Syllabus for Multi-Disciplinary Minor (MDM) Degree

in

Biotechnology and Bioengineering

Under the National Education Policy (NEP 2020)

(2023-2024)

Offered by

DEPARTMENT OF BIOLOGICAL SCIENCES AND BIOTECHNOLOGY

INSTITUTE OF CHEMICAL TECHNOLOGY

(University Under Section-3 of UGC Act, 1956)

Elite Status and Center for Excellence

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A. Preamble

The recent and continuing advances in biotechnology are crafting disruptive innovations in enabling advance human development. In recent years, biotechnology has offered superior outcome for improved health care, enhanced food security, better supplies of potable water, cleaner environment, advanced industrial, agricultural processes for transforming raw materials and facilitating energy securities of the world. Successful capture of biotechnology potential will further provide significant opportunities for sustainable economic, environmental and societal growth.

Applications of biotechnology, engineering research, and manufacturing techniques is critical to the future of creating products and services that improve the quality of human life. In the coming years, biotechnological knowledge will be essential for advance medicines, renewable and advance raw materials, to develop innovative ways of improving food-fuel-feed security of the world, and in nutshell for the overall sustainability. Therefore, there is a need to foster and ignite young minds and create a community driven by knowledge, curiosity, innovation, design and scientific acumen.

In tune with the above-mentioned requirements, "The Minor degree Course in Biotechnology and Bioengineering" has been designed to encompass diverse domains of biotechnology and bioengineering from fundamental to advance stage. The course content will enable the students to gain deep insight into a range of biotechnological fields, such as Cell Biology, Microbial Technology, Genetic Engineering, Bioinformatics, Environmental Biotechnology, Marine Biotechnology, Industrial Biotechnology, Bioprocess Technology, Animal and Plant Biotechnology and more. The course will provide the opportunity to explore the wide spectrum of biotechnology and understand its role in sustainable development.

According to National Education policy guidelines, the course has been designed for a total of 14 credits as per the requirements of a minor degree. The course contains five theory and one practical course as mentioned below. The details of each course are given in later sections.

Sr No	Semester	Course Credits	Name of the course
1	III	2	Introduction to Biological Science
2	IV	2	Fundamental of Applied Biotechnology
3	V	4	Lab Techniques in Biotechnology
4	VI	2	Genetic Engineering and Bioinformatics
5	VII	2	Bioprocess Technology
6	VIII	2	Industrial Biotechnology

B. Structure of the MDM course

Subject Code	Semester	Subject	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
BBT1201	III	Introduction to Biological Science	2	2	0	0	20	30	50	100
BBT1202	IV	Fundamental of Applied Biotechnology	2	1	1	0	20	30	50	100
BBP1303	V	Lab Techniques in Biotechnology	4	8	0	0	50	-	50	100
BBT1304	VI	Genetic Engineering and Bioinformatics	2	1	1	0	20	30	50	100
BBT1405	VII	Bioprocess Technology	2	2	0	0	20	30	50	100
BBT1406	VIII	Industrial Biotechnology	2	1	1	0	20	30	50	100
		Total	14	16						600

C. Program Specific Outcomes

Programme Specific Outcomes (PSOs) for Biotechnology and Bioengineering (MDM)

PSO1	To develop Strong foundation of Biological Sciences which is directly connected to knowing different biological organisms, understanding biomolecules as well as cellular energetic to corroborate basic life processes on the planet earth and their applications for basic science and technological advancements
PSO2	To identify, review and analyse concepts and applications pertaining to biotechnology, microbiology, bioinformatics, fermentation, genetic engineering, bioprocessing and downstream processing methods.
PSO3	To develop a multi-disciplinary human workforce with the understanding of biotechnology as an independent and integration of scientific disciplines and technologies including; biochemistry, microbiology, molecular biology, immunology bioinformatics, recombinant DNA Technology, fermentation processes and bioprocess engineering
PSO4	To understand impact of Biotechnology for individual, society, industry, environment and sustainability
PSO5	To discern basic as well as emerging biotechnological knowledge to be able to correlate both and develop innovative thinking

D. Recommended batch size: Minimum **15**; Maximum **35**

E. Eligibility criteria:

a. CGPA of the first two semesters.
b. In case the results of the 2nd semester are not available, eligibility will be based on CGPA of the 1st Semester (50% weightage) and CET/JEE score (converted into percentile based on admitted students, 50% weightage).

F. Prerequisites: None

G. Pedagogy/Teaching method

a. Lecture/Discussions: These sessions will discuss the subject matters of the course.
b. Experiential Learning: The sessions will involve hands-on training.
c. Blended learning/Hybrid learning: The sessions will involve combined traditional and online learning in a flexible and engaging way.
d. Tutorials: Problem solving / case studies / relevant real-life applications / student presentations / home assignments / individual or group projects

H. List of Faculty members who will be engaged in teaching MDM course

Prof Samir Kulkarni (SK)	Dr Hitesh Pawar (HP)
Dr Ratnesh Jain (RJ)	Dr Mayur Ladole (ML)
Dr Gunjan Prakash (GP)	Dr Chandrakant Holkar (CH)
Dr Manju Sharma (MS)	Dr Anand Jadhav (AJ)
Dr Shamlan Reshamwala (SR)	Dr Rohit Sathe (RS)

I. Faculty members associated with each subject (Tentative)

Sr No	Semester	Course Credits	Name of the course	Faculty
1	III	2	Introduction to Biological Science	SK&AJ
2	IV	2	Fundamental of Applied Biotechnology	GP&MS
3	V	4	Lab Techniques in Biotechnology	ML&CH
4	VI	2	Genetic Engineering and Bioinformatics	SR&RS
5	VII	2	Bioprocess Technology	RJ&HP
6	VIII	2	Industrial Biotechnology	GP&SK

J. Evaluation

- **Theory Courses (BBT1201, BBT 1202, BBT 1304, BBT1405, BBT1406)**
  Continuous Assessment Test (CAT): Total 20
  Flexible (Instructor specific); including but not limiting to Assignments, Quiz, problem statement, written test, presentation, short project, end of the class problem.
  Mid semester: Total 30 Marks (Theory paper)
  End semester: Total 50 Marks (Theory paper)

- **Practical Courses (BBP1303)**
  Continuous Assessment: 50 Marks (Theory + Lab)
  Performing given experiments as per the instructions, submission of lab journal on time, viva voce, group/personal discussions, and quizzes can be part of continuous assessment. The course instructor will discuss the composition of marks for these at the beginning of the course.

- **End Semester:** 50 Marks (Lab experiment performance followed by viva-voce examination).

K. Detailed syllabus

	Course Code: BBT1201	Course Title: Introduction to Biological Sciences	Credits = 2		
			L	T	P
	Semester: III	Total contact hours: 30	2	0	0

	List of Courses where this course will be Prerequisite	
	1. Fundamental and Applied Biotechnology (BBT1202) 2. Genetic Engineering and Bioinformatics (BBT1304) 3. Bioprocess Technology (BBT1405) 4. Industrial Biotechnology (BBT1406) 5. Lab Techniques in Biotechnology (BBP1303)	
	Course Contents (Topics and subtopics)	**Reqd. hours**
1	Introduction to cells • Eukaryotes and prokaryotes, Cell architecture and organelles • Asexual and sexual modes of reproduction example Binary fission, budding, fragmentation, formation of spores, bacterial conjugation, mitosis, and meiosis.	6
2	Chemistry of life • Carbohydrates: Function, Monosaccharides and Disaccharides, Polysaccharides; Glycoproteins, and Glycolipids; Proteins: Amino acids, Peptides and Proteins, Structure of amino acids and proteins. • Nucleic acids: Function, Structure, chemistry, DNA, RNA and Chromosomes • Lipids: Structure, Function, Structural Lipids in Membranes, Lipids as Signals, Cofactors	6
3	Enzymology • Nomenclature & classification of Enzymes • Enzyme structure and properties. • Mechanism of enzyme action, factors affecting enzyme action. • Activation energy; active site; activators and inhibitors.	6
4	Cellular Energetics • Energetics and Metabolism • Energy Production: aerobic and anaerobic respiration, and photosynthesis. • Free energy and biological reactions, Redox potentials in biological systems	6
5	Introduction to Metabolic Pathways and their regulation	3
6	Transition of Biological Sciences to Biotechnology	3
	List of Textbooks	
1	Prescott's Microbiology; Authors: Joanne M. Willey, Kathleen M. Sandman (Author), Dorothy H. Wood (Author), Lansing M. Prescott; Eleventh edition.	
2	Nelson, D.L. and Cox, M.M. (2017) Lehninger Principles of Biochemistry. 7th Edition, W.H. Freeman, New York, 1328.	
	List of Additional Reading Material / Reference Books	
	As suggested by the concerned faculty	

	Course Outcomes (students will be able to…)	
CO1	Learn structural and functional aspects of cell; the basic unit of life, and its different organelles and working of a cell as a factory. Classify different microorganism as well as differentiate based on a prokaryotic and eukaryotic cell	K1
CO2	Understand structure and functional aspects of macromolecules of cells	K2
CO3	Understand the importance of enzymes in the biological systems	K2
CO4	Understand different types of cell metabolism, their regulation and correlate with cellular energetics	K2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	2
CO2	3	2	2	2	2
CO3	3	2	2	2	2
CO4	3	2	2	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0− No Contribution

	Course Code: BTB1202	**Course Title: Fundamentals of Applied Biotechnology**	**Credits = 2**		
			L	**T**	**P**
	Semester: IV	**Total contact hours: 30**	**1**	**1**	**0**
	Prerequisite courses				
	1. Introduction to Biological Sciences (BBT1201)				
	List of Courses where this course will be prerequisite				
	1. Genetic Engineering and Bioinformatics(BBT1304) 2. Bioprocess Technology (BBT1405) 3. Industrial Biotechnology (BBT1406) 4. Lab Techniques in Biotechnology(BBP1303)				
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	Introduction to Biotechnology, The colours of Biotechnology, Applications of Biotechnology		3		
2	Microbiology • Types and forms of microbes, • Selective methods for isolation of pure cultures, • Growth, maintenance, and preservation of pure culture, • Quantitative measurement of growth, • Microscopy as a tool to study microbes. • Application of microbes in biotechnology		6		
3	Introduction to Animal Cell culture • History, development of cell lines, Origin of animal cell line and maintenance. Primary culture, Secondary culture, Animal culture media and growth conditions. • Biotechnological application of animal cells		3		
4	Introduction to Agriculture Biotechnology • Increased production of food to meet the demand of an increasing population, sustainable means of agriculture, Biofertilizers, Biopesticides, Secondary agriculture. • Plant Cell & Tissue culture technology and its application. • Genetic modification of Plants		4		
5	Marine Biotechnology • Diversity of marine microbes and their nutrition • Applications of Marine Biotechnology		3		
6	Environmental Biotechnology • Biodegradation, bioremediation, Bioleaching, nitrification, denitrification, enhanced phosphorus removal, Anaerobic digestion • Thermophiles, Psychrophiles, Halophiles, Acidophiles, Actinomycetes, and their applications in modern biotechnology • Environmental Biotechnology and sustainability		4		

7	Pharmaceutical Biotechnology • Introduction and application of Pharmaceutical Biotechnology in the healthcare and diagnostics • Basic principle of recombinant DNA technology and application in the production of vaccines, hormones, interferon, monoclonal antibodies etc	4
List of Textbooks		
1	Prescott's microbiology; Authors: Joanne M. Willey, Kathleen M. Sandman (Author), Dorothy H. Wood (Author), Lansing M. Prescott; Edition: Eleventh edition.	
2	Kuby, Janis Title(s): Kuby immunology/ Judith A. Owen, Jenni Punt, Sharon A. Stranford; with contributions by Patricia P. Jones. Edition: 7th ed.	
3	Plant Tissue Culture: Theory and Practice. By S.S. Bhojwani, M.K. Razdan.	
List of Additional Reading Material / Reference Books		
	As suggested by the concerned faculty	
Course Outcomes (students will be able to…..)		
CO1	Comprehend different types of biotechnology and appreciate the importance and scope of biotechnology in everyday life.	K2
CO2	Acquire basic and applied understanding of microbiology, animal culture technology, Agriculture Biotechnology, Environmental Biotechnology, Marine Biotechnology, Immunology	K2
CO3	Analyze impact of biotechnology on environmental sustainability	K3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	2
CO2	3	3	2	3	2
CO3	3	2	2	3	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0– No Contribution

	Course Code: BBP1303	**Course Title: Lab Techniques in Biotechnology**	**Credits = 4**		
			L	**T**	**P**
	Semester: V	**Total contact hours: 120**	**0**	**0**	**4**
Prerequisite course					
1. Introduction to Biological Sciences(BBT1201) 2. Fundamentals of Applied Biotechnology(BBT1202)					
List of courses where this course will be prerequisite					
	1. Genetic Engineering and Bioinformatics(BBT1304) 2. Bioprocess Technology(BBT1405) 3. Industrial Biotechnology(BBT1406)				
	Course Contents (Topics and subtopics)		**Reqd. hours**		
1	Basic Microbiology • Microbial Isolation and quantitative measurements • Microscopy, Sample preparation, morphology-based identification, • Dilution & Plating/spectrophotometric cell growth estimation • Assays: VitB12 and Antibiotic resistance assays		24		
2	Microbial Growth Kinetics • Microbial growth curve preparation, • Optical density measurement,		30		

	• Production of Bakers yeast by fermentation, • Growth and substrate analysis and correlation	
3	Biochemistry and Molecular Biology • To prepare Tris-HCl Buffer with a specific pH (eg. pH 8.8) • quantitative estimation of carbohydrates • Total Lipid extraction and gravimetric analysis • Separation of Amino acids by Paper Chromatography and Thin Layer Chromatography • determination of the unknown concentration of protein concentration by plotting a standard curve of BSA using Bradford reagent • Ammonium sulphate precipitation and dialysis for a protein • Primer designing • Analysis of Protein purity and determination of molecular weight of pure protein by SDS PAGE and Coomassie Brilliant blue staining of proteins on SDS gel • Quantitative DNA estimation (Demo)	30
4	Enzymology • Isolation and assay of enzyme from natural source • Primary screening assay for extracellular enzymes • Cell Immobilization by entrapment method	16
5	Fermentation • Bioreactor study, dress up • Demonstration of Batch cultivation	20
List of Textbooks		
1	Prescott's Microbiology; Authors: Joanne M. Willey, Kathleen M. Sandman (Author), Dorothy H. Wood (Author), Lansing M. Prescott; Eleventh edition.	
2	Principles and Techniques of Biochemistry and Molecular Biology, Keith Wilson, John Walker; Cambridge University Press (2010)	
List of Additional Reading Material / Reference Books		
	As suggested by the concerned faculty	

Course Outcomes (students will be able to….)		
CO1	Develop basic understanding of microbes, their monitoring and quantification	K3
CO2	Perform the quantitative analysis of biomolecules, Enzyme Kinetics	K3
CO3	Perform and analyze quantitative estimation for biomolecules	K4
CO4	Know different bioreactor parts and their function	K2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	2
CO2	3	2	2	2	2
CO3	3	2	2	2	2
CO4	2	2	2	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0– No Contribution

Course Code: BBT1304	**Course Title: Genetic Engineering and Bioinformatics**	**Credits = 2**		
		L	**T**	**P**
Semester: VI	**Total contact hours: 30**	**1**	**1**	**0**

Prerequisite course

1. Introduction to Biological Sciences(BBT1201)

2. Fundamentals of Applied Biotechnology(BBT1202)		
List of Courses where this course will be Prerequisite		
1. Bioprocess Technology(BBT1405) 2. Industrial Biotechnology(BBT1406)		
Course Contents (Topics and subtopics)		**Required hours**
Genetic Engineering		
1	Coding of Genetic Information • DNA replication and transcription, Protein biosynthesis , Gene regulation and gene expression	3
2	Gene Cloning • Cloning vectors, Expression vectors, Prokaryotic host cells, Restriction endonucleases, Polymerase chain reaction	5
3	Transformation of Cells • Prokaryotes, Yeast, Plant cells, Animal cells	3
4	Genome Modification and Integration Strategies, including CRISPR	2
5	Synthetic Biology • Standardization of DNA parts, Assembly of standard parts	2
Bioinformatics		
6	Introduction to Bioinformatics • History, development of the field, interdisciplinary contribution to the field, important concepts in the field, current research scenario in bioinformatics, artificial intelligence, etc.	1
7	Databases • NCBI, PDB, DDBJ, PubMed, GenBank, EMBL, PubChem, BioMed Central, etc.	2
8	File Formats • FASTA, FASTQ, PDB, alignment formats (SAM, BAM, CRAM), Stockholm formats (VCF), GFF, GTF, JSON, PHYLIP, PIR, etc.	1
9	Nucleotide Sequence Alignment • Concept of sequence alignment, Global alignment, local alignment, pairwise alignment, multiple sequence alignment, different algorithms of sequence alignment, FASTA, BLAST, EMBL-EBI, CLUSTALW	1
10	Protein Sequence Alignment • Algorithms of alignment, Clustal Omega, UniProt, SIM, ExPASy	1
11	Three-dimensional Molecular Structures • Importance of visualizing molecules in 3D, programs for 3D visualization, creating and editing 3D structures, structural alignments, geometry optimization	2
12	Molecular Modeling • Protein structures and their importance, protein structure predictions, homology modeling, different bioinformatics tools available for molecular modeling	2
13	Molecular Docking • Introduction to protein-ligand interactions, models of protein-ligand interactions, different bioinformatics tools available for molecular docking	2
14	Industrial Applications of Bioinformatics • Applications of bioinformatics and related fields into chemical, pharmaceutical, and various other industries.	1
List of Textbooks		
1	*Molecular Biotechnology: Principles and Applications of Recombinant DNA* (6th edition) by Bernard R. Glick, Cheryl L. Patten (Wiley)	
2	*Molecular Biology of the Gene* (7th edition) by James D. Watson (Cold Spring Harbor Press)	
3	*Gene Cloning and DNA Analysis: An Introduction* (6th edition) by T. A. Brown (Wiley)	
4	*Introduction to Bioinformatics* by M. Lesk (2002) Oxford University Press.	

5	*Sequence Analysis in a Nutshell: A Guide to Common Tools and Databases* by S. Markel and D. León (2003) O'Reilly Press.
6	*Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* by A. D. Baxevanis and B. F. F. Ouellette (2004) Wiley-Interscience.
7	*Fundamental Concepts of Bioinformatics by* D. E. Krane and M. L. Raymer (2002) Pearson.
8	*Developing Bioinformatics Computer Skills* by C. Gibas and P. Jambeck (2001) O'Reilly Media.
List of Additional Reading Material / Reference Books	
	As suggested by the concerned faculty

Course Outcomes (Student would be able to……)		
CO1	Choose appropriate hosts for gene expression and protein production based on the known properties.	K3
CO2	Understand basic and modern techniques of gene manipulation.	K3
CO3	Apply principles of synthetic biology to construct gene circuits.	K4
CO4	Have essential and working knowledge in bioinformatics.	K3
CO5	Generate important supplementary data to support the research hypotheses with various bioinformatics tools.	K4

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	2
CO2	3	2	2	3
CO3	3	2	2	2
CO4	2	2	2	2
CO5	2	2	2	2

3: Strong Contribution; 2: Moderate Contribution; 1: Low Contribution

	Course Code: BBT1405	**Course Title: Bioprocess Technology**	**Credits = 2**		
			L	**T**	**P**
	Semester: VII	**Total contact hours: 30**	**2**	**0**	**0**

Prerequisite course

1. Introduction to Biological Sciences(BBT1201)
2. Fundamentals of Applied Biotechnology(BBT1202)

List of course where this course will be Prerequisite

1. Industrial Biotechnology

	Course Contents (Topics and subtopics)	**Reqd. hours**
1	Introduction to Bioprocess Technology • Definition and importance of bioprocess technology, Applications of Bioprocessing in pharmaceutical, food, agriculture and bioenergy industries, Convergence of the molecular biology principles for bioprocessing: Applications and dependencies	6
2	Growth Kinetics • Growth phases of microorganisms/cells, Determination of growth rate constants • Factors influencing microbial/cell growth, Convergence of the growth principles for bioprocessing: Applications and dependencies	3
3	Bioreactor Design and Operation • Types of bioreactors and their applications, Components and functions of bioreactors, Mixing and aeration in bioreactors	3
4	Downstream Processing	3

	• Cell harvesting methods, Filtration and centrifugation, Purification techniques: chromatography, crystallization, etc.	
5	Bioprocess Control and Automation • Sensors and actuators in bioprocessing, Feedback and feedforward control, Importance of process automation	3
6	Environmental and Ethical Considerations • Environmental impact of bioprocessing, Ethical issues in biotechnology and bioprocessing, Sustainability in bioprocess technology	3
7	Case Studies in Bioprocess Technology • Success stories in bioprocessing, Failure analysis and lessons learned • Innovations and future trends	3
9	Applying Knowledge to Bioprocess Improvements • Identifying areas for bioprocess optimization, Proposing strategies for process intensification: Improvement in expression, continuous processing etc., Implementing sustainable practices,	3
10	Recap and Review • Summary of key concepts covered in the course • Final assessment and Q&A session	3
List of Textbooks		
1.	Shuler M.L. and Kargi, F. (2002). Bioprocess engineering-basic concepts, 2nd Edition, Prentice-Hall of India pvt ltd, New Delhi.	
List of Additional Reading Material / Reference Books		
	As suggested by the concerned faculty	
Course Outcomes (students will be able to…..)		
CO1	Define bioprocess technology and explain its significance in different industries.	K2
CO2	Describe the growth kinetics of microorganisms and its importance in bioprocess design.	K2
CO3	Evaluate different bioreactor design for designing a fermentation process	K3
CO4	Discuss downstream processing techniques and their role in product purification.	K3
CO5	Analyse case studies of successful bioprocess applications and learn from past failures and apply fundamental knowledge to propose improvements in bioprocess designs and strategies.	K3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	3	2
CO2	2	3	3	2	3
CO3	2	2	3	2	2
CO4	2	2	3	2	2
CO5	2	3	3	2	2

3: Strong Contribution; 2: Moderate Contribution; 1: Low Contribution

	Course Code: BBT1406	**Course Title: Industrial Biotechnology**	**Credits = 2**		
			L	**T**	**P**
	Semester: VIII	**Total contact hours: 30**	**1**	**1**	**0**
List of Prerequisite Courses					
	1. Introduction to Biological Sciences (BBT1201) 2. Fundamental of Applied Biotechnology(BBT1202) 3. Bioprocess Technology(BBT1405)				

	Course Contents (Topics and Subtopics)	Reqd. hours
1	• Introduction to Industrial Biotechnology based bioprocess • Biochemistry of fermentation. Traditional and Modern Biotechnology- A brief survey of organisms, processes, products. • Selection of Appropriate microbe/cell type for industrial biotechnology • Significance of wild type and genetically modified organisms (GMO) in Industrial Biotechnology	3
	• Submerged and Solid-state Fermentation, relative advantages and limitations, applications	2
	• Strain Improvement in Industrial Biotechnology: Conventional and advanced Methodologies (random mutagenesis, targeted mutagenesis, recombinant DNA Technology)	3
2	• Stoichiometry of cell growth and product formation, elemental balances, degrees of reduction of substrate and biomass, available electron balances, yield coefficients of biomass and product formation, productivity, maintenance coefficients	3
3	• Medium requirements for Industrial fermentation processes, Types of Media, Criteria of media design, Raw material, Industrial by products as a source of fermentation medium nutrients • Medium optimization methods: One factor at a time, Plackett Burman and Response surface method • Cost Economics of fermentation media for different product types (High Value-Low Volume and Low Value-High Volume)	5
	• Entrepreneurship opportunities and challenges in Industrial Biotechnology	2
3	**Applications-I** • Microbial production of industrial enzymes (glucose isomerase, cellulase & lipases) • Production of antibiotics, recombinant products, and amino acids • Immobilization of cells and enzymes (conventional and modern methods of immobilization techniques)	6
4	**Applications-II** • Process technology to produce cell biomass and some primary metabolites, e.g. ethanol, acetone-butanol, citric acid, dextran, • Applications of bioconversion/biotransformation. • Bioenergy-fuel from biomass, production, and economics of biofuels.	6
	List of Textbooks	
1	Biotechnology: A Textbook of Industrial Microbiology: T.D. Brock, Smaeur Associates, 1990	
2	Industrial Microbiology: L.E. Casida, Wiley Eastern Ltd., 1989	
3	Industrial Microbiology: Prescott & Dunn, CBS Publishers, 1987	
4	Bioprocess Technology- fundamentals and applications, S O Enfors & L Hagstrom (1992), RIT, Stockholm	
5	Bioseparations-Downstream processing for Biotechnology by Paul. A. Belter, E.L.Cussler and Wei-Shou Hu., John Wiley and sons	
	List of Additional Reading Material / Reference Books	
1	Bioprocess engineering principles by Pauline M. Doran, Academic Press	

2	Biotechnology, Economic & Social Aspects: E.J. Dasilva, C Rutledge & A Sasson, Cambridge Univ. Press, Cambridge	
Course Outcomes (students will be able to…..)		
CO1	Select type of fermentation based on organism, product and process economics	K3
CO2	Model the nutrient requirements for a fermentation process with economic perspective	K4
CO3	Analyse case studies of different industrial biotechnology process	K3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	2
CO2	2	3	3	3	3
CO3	2	3	3	2	2

3: Strong Contribution; 2: Moderate Contribution; 1: Low Contribution