Conjugation, transduction and transformation), Complementation, Molecular recombination, Mapping of bacterial genes; Genetic and physical maps; Replication of RNA tumor viruses	8	CO3
4	**Microbial Technology**	Isolation, maintenance and preservation of industrial strains. Strain improvement, screening and selection of industrially important microbes**.** Large scale production and commercial applications of enzymes: proteases and amylases ; solvents and antibiotics: acetic acid, ethanol, acetobutanol, penicillin and streptomycin	8	CO4

Reference Books:

1. Bailey J E and Ollis DF, "Biochemical Engineering fundamentals".
2. Stanbury PF, Whitaker A, "Principles of Fermentation Technology".
3. "Principles of Cell Energetics": BIOTOL series, Butterworth - Heinemann.
4. Moser A, "Bioprocess Technology - Kinetics & Reactors".
5. Schugerl K, "Biotechnology" Vol.4 Meaning Modeling and Control.
6. Atkinson B, Mavituna F, "Biochemical Engineering and Biotechnology Handbook".
7. Goodenough U, "Genetics".

e-Learning Source:

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

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

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

Integral University, Lucknow

Effective from Session: 2021-22							
Course Code	**BE504**	**Title of the Course**	**Cell and Molecular Biology**	**L**	**T**	**P**	**C**
Year	**I**	**Semester**	**I**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objective of the course is learning and understanding the fundamentals of molecular biology and cellular signalling. The application of the course focuses on fundamental concepts and their implications on discase processes.						

Course Outcomes	
CO1	Describe the general principles of gene organization and expression in both prokaryotic and eukaryotic organisms and replication of genome
CO2	Discuss the various levels of gene regulation and expression
CO3	Explain the basic pathways of protein function, folding and targeting
CO4	Relate properties of cancerous cells to mutational changes in gene function.
CO5	Relate different signal transduction pathways and cell cycle control with disease pathogenesis. Understanding of protein kinases as primary elements in signalling.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**DNA Replication**	Initiation, elongation and termination; Roles of DNA Polymerase I, II, III, DNA ligase, DNA gyrase, Topoisomerases, Primase, Helicase, HD protein; Okazaki fragments; RNA primers; Repair by DNA polymerase I and DNA ligase; Eukaryotic replication; Regulation of prokaryotic and eukaryotic replication; Fidelity of replication	8	CO1
2	**Transcription**	Prokaryotic and eukaryotic transcription: Initiation, elongation and termination; DNA - dependent RNA polymerase (RNA Pol in prokaryotes and RNA Pol I, II, III in eukaryotes): Physical properties, subunit structure; Sigma cycle; Promoter; Enhancer and other regulatory elements; Transcription factors; RNA - dependent DNA polymerase; Reverse transcription; Post- transcriptional / Cotranscriptional processing: Maturation of rRNA, mRNA, tRNA; 5' capping; RNA splicing; Alternative splicing; RNA editing; Poly A tail formation; Regulation of transcription in both prokaryotes and eukaryotes.	8	CO2
3	**Genetic code**	Evidence for a triplet code; Properties of the code sequential; Ubiquitous (almost); Degenerate; Wobble hypothesis, Nonsense codons; Sense codons; Translation: Activation of amino acids; Charging of tRNA; Adapter role of tRNA; Amino acyl tRNA synthetase; Initiation, elongation and termination of translation in prokaryotes and eukaryotes; A, P and E sites of ribosomes; Roles of initiation, elongation and release factors; Ribosome recycling; Post - translational processing; Protein targeting: targeting of secretory proteins - targeting to endoplasmic membrane, golgi complex, lysosomes and plasma membrane; Concept of operon: lac and trp operons.	8	CO3
4	**Mutation**	Spontaneous, induced; Chemical and physical mutagens; Non sense mutation; Missense mutation; Frame shift mutation; Suppressor mutation; Different methods of DNA repair and SOS response; Transposition.	8	CO4
5	**Cell Division**	Cell cycle and role of cyclin dependent kinases in its regulation; Cell - cell interaction; Apoptosis and factors governing apoptosis; Basics of signal transduction: G protein and phospholipids signaling, cyclic nucleotides, role of calcium in signaling, protein kinases as primary elements in signaling.	8	CO5

Reference Books:

1. Lewin, "Genes"
2. Freifelder DM, "Molecular Biology".
3. Brown TA, "Genomes"
4. Watson JD. "Molecular Biology ofthe Gene'
5. Twyman R M. "Advanced Molecular Biology"
6. Brown TA. "Gene cloning: An introduction"
7. Old & Primrose. "Principles of Gene Manipulation"
8. Primrose SB. "Molecular Biotechnology"
9. Cibelli J B. Robert P. Keith L. Michael C. West D.
10. Voet& Voct. "Biochemistry
11. Stryer L. "Biochemistry'

e-Learning Source:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6117848/

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	2	2	1						3	3	3	1
CO2	3	3	2	2	2	1						3	3	3	2
CO3	2	3	2	2	3	2						3	2	2	1
CO4	3	3	2	2	3	1						3	3	3	1
CO5	3	3	2	2	3	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: 2021-2022							
Course Code	**BE505**	**Title of the Course**	**Bioprocess Engineering**	**L**	**T**	**P**	**C**
Year	I	**Semester**	I	3	1	0	4
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	Students are made capable of designing protocols for industrial scale production of medicinally and commercially important metabolites. 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	Students will be capable of doing calculations in bioprocess engineering by a systematic approach with well-defined methods and rules
CO2	Students will be able to apply mass and energy balances to calculate the concentration of different gases in the fermenter off-gas, amount of reactant used, amount of oxygen etc.
CO3	Fluid Mechanics plays a very vital role in Mechanical, Civil and Biotech Engineering. The study will help the students in predicting the nature of fluid and to develop a concept for many real time problems which helps in the new developments
CO4	Study of thermodynamic properties of fluid and heat transfer operations will help the students to run the fermenter
CO5	Study the mass transfer operations involved in the bioreactor.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction to Bioprocess and Engineering calculations**	Role of process engineering principles in biotechnological industries, Current scenario of biotechnological industries, Dimensional analysis, Dimensionless numbers and their significance in Heat, Mass and Momentum transfer, Method/Process validation.	8	CO1
2	**Material and Energy Balances**	Steady state and unsteady state Material and Energy Balance calculations.	8	CO2
3	**Fluid mechanics**	Fluids vs solids, Fluid statics and applications including manometer; Mass and energy balances in fluid flow; Bernoullis equation, its corrections and applications including pump work; Newton's law of viscosity; Measurement of viscosity of fermentation broths; flow curves for Non- Newtonian fluids and examples from bioprocess fluids; Pressure drop due to skin friction; Significance of friction factor and Reynold's number; Boundary layer theory and form friction; Pressure drop due to form friction; Flow past immersed bodies and drag coefficients; Pressure drop in flow through packed beds; Fluidization and Pressure drop across fluidized beds; Flow machinery and control: overview of valves and pumps.	8	CO3
4	**Heat transfer**	Heat transfer requirements of microbial cultivations including correlations for the determination of heat transfer coefficients; Models of heat transfer and examples; Fourier's law of heat conduction and analogy with momentum transfer, heat transfer through a cylindrical pipe wall; Convection and concept of heat transfer coefficient, application of dimensional analysis to heat transfer from pipe to a flowing fluid; Thermal boundary layer and Prandtl number; Overall heat transfer coefficient; Correlations for heat transfer coefficients in natural and forced convection; Overview of heat exchangers and concept of LMTD.	8	CO4
5	**Mass transfer**	Diffusion and mass transfer: Fick's law of diffusion; Analogy with momentum and energy transport; Diffusivities of gases and liquids; Fundamentals of mass transfer: Theories of mass transfer, concept of mass transfer coefficient, correlation for mass transfer coefficients, Oxygen requirements of microbial culture: oxygen mass transfer fundamentals, oxygen transfer and oxygen demand, oxygen transfer by aeration and agitation, determination of oxygen transfer coefficient by various methods including sulfite oxidation, dynamic gassing out and oxygen balance methods, factors affecting oxygen transfer coefficients.	8	CO5

Reference Books:

McCabe WL, Smith JC, Harriot P, "Unit operations of Chemical Engineering", Mc Graw-Hill.

Cussler EL, "Diffusion" Cambridge University Press.

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

Edition, E. E. (2003). Transport Processes and Separation Process Principles. Christie John Geankoplis,, 932-939.

e-Learning Source:

https://nptel.ac.in/courses/103104043

https://onlinecourses.nptel.ac.in/noc21_ch07/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	PSO4	PSO5	PSO6	PSO6
CO1	3	3	3	3	2	1	2	1	0	0	0	2	3	3	2				
CO2	3	3	3	3	2	2	2	1	0	0	0	2	3	3	2				
CO3	3	3	3	3	2	2	2	1	0	0	0	2	3	3	2				
CO4	3	3	3	3	2	2	2	1	0	0	0	2	3	3	2				
CO5	3	3	3	3	2	2	2	1	0	0	0	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	**BE506**	**Title of te Course**	**Biochemistry & Microbiology Lab**	**L**	**T**	**P**	**C**
Year	**I**	**Semester**	I	**0**	**0**	**8**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The lab is designed to train the students in analytical techniques of Biochemistry. It also deals with microbial techniques of isolation, purification and maintenance of microbial cultures.						

Course Outcomes	
CO1	Understand the techniques of microbial cultures and the biochemical characterization of microbes.
CO2	Analyze of the biomolecules using separation and purification techniques.
CO3	Estimate the biomolecules by spectrophotometric method.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Maintenance and Identification**	Maintenance and identification of microorganisms.	4	CO1
2	**Biochemical characterization**	Biochemical characterization of microbes	4	CO1
3	**Analysis of pigments**	Analysis of various pigments in cyanobacteria	4	CO1
4	**Growth curve**	Standardization of growth curve of different microbes	4	CO1
5	**Electrophoresis**	Electrophoresis in Agarose and SDS gels	4	CO2
6	**Membrane separation**	Membrane separation of proteins	4	CO2
7	**Thin layer chromatography**	Extraction of phytochemicals and thin layer chromatography	4	CO2
8	**Estimation of carbohydrates**	Estimation of carbohydrates-glucose and starch	4	CO3
9	**Estimation of proteins**	Estimation of proteins and nucleic acid	4	CO3

Reference Books:

1. J. Jayaraman, Lab Manual in Biochemistry, Wiley Eastern Ltd.
2. Bergey's Journal of Determinative Biotechnology Edn.
3. Collins and Lyne, Microbiological Methods, Butterworths, Singapore, 5th Edn.
4. Plummer, An Introduction to Practical Chemistry, Tata-McGraw Hill, New Delhi, 3rd Edn.

e-Learning Source:

https://www.youtube.com/watch?v=Et1v8EQP10U

https://www.youtube.com/watch?v=S7NIkBy38To

	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	2	1	1	1	2	3	2	2	2
CO2	1	1	1	2	2	2	2	1	1	1	2	3	2	1	2
CO3	1	1	1	3	2	1	1	1	1	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: 2021-2022							
Course Code	**BE507**	**Title of the Course**	**Fermentation Technology**	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objectives of this course are to develop understanding of ideal and non-ideal bioreactors, introduce concepts of heterogeneous reaction system, develop understanding of strategies for scale-up of bioreactor, Built concepts of control and monitoring in bioreactors.						

Course Outcomes	
CO1	Analyze the performance of ideal bioreactors.
CO2	Understand the effect of catalyst porosity, size, and fluid properties on rate of reactions controlled by mass transfer.
CO3	Determine internal and overall effectiveness factors for zero and first order reactions.
CO4	Identify suitable process instrumentation for monitoring and control of bioreactors.
CO5	Scale-up bioreactors on the basis of rule of thumbs.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Analysis of Ideal Bioreactors**	The ideal batch reactor, Continuous Stirred Tank Reactor (CSTR), series of CSTRs, turbidostat, chemostat, fed batch, plug flow reactors.	8	CO1
2	**Heterogeneous Reaction Systems**	Zero order and First order kinetics of concentration profile with reference to spherical geometry and other shapes, Effectiveness factor, External and internal mass transfer, General comments on heterogeneous reactions in bioprocessing.	8	CO2
3	**Monitoring, Control and Modelling of Bioreactors**	Control of bioreactors, case studies; Solid state fermentation. Overview of methods for online and offline monitoring of bioreactors: bioprocess control methodologies; Analysis of alternate bioreactor configurations including cell-recycle, airlift, and immobilized-cell bioreactors.	8	CO3
4	**Fermentative Production of Metabolites**	Media for industrial fermentation; Large scale production of amylase, acetic acid, ethanol, penicillin, and L-Lysine.	8	CO4
5	**Scale-up of Bioreactor**	Various approaches to scale-up including regime analysis and scale-down; Scale-up methods by currently used rules-of-thumb viz. constant P/V, KLa etc.	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/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
CO1	3	3	3	3	3	2	2	2				2	3	3	2
CO2	3	3	3	3	2	2	2	1				1	3	3	2
CO3	3	3	3	3	2	1	2	1				1	3	3	3
CO4	3	3	3	3	3	2	2	2				2	3	3	3
CO5	3	3	3	3	2	2	2	2				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: 2022-23							
Course Code	**BE512**	**Title of the Course**	**Nanobiotechnology**	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	2	1	0	3
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	Use knowledge of nano science and mathematics to follow protocols, conduct science or engineering procedures, fabricate products, make conclusions about results, troubleshoot, discover and independently seek out innovations in the rapidly changing field of nano-technology. Compile and analyze data and draw conclusions at the nano level.						

Course Outcomes	
CO1	The students are equipped with interdisciplinary knowledge of physics, chemistry and biology in the field of nanotechnology at a single platform. The student will understand the concept of nanoscale and properties of nano materials.
CO2	The students will acquire the knowledge of synthesis and characterization of nanomaterials for its various applications in the field of biological sciences.
CO3	Develops 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.
CO4	Develops the ability to incorporate nanotechnology in the existing technology for developing different drug delivery systems like aerosol, inhalants, injectables etc.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Nanoscales**	What is meant by Nanoscale – Nanoscale Processes – Physical and Chemical Properties of Materials in the Nanoscales - Nanoscale Measurements.	8	CO1
2	**Synthesis, Properties and measurements of nanomaterials**	Synthesis of Nanomaterials by Physical and Chemicals Methods- Physical Methods: Ball Milling- Electrodeposition- Spray Pyrolysis- Flame Pyrolysis - DC/RF Magnetron Sputtering - Molecular Beam Epitaxy (MBE). 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). Optical Properties – Absorption and Fluroscence – Microscopy measurements – SEM –TEM - AFM and STM. Confocal and TIRF Imaging	8	CO2
3	**Nanobiotechnology**	Properties of DNA and motor proteins – Measurements of Conductivity of DNA nanowires and angular properties of motor – Protein Nanotechnology- Lipid Nanotechnology- Glyconanotechnology	8	CO3
4	**Bioconjugation of nanomaterials to biological molecules**	Reactive Groups on biomolecules (DNA & Proteins) - Conjugation to nanoparticles (ZnS-Fe_3O_4) - Uses of Bioconjugated Nanoparticles. Nano Drug Delivery: Various Drug Delivery Systems – Aerosol - Inhalants - Injectibles – Properties of Nanocarriers – Efficiency of the Systems.	8	CO4

Reference Books:

1. Nanobiotechnology: Concepts, Applications and Perspectives, Christof M. Niemeyer (Editor), Chad A. Mirkin (Editor) , Wiley-VCH; 1 edition , 2004.
2. Nanobiotechnology: BioInspired Devices and Materials of the Future by Oded Shoseyov and Ilan Levy, Humana Press; 1 edition 2007.
3. Nanobiotechnology Protocols (Methods in Molecular Biology) by Sandra J Rosenthal and David W. Wright , Humana Press; 1 edition , 2005.
4. David S Goodsell, "Bionanotechnology", John Wiley & Sons, 2004
5. Nanosystems: Molecular Machinery, Manufacturing and Computation, K E Drexler, Wiley, ISBN 0471575186.

e-Learning Source:

1. https://nptel.ac.in/courses/102107058
2. https://drive.google.com/file/d/1BXgG-J3LW5qDNGdMbe6iAaMoPHD3R4qf/view?usp=share_link

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

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

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

Integral University, Lucknow

Effective from Session: 2020-21							
Course Code	**BE509**	**Title of the Course**	**Genetic Enginering**	**L**	**T**	**P**	**C**
Year	**I**	**Semester**	II	**2**	**1**	**0**	**3**
Pre-Requisite	Molecular Biology	**Co-requisite**	NULL				
Course Objectives	The course is designed to make the students understand the concept and basic steps in gene cloning, to acquaint them with various vectors and enzymes used in recombinant DNA technology, transformation and screening techniques. They will also be acquainted with modern techniques such as PCR technology, Real-Time PCR, Site-directed mutagenesis, Antisense RNA technology and RNA interference.						

Course Outcomes	
CO1	Learn about different enzymes used in genetic engineering for DNA manipulations.
CO2	To study different vectors and their characteristics
CO3	Transformation methods and their use in Genetic Engineering, creation of different gene libraries.
CO4	Using genetic engineering for mutagenesis, gene silencing, and amplification of DNA, conceptualizes DNA finger printing.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Enzymes used in Genetic**	Enzymes used in recombinant DNA technology: Restriction endonucleases, ligases, DNA polymerases, Nucleases, Ligases, Alkaline phosphatase, Polynucleotide kinase, Reverse transcriptase, Terminal deoxynucleotidyl transferase	8	CO1
2	**Engineering 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	CO2
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	CO3
4	**PCR-based Techniques and Gene silencing**	Techniques in r-DNA Technology: DNA sequencing; PCR, Variants of PCR, Cloning of PCR product, RACE, Real-Time PCR; Site-directed mutagenesis; Antisense RNA technology; RNA interference; Cosuppression, Molecular markers: RFLP, RAPD, AFLP, EST. Selectable markers, Reporter genes, Preparation of probes, Colony hybridization, Southern hybridization, Northern hybridization, Dot blots, Western blotting, Public concerns related to recombinant DNA technology; Safety guidelines of rDNA research.	8	CO4

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
CO1	2	2	3	1	3	1	1	2	1	1	1	3	3	3	1
CO2	2	2	2	2	3	2	1	1	2	1	2	3	3	3	1
CO3	1	1	2	1	3	1	2	2	1	1	1	2	3	3	1
CO4	1	1	1	1	3	1	3	3	2	1	1	2	3	3	3

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

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

Integral University, Lucknow

Effective from Session: 2020-2021							
Course Code	**BE510**	**Title of the Course**	**ENZYME ENGINEERING**	**L**	**T**	**P**	**C**
Year	**I**	**Semester**	II	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To understand the importance of enzymes and apply the knowledge to improve the enzymes and enzymatic processes.						

Course Outcomes	
CO1	Gain knowledge about structure, properties of enzymes, enzyme types Understand the process of industrial enzyme production and applications in various sectors.
CO2	Analyse the mathematical derivations to understand enzyme reaction kinetics and types of inhibition.
CO3	Apply engineering principles in understanding immobilized enzyme reactions.
CO4	Evaluate and design different enzyme reactors and apply research-based knowledge to design solutions for large scale applications.
CO5	Understand the concept of enzymatic reactions in organic media and evaluate applied research about enzymes and present the search of recent studies about enzymes

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction**	Enzymes: Introduction, Allosteric enzymes, Ribozymes, Abzymes; Applications in industrial, medical, analytical, chemical, pharmaceutical and food sectors; Enzyme isolation and purification methods.	8	CO1
2	**Enzyme kinetics**	Enzyme kinetics of free enzymes: Michaelis-Menten kinetics, kinetics for reversible reactions; Effect of various types of inhibition, evaluation of kinetic parameters; Multi-substrate reactions and their kinetics.	8	CO2
3	**Immobilized Enzyme**	Immobilized enzymes: Methods of enzyme immobilization, factors affecting immobilized enzymes, kinetics of immobilized enzymes, internal and external mass transfer effects in immobilized-enzyme reactors, intra-particle diffusion, micro-environmental effects on enzyme kinetics, enzyme deactivation, operational stability and optimization, general design considerations for the immobilization process.	8	CO3
4	**Enzyme Reactors**	Design and Analysis of enzyme reactors: Types of Reactors (Modes of operation), Basic design of enzyme reactors under Ideal conditions (Batch and continuous mixed reactors, continuous packed bed reactor under plug flow regime), Effect of Diffusional restrictions on Enzyme reactor design and performance in heterogeneous systems. Parameters affecting the performance of enzyme reactors.	8	CO4
5	**Enzyme Improvement**	Enzyme reactions in organic media; Study cases of Enzymatic Processes: (any one enzyme/biocatalyst like Proteases, Acylases, Lipases, Oxidoreductases, Aldolases, Amylases etc. to mention a few (Recommended topics to be covered-Applications of the biocatalyst, sources and production of biocatalyst, structure and mechanism, improvement of the biocatalysis reaction)).	8	CO5

Reference Books:

1. Palmer, T., Bonner, P. L. (2007). Enzymes: Biochemistry, Biotechnology, Clinical Chemistry. United Kingdom: Elsevier Science.
2. Illanes, A. (2008). Enzyme Biocatalysis: Principles and Applications. Netherlands: Springer Netherlands.

e-Learning Source:

1. https://nptel.ac.in/courses/102103097

	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		1	1					3	3	3	2
CO2	3	3	1	3								2	3	3	2
CO3	3	3	3	3		2	2					2	3	3	2-
CO4	3	3	3	3	1	3	2					3	3	3	3
CO5	3	3	3	3	2	2	2	1	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: 2022-23							
Course Code	**BE508**	**Title of the Course**	**Downstream Processing**	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	2	1	0	3
Pre-Requisite		**Co-requisite**					
Course Objectives	To impart to the students the knowledge of various separation and purification techniques and enable them to design these processes.						

Course Outcomes	
CO1	The students will learn the different recovery process their principles and methodology, how to retrieve the desirable product in bioprocess industries.
CO2	The students will get proper knowledge about the purification of desirable product from crude with the help of different purification techniques and methods in industrial level.
CO3	The students will learn the new and recent techniques used for bioseperation with their principle and mode of operation.
CO4	The students will get proper knowledge about how to handle and treatment of wastes discarded by bio-industries, what are the techniques, reactors their mode of operation.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction to Bioprocess and Primary isolation methods**	Overview of a bioprocess including upstream and downstream processing; Intracellular and extracellular product recovery: cell disruption and extraction. Primary isolation methods including separation of particulate by filtration, centrifugation, settling, sedimentation, decanting, microfiltration and membrane-based method; Solvent extraction, sorption, precipitation, ultrafiltration and Reverse osmosis.	8	CO1
2	**Purification methods**	Fractional precipitation, electrophoresis, chromatography, adsorption, product polishing, crystallization, drying.	8	CO2
3	**New and Emerging techniques**	Pervaporation, Super liquid extraction, Foam based separation, Lyophilization, High Throughput Screening.	8	CO3
4	**Effluent Treatment**	Aerobic and anaerobic water treatment processes: activated sludge, trickling filter, fluidized expanded bed reactor, Upflow anaerobic sludge blanket reactor.	8	CO4

Reference Books:

1. Roger G. Harrison, Paul Todd, Scott R. Rudge, Demetri P. Petrides, Bioseparations Science and Engineering, Oxford University Press.
2. B.Shivshankar, Bioseparations: Priniples and Techniques, Eastern Economy Edition, PHI Learning Pvt. Ltd., Publishing House, New Delhi, 2012
3. Bioseparation & bioprocessing (2nd Ed.) 2-Volume set, Ed Subramanian Ganapathy, Wiley-VCH, (09-2007).
4. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, WileyInterscience Publication, 1988.
5. Separation and purification techniques in biotechnology, Fredreich Dechow, 1989

e-Learning Source:

https://drive.google.com/file/d/1aC-qEL_ldNFJh61WcrE0ajhMRSPC2y1K/view?usp=share_link

	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	2	2	1	2	1	1	1	1	1	3	2	2
CO2	3	2	2	2	2	1	2	1	1	1	1	1	3	2	2
CO3	1	2	3	2	2	2	1	1	1	1	1	1	2	2	2
CO4	3	2	3	3	2	3	3	2	1	1	1	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: 2022-23							
Course Code	**BE513**	**Title of the Course**	**Plant Cell Technology**	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	2	1	0	3
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objective of the course is to make students aware of the basic concepts of plant tissue culture. It deals with the initiation and maintenance of different types of cultures and genetic engineering techniques. The concepts of molecular markers and their applications are also being taught.						

Course Outcomes	
CO1	Give an account of the nutritional components of a plant tissue culture media. Discuss the concept of totipotency and regeneration of plants by micropropagation via organogenesis and somatic embryogenesis.
CO2	Write note on types and applications of different cultures: callus, suspension, meristem, protoplast, anther, pollen and ovule. Discuss in vitro production of secondary metabolites by plant cell cultures using different techniques.
CO3	Describe biological and physical methods of genetic transformation for the production of transgenic plants and discuss the social, moral and ethical considerations with respect to safety of genetic engineering.
CO4	Write about different types of molecular markers and their applications.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction to Plant tissue culture**	Totipotency; Regeneration of plants; Different types of culture media; Nutritional components of culture media; Regulation of cell differentiation; Types of culture: callus, suspension, organogenesis, somatic embryogenesis, micropropagation.	8	CO1
2	**Types of plant cell cultures**	Isolation, purification and culture of protoplasts; Protoplast fusion and somatic hybridization; Selection systems for somatic hybrids / cybrids; Production of haploid plants: anther, pollen culture and ovule culture; Induction of mutation; Somaclonal variation; Production of disease free plants (meristem culture).	8	CO2
3	**In vitro Production of secondary metabolites**	Production of secondary metabolites by plant cell cultures; batch and continuous cultures. Biotransformation using plant cell cultures; Bioreactor system and models for mass cultivation of plant cells, hairy root culture.	8	CO3
4	**Genetic transformation in plants and molecular markers**	Genetic transformation methods for production of transgenic plants: Microprojectile bombardment, microinjection and electroporation. Detailed mechanism of Agrobacterium mediated genetic transformation; Applications of transgenic plants; Reporter genes; Selectable markers. Genetic engineering-Safety, social, moral and ethical considerations. Molecular Markers: RFLP, RAPD, AFLP, microsatellites, SCAR (sequence characterized amplified regions) and SSCP (single strand conformational polymorphism).Molecular Markers: RFLP maps, RAPD maps, STS, microsatellites, SCAR (sequence characterized amplified regions), SSCP (single strand conformational polymorphism), AFLP, ESTs, QTL, map based cloning, molecular marker assisted selection.	8	CO4

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. Stafford A, Warren G, “Plant Cell and Tissue Culture (Biotechnology Series)”.

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

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

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

Integral University, Lucknow

Effective from Session:							
Course Code	**BE514**	**Title of the Course**	**Pharmaceutical biotechnology**	**L**	**T**	**P**	**C**
Year	**I**	**Semester**	**II**	**2**	**1**	**0**	**3**
Pre-Requisite	**None**	**Co-requisite**	**None**				
Course Objectives	To equip students with the know-how of various pharmaceutical products and processes, and also with the applications of biotechnology in the pharmaceutical sector.						

Course Outcomes	
CO1	Describe the general principles of drug development and enhance learning of economic and regulatory guidelines related to pharmaceutical biotechnology.
CO2	Discuss the various aspects of drug action, metabolism and pharmacokinetics.
CO3	Explain the rationale behind drug design and types of chemotherapeutics viz., chemotherapy for infectious diseases and cancer.
CO4	Discuss the importance of Biopharmaceuticals and drug interactions vis a vis safety and efficacy of the drug.
CO5	Understand the principles of drug manufacture and preparation of various formulations. Awareness about GMP guidelines and usage of Analytical methods and other tests used in drug manufacture and quality management of Drugs.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction**	Pharmaceutical industry & development of drugs; types of therapeutic agents and their uses; economics and regulatory aspects.	8	CO1
2	**Drug Action, Metabolism and Pharmacokinetics**	Mechanism of drug action; Physico-chemical principles of drug metabolism; radioactivity; pharmacokinetics.	8	CO2
3	**Chemotherapeutics**	Chemotherapy for bacterial, fungal, viral infections, drugs acting on protozoal infection, malarial infection and helminth parasites. Cancer chemotherapy, Drug interactions.	8	CO3
4	**Principles of Drug Manufacture; Biopharmaceuticals**	Compressed tablets; dry and wet granulation; slugging or direct compression; tablet presses; coating of tablets; capsule preparation; oral liquids — vegetable drugs — topical applications; preservation of drugs; analytical methods and other tests used in drug manufacture; packaging techniques; quality management; GMP. BIOPHARMACEUTICALS: Various categories of therapeutics like vitamins, laxatives, analgesics, contraceptives, hormones and biologicals.	8	CO4, CO5
5				

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

e-Learning Source:

1. https://iopscience.iop.org/book/mono/978-0-7503-1299-8
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3525971/

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

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

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

Integral University, Lucknow

Effective from Session: 2021-2022							
Course Code	**BE515**	**Title of the Course**	**Bioreactor Engineering**	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objective of the course is to develop the concepts of ideal and non- ideal bioreactor design, residence time distribution in ideal and non-ideal bioreactors.						

Course Outcomes	
CO1	Understand the design of equipment to maintain sterility in biochemical reactors.
CO2	Analyze reaction kinetics in ideal bioreactors
CO3	Understand the design of unconventional bioreactors.
CO4	Understand the concept of residence time distribution in ideal and non-ideal bioreactors.
CO5	Understand cost estimation process biochemical reactors

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction to reactor design**	General design information; Design considerations for maintaining sterility of process streams and process equipments; piping and instrumentation; materials of construction for bioprocess plants. Flow injection analysis for measurement of substrates, product and other metabolites.	8	CO1
2	**Analysis of Reactors**	Bioreactors for submerged liquid fermentation of microbial cells in: batch reactors - Calculation of batch time, Non-ideality; in semi-continuous reactors; in continuous reactors – PFTR, CSTR; and Combination of reactors.	8	CO2
3	**Design of unconventional Bioreactors**	Design and analysis of Packed Bed Bioreactor, Airlift Bioreactor, Hollow Fiber Bioreactor, Plant Cell Bioreactor, Mammalian Cell Bioreactor, and bioreactors for solid state fermentation.	8	CO3
4	**Introduction to Residence Time Distribution**	Residence Time Theory; Residence Time Models: Ideal Reactors and Reactor Combinations, Hydrodynamic Models; Drawbacks of Classical RTD measurements; Transient behavior in bioreactor. Capital Cost Estimating: Components of Capital Cost, Working Capital; Estimating Purchased Equipment Costs; Estimating Installed Costs.	8	CO4 and CO5

Reference Books:

Panda, Tapobrata. Bioreactors: Analysis and Design. Tata McGraw Hill, 2011.

Moser, Anton, Bioprocess Technology: Kinetics and Reactors. Springer Verlag, 1988.

Bailey J.E. & Ollis, D.F. Biochemical Engineering Fundamentals, 2nd ed., McGraw Hill, 1986.

Lee, James M. Biochemical Engineering, PHI, USA.

Atkinson, Handbook of Bioreactors, Blanch, H.W. Clark, D.S. Biochemical Engineering, Marcel Decker, 1999.

Max S. Peters and Klaus, D. Timmerhaus, Plant Design and Economics for Chemical Engineers, 4th Edition, McGraw Hill Book Co., 1991.

e-Learning Source:

https://onlinecourses.nptel.ac.in/noc22_bt19/preview

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
CO1	3	3	3	3	3	1	2	1				2	3	3	2
CO2	3	3	3	3	2	2	2	1				2	3	3	2
CO3	3	3	3	3	2	2	2	1				2	3	3	2
CO4	3	3	3	3	2	2	2	1				2	3	3	2
CO5	3	3	3	3	2	2	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:							
Course Code	**BE511**	**Title of the Course**	**Fermentation Technology and Genetic Engineering Lab**	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	0	0	6	3
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The lab is designed to train the students to use the microbial cells/ culture for fermentative production of valuable products at the lab scale as well as industrial scale and also use the molecular biology techniques for advanced genetic engineering practical.						

Course Outcomes	
CO1	Perform Immobilization of whole cells and enzymes.
CO2	Demonstrate the fermentative production of organic acid/ alcohol/ enzyme. Design experiment for scale-up of fermentation parameters.
CO3	Ability to isolate plasmid/ phage and plant/ animal (genomic) DNA, quantify and visualize DNA on gels, amplify DNA (using PCR). Demonstrate the use of various molecular markers to study biodiversity.
CO4	Prepare Competent cells and carry out experiments related to transformation, ligation and screening of transformants.
CO5	Demonstrate Blotting Techniques like Southern/ Northern/ Western Blot Techniques and apply them in various sectors of Biotechnology.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Cell Immobilization**	Immobilization (calcium alginate/ polyacrylamide/glutaraldehyde) of whole cells and enzymes.	3	CO1
2	**Bioproduction**	Organic acid/ alcohol/ enzyme production through fermentation, estimation of product, its separation and its purification	3	CO2
3	**Fermentor**	Design and scale-up of fermentation parameters	3	CO2
4	**DNA Isolation**	Isolation of plasmid/ phage and plant/ animal (genomic) DNA.	3	CO3
5	**Electrophoresis**	Agarose gel electrophoresis, visualization of DNA on gels and analysis of isolated DNA.	3	CO3
6	**DNA amplification**	Amplification of DNA (using PCR) and restriction digestion.	3	CO3
7	**RAPD**	RAPD to study biodiversity.	3	CO3
8	**Transformation**	Competent cell preparation, transformation, ligation and screening of transformants.	3	CO4
9	**DNA estimation**	Quantitative estimation, absorption spectra and Tm determination of DNA.	3	CO3
10	**Blotting techniques**	Blotting Techniques: Southern/ Northern/ Western Blot Techniques.	3	CO5

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

Skalak, R., & Chien, S. (Eds.). (1987). Handbook of Bioengineering (p. 85). New York: McGraw-Hill.

e-Learning Source:

https://www.vlab.co.in/

	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	1	3	1	0	1	1	1	3	1	1	3	3	2	3
CO2	2	2	3	2	3	2	1	1	3	1	1	3	3	2	3
CO3	3	1	3	1	3	1	1	1	3	1	1	2	3	2	3
CO4	3	3	3	1	3	1	1	1	3	1	1	2	3	2	3
CO5	3	3	3	1	2	1	1	1	3	1	1	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: 2020-21							
Course Code	**BE 516**	**Title of the Course**	**Applied Microbiology and Biotechnology**	**L**	**T**	**P**	**C**
Year	I	**Semester**	II	**2**	**1**	**0**	**0**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The course helps in recollecting some basic but very important concepts in microbiology and biotechnology with advanced knowledge of various recent developments at industrial level in microbiology and biotechnology.						

Course Outcomes	
CO1	The students will learn about the basics microbial diversity and its genetic system
CO2	The students will learn about the useful microbial products and its processing. By gaining the knowledge of microbial production and processing, students may get an idea to develop their own ventures and become entrepreneurs
CO3	The students will learn about the Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry.
CO4	The students will learn about the principle of fermentation technology and reactor design

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Types of microorganisms**	Structure and genetic system of viruses and bacteria, Actinomycetes, fungi, Cyanobacteria and algae, Criteria used in the classification of microorganisms: morphology, cytology, genetics, host specialization, serology.	8	CO1
2	**Modern trends in microbial production**	Modern trends in microbial production of bioplastics (PHB, PHA), bioinsectices (thuricide), biopolymer (dextran, alginate, Xanthan, pullulan), Biofertilizers (Nitrogen fixer/Phosphate Solubilizers/siderophore producers), Single Cell Protein, micro algae as – food – feed and colourant. Potential Application of Spirulina arthrospira as a nutritional and therapeutic supplement in health management.	8	CO2
3	**Pharmaceutical Microbiology**	Antibiotics and synthetic antimicrobial agents, Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis). Bacterial resistance to antibiotics. Microbial contamination and spoilage of pharmaceutical products, Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry.	8	CO3
4	**Industrial microbes and their products**	A brief idea about the products obtained from microbes, biology of industrial microorganisms such as Streptomyces, yeasts, *Spirulina*and*Penicillium*, Basic principle of fermentation technology, Overview of fermenter design, factors governing the chemical and biological aspects in a bioreactor, commercial production of penicillin, ethanol, vinegar, vitamin B12, Protease, citric acid and glutamic acid from microbial sources–production of commercially useful non-microbial products produced through recombinant microbes.	8	CO4

Reference Books:

1. Prescott, Harley and Klevin; Microbiology; 2 nded.
2. Microbiology,Peleczar, TMH Publication
3. Pirt SJ, "Principles of Microbe and Cell Cultivation
4. Murray Moo-Young, Comprehensive Biotechnology, Vol. 1& III.

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	2	2	1	1		1	2	1	1			3	3	2	1
CO2	2	2	1	2		1	2	1	1			3	3	2	1
CO3	2	2	1	1		1	2	1	1			3	2	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**