HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY - BIOCHEMICAL ENGINEERING

M. Tech. Chemical Technology-Biochemical Engineering

(Applicable from Session 2023-2024 for new entrants)

Year I, Semester-I

Course Title: ADVANCE BIOREACTOR DESIGN

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	NBE 501	4	3	1	0	15	20	15	50	50	100

Objective:- To provide the basic principles of reactor design for bioprocess and biotechnology applications.

Course outcome:- On successful completion of the course student will be able to –

CO1	comprehend the state of the arts in bioreactor technology and its broad range of applications. techniques to measure and control these parameters.	**Apply**
CO2	Understand and specify reactors used in industrial bioprocesses, develop mathematical models for bioreactors and analyze their behaviour (dynamic and steady state).	**Apply**
CO3	Understand basic principles of mass and energy conservation to analyze bioreactor systems, identify the major engineering parameters that characterizes the performance of bioreactors and techniques to measure and control these parameters	**Apply**
CO4	Understand suitable process instrumentation for monitoring and control of bioreactors	**Apply**
CO5	Understand analyze the problem of selection of suitable bioreactor configuration.	**Apply**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					2						3	3	3
CO2	3					2						3	3	3
CO3	3	3	2			2						3	3	3
CO4	3	2	2	2		2	2					3	3	3
CO5	3	1	2			2						3	3	3
Total	**3**	**2**	**2**	**2**		**2**	**2**					**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit 1: Bioreactors for microbial, animal and plant cell culture. Stirred tank reactor for bio-processing.

Unit 2: Design principles, mixing & mass transfer behavior and characterization of plug flow reactor, Air-lift reactor, tubular reactor etc.

Unit 3: Bioreactors used for immobilized cells and enzymes.

Unit 4: Design and applications of non-conventional bioreactors such as spiral reactor, membrane reactor, photo-bioreactor, tower reactors.

Unit 5: Monitoring, on-line measurements & computer control of bioreactors.

References:

1. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
2. "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.
3. "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
4. Bioprocess Engineering Basic Concepts. 2nd edition.. Michael L. Shuler and Fikret Kargi, Prentice Hall, Upper Saddle River, NJ.
5. Bioprocess Engineering Principles Pauline Doran, Academic Press, London.
6. T Panda, Bioreactors analysis and design, Tata McGraw Hill, New Delhi, New York, 2011

Course Title: STRUCTURAL AND MOLECULAR BIOLOGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	NBE 503	4	3	1	0	30	20	-	50	50	100

Objective:-

- To teach and demonstrate the cell organization, function and interaction of cell organelles.
- To demonstrate the mechanism of transcription, translation and its regulation.
- To teach the concept of genes and heredity.
- Students will come to know about r-DNA technology and the concepts of gene expression and its control.

Course outcome:- On successful completion of the course student will be able to –

CO 1	Understand to improve the microbial strains for their productivity.	**Apply**
CO2	Understand the fundamentals of molecular biology and genetic engineering.	**Apply**
CO3	Understand to recent developments in genetic engineering-gene cloning, treatment of various diseases including cancer, diabetes and hereditary diseases.	**Apply**
CO4	Understand to improve the microbial strains for their productivity.	**Apply**
CO5		

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3											3	3	3
CO2	2	2	2			2						3	3	3
CO3	3											3	3	3
CO4	3					2						3	3	3
CO5	3	2				2						3	3	3
Total	**3**	**2**	**2**			**2**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit I

Structure & characteristics of prokaryotic and eukaryotic cells; cell organelles- structure & function; Prokaryotic cell organization (Prokaryotic cell structure, Bacterial cell walls), Eukaryotic cell organization (Brief idea of structure and function of Plasma membrane, Nucleus, Endoplasmic reticulum, Golgi apparatus, Mitochondria, Chloroplast, Lysosome, Peroxisome, Plant cell wall, Plant cell vacuole); Concept of intra- and intermolecular interaction (covalent bond, ionic bond, hydrogen bond, hydrophobic interaction, van der Waals interaction).

Unit-II

Structure and functions of biomolecules; Carbohydrate: Structure, Function and properties of Monosaccharides (Hexoses and pentoses), Disaccharides (sucrose, lactose, maltose), storage & structural polysaccharide (glycogen, starch and cellulose; Definition and classification of lipids, Structure and function of fatty acid, storage lipids, structural lipids. Roles of lipid in Membrane structure, fluid Mosaic model of membrane structure, Transport of small molecules (Passive and active transport), Transport of macromolecules (exocytosis, endocytosis, phagocytosis, pinocytosis).

Unit-III

Amino acids: structure & classification of Amino acids; Proteins: classification of proteins on the basis of composition, conformation and function, different level of structural organization of proteins (primary, secondary, tertiary & quaternary; Enzymes: classification and nomenclature. Structure and Functions of Nucleic Acids; Nucleic acid as the genetic material (Griffith's experiment, Avery, MacLeod and McCarty’s experiment, Hershey-Chase experiment); Watson-Crick model, Supercoiled DNA, Conformation of nucleic acids: A-, B-, Z-, DNA; Genome and its organization.

Unit-IV

Importance of Molecular Biology, Central Dogma of Molecular Biology; Replication of DNA in prokaryotes; Features of DNA Replication, Proof of semiconservative nature of DNA replication; Transcription in prokaryotes with E. Coli as model system: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains; Genetic code, properties of genetic code, Wobble hypothesis.

Unit-V

Components of Protein synthesis machinery: Messenger RNA, tRNA structure and function, Charging of tRNA, aminoacyl tRNA synthetases, ribosome structure and assembly, Mechanism of protein synthesis in prokaryotes: initiation, elongation and termination; Principles of gene regulation, negative and positive regulation, concept of operons, Regulation of gene expression in bacteria: lac operon concept.

References :

1. "Principles and Techniques of Biochemistry and Molecular Biology" (7th edition), Keith Wilson and John Walker, Cambridge University Press(2010).
2. "Molecular Biology of the Gene", J.D. Watson, Melnopark, California.
3. "Lewin's GENES XII", Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Learning, (2017).
4. "Molecular Cell Biology", Harvey Lodish et al; W. H. Freeman (2016)
5. "Cell Biology : A laboratory hand book", Julio E. Celis, Academic Press(2006)
6. " Recombinant DNA Technology", Dhillon J.R., John Wiley & Sons, New York.
7. "Genetics", P.K. Gupta, Rastogi Publication, Meerut.

Course Title : ADVANCES IN ENVIRONMENTAL BIOTECHNOLOGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	**NBE 505**	**4**	**3**	**0**	**2**	**15**	**20**	**15**	**50**	**50**	**100**

Objective: -

To acquaint in the student with impacts of environmental pollution and use of engineering and Biotechnology in abatement of pollution.

Course outcome: - On successful completion of the course student will be able to –

CO1	Understand about sources and nature of air pollutants and necessity of legislation for their control.	**Apply**
CO2	Understand strategies and methods for control of air pollutants.	**Apply**
CO3	Understand characteristics of waste water and various treatment technologies.	**Apply**
CO4	Understand about elements of solid waste management and its implementation.	**Apply**
CO5	Understand experimental aspects involved in environmental studies.	**Apply**

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					2						3	3	3
CO2	3					2						3	3	3
CO3	3	3				2						3	3	3
CO4	3	3				2						3	3	3
CO5	3	3	3	2		2						3	3	3
CO6	3	3	2	2		2			2			3	3	3
Total	**3**	**3**	**2.5**	**2**		**2**			**2**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit-I

Air pollution sources and effect on livings and nonliving bodies, classification and characteristics of air pollutants and their distribution, air pollution control legislation.

Unit-II

Control strategies and methods for control of air pollutants**.**

Unit-III

Water pollution- sources and impact of major pollutant of concern in water, aerobic ,anaerobic and advanced waste water treatment methods.

Unit-IV

Solid waste- sources type and effects of solid waste. Solid waste management treatment and disposal.

Unit-V

Laboratory exercise DO, BOD, COD, and solids determination, colour and odour measurement, evaluation of performance of aerobic and anaerobic reactor.

REFERENCE:

1. "Environmental Engineering" by Peavy & Row
2 "Waste water Engineering: Treatment, Disposal and Reuse", Metcalf & Eddy, Inc.; Tata McGraw-Hill Publishing Company Ltd., New Delhi.
3. "Water supply and Pollution Control", Warren Viessman Jr. and Mark J. Hammer; Harper& Row Publishers; New York.
4.Waste water Treatment: Rational Methods of Design & Industrial Practices Rao &Dutta published by Oxford & IBH Publishing Company Private Ltd. II Edison

Course Title: ANALYTICAL METHODS IN BIOPROCESSES

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	**NBE 509**	**4**	**3**	**1**	**0**	**30**	**20**	**-**	**50**	**50**	**100**

Course Objective: To demonstrate ability to plan and execute experiments, and analyze and interpret outcomes.

Course outcome:- On successful completion of the course student will be able to –

CO1	Analyze the basic principle and application of microscopic techniques.	**Analyze**
CO2	Analyze the process of chromatography for the separation of biomolecules.	**Analyze**
CO3	Analyze the basic principles and important instruments frequently used in bioprocess industries.	**Analyze**
CO4	Analyze the techniques of separation of biomolecules by centrifugation	**Analyze**
CO5	Analyze the process of electrophoresis for the separation of biomolecules.	**Analyze**

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					3	3					3	3	3
CO2	3			2		3						3	3	3
CO3	3	3		2		3			2			3	3	3
CO4	3	3	3	2	2	3			2			3	3	3
CO5	3	3	3	2	2	3			2			3	3	3
Total	**3**	**3**	**3**	**2**	**2**	**3**	**3**		**2**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit I

Nature & properties of biochemical metabolites. Introduction to basic principles and applications: Light microscopy (bright field, dark field, phase contrast, and fluorescence microscopy), electron microscopy (TEM and SEM)

Unit II

Principle and application of Chromatography. Working principle, instrumentation, and application of: Paper Chromatography, Thin Layer Chromatography, Column Chromatography (Affinity Chromatography, Ion-exchange Chromatography, Gel filtration Chromatography or Exclusion Chromatography), and HPLC

Unit III

Introduction to basic principles and applications: Beer Lambert's Law, Spectrophotometry (UV-visible, infrared, AAS), Mass spectroscopy.

Unit IV

Centrifugation: principle, differential, and density gradient centrifugation, ultracentrifugation (preparative and analytical centrifuges) sedimentation analysis & RCF

Unit V

Principle, factors affecting electrophoresis- pH, voltage, supporting medium (agar, polyacrylamide, dextran). Agarose gel electrophoresis, PAGE, SDS-PAGE. Isoelectric focusing.

References:

1. H-P Schmauder, M Schweizer and L M Schweizer., Methods in Biotechnology, (eds), Taylor & Francis Publishers,2002.
2. K. Wilson & J. Walker, Practical Biochemistry: Principles and Techniques. (eds) Cambridge University Press, New York, 1995.
3. Douglas A. Skoog and James J. Leary, Principles of Instrumental Analysis. 4th Edition. Saunders College Publishing, 1992.
4. Methods in Modern Biophysics, B Notting, Springer Verlag Berlin Heidelberg New York, 2003
5. Principles and Techniques of Biochemistry and Molecular Biology, 6th edition, K Wilson and J Walker (ed.), Cambridge University Press, 2007
6. Bioinstrumentation, J G Webster, John Wiley & Sons Inc. 2004
7. Essentials of Biophysics, P Narayanan, New Age Int. Pub. New Delhi. 2000
8. Spectroscopy for the Biological Sciences, G G Hames, John Wiley & Sons Inc. 2005

Course Title: DESIGN OF FERMENTERS

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	NBE 511	4	3	1	0	15	20	15	50	50	100

Objective:-To provide the basic principles of reactor design for bioprocess and biotechnology applications.

Course outcome:-On successful completion of the course student will be able to –

CO1	Understand the basic concepts of microbial growth and nutritional requirements.	**Apply**
CO2	Understand the lab scale upstream processing and microbial production processes.	**Apply**
CO3	Understand basic principles of instrumentation used during fermenter operations.	**Apply**
CO4	Understand the principles of fermenter design.	**Apply**
CO5	Understand and analyze the problem of selection of suitable bioreactor configuration.	**Apply**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					2						3	3	3
CO2	3					2						3	3	3
CO3	3	3	2			2						3	3	3
CO4	3	2	2	2		2	2					3	3	3
CO5	3	1	2			2						3	3	3
Total	**3**	**2**	**2**	**2**		**2**	**2**					**3**	**3**	**3**

1:Slight(Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit 1: Basic concepts of microbial growth, kinetics, nutritional requirement etc.

Unit 2: Aspects of laboratory scale production of microbes and products thereof. Aseptic conditions, sterilization techniques (media and air).

Unit 3: Monitoring, on-line measurements & computer control of bioreactors.

Unit 4: Design principles of fermenters, mixing and mass transfer aspects.

Unit 5: Design and applications of non-conventional fermenters.

References:

1. “Principle of Fermentation Technology”, P.F. Stanbury and A. Whitaker; Pergamon Press.
2. “Basic Biotechnology”, J. Bu’lock, B. Kristiansen, Academic Press.
3. “Biochemical Engineering Fundamentals” by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
4. Bioprocess Engineering Basic Concepts. 2nd edition.. Michael L. Shuler and Fikret Kargi, Prentice Hall, Upper Saddle River, NJ.
5. Bioprocess Engineering Principles Pauline Doran, Academic Press, London.
6. T Panda, Bioreactors analysis and design, Tata McGraw Hill, New Delhi, New York, 2011

Course Title: ADVANCED MOLECULAR BIOLOGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	NBE 513	4	3	1	0	30	20	-	50	50	100

Objective:-

- Students will know about DNA structure, its hereditary role and packaging inside the nucleus.
- Students will understand concept of transcription, translation and its regulation.
- Students will come to know about r-DNA technology and the concepts of gene expression and its control.
- Students will understand the concept of DNA sequencing and gene cloning.

Course outcome:- On successful completion of the course student will be able to –

CO1	Understand the DNA structure, its hereditary role and packaging inside the nucleus.	**Apply**
CO2	Understand to apply concepts of molecular genetics to develop new techniques in various fields like medical, pharmaceuticals, food production etc.	**Apply**
CO3	Understand the fundamentals of molecular biology and genetic engineering.	**Apply**
CO4	An exposure to recent developments in genetic engineering-gene cloning, treatment of various diseases including cancer, diabetes and hereditary diseases.	**Apply**
CO5	Understand to improve the microbial strains for their productivity.	**Apply**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3			2		2	2					3	3	3
CO2	3					2						3	3	3
CO3	3	3	2			2						3	3	3
CO4	3	2	2	2		2	2					3	3	3
CO5	3	1	2			2						3	3	3
Total	**3**	**2**	**2**	**2**		**2**	**2**					**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit-I

Chronological Development of Molecular Biology. Nucleic acids: forms structure and functions. Structure of chromosomes: DNA packaging, features of metaphase chromosomes. Gene: Its concept, functioning and inheritance. Inter and intra molecular non-covalent interaction in living system.

Unit-II

DNA replication: semi-conservative replication, DNA polymerases, events at the replication form, replication of the lagging strand, telomeres, consequences of defects in telomerase.
Replication of genomes: origins of replication control of DNA replication. Transcription and its regulation. Genetic codon: their identification, characteristics and function.Repression and inhibition mechanism. Prokaryotic translation process.

Unit-III

Controlling of Prokaryotic Gene Expression: control circuit of operon. Construction and control of Lac operon and Tryptophan operon.

Unit-IV

r-DNA Technology: Principles, construction, properties of vectors. Restriction enzyme: properties, function and application. Strategy of Gene cloning, expression of gene and selection of genetically modified cells.

Unit-V

Case studies for genetic modification in *E. coli* and yeast. PCR,Restriction mapping and DNA sequencing.

References:

1. "Molecular Biology of the Gene", J.D. Watson, Melnopark, California.
2. "Lewin's GENES XII", Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Learning (2017).
3. "Biochemistry", A.L. Lehninger, Worth Publication, New York.
4. "Recombinant DNA Technology", Dhillon J.R., John Wiley & Sons, New York.

Course Title: PLANT CELL CULTURE TECHNIQUES

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	**NBE 515**	**4**	**3**	**1**	**0**	**30**	**20**	**-**	**50**	**50**	**100**

Course Objectives:

- Students will understand about tissue culture techniques.
- To familiarize the students with applied aspects of plant biotechnology.
- To make the students aware of transgenic plants.
- To teach the students the production of secondary metabolites of plant origin.

Course outcome: - On successful completion of the course student will be able to –

CO1	Understand to use cell and tissue culture technique	**Understand**
CO2	Understand to apply gene transfer techniques for improvement of plants.	**Understand**
CO3	Understand to use secondary metabolites of plant origin at any level	**Understand**
CO4	Apply the concept of hydrodynamic shear, its quantification and aspects of impeller design.	**Apply**
CO5	Evaluate the different types of plant cell reactors, root cultures and their cultivation	**Evaluate**

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3			1		2	3					3	3	3
CO2	3	2	2	1	1	2	3			3	2	3	3	3
CO3	3									3		3	3	3
CO4	3									3		3	3	3
CO5	3	2				2	3					3	3	3
Total	**3**	**2**	**2**	**1**	**1**	**2**	**3**			**3**	**2**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

UNIT-I

Special features and organization of plant cells. Totipotency, penetration of plants. Plant products of industrial importance. Biochemistry of major metabolic pathways and products.

UNIT-II

Autotrophic and heterotrophic growth. Plant growth regulators and Elicitors: cell suspension culture development: methodology, kinetics of growth and product formation, nutrient optimization.

UNIT-III

Production of secondary metabolites by suspension cultures with a few case studies.

UNIT-IV

Biological & technological barriers- hydrodynamic shear and its quantification and impeller design aspects.

UNIT-V

Plant cell reactors: Comparison of reactor performances. Immobilized plant cell and cell retention reactors. Hairy root cultures and their cultivation.

References:

1. "Introduction to Plant Biotechnology", H. S. Chawla, Science Publishers(2002).
2. "Introduction to Plant Tissue Culture", M. K. Razdan, Science Publishers(2003).
3. "Plant Biotechnology: The genetic manipulation of plants", Adrian Slater, Mark R. Fowler & Nigel W. Scott, Oxford University Press (2008).

Year I, Semester-II

Course Title : ADVANCED INDUSTRIAL ENZYMES

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	NBE 502	4	3	1	0	30	20	-	50	50	100

Objective: -

The objective of this course is to acquaintance students with recent development in enzyme engineering and technology.

Course outcome: - On successful completion of the course student will be able to –

CO1	Understand enzyme properties and production methods.	**Apply**
CO2	Understand downstream processing.	**Apply**
CO3	Understand immobilization techniques and their application feasibility	**Apply**
CO4	Understand specific role of enzymes in particular industry.	**Apply**
CO5	Understand reactor configuration and criteria for selection of reactors.	**Apply**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3											3	3	3
CO2	3	2	1			1						3	3	3
CO3	3	2	1			1						3	3	3
CO4	3	2	1			1						3	3	3
CO5	3		1									3	3	3
Total	**3**	**2**	**1**			**1.25**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

Unit-I

Sources and general aspects of productions.

Unit-II

Recovery, purification and isolation.

Unit-III

Immobilized enzymes and their commercial applications.

Unit-IV

Application of enzymes: food, Pharmaceuticals, textiles and leather and for analytical purposes

Unit-V

Development in Enzyme reactors, configuration and selection criteria, enzyme reactors.

Reference:

1. “ Biochemical Engineering Fundamentals” by J.E. Bailey and D.F.. Ollis, Mcgraw-Hill Book Co, New York.
2. “Immobilized Enzymes” by Trevan.
3. Enzyme Kinetics by Roberts.
4. Enzyme Engineering by Laidler

Course Title: BIOENERGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	NBE 504	4	3	1	0	30	20	-	50	50	100

Objective: -

- To give an overview of biomass energy source
- To create an understanding on biomass derived fuel system
- To generate understanding on energy utilization of bio-based fuel.

Course Outcome: - On successful completion of the course student will be able to –

CO1	To learn about present energy scenario in the world and importance of alternate energy	Understand
CO2	To understand basics of biofuels, their production technologies and applications in various energy utility routes	Understand
CO3	To understand and evaluate various biomass pretreatment and processing techniques in terms of their applicability for different biomass type for biomass conversion processes	Evaluate
CO4	Able to understand the process of pyrolysis and gasification of biomass: Thermo-chemical conversion	Understand,
CO5	The student will be capable to explain Biochemical conversion process	Evaluate

Syllabus

UNIT I

Introduction: Energy world demand, Bio Energy Resources, World Bio Energy Potential, India’s Bio Energy Potential, Biomass Resources and classification, Physio-chemical characteristics. Energy and fossil fuel use, fossil fuel reserves, sustainable fuel sources. Consequences of burning fossil fuel – effects of industrial (anthropogenic) activity on greenhouse gases, reduction in global greenhouse gases, sequestration of carbon dioxide, alternative energy sources.

Unit II: Bioenergy systems

Current bio-energy applications and conversion technologies, Advantages of applied bioenergy over other sources of energy.

Biomass conversion routes: biochemical, chemical, thermochemical and physical processes; Bio-refinery concept: definition; different types of bio-refinery

Unit-III: Biochemical conversion

Aerobic and Anaerobic conversion, Fermentation; Bio-methanation: biogas production mechanism and technology, types of digesters; Design of biogas plants, installation, operation and maintenance of biogas plants, biogas slurry utilization and management, biogas applications; Cost benefit analysis of biogas for cooking, lighting, power generation applications, Case studies.

Unit-IV: Biogas Systems

Principle, Design of Bio mass Gasifiers, updraft gasifier, down draft gasifier, zero carbon biomass gasification plants, Gasification of plastic-rich waste. Pyrolysis and Gasification of Biomass: Thermo-chemical conversion of ligno-cellulose biomass for liquid fuel production - Pyrolysis of biomass-Pyrolysis regime, effect of particle size, temperature, and products obtained.

Unit-V : **Biomass and Biofuel**

Biomass composition and energy content; Biofuels, types of biofuels , Biological solid fuels 1 st, 2nd and 3rd generation biofuels. Liquid biofuels to replace petrol – methanol production. Large scale ethanol production from biomass, use of lignocellulosics for ethanol production, ethanol extraction after production, use of ethanol as fuel. Liquid biofuel to replace diesel – synthetic diesel (FT synthesis).

Suggested texts and reference materials

1. Ralph E.H. Simsed. (2004); Bioenergy options for cleaner environment by World Renewable Energy Network.
2. Mutha, V. K. (2010). Handbook of bioenergy and biofuel SBS Publishers, Delhi
3. Clark, J. H., & Deswarte, F. (Eds.). (2014). Introduction to chemicals from biomass. John Wiley & Sons. 3. Klass, D. L. (1998). Biomass for renewable energy, fuels, and chemicals. Elsevier.
4. Mukunda, H. S. (2011). Understanding clean energy and fuels from biomass. Wiley India
5. Speight, J. (2008). Synthetic fuels handbook: properties, process and performance. McGraw-Hill
6. Dahiya, A. (Ed.). (2014). Bioenergy: Biomass to biofuels. Academic Press. 8. Hall, D. O., & Overend, R. P. (1987). Biomass: regenerable energy.

Course Title: BIOPROCESS TECHNOLOGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	NBE 506	4	3	1	0	30	20	-	50	50	100

Objective:-

The objective of this course is to acquaintance students to understand the biological systems; and to understand the role of microorganisms in the upstream processing and importance of downstream processing in biotechnology.

Course outcome:- On successful completion of the course student will be able to –

CO1	Evaluate the kinetics and mechanism of enzymatic process	**Evaluate**
CO2	Undererstand the metabolism and microbial growth kinetics	**Undererstand**
CO3	Evaluate the bioreactors, design features and the instrumentation and control of bioreactors	**Evaluate**
CO4	Analyse the role of downstream processing in biotechnology	**Analyse**
CO5	Analyse advanced separation processes such as Chromatography, Electrophoresis, Crystallization , drying and freeze drying.	**Analyse**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					1	2					3	3	3
CO2	3					1	2					3	3	3
CO3	3					1	2					3	3	3
CO4	3	2	1			1	2					3	3	3
CO5	3					1	2					3	3	3
Total	3	2	1			1	2					3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

SYLLABUS

UNIT I-Enzyme Technology

Introductions: Enzymes- Michaelis-Menten kinetics. Kinetics and Statistics-Inhibition- Effect of pH and temperature-Enzymology- Immobilized enzymes: Methods, Mass transfer considerations and Industrial enzymes.

UNIT II-Metabolism, Stoichiometry and Microbial Growth Kinetics

Introduction to metabolism- Nutrient transport- Glycolysis - TCA cycle and other pathways - Control of metabolism. Factors affecting microbial growth –Stoichiometry- mass balances and energy balances. Growth kinetics- Measurement of growth.

UNIT III-Bioreactors, Sterilization, Sensors and Instrumentation

Introduction to bioreactors - Batch and Fed-batch bioreactors, Continuous bioreactors, Immobilized cells. Bioreactor operation, Sterilization, Aeration, Sensors. Instrumentation, Culture - specific design aspects: plant/mammalian cell culture reactors.

UNIT IV-Primary Separation Process

Biomass removal - Biomass disruption – Membrane based techniques. Extraction -solvent, aqueous two phases, super critical, and Adsorption.

UNIT V-Secondary Separation Process

Chromatography, Precipitation (Ammonium Sulfate, solvent), Electrophoresis (capillary), Crystallization, Drying and Freeze drying.

References

1. Michael Shuler and Fikret Kargi. "*Bioprocess Engineering: Basic Concepts*", 2nd Edition, Prentice Hall, and Englewood Cliffs, NJ, 2002.
2. Pauline Doran. "*Bioprocess engineering principles*", Academic Press,1995.
3. Colin Ratledge, Bjorn Kristiansen, "*Basic Biotechnology*", 2nd Edition, Cambridge University Press, 2001.
4. Roger Harrison et al., "*Bioseparation Science and Engineering*", Oxford University Press, 2003.
5. Harrison R.G. Todd P., Rudge S.R. "*Bioseparation Science and Engineering*", Oxford Press 2003.

Course Title: ADVANCED PROTEIN ENGINEERING

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	NBE 508	4	3	1	0	30	20	0	50	50	100

Course Objectives:	The course aims: • To enable students to describe rational and combinatorial methods of protein engineering • To train students to critically analyze data and conclusions from the primary literature • To enable students to converse at an advanced level about current key topics of investigation in the field of protein engineering

Course outcome: **-**On successful completion of the course student will be able to –

CO1	Explain the structure and properties of Proteins	**Apply**
CO2	Measure the stability of a protein with the help of different analytical techniques	**Apply**
CO3	Explain the interactions and thermodynamic behaviour between the protein molecules.	**Apply**
CO4	Describe the structure and construction of protein 3-D structure, and protein folding by computer-based methods,	**Apply**
CO5	Use the concept of Proteomics for design of proteins	**Apply**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3		2	-		-	-	-	-	-	-	3	3	3
CO2	3	2	2	-	3	-	-	-	-	-	-	3	3	3
CO3	3	2	3	-	3	-	-	-	-	-	-	3	3	3
CO4	3	2	2	-	3	-	-	-	-	-	-	3	3	3
CO5	3	3	3	-	3	-	-	-	-	-	-	3	3	3
Total	**3**	**2**	**2**	-	**3**	-	-	-	-	-	-	**3**	**3**	**3**

1:Slight(Low), 2: Moderate (Medium), 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit I: Introduction to protein engineering

Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters such as pH, temperature and amino acid sequence, aggregation propensities, etc. Protein engineering with unnatural amino acids and its applications.

Unit II: Stability of protein structure

Methods of measuring the stability of a protein; Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UV CD; Fluorescence; UV absorbance; ORD; Hydrodynamic properties–viscosity, hydrogen deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be measured/obtained from NMR and their interpretation.

Unit III: Applications

Forces stabilizing proteins – Van der Waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, etc., Optimization and high throughput screening methodologies like Giga Metrix, High throughput microplate screens, etc.,

Unit IV: Computational approaches

Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles vis-à-vis those from mesophiles; Protein design, Directed evolution for protein engineering and its potential.

Unit V: Proteomics

Introduction to the concept of the proteome, components of proteomics, proteomic analysis, the importance of proteomics in biological functions, protein-protein interactions, and methods to study it: protein arrays, cross-linking methods, affinity methods, yeast hybrid systems and protein arrays.

Textbooks:

1. Edited by T E Creighton, (1997), Protein Structure: a Practical Approach, 2nd Edition, Oxford university press.
2. Cleland and Craik, (2006), Protein Engineering, Principles and Practice, Vol 7, Springer Netherlands.
3. Mueller and Arndt, Protein Engineering Protocols, 1st Edition, Humana Press.
4. Ed. Robertson DE, Noel JP, (2004), Protein Engineering Methods in Enzymology, 388, Elsevier Academic Press.
5. J Kyte; (2006), Structure in Protein Chemistry, 2nd Edition, Garland publishers.
6. Pennington, S.R and M.J. Dunn, “Proteomics: Protein Sequence to Function”. Viva Books, 2002.
7. Liebler, “Introduction to Proteomics” Humana Press, 2002.

Course Title: BIOPROCESS PLANT DESIGN

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	NBE 510	4	3	1	0	30	20	-	50	50	100

Objective:- This course is designed to apply biochemical engineering knowledge gained in earlier courses to the complete design of a bioprocess plant for the production of biotech products.

Course outcome: - On successful completion of the course student will be able to –

CO1	Understand and identify the important parameters of equipment design.	**Apply**
CO2	Understand the basic concepts of flow sheeting, material and energy balances and process development	**Apply**
CO3	Gain knowledge of estimation of capital investment, total product costs, depreciation, cash flows, and profitability	**Apply**
CO4	Design special vessels (e.g. fermenter) and various parts, design of equipment's based on economics and process considerations.	**Apply**
CO5	Design heat and mass transfer equipment.	**Apply**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3											3	3	3
CO2	2	2	2			2						3	3	3
CO3	3											3	3	3
CO4	3					2						3	3	3
CO5	3	2				2						3	3	3
Total	**3**	**2**	**2**			**2**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit I

Introduction, general design information, mass and energy balance, flow sheeting, piping and instrumentation.

Unit II

Material of construction for bioprocess plants. Mechanical design of process equipment, vessels for biotechnology applications, design of fermenters, design consideration for maintaining sterility of process streams and processing equipment.

Unit III

Selection and specification of equipment for handling fluids and solids. Selection specification and design of heat and mass transfer equipment used in bioprocess industries. Design of facilities for cleaning of process equipment used in biochemical industries.

Unit IV

Utilities for biotechnology production plants. Process economics, bioprocess validation, safety consideration

Course Title: ADVANCED BIOSEPARATION PROCESSES

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	NBE 601	4	3	1	0	15	20	15	50	50	100

Course Objectives:	To enable the students to • Understand the methods to obtain pure proteins, enzymes, and in general product development R & D. • Have depth knowledge and hands-on experience with downstream processes.

Course outcome: - On successful completion of the course, a student will be able to –

CO1	Describe the principles that underlie major unit operations used in downstream processing	**Apply, Analyze**
CO2	Define and carry out the separation and purification of fermentation products	**Apply and Analyze**
CO3	Design and formulate effective strategies of downstream processing based on characteristics of biomolecules	**Apply and Analyze**
CO4	Analyze the quality and characteristics of the purified product	**Apply and Analyze**
CO5	Integrate biological and engineering principles involved in the production and recovery of commercial products.	**Apply and Analyze**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1													3	3
CO2													3	3
CO3													3	3
CO4													3	3
CO5													3	3
Total													3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit I: Introduction to Bioseparation Process

Role and importance of bioseparation in biotechnological processes: RIPP scheme, Problems and requirements of bioproducts purification - Properties of Biomolecules - Characteristics of fermentation broth - Biological activity, Analysis of purity-Process economics: Capital and operating cost analysis.

Unit II: Removal of Insoubles

Cell disruption methods for intracellular products: Physical, chemical, enzymatic and mechanical - Removal of insoluble: Biomass and particulate debris separation techniques - flocculation - sedimentation - centrifugation and filtration methods.

Unit III - Isolation of Products

Adsorption: Principles - Langumir - Freundlich isotherms - Extraction: Basics- Batch and continuous, aqueous two-phase extraction - supercritical extraction - in situ product removal - Precipitation: Methods of precipitation with salts - organic solvents and polymers - Membrane-based separations: Micro and ultrafiltration - theory - design and configuration of membrane separation equipment and its applications.

Unit IV: Purification of Bioproduct

Basic principles of Chromatographic separations: GC-HPLC - gel permeation - ion-exchange - affinity - reverse phase and hydrophobic interaction chromatography - Electrophoretic separation techniques: capillary - isoelectric focusing-2D gel electrophoresis - Hybrid separation technologies: GC-MS and LC-MS.

Unit V - Product Polishing

Crystallization: Principles-Nucleation-Crystal growth-Kinetics-Batch crystallizers: Scale-up and design, Drying: Principles-Water in biological solids- Heat and mass transfer-Drying equipment: description and operation-Vacuum shelf - rotary dryer-Freeze dryer-Spray dryer. Biomolecules of Commercial importance Ethanol, citric acid, lysine, steroids, penicillin, dextran, trehalose, subtilisin, chymosin, vitamin B12, hepatitis B vaccine, insulin, erythropoietin, monoclonal antibodies.

References:

1. Coulson & Richardson’s Chemical Engineering – Volume 3 (Chemical and Biochemical Reactors and process controls) ed. Richardson, J.F., Peacock, D.G., First Indian ed. Asian Books Pvt. Ltd. 1998.
2. Process Biotechnology Fundamentals by S.N. Mukhopadhyay (2001). Viva Books Private Limited.
3. Roger G. Harrison, Paul Todd, Scott R. Rudge, Demetri P. Petrides, "Bioseparation Science and Engineering" Oxford University Press, 2003.

4. Protein: Biochemistry and Biotechnology by Gary Walsh (2002 John Wiley & Sons Ltd.)
5. Geankoplis, C.J. Transport Processes and Unit Operations Prentice Hall of (I) 3rd ed. 1997.
6. Mukhopadhyay, S.N. Process Biotechnology Fundamentals, Viva Books Pvt. Ltd. 2001.
7. Keith Wilson and John Walker, Practical Biochemistry—Principles and Techniques, Cambridge, 5th Ed.2000

Course Title: BIOENTERPRENEURSHIP AND REGULATORY ISSUES

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	NBE 603	4	3	1	0	30	20	-	50	50	100

Course Objective: This course is designed to understand the entrepreneurial decision making process – from business model design to the launch of the new venture in the biotechnology field. Also, to develop a wide range of strategic, financial and human resource planning skills necessary to the new venture planning process.

Course outcome: - On successful completion of the course student will be able to –

CO1	Understand and differentiate and relate entrepreneurship and innovation	**Apply**
CO2	Understand identify the attitudes, values, characteristics, and processes associated with successful entrepreneurial behavior.	**Apply**
CO3	Understand the fundamentals of marketing practices.	**Apply**
CO4	Understand the fundamentals of finance management for biotechnology industries. analyze the legal and ethical issues in biotechnological practices. Acquire a wide source of material that facilitates a continual learning process	**Apply**
CO5	Understand the concepts and practice of bioentrepreneur ship.	**Apply**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3											3	3	3
CO2	3		2			2						3	3	3
CO3	3		2			2						3	3	3
CO4	3	2	2			2						3	3	3
CO5	3	2	2	1		2						3	3	3
Total	**3**	**2**	**2**	**1**		**2**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit I

Overview of biotechnology Industry management: Business of biotechnology, Emerging areas of biotechnology industry, corporate governance and bioethics and societal issues in biotechnology industry; Biotechnology Product Management: Product development, assessment of market potential, testing and lifecycle analysis, preclinical and clinical trial design and conduct, risk analysis, quality control and assurance, fundamentals of validation, good manufacturing practices.

Unit II

Biotechnology Entrepreneurship: Entrepreneurial process and the practicalities of venture creation, specific features of biotechnology-based products and services, human resource management, partnerships with other businesses; negotiation techniques and motivation, leadership skills, communication, conflict resolution, and goal integration, key tasks and challenges faced by biotech entrepreneurs, crisis management principles, strategies, tactics, and communications methods

Unit III

Marketing in biotechnology industry: Marketing practices and application, marketing plan, relationship between the marketing and sales functions, marketing a scientific product and a scientific service, pricing strategies, distribution alternatives, communications, promotion, and the importance of perception. International business and marketing trends in biotechnology; advertising approved products.

Unit IV

Finance management for biotechnology industry: Defining and distinguishing the biotechnology industry, competitive forces and impact on strategy, regulation of genetic products, planning under uncertainty, system thinking and system failure, the economic environment, estimating costs and benefits, strategic components, marketing and sales, modeling, costs and benefits, and ratio and break-even analysis, commercializing biotechnology and technology transfer

Unit V

Biotechnology regulatory issues: Regulatory processes and agencies, Legal Aspects of Biotechnology, Intellectual Property Rights- Basis of Patentability, Patent Application Procedure, Compulsory License, Infringement of Patents, Product Registration for Regulated and Non Regulated Markets, Scientific Exchange in Biotechnology research, Treaties/Conventions and regulatory policies relevant to India, International regulatory affairs, regulatory information, drug submissions, biologics submissions, medical device submissions, GLP, GCP, GMP, inventorship and ownership issues in academia and industry.

Course Title: FERMENTATION TECHNOLOGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	OBE 601	4	3	1	0	30	20	-	50	50	100

Course Objectives:	To introduce the students to the various concepts of fermentation and impart knowledge about biological and biochemical technology, with a focus on industrial products such as alcohol, organic acids, enzymes, and amino acids.

Course outcome: - On successful completion of the course, the student will be able to –

CO1	Understanding of the concepts and process technologies of fermentation.	**Understand**
CO2	Understand the basic design of the fermenter- Components and their functions,	**Understand**
CO3	Concepts of the scale-up and scale-down criteria of the fermentation process	**Understand**
CO4	Understand the technology behind the production of various fermented products	**Understand**
CO5	Design bioreactors for the bioprocessing of different products and scale up the bioprocess for large-scale production	**Apply**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	-	3	-	-	-	-	-	-	-	-	-	3	3
CO2	3	3	2	-	-	-	-	-	-	-	-	-	3	3
CO3	3	3	2	3	-	-	3	-	-	-	2	3	3	3
CO4	3	-	-	-	-	-	-	-	-	-	3	-	3	3
CO5	3	3	3	-	3	-	2	-	-	2	2	3	3	3
Total	3	3	3	3	3	-	3	-	-	2	3	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit I

Introduction to Fermentation Technology, History, and development of the fermentation industry. Microbial culture selection for fermentation processes, Strain development; Preservation, and improvement of industrially important microorganisms.

Unit II

Inoculum development for industrial fermentation, Criteria for transfer of inoculum, development of inocula for bacterial processes, yeast processes, and mycelial processes. Inoculum development for plant fermenter, aseptic method of inoculation, achievement, and maintenance of aseptic conditions.

Unit III

Design of a fermenter- Basic functions of a fermenter, its design and operation; Its measurement and control in fermentation, Aeration, and agitation in fermentation: Oxygen requirement, sterilization of air and media; scale up in fermentation. Various types of fermentation systems (submerged, surface, and solid-state fermentation)

Unit IV

Types of fermenters: Shake flask, Batch/Stir tank, Continous, Bubble Column, Airlift, and tower fermenter. Basis and Principles fermentation process, Batch culture, continuous culture, industrial applications of continuous culture processes, fed-batch culture. Fermentation Material and Energy balance.

Unit – V

Typical Fermentation Processes: Antibiotic Fermentation (Penicillin, Streptomycin) Anaerobic Fermentation: acetone-butanol Fermentation, Bear and wine, Industrial Alcohol, Organic acid (Lactic Acid and Citric acid), Aminoacid fermentation(Lysine and Glutamic acid)

Text Books:

1. Stanbury, P.F. and Whitaker, A., and Hall S. J. Principles of Fermentation Technology, Pergamon Press (2007).
2. Doran, P.M Bioprocess Engineering Principles, Academic Press (2012).

Reference Books:

1. Aiba, S., Humphrey, A.E and Millis, N.F., Biochemical Engineering, Academic Press (1973).
2. Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals, McGraw-Hill (1986).
3. Shuler, M.L. and Kargi, F., Bioprocess Engineering: Basic Concepts, Prentice-Hall (1992)

4. R.O. Jenkins, (Ed.), Product Recovery in Bioprocess Technology – Biotechnology, Open Learning Series, Butterworth-Heinemann

SEMINAR

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	**NBE 607**	**1**	**0**	**0**	**2**	**-**	**50**	**-**	**50**	**50**	**100**

OBJECTIVE: The objective of this course is to enable the students

- to study a topic of latest developments/innovative technology on their own and to prepare a dissertation report on this topic.
- to present a lecture on the topic on power point format.
- to improve the communication skill of the students.

Course Outcome

On the successful completion of the course, students will be able to

CO1	Understand a topic of latest developments/innovative technology.	Understand
CO2	Apply the knowledge to prepare a dissertation report on this topic.	Apply
CO3	Deliver a lecture on the topic on power point format.	Evaluate
CO4	Improve the communication skill of the students.	Evaluate
CO5	Analyze environment and sustainability of related technology	Analyze

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3			1		2	3					3	3	3
CO2	3	2	2	1	1	2	3			3	2	3	3	3
CO3	3									3		3	3	3
CO4	3									3		3	3	3
CO5	3	2				2	3					3	3	3
Total	**3**	**2**	**2**	**1**	**1**	**2**	**3**			**3**	**2**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

DISSERTATION-I

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	**NBE 609**	**8**	**0**	**0**	**16**	**-**	**50**	**-**	**50**	**50**	**100**

OBJECTIVE: The objective of this course is to enable the students

- to identify a biochemical product and industrial plant design for its production involving experimental studies.
- to prepare a feasibility report for a project based on manufacturing of product.
- to present a lecture on the topic on power point format.
- to improve the communication skill of the students.

Course Outcome

On the successful completion of the course, students will be able to

CO1	Understand a topic of latest developments/innovative technology.	**Understand**
CO2	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	**Apply**
CO3	Deliver a lecture on the topic on power point format.	**Evaluate**
CO4	Improve the communication skill of the students.	**Evaluate**
CO5	Analyze environment and sustainability of related technology	**Analyze**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3			1		3	3		3			3	3	3
CO2	3	2	2	1	1	3	3		3	3	3	3	3	3
CO3										3		3	3	3
CO4							3			3		3	3	3
CO5						3	3		3			3	3	3
Total	**3**	**2**	**2**	**1**	**1**	**3**	**3**		**3**	**3**	**3**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

DISSERTATION-II

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	NBE 602	16	0	0	32	-	50	-	50	50	100

OBJECTIVE:

- The students select a topic and does research oriented experimental work. Base on experimental studies the students submits thesis which is evaluated by external expert for award of marks and degree.

Course Outcome

On the successful completion of the course, students will be able to

CO1	Understand a topic of latest developments/innovative technology.	**Understand**
CO2	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	**Apply**
CO3	Deliver a lecture on the topic on power point format.	**Evaluate**
CO4	Improve the communication skill of the students.	**Evaluate**
CO5	Analyze environment and sustainability of related technology	**Analyze**

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3			1		3	3		3			3	3	3
CO2	3	2	2	1	1	3	3		3	3	3	3	3	3
CO3										3		3	3	3
CO4							3			3		3	3	3
CO5						3	3		3			3	3	3
Total	3	2	2	1	1	3	3		3	3	3	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*