GOVERNMENT COLLEGE OF TECHNOLOGY, COIMBATORE – 641 013

B.Tech. INDUSTRIAL BIOTECHNOLOGY (FULL TIME)

2018A REGULATIONS : VERTICALS CURRICULA AND SYLLABI

S. No.	Vertical I Medical Biotechnology	Vertical II rDNA Technology	Vertical III Bioprocess Technology	Vertical IV Quality and Regulatory Affairs	Vertical V Biosciences
1.	18BPE$16 Immunotechnology	18BPE$13 Genomics and Proteomics	18BPE$28 Aspects of Biochemical Engineering	18BPE$34 Clinical trials and health care policies in Biotechnology	18BPE$42 Human Anatomy and Physiology
2.	18BPE$25 Neurobiology and cognitive sciences	18BPE$20 Metabolic Engineering	18BPE$29 Fermentation Technology	18BPE$35 Biotechnological products and its validation	18BPE$43 Bioethics
3.	18BPE$10 Molecular Pathogenesis	18BPE$07 Plant Biotechnology	18BPE$04 Food Process Engineering	18BPE$36 Quality assurance and quality control in Biotechnology	18BPE$44 Biomass and Bioenergy (NPTEL)
4.	18BPE$08 Cancer Biology	18BPE$12 Animal Biotechnology	18BPE$30 Bioreactor design and scale up process	18BPE$37 Entrepreneurship and patent design	18BPE$09 Environmental Biotechnology
5.	18BPE$17 Biopharmaceutical Technology	18BPE$21 Protein Engineering	18BPE$31 Solid State Bioprocessing	18BPE$38 Intellectual property rights in Biotechnology	18BPE$02 Biopolymer technology
6.	18BPE$19 Tissue Engineering	18BPE$06 Marine Biotechnology	18BPE$32 Bio process control and instrumentation	18BPE$39 Biosafety and Hazard management	18BPE$11 Nanobiotechnology
7.	18BPE$26 Molecular forensics	18BPE$22 Pharmacogenomics	18BPE$33 Bioprocess modelling and simulation	18BPE$40 Conservation economics (NPTEL)	18BPE$45 Biomass conversion and Biorefinery (NPTEL)
8.	18BPE$27 Medicinal chemistry (NPTEL)	18BPE$23 Genetics	18BPE$18 Bioprocess economics and plant design	18BPE$41 Chemical Process safety (NPTEL)	18BPE$46 Introduction to Biostatistics

GOVERNMENT COLLEGE OF TECHNOLOGY, COIMBATORE – 641 013

B.Tech. INDUSTRIAL BIOTECHNOLOGY (FULL TIME)

VERTICAL-I:MEDICAL BIOTECHNOLOGY

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	18BPE$16	Immunotechnology	PE	40	60	100	3	0	0	3
2	18BPE$25	Neurobiology and cognitive sciences	PE	40	60	100	3	0	0	3
3	18BPE$10	Molecular Pathogenesis	PE	40	60	100	3	0	0	3
4	18BPE$08	Cancer Biology	PE	40	60	100	3	0	0	3
5	18BPE$17	Biopharmaceutical Technology	PE	40	60	100	3	0	0	3
6	18BPE$19	Tissue Engineering	PE	40	60	100	3	0	0	3
7	18BPE$26	Molecular forensics	PE	40	60	100	3	0	0	3
8	18BPE$27	Medicinal chemistry (NPTEL)	PE	40	60	100	3	0	0	3

VERTICAL-II :rDNA TECHNOLOGY

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	18BPE$13	Genomics and Proteomics	PE	40	60	100	3	0	0	3
2	18BPE$20	Metabolic Engineering	PE	40	60	100	3	0	0	3
3	18BPE$07	Plant Biotechnology	PE	40	60	100	3	0	0	3
4	18BPE$12	Animal Biotechnology	PE	40	60	100	3	0	0	3
5	18BPE$21	Protein Engineering	PE	40	60	100	3	0	0	3
6	18BPE$06	Marine Biotechnology	PE	40	60	100	3	0	0	3
7	18BPE$22	Pharmacogenomics	PE	40	60	100	3	0	0	3
8	18BPE$23	Genetics	PE	40	60	100	3	0	0	3

VERTICAL-III :BIOPROCESS TECHNOLOGY

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	18BPE$28	Aspects of Biochemical Engineering	PE	40	60	100	3	0	0	3
2	18BPE$29	Fermentation Technology	PE	40	60	100	3	0	0	3
3	18BPE$04	Food Process Engineering	PE	40	60	100	3	0	0	3
4	18BPE$30	Bioreactor design and scale up process	PE	40	60	100	3	0	0	3
5	18BPE$31	Solid State Bioprocessing	PE	40	60	100	3	0	0	3
6	18BPE$32	Bio process control and instrumentation	PE	40	60	100	3	0	0	3
7	18BPE$33	Bioprocess modelling and simulation	PE	40	60	100	3	0	0	3
8	18BPE$18	Bioprocess economics and plant design	PE	40	60	100	3	0	0	3

VERTICAL-IV :QUALITY AND REGULATORY AFFAIRS

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	18BPE$34	Clinical trials and health care policies in Biotechnology	PE	40	60	100	3	0	0	3
2	18BPE$35	Biotechnological products and its validation	PE	40	60	100	3	0	0	3
3	18BPE$36	Quality assurance and quality control in Biotechnology	PE	40	60	100	3	0	0	3
4	18BPE$37	Entrepreneurship and patent design	PE	40	60	100	3	0	0	3
5	18BPE$38	Intellectual property rights in Biotechnology	PE	40	60	100	3	0	0	3
6	18BPE$39	Biosafety and Hazard management	PE	40	60	100	3	0	0	3
7	18BPE$40	Conservation economics (NPTEL)	PE	40	60	100	3	0	0	3
8	18BPE$41	Chemical Process safety (NPTEL)	PE	40	60	100	3	0	0	3

VERTICAL-V :BIOSCIENCES

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	18BPE$42	Human Anatomy and Physiology	PE	40	60	100	3	0	0	3
2	18BPE$43	Bioethics	PE	40	60	100	3	0	0	3
3	18BPE$44	Biomass and Bioenergy (NPTEL)	PE	40	60	100	3	0	0	3
4	18BPE$09	Environmental Biotechnology	PE	40	60	100	3	0	0	3
5	18BPE$02	Biopolymer technology	PE	40	60	100	3	0	0	3
6	18BPE$11	Nanobiotechnology	PE	40	60	100	3	0	0	3
7	18BPE$45	Biomass conversion and Biorefinery (NPTEL)	PE	40	60	100	3	0	0	3
8	18BPE$46	Introduction to Biostatistics	PE	40	60	100	3	0	0	3

VERTICAL-I

MEDICAL BIOTECHNOLOGY

18BPE$16	IMMUNOTECHNOLOGY

Category: PE

PRE-REQUISITES:
1. Immunology

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To find therapeutical solutions to health problems based on immunological principles
2. To demonstrate use of various diagnostic kits to identify antigens at cellular and tissue levels
3. To develop strategies to produce engineered immune molecules.

UNIT – I: ANTIGENS	**(9 Periods)**
Types of antigens, preparation of antigens for raising antibodies, handling of animals, adjuvants and their mode of action.	
UNIT – II : ANTIBODIES & IMMUNODIAGNOSIS	**(9 Periods)**
Monoclonal and polyclonal antibodies – production, Western blot analysis, immunoelectrophoresis, SDS-PAGE - purification and synthesis of antigens, ELISA-principle and applications, radio immuno assay (RIA) – principles and applications, non isotopic methods of detection of antigens-enhanced chemiluminescence assay.	
UNIT – III : ASSESMENT OF CELL MEDIATED IMMUNITY	**(9 Periods)**
Identification of lymphocytes and their subsets in blood using flow cytometry. Estimation of cytokines, macrophage activation, macrophage microbicidal assay, in-vitro experimentation to understand the pathogenesis and defense mechanisms.	
UNIT – IV : IMMUNOPATHOLOGY	**(9 Periods)**
Preparation and storage of tissues, identification of various cell types and antigens in tissues, isolation and characterization of cell types from inflammatory sites and infected tissues, immunocytochemistry –immunofluoresecence, immunoenzymatic technique, immuno electron microscopy.	
UNIT – V : MOLECULAR IMMUNOLOGY	**(9 Periods)**
Preparation of vaccines, application of recombinant DNA technology for the study of the immune system, production of anti idiotypic antibodies, catalytic antibodies, application of PCR technology to produce antibodies and other immune molecules, immunotherapy with genetically engineered antibodies – Tetramer.	

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Talwar G.P., and Gupta S.K., **"A hand book of practical and clinical immunology"**, vol. 1 & 2, CBS Publications,1992.*
2. *MRoitt I., Male., Brostoff,**"Immunology"**, Mosby Publ., 12th edition, 2002.*
3. *Rose, N.R., Hamilton, R.G. and Detrick, B, **"Manual of Clinical laboratory Immunology"**, 6th edition., ASM Press, Washington DC, 2002.*

REFERENCE BOOKS:

1. *Chakaravarthy A.K., **"Immunology and Immunotechnology"**, Oxford University Press Indid, 1st edition, 2006.*
2. *Goldsby R.A., Kindt T.J., Osbome B.A. and Kuby J. **"Immunology"**, 5th edition,W.H. Freeman,2003*
3. *Weir D.M. and Stewart J, **"Immunology"**, 8th edition, Cheerchill, Linvstone, 1997.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Describe the preparation and use of antigens
CO2: Demonstrate various diagnostic methods based on antigen-antibody interactions
CO3: Critically analyze and assess health problems with immunological background
CO4: Outline the state of pathogenesis of infectious diseases at cellular and tissue level based on immunopathology
CO5: Define strategies for the production of engineered antibodies and design ofvaccines.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	-	-	L	-	-	-	-	-	L	-	M	L
CO2	L	M	H	-	M	L	-	L	M	M	L	M	M	M
CO3	L	L	-	-	-	-	-	-	-	M	-	-	L	H
CO4	L	M	-	-	L	L	M	-	-	M	L	-	M	H
CO5	L	M	H	L	M	H	-	-	L	M	H	M	M	M
18BPE $16	L	M	H	L	M	L	M	L	M	M	L	M	M	H

L - Low, M-Moderate (Medium), H- High

18BPE$25	NEUROBIOLOGY AND COGNITIVE SCIENCES

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To provide an understanding on the fundamentals on neuronal systems, neuronal drugs and on how the brain responds and adapts to changing environments and outline of their mechanism of action.
- To learn the fundamental relationships among neural activity, drug therapy, cognition and behavior.

UNIT – I :NEUROANATOMY	**(9)**
Classification of central and peripheral nervous system;Structure and function of neurons; type of Neurons; Synapses; Glial cells; Myelination;Brief anatomy of Brain andSpinalcord Blood Brain barrier;Meninges and Cerebrospinal fluid; Spinal Cord; Neural Development.	
UNIT – II : NEUROPHYSIOLOGY	**(9)**
Resting and action potentials; Mechanism of action potential conduction; Voltage dependent channels - sodium and potassium channels; nodes of Ranvier;Chemical and electrical synaptic transmission; information representation and coding by neurons.	
UNIT – III :NEUROPHARMACOLOGY	**(9)**
Classification of neurotransmittersand their mechanism of action: acetyl choline,serotonin, dopamine and -amino butyric acid (GABA); Peptide transmitters: mechanism of action;Nicotinic and muscarinic acetyl choline receptors;hormones and their effect on neuronal function.	
UNIT – IV : APPLIED NEUROBIOLOGY	**(9)**
Basic mechanisms of sensations like touch, pain, smell and taste; neurological mechanisms of vision and audition; skeletal muscle contraction.	
UNIT – V : BEHAVIOUR AND COGNITIVE SCIENCE	**(9)**
Basic mechanisms associated with motivation; control of feeding, sleep, hearing and memory; Disorders associated with the nervous system - Parkinson's disease, Alzheimer's disease, chizoprenia, Epilepsy; Anxiety and mooddisorders - Depression, Agrophobia.	

Contact Periods: 45

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Dale Purves, George J. Augustine, David Fitzpatrick, W illiam C. Hall,"Neuroscience", Oxford university press, sixth edition, 2018.*
2. *Striedter, G. F, " Neurobiology: a functional approach", Oxford University press, 2016.*

REFERENCE BOOKS:

1. GondonM.Shepherd***"Neurobiology"***, Oxford University Press, Third edition, 1994.
2. Mark F. Bear, Barry W. Connors, MichaelA. Paradiso, ***"Neuroscience: Exploring the Brain"***, Lippincott Williams and Wilkins, Fourth Edition, 2015.
3. Squire, L., Berg, D., Bloom, F.E., du Lac, S., Ghosh, A., Spitzer, N.C, ***"Fundamental Neuroscience"***, UK: Academic Press, Fourth edition, 2012.
4. Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, Steven A. Siegelbaum, A. J. Hudspeth, ***"Principles of Neural Science"***, McGraw Hill / Medical, Fifth Edition, 2012.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Comprehend the central and peripheral nervous system, and describe the structure and functions of neurons and supporting cells

CO2: Analyze the functioning of voltage-dependent channels and conduction mechanism

CO3: Understand the concept of synaptic transmission and the working detailsof various neurotransmitters.

CO4: Evaluate the mechanism of sensations and skeletal muscle contraction

CO5: Fathom the fundamental concepts behind behavioural science and associated disorders.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	-	-	-	-	-	-	-	-	-	-	L	L
CO2	L	L	-	-	-	-	-	-	-	-	-	-	L	L
CO3	L	L	-	-	-	-	-	-	-	-	-	-	L	L
CO4	L	L	-	-	-	-	-	-	-	-	-	-	L	L
CO5	L	L	-	-	-	-	-	-	-	-	-	-	L	L
18BPE$25	L	L	-	-	-	-	-	-	-	-	-	-	L	L

L - Low, M-Moderate (Medium), H- High

18BPE$10	MOLECULAR PATHOGENESIS

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Microbiology
2. Immunology

COURSE OBJECTIVES:

- To understand the principles of microbial pathogenesis, clinical importance of specific pathogens.
- To inculcate knowledge on recent outbreaks and their disease transmission.
- To understand the recent techniques to study the pathogens.

UNIT – I : BASICS OF MICROBIOLOGY AND IMMUNOLOGY	**(9 Periods)**
Louis Pasteur's contributions - Robert Koch's postulates - early discoveries of microbial toxins, Vaccines and Antibiotics - Attributes & components of microbial pathogenesis, Host natural defense mechanism - humoral and cellular defense mechanisms – complements - inflammation process - general disease symptoms – Pathogen resistance to the defense mechanisms.	
UNIT – II : PATHOGENESIS OF DISEASES	**(9 Periods)**
Virulence factors - gene regulation in virulence of pathogens - labile & stable toxins; Vibrio Cholera - Cholera toxin - E.coli pathogens: - ETEC – EPEC - EHEC - EIEC Hemolytic Uremic Syndrome - Shigella toxin - Plasmodium Life cycle - Antimalarials based on transport processes - Influenza virus - action of amantidine.	
UNIT – III : RECENT DISEASE OUTBREAKS	**(9 Periods)**
Clinical features and molecular mechanism of pathogenesis- Superficial mycoses- Dermatophytes- Intracellular stage-H1N1; HIV- Disease transmission of Chickengunya – Dengue.	
UNIT – IV : EXPERIMENTAL STUDIES ON HOST PATHOGEN INTERACTIONS	**(9 Periods)**
Virulence assays; cytopathic - cytotoxic effects. Criteria and tests in identifying virulence factors - attenuated mutants - signal transduction and host responses.	
UNIT – V : MODERN APPROACHES TO CONTROL PATHOGENS	**(9 Periods)**
Serotyping - Immuno and DNA based techniques - New therapeutic strategies based on life threatening pathogens - Vaccines - DNA, subunit and cocktail vaccines. Modern diagnosis based on highly conserved virulence factors.	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Iglewski B.H and Clark V.L **"Molecular basis of Bacterial Pathogenesis"**, Academic Press, 1990.*
2. *Peter Williams, Julian Ketley& George Salmond, **"Methods in Microbiology:Bacterial Pathogenesis"**, Vol. 27, Academic Press, 1998.*
3. *Talaron K, Talaron A, Casita, Pelczar and Reid, **"Foundations in Microbiology"**, W.C. Brown Publishers, 1993.*

REFERENCE BOOKS:

1. *Recent reviews in Infect. Immun., Mol. Microbiol., Biochem. J., EMBO etc*
2. *Nester, Anderson, Roberts, Pearsall, Nester, **"Microbiology: A Human Perspective"**, Mc Graw Hill, 3rd Edition, 2001.*
3. *Eduardo A. Groisman, **"Principles of Bacterial Pathogenesis"**, Academic Press, 2001.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To understand the basics of microbiology and the discovery.
CO2: To know how to analyze pathological condition in molecular level.
CO3: To acquire knowledge on the pathogenesis of recent outbreaks.
CO4: To learn basic molecular biology and experimental skills.
CO5: To Study the modern approaches to control pathogens.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	M	-	-	L	-	L	-	-	-	-	H	L
CO2	L	-	M	-	L	M	-	-	-	-	-	-	L	M
CO3	H	L	M	-	M	M	-	-	-	-	-	-	M	M
CO4	M	L	L	-	H	L			-	-	-	-	M	H
CO5	L	L	L	-	H	L			-	-	-	-	M	L
18BPE $10	M	L	M	-	H	L		L	-	-	-	-	M	M

L - Low, M-Moderate (Medium), H- High

18BPE$08	CANCER BIOLOGY

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Cell Biology
2. Molecular Biology

COURSE OBJECTIVES:

- To gain an appreciation of the complexity of cancer development process in cellular and molecular level.
- To understand the regulatory networks involved in the growth control and tissue organization.
- To understand the current strategies of cancer diagnosis, prevention and treatment.

UNIT – I : FUNDAMENTALS OF CANCER BIOLOGY	**(9 Periods)**
Epidemiology of cancer: Environmental factors, Viruses, Life style habits, Mutations and DNA repair. Regulation of cell cycle, Modulation of cell cycle in cancer:pRb, p53. Classification of cancer forms and hallmarks of cancers.	
UNIT – II : PRINCIPLES OF CARCINOGENESIS	**(9 Periods)**
Theory of carcinogenesis, Chemical carcinogenesis, Physical carcinogenesis; X-ray radiation: mechanisms of radiation carcinogenesis. Mutations that cause changes in signal molecules. Genetic basis of cancer: DNA repair.	
UNIT – III : PRINCIPLES OF MOLECULAR CELL BIOLOGY OF CANCER	**(9 Periods)**
Cyclin dependent kinases, Tumor suppressor genes, Oncogenes, Virus and cancers: DNA viruses, Retroviruses. Signalling Pathways: GPCR, RAS, JAK-STAT, Wnt-β-Catenin, Notch, Hedgehog, Myc, NF-κB. Growth factors related to transformation, Telomerases, Apoptosis: p53.	
UNIT – IV : PRINCIPLES OF CANCER METASTASIS	**(9 Periods)**
Clinical significances of invasion, Three step theory of invasion, Proteinases and tumour cell invasion. Angiogenesis: VEGF signaling.	
UNIT – V : CANCER DETECTION AND THERAPY	**(9 Periods)**
Cancer screening and early detection, Detection using biochemical assays, Tumor markers. Advances in cancer detection. Different forms of therapy- Chemotherapy, Radiation therapy, Immunotherapy, Molecular therapy, Use of signal targets towards therapy of cancer; Gene therapy.	

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Stella Pelengaris, Michael Khan, **"The Molecular Biology of Cancer"**, Blackwell Publishing 1st edition, 2006.*
2. *Robert A. Weinberg, **"The Biology of Cancer",** Garland Science, 2nd edition, 2014.*

REFERENCE BOOKS:

1. *R. W. Ruddon, "**Cancer Biology**", Oxford, Oxford University Press, 2007.*
2. *C. Athena Aktipis, Randolph M Nesse, **"Evolutionary foundations for cancer biology",**Evol Appl. 2013 January; 6(1): 144–159.*

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO 1: Understand the epidemiology of carcinogenesis.

CO2: Understand the complex pathways and molecular switches involved in the transformation of a normal cell to a cancer cell.

CO 3: Understand the stages of cancer leading to the movement of cancer cells throughout the body.

CO 4: Develop knowledge on the current strategies of cancer diagnosis and treatment.

CO5: Summarize the importance of understanding cell biology in the study of cancer, its causes, its progression and its treatment

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	-	-	L	L	-	-	-	-	-	L	L	L
CO2	-	-	-	L	L	-	-	-	-	-	-	-	H	M
CO3	-	-	-	L	L	-	-	-	-			-	L	M
CO4	-	H	-	-	-	M	H	H	H	-	-	-	L	H
CO5	-	M	M	-	-	-	H	L	H	-	-	-	L	H
18BPE $08	L	H	M	L	L	M	H	H	H	-	-	L	L	H

L – Low, M – Moderate (Medium), H – High

18BPE$17	BIOPHARMACEUTICAL TECHNOLOGY

Category: PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To provide foundation and inform biopharmaceutical aspects in drug development.
- To gain knowledge in physiochemical properties, pharmacology and formulation of biopharmaceuticals.
- To learn the procedures in drug manufacturing and delivery systems.

UNIT – I : INTRODUCTION	**(9 Periods)**
Pharmaceutical industry & development of drugs, Historical perspective of Biopharmaceutics, types of therapeutic agents , Generics and its advantages, Drugs and cosmetic act and regulatory aspects.	
UNIT – II : DRUG ACTION, METABOLISM AND PHARMACOKINETICS	**(9 Periods)**
Mechanism of drug action, physico-chemical principles of drug metabolism, barriers to distribution of drugs, pharmacokinetics. (ADME), pharmacokinetics - Zero, First, Second order reactions, compartment modeling, kinetics of protein – drug binding, bioavailability and bioequivalence, Biotransformation of drugs, Prodrugs.	
UNIT – III : DOSAGE FORMS	**(9 Periods)**
Classification of dosage forms (solid unit dosages – Tablets- types, manufacture and coating, capsules – preparation and coating; liquids – solutions, suspension; semi-solid – ointments, pastes, suppositories - laxatives; Parenterals), Analytical methods in drug product analysis, packing techniques, Radiopharmaceuticals.	
UNIT – IV : BIOPHARMACEUTICAL PRODUCT DEVELOPMENT	**(9 Periods)**
Reaction process for bulk drug manufacture - Penicillin, Streptomycin, Vitamins A, B12, cancer vaccines, antibodies, Insulin, Interferons, recombinant proteins – streptokinase, Asparginase and growth hormones-Gonadotrophins, Erythropoietin.	
UNIT – V : DRUG DELIVERY	**(9 Periods)**
Design and pharmacokinetic principles of controlled drug delivery systems, Oral, Parenteral controlled release systems, Transdermal, Ophthalmic drug delivery systems.	

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Gary Walsh, **"Pharmaceutical Biotechnology: Concepts and Applications"**, John Wiley and Sons, Fourth edition,2007*
2. *Remington's, **"Pharmaceutical Sciences"** Mark publishing.*
3. *Leon Lachman et al, **"Theory and Practice of Industrial Pharmacy"**, Lea and Febiger, 3 Edition,1986.*

REFERENCE BOOKS:

1. *Gareth Thomas.* ***"Medicinal Chemistry"****. An introduction. John Wiley. 2000.*
2. *Katzung B.G.* ***"Basic and Clinical Pharmacology"****, Prentice Hall of Intl. 1995.*
3. *Leon Lachman et al,* ***"Theory and Practice of Industrial Pharmacy"****, 3 Edition, Lea and Febiger, 1986.*
4. *Brahmankar D M, Jaiswal S B,* ***"Biopharmaceutics and Pharmacokinetics A Treatise"****, Vallabh Publisher, (2008)*

COURSE OUTCOMES

Upon completion of the course in Biopharmaceutical Technology graduates will be able to

CO1: Perceive the pharmacological terms and drug development and its regulation.

CO2: Interpret the basic concepts of pharmacokinetics and drug metabolism.

CO3: Understand the forms of dosage, packing and contaminant analysis.

CO4: Enlighten the process involved in bulk drug manufacturing.

CO5: Discuss novel methods for production and delivery of biopharmaceuticals.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	M	L	H	L	-	-	M	-	L	H	H	L
CO2	L	H	L	-	L	L	-	-	H	-	L	-	L	H
CO3	-	H	H	L	M	-	-	-	-	-	M	L	L	H
CO4	L	L	-	-	H	-	-	-	M	-	M	M	H	L
CO5	L	H	H	L	M	M	-	-	H	-	L	L	L	M
18BPE $17	L	H	H	L	M	L	-	-	H	-	L	L	L	H

L - Low, M-Moderate (Medium), H – High

18BPE$19	TISSUE ENGINEERING

Category: PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To learn the fundamentals of tissue engineering and tissue repairing
- To acquire knowledge on clinical applications of tissue engineering
- To understand the basic concept behind tissue engineering focusing on the stem cells, Bio materials and its applications.

UNIT – I : INTRODUCTION	**(9 Periods)**
Introduction to tissue engineering: Basic definition; current scope of development; use in therapeutics, cells as therapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology, number viability, motility and functions. Measurement of tissue characteristics, appearance, cellular component, ECM component, mechanical measurements and physical properties.	
UNIT – II : TISSUE ARCHITECTURE	**(9 Periods)**
Tissue types and Tissue components, Tissue repair, Engineering wound healing and sequence of events. Basic wound healing Applications of growth factors: VEGF/angiogenesis, Basic properties, Cell-Matrix& Cell-Cell Interactions, telomeres and Self-renewal, Control of cell migration in tissue engineering.	
UNIT – III : BIO MATERIALS	**(9 Periods)**
Biomaterials: Properties of biomaterials,Surface, bulk, mechanical and biological properties. Scaffolds & tissue engineering, Types of biomaterials, biological and synthetic materials, Biopolymers, Applications of biomaterials, Modifications of Biomaterials, Role of Nanotechnology.	
UNIT – IV : BASIC BIOLOGY OF STEM CELLS	**(9 Periods)**
Stem Cells: Introduction, hematopoietic differentiation pathway Potency and plasticity of stem cells, sources, embryonic stem cells, hematopoietic and mesenchymal stem cells, Stem Cell markers, FACS analysis, Differentiation,Stem cell systems- Liver, neuronal stem cells, Types & sources of stem cell with characteristics: embryonic, adult, haematopoetic, fetal, cord blood, placenta, bone marrow, primordial germ cells, cancer stem cells induced pleuripotent stem cells.	
UNIT – V : CLINICAL APPLICATIONS	**(9 Periods)**
Stem cell therapy, Molecular therapy, In vitro organogenesis, Neurodegenrative diseases, spinal cord injury, heart disease, diabetes, burns and skin ulcers, muscular dystrophy, orthopedicapplications, Stem cells and Gene therapy Physiological models, issue engineered therapies, product characterization, components, safety, efficacy. Preservation –freezing and drying. Patent protection and regulation of tissue-engineered products, ethical issues.	

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

*1. Bernhard O.Palsson, SangeetaN.Bhatia, **"Tissue Engineering"**, Pearson Publishers 2009.*
*2. Meyer, U.; Meyer, Th.; Handschel, J.; Wiesmann, H.P., **"Fundamentals of Tissue Engineering and Regenerative Medicine"**, 2009.*

REFERENCE BOOKS:

1. *Bernard N. Kennedy (editor)., **"Stem cell transplantation, tissue engineering, and cancer applications"**, Nova Science Publishers, 2008.*
2. *Raphael Gorodetsky, Richard Schäfer., **"Stem cell-based tissue repair"**, RSC Publishing, 2011.*
3. *R. Lanza, I. Weissman, J. Thomson, and R. Pedersen, **"Handbook of Stem Cells", Two Volume, Volume 1-2: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells**, Academic Press, 2004.*
4. *R. Lanza, J. Gearhart etal (Eds), **"Essential of Stem Cell Biology"**, Elsevier Academic press, 2006.*
5. *J. J. Mao, G. Vunjak-Novakovic et al (Eds), **"Translational Approaches In Tissue Engineering &Regenrative Medicine"**, Artech House, INC Publications, 2008.*
6. *Naggy N. Habib, M.Y. Levicar, , L. G. Jiao,.and N. Fisk, **"Stem Cell Repair and Regeneration"**, volume-2, Imperial College Press,2007.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Ability to understand the components of the tissue architecture.
CO2: Opportunity to get familiarized with the stem cell characteristics and their relevance inmedicine.
CO3: Awareness about the properties and broad applications of biomaterials.
CO4: Overall exposure to the role of tissue engineering and stem cell therapy in Organogenesis.
CO5: Understand the role of tissue engineering and materials in clinical applications.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	-	-	-	-	L	M	M	M	M	-	M	H	L
CO2	L	M	-	-	-	L	M	M	M	M	-	M	H	L
CO3	H	L	-	-	-	M	H	M	M	M	-	M	H	M
CO4	M	L	-	-	-	-	H	M	M	M	-	M	H	L
CO5	M	-	H	M	M	H	H	H	H	M	-	M	H	H
18BPE $19	M	-	M	-	-	H	M	M	L	M	-	M	H	L

L - Low, M-Moderate (Medium), H- High

18BPE$26	MOLECULAR FORENSICS

Category: PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To enable the students to understand the importance of molecular biology tools in the field of forensic science.
- To emphasize the role of various analytical tools used for the analysis of a diversity of samples.
- To examine samples such as hair, fiber and interpret the results efficiently.
- To understand the role of toxicology in the analysis of various types of samples.
- To learn about the metabolism of a toxicants in a human system.

UNIT – I	BASIC MOLECULAR BIOLOGY	(9 Periods)
The structure of DNA, source of DNA sample, extraction, profiling, Restriction Fragment Length Polymorphism, Polymerase Chain Reaction, Short Tandem Repeat Markers, Single Nucleotide Polymorphism markers, Determination of ethnicity, Determination of physical appearance, Determination of personality traits, mitochondrial DNA, RNA and DNA database.		
UNIT – II	**GENERAL FORENSIC TOOLS AND TECHNIQUES**	**(9 Periods)**
Need of Instrumentation in Forensic Science, Qualitative and quantitative methods of analysis, Destructive and Non-Destructive Methods, Centrifuge Techniques: Centrifugation Techniques, Basic principles of sedimentation, Microscopy: Theory and basic principles, setup and Forensic applications of Chromatography.		
UNIT – III	**FORENSIC EXAMINATION OF SAMPLES**	**(9 Periods)**
Hair: Importance, nature, location, structure, growth phases of hair, collection, evaluation and tests for their identification, variation in different major population groups, somatic origin. Fiber Examination: Introduction, Classification, Fiber transfer and persistence. Microscopic Examination of samples.		
UNIT – IV	**ANALYTICAL FORENSIC TOXICOLOGY**	**(9 Periods)**
Samples required in Toxicological analysis:Classes of samples (Biological and Non-biological), Methods of sample collection (Living and Dead person). Alternative specimens: Hair analysis, Drugs in oral fluid, Detection of drugs in sweat etc., Analysis of Exhumed and decomposed bodies.Alcohol Intoxication & analysis: Properties and types of Alcohols, Pharmacology, Toxic properties and effects of alcohol. Chemical tests for alcohol in blood and urine, Gaseous and Food poisoning.		
UNIT – V	**FORENSIC PHARMACOLOGY**	**(9 Periods)**
Toxicokinetics: Overall Drug Disposition, Absorption, Bioavailability, First-Pass Metabolism, Distribution of Free and Bound Drugs, Biotransformation: Phase-I and Phase-II reactions. Detection of poison on the basis of their Metabolic studies, Toxicants-Distribution and Metabolism of Toxicants in the body, Measuring Toxicity:Qualitative Descriptions of Toxicity Exposure Limits Determination of LD50 and ED50, Units in Toxicology.		

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Max M Houck.**"Forensic Chemistry (Advanced Forensic Science Series)",** Elsevier,2015.*
2. *W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher. "**Techniques of Crime Scene Investigation'**, CRC Press, Boca Raton, 2013.*

REFERENCE BOOKS:

1. *R. Saferstein, **"Criminalistics: An Introduction to Forensic Science"**, 8th Edition, Prentice Hall, New Jersey, 2011.*
2. *S.B. Karch, "**The Pathology of Drug Abuse"**, CRC Press, Boca Raton, 1996.*
3. *Levine Barry, "**Principles of Forensic Toxicology"**, AACC Press, 2nd Edn., 2006.*
4. *S.H James and J.J Nordby, "**Forensic Science: An introduction to scientific and Investigative Techniques**", 2nd Edition, CRC Press, 2005.*

COURSE OUTCOMES:

Upon completion of the course, the students will be able to:

CO1: Apply the knowledge gained in the molecular biology and genetic engineering in crime scene investigations.

CO2: Appreciate the role of various analytical instruments in the field of forensics.

CO3: Understand the significance and handling of samples such as hair and fiber.

CO4: Know about toxicology and poisons

CO5: Understand the metabolism of toxicants in a human body.

COURSE ARTICULATION MATRIX :

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	0	M	0	0	0	L	0	0	0	L	0	0
CO2	0	0	L	0	0	0	0	0	L	M	0	L	0	0
CO3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO5	L	0	0	0	0	M	0	0	0	0	0	0	0	0
18BPE$26	M	L	L	M	0	M	0	L	L	M	0	M	0	0

L – Low, M – Moderate (Medium), H – High

18BPE$27	MEDICINAL CHEMISTRY

PRE-REQUISITIES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To familiarize with different types of drug targets.
- To understand the synthetic methods for drug and approaches for drug discovery.
- To understand the relationship between structure and activity of drugs
- To understand the drug metabolism and the concept of prodrugs& drug delivery

UNIT – I : INTRODUCTION TO DRUG TARGETS	**(9 Periods)**
An overview of drugs and drug targets. intermolecular binding forces; classification of drugs, Enzymes as drug targets, drug-receptor interaction; dose-response curves, ; DNA Interactive agents and chemotherapy: DNA binding agents; intercalation and alkylation; DNA strand breakers	
UNIT – II : COMBINATORIAL CHEMISTRY AND DRUG DISCOVERY	**(9 Periods)**
Synthetic methods in medicinal chemistry: Combinatorial and parallel synthesis: solid phase techniques, mix and split method in combinatorial synthesis; Lead discovery; Bioassays; drug targets; Lead Modification; optimization; Pharmacophore; Homologation; Bioisostere; chain branching	
UNIT – III : STRUCTURE ACTIVITY RELATIONSHIP	**(9 Periods)**
Electronic effects; Lipophilicity; Structure-Activity Relationships; Quantitative-Structure activity relationships (QSAR).	
UNIT – IV : DRUG METABOLISM	**(9 Periods)**
Drug metabolism and pharmacology: Analytical methods in metabolism; Phase I and II transformations; ADME; bioavailability; pre-clinical and clinical development; therapeutic index and therapeutic window.	
UNIT – V : PRODRUG AND DRUG DELIVERY	**(9 Periods)**
Prodrugs and drug delivery systems: Use of prodrug systems; prodrugs for stability, solubility and slow release; overview of drug delivery, Drug resistance mechanisms and synergism: Mechanisms of drug resistance; circumventing drug resistance; drug synergy	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1.*Kluvver and Williams, 2013, Foye's* ***'Principles of Medicinal Chemistry'****, Seventh edition*

2. Gareth Thomas, 2003, ***'Fundamentals of Medicinal Chemistry'****, Wiley*

REFERENCE BOOKS:

1.*H.JohnSmith,Hywell Williams,2005****, 'Introduction to principles of drug design and action'****, CRC Press*

2.Linda Felton,2013, Remington's ***'Essentials of Pharmaceutics'****, Pharmaceutical press.*

COURSE OUTCOMES:
Upon completion of the course the students will be able to

CO1: Familiarized with the different types of drug targets.
CO2: Understand the synthetic methods for drug synthesis and basics of drug discovery
CO3: Understand the relationship of structure-activity relationship of drugs
CO4: Understand the different stages of drug metabolism
CO5: Understand the concept of prodrugs and drug delivery

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	M	-	L	-	-	M	-	-	-	-	-	L	M	-
CO2	H	M	M	L	L	M	-	L	L	-	-	-	M	-
CO3	H	M	L	L	M	L	-	-	-	L	-	L	-	M
CO4	L	-	-	M	-	H	-	-	-	-	-	-	L	-
CO5	-	L	-	-	-	M	L	-	-	-	L	L	M	L
18BPE$ 27	M	M	L	L	M	M	L	L	L	L	L	L	-	-

L - Low, M-Moderate (Medium), H- High

VERTICAL-II

rDNA TECHNOLOGY

18BPE$13	GENOMICS AND PROTEOMICS

PRE-REQUISITIES:

1. Cell Biology
2. Molecular Biology
3. Genetic Engineering

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Provide basic knowledge of genomes and proteomes.
- Introduce relevant tools for the analysis of genomes.
- Describe methodologies of genomic and proteomic techniques.

UNIT – I : OVERVIEW OF GENOMES OF BACTERIA, ARCHAEA AND EUKARYOTA	**(9 Periods)**
Genome organization of prokaryotes and eukaryotes, Gene structure of Bacteria, Archaea and Eukaryotes, Human genome project, Introduction to functional and comparative genomics.	
UNIT – II : PHYSICAL MAPPING TECHNIQUES	**(9 Periods)**
Cytogenetic mapping, Radiation hybrid mapping, Fish-STS mapping, SNP mapping, Optical mapping. Top down and bottom up approach, Linking and jumping of clones, Gap closure, Pooling strategies, Automation in Genome sequencing-Next Generation Sequencing.	
UNIT – III : FUNCTIONAL GENOMICS	**(9 Periods)**
Gene finding, Annotation of genome – experimental and computational approach. ORF and functional prediction, Subtractive DNA library screening, Differential display and representational difference analysis, SAGE.	
UNIT – IV : PROTEOMICS TECHNIQUES	**(9 Periods)**
Protein level estimation-Edman protein microsequencing, Protein cleavage, 2D gelelectrophoresis, metabolic labelling. Detection of proteins on SDS gels. Mass spectrometry principles of MALDI-TOF, Fourier Transform Ion Cyclotron Resonance Mass Spectrometer, Orbitrap Mass Analyzer, Tandem MS, Peptide mass fingerprinting.	
UNIT – V : PROTEIN PROFILING	**(9 Periods)**
Post translational modification, Protein-protein interactions, Glycoprotein analysis, Phosphoprotein analysis.	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *R.M.Twyman, S.B. Primrose,* ***"Principle of Genome Analysis and Genomics"****, Wiley Blackwell Publications, 2007.*
2. *T.A Brown,* ***"Introduction to Genetic: A molecular Approach"****, Garland Science, Taylor and Francis, 2012.*

REFERENCE BOOKS:

1. *Liebler,* ***"Introduction to Proteomics"****, Humana Press, 2002*
2. *T.W. Veenstra, Tates III Jr,* ***"Proteomics for Biological Discovery"****, Wiley Publications, 2006.*

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO1: Understand the basic structure and organization of genomes of Prokaryotes

CO2: Understand the basic structure and organization of genomes of Eukaryotes

CO3: Have insight on basic organization of proteomes.

CO4: Analyze proteomes and genomes using the relevant tools.

CO5: Get familiarize with the principles of the methodologies of genomic and proteomic technique.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	-	-	-	-	-	-	-	-	-	-	-	H	L
CO2	H	-	-	-	-	-	-	-	-	-	-	-	H	L
CO3	H	-	-	-	-	-	-	-	-	-	-	-	H	L
CO4	M	H	H	-	H	-	-	-	-	-	-	-	L	H
CO5	M	H	M	-	H	-	-	-	-	-	-	M	L	H
18BPE $13	H	H	H	-	H	-	-	-	-	-	-	M	H	L

L – Low, M – Moderate (Medium), H – High

18BPE$20	METABOLIC ENGINEERING

PRE-REQUISITIES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To provide a quantitative basis, based on thermodynamics, enzyme kinetics, for the understanding of metabolic networks in single cells and at the organ level.
- To enable the students to use organisms to produce valuable substances on an industrial scale in cost effective manner.

UNIT – I : INTRODUCTION TO EXAMPLES OF PATHWAY MANIPULATION - QUALITATIVE TREATMENT	**(9 Periods)**
Enhancement of Product Yield and Productivity, Extension of substrate Range, Extension of Product spectrum and Novel products, Improvement of Cellular properties, Xenobiotic degradation.	
UNIT – II : MATERIAL BALANCES AND DATA CONSISTENCY	**(9 Periods)**
Comprehensive models of cellular reactions; stoichiometry of cellular reactions, reaction rates, dynamic mass balances, yield coefficients and linear rate equations, analysis of over determined systems- identification of gross measurement errors. Introduction to MATLAB®	
UNIT – III : METABOLIC FLUX ANALYSIS	**(9 Periods)**
Theory, over determined systems, underdetermined systems- linear programming, sensitivity analysis, methods for the experimental determination of metabolic fluxes by isotope labeling, applications of metabolic flux analysis.	
UNIT – IV : METABOLIC CONTROL ANALYSIS	**(9 Periods)**
Fundamentals of Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients, MCA of linear pathways, branched pathways, theory of large deviations	
UNIT – V : ANALYSIS OF METABOLIC NETWORKS	**(9 Periods)**
Control of flux distribution at a single branch point, Grouping of reactions, case studies, extension of control analysis to intermetabolite, optimization of flux amplifications, consistency tests and experimental validation.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen,* ***"Metabolic Engineering: Principles and Methodologies"****, Academic Press 1998.*
2. *Sang Yup Lee E. Terry Papoutsakis Marcel Dekker,* ***"Metabolic Engineering"****, inc 1998*
3. *Nielsen J and Villadsen J. (1994),* ***"Bioreaction Engineering Principles"****, Newyork: Plenum Press.*

REFERENCE BOOKS:

1. ***"Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists and Molecular Biologists"*** *by Eberhard O. Voit Cambridge University Press 2000.*
2. *"Applications of Plant Metabolic Engineering", R. Verpoorte, A. W. Alfermann and T. S. Johnson (eds). Springer, P.O. Box 17, 3300 AA Dordrecht, The Netherlands. 2007.*
3. ***"Systems Modeling in Cellular Biology: From Concepts to Nuts and Bolts",*** *Edited by Zoltan Szallasi, JorgStelling and VipulPeriwal MIT Press Cambridge 2006.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To learn stoichiometry and energetics of metabolism.

CO2: To apply practical applications of metabolic engineering in chemical, energy, medical and environmental fields.

CO3: To integrate modern biology with engineering principles.

CO4: To design a system, component, or process to meet desired needs.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	-	-	-	-	L	M	M	M	M	-	M	H	L
CO2	L	M	-	-	-	L	M	M	M	M	-	M	H	L
CO3	H	L	-	-	-	M	H	M	M	M	-	M	H	M
CO4	M	L	-	-	-	-	H	M	M	M	-	M	H	L
18BPE $20	M	-	M	-	-	H	M	M	L	M	-	M	H	L

L - Low, M-Moderate (Medium), H- High

18BPE$07	PLANT BIOTECHNOLOGY

PRE-REQUISITIES:

1. Molecular biology
2. Genetic Engineering

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To provide the basics of Agrobacterium and applications of plant biotechnology
- To provide the fundamentals of plant cell culture and offer the knowledge about the micromanipulation and transgenic plants.

UNIT- I : PLANT GENOMES AND PLANT TISSUE CULTURE	**(9 Periods)**
Introduction-gene structure and gene expression-regulation, implication for plant transformation-heterologous promoters, genome size and organization, mitochondrial and chloroplast genome. Plant tissue culture-plasticity and totipotency, culture, environment, growth regulators, media regulators, culture types, plant regeneration.	
UNIT- II : PLANT TRANSFORMATION TECHNIQUES	**(9 Periods)**
Introduction- Agrobacterium mediated gene transfer –Ti-plasmid-process of T-DNA transfer and integration, transformation in plant, Direct gene transfer methods, Binary vectors- basic features of vectors-optimization, clean gene technology, viral vectors- Gemini virus - cauliflower mosaic virus.	
UNIT- III : TRANSGENIC PLANTS-HERBICIDE AND PEST RESISTANCE	**(9 Periods)**
Herbicide resistance-use of herbicide in modern agriculture-strategies for engineering herbicide-resistance. Environmental impact, pest resistance-nature and scale of insect / pest damage to crop-GM strategies- Bt approach to insect resistance-copy nature strategy-insect resistant crops and food safety.	
UNIT- IV : PLANT DISEASE RESISTANCE AND STRESS TOLERANCE	**(9 Periods)**
Introduction-plant-pathogen interactions-natural disease resistance pathways biotechnological approaches to disease resistance. Plant viruses- types-entry and replication transgenic approach-PDR Stress tolerance-abiotic stress-water deficit stress and various approaches for tolerance.	
UNIT- V :MOLECULAR FARMING AND GM CROPS FUTURE PROSPECTS	**(9 Periods)**
Introduction-carbohydrates and lipids production-molecular farming of proteins, economic considerations for molecular farming.GM crops-current status-concerns about GM crops-regulations of GM crops and products-Greener genetic engineering.	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS

1. *Adrian Slate., Nigel W.Scott.., Mark R.Fowler., **"Plant Biotechnology-The genetic manipulation of plant's"**, Second edition Oxford University Press 2008.*
2. *Ignacimuthu .S., "**Plant Biotechnology**", Oxford and IBH Publishing Co Pvt. Ltd. New Delhi, 2003.*
3. *Singh B.D., **"Text Book of Plant Biotechnology"**, Kalyani Publishers, 1998.*

REFERENCE BOOKS

1. *Heldt H., **"Plant Biochemistry & Molecular Biology",** Oxford University Press, 1997.*
2. *Bhojwani S.S., Razdan M.K. **"Plant tissue culture: Theory and Practice"**, A revised edition, Elsevier science, 1996.*
3. *Dseke L.J., Kirakosyan A., Kanfman P., Warber S., Duke J.A., Brielmann H.L, "**Natural Products from plants"**, second edition, Taylor and Francis groups, 2006.*
4. *Ignacimuthu.**"Plant Biotechnology",** Oxford Publishing co Pvt. Ltd, New Delhi, 1997.*

COURSE OUTCOME

Upon completion of the course, the students will be able to

CO1: Apply the basic concepts of genetic engineering to establish plant tissue culture.

CO2: Gain knowledge about the significance of viral vectors in genetic transformation.

CO3: Understand GM strategies and BT approaches to develop pesticide and herbicide resistance plants.

CO4: Demonstrate plant-pathogen interactions and various approaches forresistances.

CO5: Understand the importance of Molecular Pharming.

COURSE ARTICULATION MATRIX

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	-	-	-	-	-	-	-	-	-	-	H	-
CO2	H	M	-	-	-	-	-	-	-	-	-	-	M	-
CO3	H	L	-	-	-	H	-	M	-	-	-	-	M	H
CO4	H	M	-	-	-	-	-	-	-	-	-	-	M	-
CO5	H	M	-	-	-	-	-	-	-	-	-	-	H	-
18BPE $07	H	M	-	-	-	H	-	M	-	-	-	-	H	H

L – Low, M – Moderate, H- High

18BPE$12	ANIMAL BIOTECHNOLOGY

PRE-REQUISITIES:

1. Microbiology
2. Genetic Engineering
3. Immunology

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To provide the basics and applications of animal cell culture.
- To inculcate knowledge about the micromanipulation technology and transgenic animal production.

UNIT – I : ANIMAL CELL CULTURE	**(9 Periods)**
Introduction to basic tissue culture techniques, Equipment and instruments in ATC - Chemically defined and Serum free media - Animal cell cultures - Maintenance and preservation - Various types of cultures; Suspension cultures – Continuous flow cultures – Immobilized cultures - Somatic cell fusion - Organ cultures.	
UNIT - II: ANIMAL DISEASES AND THEIR DIAGNOSIS	**(9 Periods)**
Bacterial and viral diseases in animals - Monoclonal antibodies – Diagnosis - Molecular diagnostic techniques; PCR - *in-situ* hybridization - Northern blotting, Southern blotting, RFLP.	
UNIT – III : THERAPY OF ANIMAL DISEASES	**(9 Periods)**
Recombinant cytokines – Therapeutic applications of monoclonal antibody, Vaccines - DNA, sub unit, cocktail vaccines - Gene therapy for animal diseases.	
UNIT – IV : MICROMANIPULATION OF EMBRYO	**(9 Periods)**
Micromanipulation technology - Equipment - Enrichment of x and y bearing sperms from semen samples – Artificial insemination - Germ cell manipulations – *In vitro* fertilization -Embryo transfer - Micromanipulation technology and breeding of farm animals.	
UNIT – V : TRANSGENIC ANIMALS	**(9 Periods)**
Concepts of transgenic animal technology; Strategies for the production of transgenic and knock out animals– significance in biotechnology - Stem cell cultures in production of transgenic animals.	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Ranga M.M, **"Animal Biotechnology"**, 3rd Edition, Agrobios India Limited 2010.*
2. *Ramadass. P and Meera Rani. S, **"Text Book of Animal Biotechnology"**, Agrobios India Limited 2002.*
3. *Sasidhara.R, **"Animal Biotechnology"**, MJP Publishers, 2009.*

REFERENCE BOOKS:

1. *Ashish S.Varma and Anchalsingh, **"Animal biotechnology-Models in Discovery and Translation"**, Elsevier publication, 2014.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Exploit the biomolecular techniques for the study and diagnosis of infective and parasitic animal diseases, as well as for the formulation of innovative biotechnological vaccines to beimplemented in field of veterinary science.

CO2: Perceive and deduce the contemplative ethical problems subjective to testing protocols involving animals**.**

CO3: Demonstrate various diagnostic and therapeutic techniques for the identification and curing of animal diseases.

CO4: Reckon and utilize the concept of gamete and embryo manipulation technology for the production of transgenic animals and cloning.

CO5: Acquire knowledge about the concept of transgenic animal production and its significance in biotechnology.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	H	-	-	-	-	-	-	-	-	-	-	H	L
CO2	-	-	-	-	-	M	-	H	-	-	-	-	L	H
CO3	M	H	M	-	-	-	-	-	-	-	-	-	M	M
CO4	M	M	M	-	-	L	-	M	-	-	-	-	H	M
CO5	H	M	M	-	-	L	M	M	-	-	-	-	H	L
18BPE $12	M	H	M	-	-	L	M	M	-	-	-	-	H	M

L - Low, M-Moderate (Medium), H- High

18BPE$21	PROTEIN ENGINEERING

PRE-REQUISITIES:

1. Biochemistry

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To acquire knowledge on different bonds in protein and structure elucidation methods.
- To learn the various topologies of secondary, super secondary, tertiary and quaternary structures.
- To understand the relationship between protein structure and function using some models.
- To learn the fundamentals of protein engineering and design

UNIT – I : BONDS IN PROTEIN & STRUCTURE ELUCIDATION	**(9 Periods)**
Covalent, Ionic, Hydrogen, hydrophobic and Vanderwaals interactions in protein structure. Elucidation of Secondary structure- Circular Di-chroism; Elucidation of tertiary structure of protein using X-ray diffraction and Nuclear Magnetic Resonance (NMR).	
UNIT – II : POST TRANSLATIONAL MODIFICATION AND PEPTIDE ANALYSIS	**(9 Periods)**
Amino acids - Molecular properties (size, solubility, charge, pKa), Post translational modification- modification at N-terminus and C-terminus, Glycosylation; Determination of amino acid composition, peptide sequencing - automated edman method & mass-spectrometry, peptide synthesis, peptide mapping.	
UNIT – III : PROTEIN ARCHITECTURE	**(9 Periods)**
Primary structure, Secondary structures-alpha helix, beta sheet and turns. Super-secondary structure: alpha-turn-alpha, beta-turn-beta (hairpin), beta-sheets, alpha-beta-alpha, topology diagrams, Tertiary structure – types of different domains (α, β and α / β); α domain – Coiled to coil structure and Four helix bundle; β domain – up and down, Greek key and jelly roll barrels; α / β domains – TIM barrel, Rossman fold and Horseshoe fold; Protein folding – role of molecular chaperones, protein disulphide isomerase and peptidyl prolyl cis-trans isomerase; Quaternary structure- Modular nature and formation of complexes.	
UNIT – IV : STRUCTURE-FUNCTION RELATIONSHIP	**(9 Periods)**
DNA-binding proteins: prokaryotic transcription factors, Helix-turn-Helix motif in DNA binding, *trp* repressor, Eucaryotic transcription factors, Zn fingers, helix-turn helix motifs in homeodomain, Leucine zippers, Membrane proteins and receptors - Bacteriorhodopsin and Photosynthetic reaction center, Immunoglobulins: IgG Light chain and heavy chain architecture, Enzymes: Serine proteases.	
UNIT – V : CASE STUDIES IN PROTEIN ENGINEERING	**(9 Periods)**
Advantages - protein data base analysis – methods to alter primary structure of proteins, examples of engineered proteins, thermal stability of T_4-lysozyme, recombinant insulin to reduce aggregation and inactivation, de novo protein design – principles and examples.	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Voet D. and Voet G, **"Biochemistry"**, John Wiley and Sons, Third edition,2001.*
2. *Branden C. and Tooze,**"Introduction to Protein Structure"**, Second Edition, Garland Publishing, NY, USA, 1999.*
3. *Creighton T.E, **"Proteins"**, Second Edition, Freeman WH publishers, 1993.*

REFERENCE BOOKS:

1. *Lilia Alberghina ,**"Protein Engineering for Industrial Biotechnology"**, Lilia Alberghina, CRC Press, 2003.*
2. *Stefan Lutz, Uwe Theo Bornscheuer**, "Protein Engineering Handbook Volume1"**, Wiley Publications, 2012.*
3. *Moody P.C.E. and Wilkinson A.J., **"Protein Engineering"**, IRL Press, Oxford, UK, 1990.*

COURSE OUTCOMES:

Upon completion of the course the students will be able to

CO1: Acquire knowledge about the bonds and energies in protein and elucidation of protein structure.

CO2: Understand the basics of post translational modification and peptide analysis.

CO3: Understand the architecture of proteins

CO4: Elucidate the structure function relationship of proteins

CO5: Understand the basics and steps involved in protein engineering

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L		L	M								M	L
CO2	L	L			H		L					L		M
CO3	M	L								L			M	L
CO4	H	L				L							M	
CO5		L	L	M	L									M
18BPE $21	M	L	L	M	H	L	L			L		L	M	M

L - Low, M-Moderate (Medium), H- High

18BPE$06	MARINE BIOTECHNOLOGY

PRE-REQUISITIES:

1. Microbiology
2. Environmental Sciences and Engineering

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To learn the basis of marine environment and various applications of marine organisms
- To equip the students in understanding of how biotechnology could be applied in finding solutions to marine problems

UNIT – I :INTRODUCTION TO MARINE ENVIRONMENT	**(9 Periods)**
Marine ecosystem and its functioning: intertidal, estuarine, open ocean, deep sea; Biology of marine organisms- feeding and reproduction - Marine flora-Phytoplankton, seaweeds, sea grasses and mangroves; Marine fauna–Zooplankton; marine invertebrates -crustaceans &molluscs; Vertebrates and marine mammals - dolphins and whales.	
UNIT – II : BIOACTIVE COMPONENTS AND BIOMATERIALS FROM MARINE ENVIRONMENT	**(9 Periods)**
Marine toxins – tetrodotoxins, conotoxins and ciguateratoxins; Marine enzymes-protease, lipase, chitinase, glucanase, Marine Biominerals, Biopolymers-polysaccharides, chitin, marine collagens, GFP, Probiotics, antiviral and antimicrobial agents.	
UNIT – III : MARINE ENVIRONMENTAL BIOTECHNOLOGY	**(9 Periods)**
Marine pollution – biology indicators (marine micro, algae) – biodegradation & bioremediation – marine fouling and corrosion.	
UNIT – IV : AQUACULTURE TECHNOLOGY	**(9 Periods)**
Important of coastal aquaculture – marine fishery resources – common fishing crafts and gears – aqua farm design and construction.	
UNIT – V : MANIPULATION TECHNIQUES	**(9 Periods)**
Chromosome manipulation in aquaculture – hybridization; Ploidy induction; Gynogenesis, Androgenesis and sex reversal in commercially important fishes.	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Fingerman M, Nagabhushanam R, Thompson M.F,* ***"Recent advances in marine biotechnology"****,Volume 2, Science Pub Inc, 1999.*
2. *Fingerman M, Nagabhushanam R, Thompson M.F,* ***"Recent advances in marine biotechnology"****, Volume 3, Oxford & IBH Publishing company, 1999.*

REFERENCE BOOKS:

1. *Joanne M. W, Sherwood L, Woolverton C.J,* ***"Prescott's Microbiology"****, McGraw-Hill, 8th edition., 2011.*
2. *Kaiser M.J and Attrill M.J,* ***"Marine Ecology: Process, Systems and Impacts"****, Oxford, 2nd edition., 2011.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Learn the basic of ocean structure and characteristics
CO2: Explain the marine eco system
CO3: Describe the important microorganism in marine system
CO4: Understand importance of biotechnological solution for marine problems
CO5: Elaborate on various active compounds extract from marine organisms
CO6: Review on basic aqua culture methods

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	-	-	-	-	L	L	-	-	-	-	L	H	H
CO2	L	-	-	-	-	-	L	-	-	-	-	L	M	L
CO3	-	M	-	-	M	L	L	-	-	-	-	L	H	M
CO4	L	-	-	-	-	-	-	-	-	-	-	L	L	L
CO5	L	-	L	-	-	-	-	-	-	-	-	L	L	M
CO6	M	H	-	-	L	-	-	-	L	-	-	L	M	L
18BPE $06	L	M	-	-	L	-	L	-	L	-	-	M	H	-

L - Low, M-Moderate (Medium), H- High

18BPE$22	PHARMACOGENOMICS

PRE-REQUISITIES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- The course intends to provide knowledge about pharmacogenomics and drug design using genomic applications for drug action andtoxicity.
- To understand how individualization of drug therapy can be achieved based on a person's genetic makeup while reducing unwanted drugeffects.

UNIT – I : PHARMACOGENOMICS ANDPERSONALIZEDMEDICINE	**(9 Periods)**
Pharmacogenetics- Roots of pharmacogenomics and it is not just pharmacogenomics, Genetic drug response profiles, the effect of drugs on Gene expression, pharmacogenomics in drug discovery and drug development. Concept of individualized drug therapy, Drivers and the promise of personalized medicine, Strategies for application of pharmacogenomics to customize therapy, Barriers.	
UNIT – II : HUMANGENOME	**(9 Periods)**
Expressed sequence Tags (EST) and computational biology, Microbial genomics, computational analysis of whole genomes, computational genome analysis, Genomic differences that affect the outcome of host pathogen interactions, Protein coding genes, repeat elements, genome duplication, analysis of proteome, DNA variation, Biological complexity. Single nucleotide polymorphisms (SNP's) in Pharmacogenomics - approaches, number and types of SNPs, Study design for analysis, Analytical issues, Development of markers.	
UNIT – III : ASSOCIATION STUDIESINPHARMACOGENOMICS	**(9 Periods)**
Viability and Adverse drug reaction in drug response, Multiple inherited genetic factors influence the outcome of drug treatments, Association studies in pharmacogenomics, Strategies for pharmacogenomics Association studies, Benefits of Pharmacogenomics in Drug R & D.	
UNIT – IV : GENOMICS APPLICATIONS FOR DRUG ACTION, TOXICITYAND DESIGN	**(9 Periods)**
Platform technologies and Pharmaceutical process, its applications to the pharmaceutical industry, Understanding biology and diseases, Target identification and validation, Drug candidate identification and optimization, safety and toxicology studies. The need of protein structure information, protein structure and variation in drug targets-the scale of problem, Mutation of drug targets leading to change in the ligand binding pocket.	
UNIT – V : PHARMACOGENOMICS –CASESTUDIES	**(9 Periods)**
Study of pharmacogenomics of human P-Glycoprotein, drug transporters, lipid lowering drugs, chemotherapeutic agents for cancer treatment.	

TEXT BOOKS

1. *Russ B. Altman , David Flockhart , David B. Goldstein, **"Principles of Pharmacogenetics and Pharmacogenomics"**, Cambridge University Press; 1 edition.*

REFERENCE BOOKS:

1. *Martin M. Zdanowicz, M.M. **"Concepts in Pharmacogenomics"**, American Society of Health-System Pharmacists, Second Edition , 2017.*
2. *Russ B. Altman, David Flockhart, David B. Goldstein, **"Principles of Pharmacogenetics and Pharmacogenomics"**, UK: John Wiley, 2012.*
3. *Rothstein, Mark, A. **"Pharmacogenomics: Social, Ethical and Clinical Dimensions"**, Wiley-Liss, 2003.*
4. *SandoshPadmanabhan, **"Handbook of Pharmacogenomics and Stratified Medicine"**, Elsevier Science, 2014.*

COURSE OUTCOMES:

Upon completion of the course the students will be able to

CO1: Distinguish the effect of genetic differences between individuals in theoutcome of drug therapy and in drug efficacy andtoxicity.

CO2: Describe the role of single nucleotide polymorphism as a biomarker forthe prediction of risk, therapeutic response and prognosis ofmalignancies.

CO3: Understand the role of the protein structural techniques in drugidentification

CO4: Utilize and manage the new genomics based tools as they becomeavailableas well as make best treatmentchoices.

CO5: Understand the concept of personalized medicines and the possibleapplicability.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L		L	M								M	L
CO2	L	L			H		L					L		M
CO3	M	L								L			M	L
CO4	H	L				L							M	
CO5		L	L	M	L									M
18BPE $22	M	L	L	M	H	L	L			L		L	M	M

L - Low, M-Moderate (Medium), H- High

18BPE$23	GENETICS

PRE-REQUISITIES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To give an understanding on the fundamentals of conventional genetics and its relevance in disease and therapy.
2. To describe various genetic laws, learn the chromosome structure function and understand methodologies for cytogenetic applications.

UNIT – I: BACTERIAL GENETICS	**(9 Periods)**
Transformation, Transduction, Conjugation – mapping, fine structure in merozygotes- plasmids and episomes.	
UNIT – II : CLASSICAL GENETICS	**(9 Periods)**
Mendel's Principles and experiments, segregation, mutiple alleles – independent assortments, genotypic interactions, epistasis and sex chromosomes, sex determination, dosage compensation, sex linkage and pedigree analysis.	
UNIT – III : APPLIED GENETICS	**(9 Periods)**
Chromosomeorganization,structureandvariationinprokaryotesandeukaryotes,giantchromosomes – polytene and lampbrush, deletion, inversion, translocation, duplication, variation in chromosomal numbers-aneuploidy,euploidy,polyploidy,Amestest,karyotypinglinkage,crossingover– cytologicalbasisofcrossingover,chromosomemapping–twoand threefactorcross– interference,somaticcellhybridization.	
UNIT – IV : POPULATION GENETICS	**(9 Periods)**
Hardy-Weinberg equilibrium, Extensions of Hardy- Weinberg equilibrium, nonrandom mating, population analysis, Models for population genetics. Mutation and Migration size, Genetic variation and Sociobiology.	
UNIT – V : GENETIC DISEASES	**(9 Periods)**
Inborn errors of metabolism, Sickle cell, hemochromatosis, cystic fibrosis, hypogonadotropic hypogonadism, Gaucher's disease, achondroplasia, phenylketonuria, Huntington's Disease, Cystic fibrosis, hemoglobinopathies, Age-related macular degeneration, Obesity, Type 2 diabetes, Psychiatric disease, including missing heritability, autism.	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Tamarin, R.H., **"Principles of Genetics"**, Tata McGraw Hill, New Delhi, 2002.*
2. *De Robertis, E. D. P. and De Robertis, E. M. F., **"Cell and Molecular Biology"**, 8th Edition, Lippincott Williams & Wilkins, New York, USA, 2001.*

REFERENCE BOOKS:

1. *Gardner, E.J, Simmons, M.J, and Snustad, D.P., **"Principles of Genetics"**, 8Edition, JohnWiley& Sons, Singapore, 2003.*
2. *Strickberger, M.W., **"Genetics"**, 3rd Edition, Prentice Hall of India, New Delhi, 2008.*
3. *Klug, W.S. and Cummings, M.R., **"Concepts of Genetics"**, Pearson Education, New Delhi, 2003.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To give an understanding on the fundamentals of conventional genetics and its relevance in disease and therapy.

CO2: To describe various genetic laws, learn the chromosome structure function and understand methodologies for cytogenetic applications.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	-	-	L	-	-	-	-	-	L	-	H	L
CO2	L	M	H	-	M	L	-	L	M	M	L	M	L	M
18BPE $23	L	M	H	L	M	L	M	L	M	M	L	M	H	L

L - Low, M - Moderate (Medium), H – High

VERTICAL-III

BIOPROCESS TECHNOLOGY

18BPE$28	ASPECTS OF BIOCHEMICAL ENGINEERING

PRE-REQUISITIES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To understand the basic aspects of biochemical processes and industrial bioproducts.
- To acquire knowledge about the stoichiometric analysis and biochemical thermodynamics.
- To familiarize about the various types, design and analysis of bioreactors.
- To inculcate the kinetic aspects of chemical and enzymatic reactions.
- To impart knowledge about the operation and process control of industrial fermenter.

UNIT – I	INTRODUCTION	9Periods
Introduction-applications of biochemical processes- differences between chemical engineering and biochemical engineering -advantages of biochemical products-classifications of the living organisms-taxonomy of the microorganisms- classifications of the microorganisms - applications of microorganisms -microbial culture and composition of the medium- strain development and improvement scale-up of inoculums development- anabolism and catabolism of living systems, major metabolic pathways-bioproducts and their availability, classification of bioproducts, industrial fermentation process-industrial bioproducts and their market values.		
UNIT – II	**STOICHIOMETRY AND THERMODYNAMICS OF BIOCHEMICAL REACTIONS**	**9Periods**
Stoichiometry of biochemical processes: law of conservation of mass- degree of reduction, thermodynamic efficiency of aerobic and anaerobic processes- development of the complete stoichiometric equation of a biochemical process: calculation of O_2 requirement and heat evolved in aerobic fermentation process- calculation of theoretical yield of biomass in aerobic fermentation process-stoichiometric analysis of anaerobic fermentation process: calculation of theoretical yield of methane from the anaerobic digestion of organic waste, Definition of thermodynamics: first law of thermodynamics- change of entropy in exothermic and endothermic reactions- Gibb's free energy of chemical reaction and Hess' law-characteristics of chemical equilibrium- factors affecting chemical equilibrium constant.		
UNIT – III	**BIOREACTOR TYPES, DESIGN AND ANALYSIS**	**9Periods**
Different types of reactor- reactor analysis- analysis of CSTR and PFR- -design and analysis of activated sludge process- design and analysis of anaerobic digestion process- scale up of bioreactor- transport phenomenon in bioprocess- air and medium sterilization.		
UNIT – IV	**KINETIC ASPECTS OF CHEMICAL AND ENZYMATIC REACTIONS**	**9Periods**
Kinetics of homogenous chemical reactions-kinetics of enzyme catalyzed reactions using free and immobilized enzymes-kinetics of substrate utilization, product formation and biomass production of microbial cells.		
UNIT – V	**OPERATION AND PROCESS CONTROL**	**9Periods**
Operation of industrial fermenter and material analysis: schematic diagram of fermenter accessories of a fermenter-flow diagram of the citric acid fermentation process- materials analysis of citric acid fermentation process-process control: process control of bioprocesses- different parameters involve in bioprocesses- monitoring and control of physical parameters- monitoring and control of chemical parameters- automated process control system- overview of downstream processing- economic analysis of biochemical processes.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK :

1 *Kargi. F., Shuler. M.L.,* ***"Bioprocess Engineering: Basic Concepts",*** *3rd Edition. Prentice Hall, 2017.*

2 *Doran. P. M.,* ***"Bioprocess Engineering Principles",*** *Academic Press, 2012*

REFERENCES

1 *Najafpour G.,* ***"Biochemical Engineering and Biotechnology****", 2nd Edition, Elsevier, 2015*

2 *Scott F.H.,* ***"Elements of Chemical Reaction Engineering****", 5th Edition, Pearson Education, Inc., 2015*

3 *Schügerl K., Bellgardt K.-H.,* ***"Bioreaction Engineering: Modeling and Control",*** *Springer, 2000*

COURSE OUTCOMES:

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

CO1: Understand the basic aspects of biochemical processes and industrial bioproducts.
CO2: Acquire knowledge about the stoichiometric analysis and thermodynamics of biochemical processes.
CO3: Familiarize about the various types, design and analysis of bioreactors
CO4: Inculcate the kinetic aspects of chemical and enzymatic reactions
CO5: Impart knowledge about the operation and process control of industrial fermenter.

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	-	-	-	-	-	-	-	-	-	L	M
CO2	L	L	M	L	L	-	-	-	-	-	-	-	L	M
CO3	L	L	M	1	M	-	-	-	-	-	-	-	M	M
CO4	L	L	L	M	-	-	-	-	-	-	-	-	L	L
CO5	L	L	L	-	-	-	-	-	-	-	-	-	L	M
18BPE$28	M	L	M	L	L	-	-	-	-	-	-	-	M	M

L - Low, M - Moderate (Medium), H - High

18BPE$29	FERMENTATION TECHNOLOGY

PRE-REQUISITIES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To gain the knowledge about basics of fermentation process.
- To familiarize about the beer fermentation process.
- To understand about the processing steps in wine production.
- To explore about the various fermented food products.
- To inculcate the knowledge about the advances in fermentation process.

UNIT – I	INTRODUCTION	9 Periods
Fermentation processes-basic requirements of fermentation processes – An overview of aerobic and anaerobic fermentation processes and their application in industry -Medium requirements for fermentation processes - Design and usage of commercial media for industrial fermentation- Fundamentals of material and energy balance for fermentation processes.		
UNIT – II	**BEER FERMENTATION**	**9 Periods**
Barley Beer-types, bottom and top fermented beers; Raw materials for beer fermentation-Barley malt, adjuncts, hops, water, yeast; Brewing process- malting, milling, mashing, wort boiling, fermentation, lagering and packaging; Beer defects; Continuous brewing process.		
UNIT – III	**WINE FERMENTATION**	**9 Periods**
Grape wine-types; Wine making process-crushing of grapes, fermentation, ageing, storage,clarification, packaging; Wine defects		
UNIT – IV	**FOOD FERMENTATION**	**9 Periods**
Introduction to fermented foods, microbial cultures used in food industry, fermented dairy products, fermented meat products, fermented vegetable products, fermented oriental food products, fermentation for flavor production, fermented, dried and smoked fish products- microorganisms as food-single cell protein, mycoprotein production.		
UNIT – V	**ADVANCED FERMENTATION PROCESSES**	**9 Periods**
Recombinant protein expression with *E.coli* and fermentation. Expression in yeast *Pichia pastoris*, production of recombinant vaccines, purification of recombinant proteins. Animal cell culture, Plant cell culture; Cell culture practices, nutritional requirement of cultured cell, cell growth and propagation, prevention and eradication of contamination, Cell synchronization; Cell cloning. Scaling-up of animal and plant cell culture.		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK :

1 *Okeke, Benedict C., and Okafor, Nduka. "**Modern Industrial Microbiology and Biotechnology",** CRC Press, Taylor & Francis Group, 2018.*

2 *Waites, Michael J., et al. "**Industrial Microbiology: An Introduction**", Wiley, 2009.*

REFERENCES:

1 *Whitaker, Allan., Stanbury, Peter F., Hall, Stephen J. **"Principles of Fermentation Technology"** Elsevier, 2016.*

2 *Charles W. Bamforth, David J. Cook, **"Food, Fermentation, and Micro-organisms",** John Wiley & Sons, 2019.*

3 *Gopal Kumar Sharma, "**Advances In Fermented Foods And Beverages",** New India Publishers, 2021.*

COURSE OUTCOMES:

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

CO1 Gain the knowledge about basics of fermentation process.

CO2 Familiarize about the beer fermentation process.

CO3 Understand about the processing steps in wine production .

CO4 Explore about the various fermented food products.

CO5 Inculcate the knowledge about the advances in fermentation process.

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	-	-	-	-	-	-	-	-	-	-	L	L
CO2	L	L	-	-	-	-	-	-	-	-	-	-	L	L
CO3	L	L	M	M	-	-	-	-	-	-	-	-	L	M
CO4	L	L	M	M	-	-	-	-	-	-	-	-	L	M
CO5	L	L	M	M	-	-	-	-	-	-	-	-	L	M
18BPE$29	L	L	M	M	-	-	-	-	-	-	-	-	L	M

L - Low, M - Moderate (Medium), H – High

18BPE$04	FOOD PROCESS ENGINEERING

Category: PE

PRE-REQUISITES:

1. Microbiology
2. Fluid Mechanics
3. Biochemistry
4. Mass Transfer operations

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To enable the student to understand the chemistry and microbiology of aspects food.
- To gain knowledge in various aspects of food processing & its importance.

UNIT – I : BASICS OF FOOD CHEMISTRY AND MICROBIOLOGY	**(9 Periods)**
Constituents of food- water – bound and unbound water activity, carbohydrate, lipids, proteins-organoleptic and textural characteristics; Bacteria, yeasts and molds – sources, types and species of importance in food processing and preservation; Fermented foods; Single cell protein.	
UNIT – II : FOOD PRESERVATION	**(9 Periods)**
High Temperature – blanching, pasteurization, sterilization, evaporation, dehydration, distillation, baking, roasting, frying; Thermal death time relationships (D, Z and F values); Low Temperature – microbial activity at low temperature and methods – chilling, freezing; Irradiation; Chemicals preservation; Hurdle technology.	
UNIT – III : UNIT OPERATIONS IN FOOD PROCESSING	**(9 Periods)**
Raw material preparation- cleaning, sorting, grading and peeling; Size reduction; Pumping; Mixing and forming; Separation and concentration – centrifugation, filtration, extraction, crystallization; Heat transfer–conduction, convection, radiation, extruders (Theory and equipment only); Large scale processing – meat, beverage, confectionary, dairy, fresh fruits and vegetables.	
UNIT – IV : FOOD PACKAGING	**(9 Periods)**
Types of packaging material and containers; Interactions between packaging and foods; Controlling packaging atmosphere, Modified atmosphere packaging, Aseptic packaging, Active and intelligent packaging; Packing – meat, dairy, fresh fruits and vegetables, beverages and confectionaries; Food packaging closure and sealing system; Nutrition labelling and legislative requirements.	
UNIT – V : FOOD SAFETY AND QUALITY CONTROL	**(9 Periods)**
Objectives, importance and functions of quality control; Food safety- definition, food laws and regulations – FSSAI, FDA; Grades and standards; Concept of codex almentarious/HACCP/ /ISO 9000 series etc; Food recalls.	

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

*1.Fellows P.J, **"Food Processing Technology: Principles and Practices"**, Woodhead Publishing 4th edition,2016.*

*2.Robertoson G.L, **"Food Packaging: Principles and Practice"**, CRC Press 3rd edition ,2016.*

REFERENCE BOOKS:

1. *Srinivasan Damodaran and Kirk L. Parkin.,* ***"Fennema's Food Chemistry"****, CRC Press, 5th edition. 2017.*
2. *Frazier W.C and Westoff D.C.,* ***"Food Microbiology"****, McGraw Hill, 5th edition, 2013.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the basic constituents of foods and their functional role
CO2: Describe the relationship between food and microorganism that basis for fermentation and preservation
CO3: Explain various preservation and packaging techniques for food product
CO4: Describe the operation principles involved in food processing
CO5: Sketch food quality, safety and regulations

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	-	-	-	-	-	-	-	-	-	L	H	L
CO2	H	L	-	-	-	L	-	-	-	-	-	L	H	L
CO3	-	H	-	-	L	-	-	-	-	-	-	L	H	H
CO4	-	H	L	-	L	-	-	-	-	-	-	L	H	H
CO5	-	-	M	-	-	H	L	-	-	-	L	L	M	H
18BPE $04	-	-	-	-	-	H	L	M	-	-	L	L	M	H

L - Low, M-Moderate (Medium), H- High

18BPE$30	BIOREACTOR DESIGN AND SCALE UP PROCESS

PRE-REQUISITIES: NIL **Category: PE**

COURSE OBJECTIVES

L	T	P	C
3	0	0	3

- To understand the operation modes of bioreactor.
- To gain knowledge about the mass transfer process in bioreactor system.
- To familiarize about the design and analysis of bioreactors.
- To understand about bioreactor scale up and scale down issues.
- To gain knowledge about bioreactor instrumentation and process control.

UNIT – I	BASIC BIOREACTOR CONCEPTS	9Periods
Bioreactor Operation – Batch operation, semi-continuous and fed-batch operation, ContinuousOperation – Chemostat, turbidostat – Microbiological reactors, enzyme reactors – Tank-type,Column-type biological reactors – Case studies – Continuous Fermentation with Biomass Recycle,Tanks-in-series, Tubular plug flow bioreactors.		
UNIT – II	**AERATION AND AGITATION IN BIOPROCESS SYSTEMS**	**9Periods**
Mass transfer in agitated tanks – Effect of agitation on dissolved oxygen - Correlations with kLa in Newtonian and non Newtonian liquid – Power number, Power requirement for mixing in aerated and non aerated tanks for Newtonian and non Newtonian liquids – Agitation rate studies - Mixing time in agitated reactor, residence time distribution – Shear damage, bubble damage, Methods of minimizing cell damage – Laminar and Turbulent flow in stirred tank bioreactors.		
UNIT – III	**SELECTION AND DESIGN OF BIOPROCESS EQUIPMENT**	**9Periods**
Materials of construction for bioprocess plants – Design considerations for maintaining sterility of process streams processing equipments, selection, specification – Design of heat and mass transferequipment used in bioprocess industries – Requirements, design and operation of bioreactor for microbial, plant cell and animal cell.		
UNIT – IV	**SCALE UP AND SCALE DOWN ISSUES**	**9Periods**
Effect of scale on oxygenation, mixing, sterilization, pH, temperature, inoculum development, nutrient availability and supply – Bioreactor scale-up based on constant power consumption per volume,mixing time, impeller tip speed (shear), mass transfer co-efficients – Scale up of downstreamprocesses – Adsorption (LUB method), Chromatography (constant resolution etc.), Filtration(constant resistance etc.), Centrifugation (equivalent times etc.), Extractors (geometry based rules) –Scale–down related aspects.		
UNIT – V	**BIOREACTOR INSTRUMENTATION AND CONTROL**	**9Periods**
Sensor Design and Operating Principle: Temperature, flow measurement and control, Pressure measurement and control, shaft power, rate of stirring, detection and prevention of foam, measurement of cells, measurement and control of dissolved oxygen, inlet and outlet gas analysis, pH measurement and control, SCADA systems for Bioreactors: SCADA architecture, SCADA communication, SCADA functions; Case Studies in Bioreactor Instrumentation and Control.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Impre, J.F.M.V., Vanrolleghem, P.A. and Iserentant, D.M., "**Advanced Instrumentation, Data Interpretation and Control of Biotechnological Processes**", Kluwer Academic Publishers, 2010.*

2 *Mansi, E.M.T.EL., Bryce, C.F.A., Demain, A.L. and Allman, A.R., **"Fermentation Microbiology and Biotechnology**", Taylor and Francis, 2012.*

REFERENCES:

1 *Towler, G. and Sinnott, R., "**Chemical Engineering Design: Principles, Practice, Economics of Plant and Process Design"**, Butterworth – Heinemann ltd., Elsevier, 2012.*

2 *Mann, U., "**Principles of Chemical Reactors Analysis & Design: New tools for Industrial Chemical Reactor Operations**", Willey–VCH, 2009.*

COURSE OUTCOMES

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

CO1: Understand the operation modes of bioreactor.
CO2: Gain knowledge about the mass transfer process in bioreactor system.
CO3: Familiarize about the design and analysis of bioreactors.
CO4: Understand about bioreactor scale up and scale down issues .
CO5: Gain knowledge about bioreactor instrumentation and process control.

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	-	-	-	-	-	-	-	-	-	M	L
CO2	L	L	M	L	L	-	-	-	-	-	-	-	M	L
CO3	L	L	M	L	M	-	-	-	-	-	-	-	M	L
CO4	L	L	L	M	-	-	-	-	-	-	-	-	M	L
CO5	L	L	L	M	-	-	-	-	-	-	-	-	M	L
18BPE$30	M	L	M	L	L	-	-	-	-	-	-	-	M	L

L - Low, M - Moderate (Medium), H - High

18BPE$31	SOLID STATE BIOPROCESSING

PRE-REQUISITIES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To understand the basic concepts and biotechnological principles involved in SSF.
- To develop knowledge about the general considerations and kinetics of SSF.
- To explore about the various types of bioreactors for SSF.
- To gain knowledge about the production of bulk chemicals and products by SSF.
- To inculcate the application prospects of modern SSF.

UNIT – I	INTRODUCTION	9 Periods
Solid-State Fermentation (SSF)-Difference Between Solid-State Fermentation and Submerged Fermentation-Advantages and Applications of SSF; Principles and Regulations of SSF based on biological and substrate characteristics; Biotechnology Principles of Solid State Fermentation-Microbial Growth and Metabolic Characteristics, Filamentous, Bacterial, yeast growth on the Solid Matrix; Properties of the Solid Matrix in SSF.		
UNIT – II	**GENERAL CONSIDERATIONS FOR SSF**	**9 Periods**
Factors affecting SSF-strain selection, medium, C/N ratio, temperature, moisture, water activity, pH, aeration and agitation, particle size; Energy balance ; Heat and Mass Transfer in SSF; Kinetics of SSF-estimation of kinetic parameters.		
UNIT – III	**BIOREACTORS FOR SSF**	**9 Periods**
Overview of bioreactors employed in SSF; Types-Unaerated and Unmixed (Tray reactor), Forcefully-Aerated Bioreactors Without Mixing (Packed bed reactor), Rotating-Drum and Stirred-Drum Bioreactors, Continuously-Mixed, Forcefully-Aerated Bioreactors (Stirred Beds with Mechanical Agitators, Gas-Solid Fluidized Beds), Intermittently-Mixed Forcefully-Aerated Bioreactors; Continuous SSF Bioreactors-Continuous Tubular Flow Bioreactors, Continuous Rotating Drum Bioreactor, Continuous Stirred Tank Bioreactor; Scale-up challenges in SSF.		
UNIT – IV	**SSF FOR BULK CHEMICALS AND PRODUCTS**	**9 Periods**
Production of organic acids (citric acid-lactic acid); Production of enzymes (proteases,lipases),factors affecting enzyme production in SSF system-recovery of enzymes- Production of mushroom-microorganisms-substrates -physiological and environmental control for mushroom production by SSF-bioremediation and detoxification of mushroom strains-Microbial pigments production.		
UNIT – V	**APPLICATION PROSPECTS OF MODERN SSF**	**9 Periods**
Applicability of solid biomass used as substrate-characteristics of solid substrate-solid biomass bioconversion, Biomass bioconversion technology based on SSF- biological pretreatment-enzyme production for biomass bioconversion -high and Low value-added bioconversion of biomass.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Period

TEXT BOOK:

1 *Chen, Hongzhang,* ***"Modern Solid State Fermentation: Theory and Practice"****, Springer Netherlands, 2013.*
2 *Ashok Pandey, C.R. Soccol, Christian Larroche,****"Current Developments in Solid-state Fermentation",*** *Springer New York, 2008.*

REFERENCES:

1 *Susanne Steudler, Anett Werner, Jay J. Cheng , "****Solid State Fermentation: Research and Industrial Applications",*** *Springer International Publishing, 2019.*
2 *Krieger, Nadia., Mitchell, David A.,* ***"Solid-State Fermentation Bioreactors: Fundamentals of Design and Operation",*** *Springer Berlin Heidelberg, 2006.*
3 *B.K. Lonsane, G. Viniegra-Gonzalez, Gustavo Viniegra, M. Raimbault, S. Roussos, "****Advances in Solid State Fermentation",*** *Springer Netherlands, 2013.*
4 *Ashok Pandey* ***"Solid-state Fermentation",*** *Wiley Eastern, 1994.*

COURSE OUTCOMES:

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

CO1: Understand the basic concepts and biotechnological principles involved in SSF.
CO2: Develop knowledge about the general considerations and kinetics of SSF.
CO3: Explore about the various types of bioreactors for SSF.
CO4: Gain knowledge about the production of bulk chemicals by SSF
CO5: Inculcate the application prospects of modern SSF.

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	-	-	-	-	-	-	-	-	-	-	L	L
CO2	L	L	-	M	-	-	-	-	-	-	-	-	L	L
CO3	L	L	M	M	-	-	-	-	-	-	-	-	L	M
CO4	L	L	M	M	-	-	-	-	-	-	-	-	L	M
CO5	L	L	M	M	-	-	-	-	-	-	-	-	L	M
18BPE$31	L	L	M	M	-	-	-	-	-	-	-	-	L	M

L - Low, M - Moderate (Medium), H - High

18BPE$32	BIOPROCESS CONTROL AND INSTRUMENTATION

PRE-REQUISITIES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

* To categorize Bioprocess instrumentation for the measurement of various parameters
* To understand the components of control system in bioprocesses
* To develop the closed loop control system using P/PI/PID controller**.**
* To analyze the stability of feedback control system.
* To gain knowledge about the advanced control system in bioreactors

UNIT – I	BIOPROCESS INSTRUMENTATION	9 Periods
Temperature, pH, Level, Flow, Pressure, DO sensors. Response of First order systems: Transfer Function, Transient Response, Forcing Functions and Responses. Physical examples of First and second order systems: Examples of First order systems, Linearization, Transportation Lag.		
UNIT – II	**COMPONENTS OF CONTROL SYSTEM**	**9 Periods**
Block Diagram, Development of Block Diagram, Controllersand Final Control Elements. Closed loop Transfer functions: Standard Block-Diagram Symbols,Transfer Functions for Single-Loop Systems and Multi-loop Systems.		
UNIT – III	**TRANSIENT RESPONSE OF SIMPLE CONTROL SYSTEMS**	**9 Periods**
Servo Problem, Regulatory Problem, Controllers:Proportional, Proportional-Integral, PID Controllers.Ziegler-Nichols Controller Settings. Stability:Routh Test for Stability, Root Locus.		
UNIT – IV	**INTRODUCTION TO FREQUENCY RESPONSE**	**9 Periods**
Substitution Rule, Bode Diagrams. Control system designbased on frequency response: Bode and Nyquist Stability Criterion, Gain and Phase Margins.		
UNIT – V	**ADVANCED CONTROLS IN BIOREACTORS**	**9 Periods**
Introduction to dead time compensation, pHmeasurement and control, Oxygen measurement and control, Adaptive control and onlineestimation, Cascade control for jacketed bioreactors		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 *Impre, J.F.M.V., Vanrolleghem, P.A. and Iserentant, D.M., "**Advanced Instrumentation, Data Interpretation and Control of Biotechnological Processes**", Kluwer Academic Publishers, 2010.*

2 *Stephanopoulose G, "**Chemical Process Control: An Introduction to Theory and Practice",** Prentice Hall of India, New Delhi, 1993.*

REFERENCES:

1 *Seborg D E, Edgar TF, Mellichamp D A, Doyle FJ,* ***"Process Dynamics and Control",*** *3/e, John Wiley & Sons, 2010.*

2 *Tapobrata Panda, "****Bioreactor Analysis and Design****", Tata McGraw Hill, 2011.*

3 *LeBlanc, SE., Coughanowr, DR.. "****Process Systems Analysis and Control"****. McGraw-Hill Higher Education, 2009.*

COURSE OUTCOMES:

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

CO1: Categorize Bioprocess instrumentation for the measurement of various parameters

CO2: Understand the components of control system in bioprocesses.

CO3: Develop the closed loop control system using P/PI/PID controller

CO4: Analyze the stability of feedback control system

CO5: Gain knowledge about the advanced control system in bioreactors.

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L										M	L
CO2	L	L	M	L	L								M	L
CO3	L	L	M	M	M								M	L
CO4	L	L	M	M	M								M	L
CO5	L	L	M	M	M								M	L
18BPE$32	M	L	M	M	M								M	L

L - Low, M - Moderate (Medium), H - High

18BPE$33	BIOPROCES MODELING AND SIMULATION

PRE-REQUISITIES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- Introduce the fundamental aspects of modeling of various biological systems
- Address the various modeling paradigms, based on the level of detail.
- The extent of data available as well as the question the model
- Outline the applications of such modeling techniques.

UNIT – I	MODELING OF BIOLOGICALSYSTEMS	9 periods
Modeling Principles, model development from first principles. Modeling approaches forBiological systems – structured and unstructured systems; Compartment models; Deterministic and stochastic approaches for modeling structured systems.		
UNIT – II	**MODELLING OF DIFFUSION SYSTEMS (BIOFILM AND IMMOBILIZED ENZYME SYSTEMS**	**9 periods**
External mass transfer, Internal diffusion and reaction within biocatalysts, derivation of finitemodel for diffusion-reaction systems, dimensionless parameters from diffusion-reactionmodels,the effectiveness factor concept, case studies; oxygen diffusion effects in a biofilm,biofilm nitrification		
UNIT – III	**MODELING BIOREACTOR**	**9 periods**
Bioreactor modelling: Ideal and non-ideal bioreactors; Stirred tank models; characterization of mass and energy transfer distributions in stirred tanks, Tower Reactor Model; Flow modeling,bubble column flow models, mass transfer modeling, structured models for mass transfer in tower reactors, process models in tower reactors, airlift models,		
UNIT – IV	**LINEAR SYSTEM ANALYSIS**	**9 periods**
Study of linear systems, linearization of non-linear systems; Simulation of linear models using software; Parameter estimation and sensitivity analysis; Steady state and unsteady state systems; stability analysis; Case study of recombinant protein production.		
UNIT – V	**HYBRID AND OTHER MODELING TECHNIQUES**	**9 periods**
Advanced modeling techniques such as fuzzy logic, neural network, hybrid systems and fuzzy logic systems; case studies.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK:

1 *Moser, Anton., "**Bioprocess technology: kinetics and reactors**", Springer Science & Business Media, 2012.*

2 *B. Wayne Bequette, **"Process Control: Modeling, Design, and Simulation"**, Prentice-Hall, 2023.*

REFERENCES :

1 *Said S.E.H. Elnashaie, Parag Garhyan,* ***"Conservation Equations and Modeling of Chemical and Biochemical Processes"****, Marcel Dekker, 2003.*
2 *ElmarHeinzle, I.J. Dunn,* ***"Biological Reaction Engineering: Dynamic Modeling Fundamentals with 80 Interactive Simulation Examples"****, Wiley-VCH., 2021.*
3 *Najafpour, G.D., "****Biochemical Engineering & Biotechnology",*** *2nd Edition, Elsevier, 2015*

COURSE OUTCOMES:

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

CO1 Understand the modelling of biological systems and bioreactors.
CO2 Design new models for biological systems, biofilm and immobilized enzyme systems, and bioreactors
CO3 Carry out simulation of models using software.
CO4 Analyze the simulation studies and stability and sensitivity of the system.
CO5 Understand advanced modelling techniques

Course Articulation Matrix														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	L	L	L	-	-	-	-	-	-	-		H	H
CO2	H	M	H	H	M	M	-	-	L	-	L	L	M	L
CO3	H	M	M	L	H	L	-	-	L	-	L	L	H	M
CO4	H	H	H	H	L	L	-	-	M	-	L	L	L	L
CO5	H	H	H	H	L	L			M		L	L	M	M
18BPE$33	H	M	M	M	M	L	-	-	L	-	L	L	H	-
L – Slight, M – Moderate, H – Substantial														

18BPE$18	BIOPROCESS ECONOMICS AND PLANT DESIGN

Category: PE

PRE-REQUISITES:

1. Mass Transfer Operations
2. Bioprocess Engineering

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the basic engineering fundamentals that include process selection, design and flow sheet preparation for the particular bioprocess plant
- To develop knowledge to select plant location, layout, utilities and safety considerations that will help in installation procedures of new process plants
- To understand the basic concepts of cost estimation and profitability analysis of bioprocess plants

UNIT – I : INTRODUCTION TO DESIGN PROJECT	**(9 Periods)**
Introduction to Design – nature of design – Technical feasibility survey - Organization of project-process development – data acquisition – design data information of project – Project documentation – codes and standards.	
UNIT – II : PROCESS DESIGN DEVELOPMENT	**(9 Periods)**
Equipment selection and specifications; materials of construction; flow sheeting; piping and instrumentation; process safety and loss prevention- HAZOP analysis.	
UNIT – III : GENERAL SITE CONSIDERATIONS	**(9 Periods)**
Introduction – plant location and site selection; site layout- plant layout utilities; environmental considerations – waste management – visual impact; government regulations and other legal restrictions; community factors and other factors affecting investment and production costs; human resources.	
UNIT – IV : COSTING AND PROJECT EVALUATION	**(9 Periods)**
Introduction – Accuracy and purpose of capital cost estimates; fixed and working capital operating costs – estimation of purchased costs – inflation – rapid and factorial method of cost estimation, Lang factors; plant overheads; Administration- safety and other auxiliary services - payroll overheads- warehouse and storage facilities etc.	
UNIT – V : ECONOMIC EVALUATION OF PROJECTS	**(9 Periods)**
Cash flow diagrams – tax depreciation – discounted cash flow – rate of return – payback time-sensitivity analysis; computer methods for costing and project evaluation; accounting for uncertainty and variations for future development; Optimization techniques.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Moran, S., **"An Applied Guide to Process and Plant Design"**, Elsevier, 2015.*
2. *Towler, G., Sinnot, R.K., **"Chemical Engineering Design Principles, Practice and Economics of Plant and Process Design"**, 2nd Edition, Butterworth Heinemann, 2013.*
3. *Sinnott.R.K., **"Coulson &Richardson's Chemical Engineering, Series Vol-6"**, 2nd Edition, Butterworth Heinemann, 2005.*
4. *Peters, M., Timmerhaus,K., West,R., **"Plant Design and Economics for Chemical Engineers"**, 5th Edition , McGraw Hill, 2003.*

REFERENCE BOOKS:

1. *Backhurst, J.R., Harker, J.H., **"Process Plant Design"**, Butterworth-Heinemann, 2013.*
2. *Baasal, W.D., **"Preliminary Chemical Engineering Plant Design"**, Springer, 1989.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the basics engineering fundamentals for project development and process design.
CO2: Design process equipment and consider safety, operability and other design constraints in bioprocess plant design.
CO3: Develop knowledge to select plant location, layout and utilities for new process plants.
CO4: Calculate capital investment and operating costs for process plants.
CO5: Understand the basic concepts of cost estimation and profitability analysis.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	H	-	L	L	L	L	L	L	L	M	H	L
CO2	M	M	H	M	M	-	-	-	-	-	-	-	M	M
CO3	M	-	-	-	-	-	L	-	-	-	L	-	L	H
CO4	M	M	-	-	M	-	-	-	-	-	-	-	M	H
CO5	M	M	-	-	M	-	-	-	-	-	M	-	M	H
18BPE $18	M	M	H	M	M	L	L	L	L	L	L	M	M	H

L - Low, M-Moderate (Medium), H- High

VERTICAL-IV

QUALITY AND REGULATORY AFFAIRS

18BPE$34	CLINICAL TRIALS AND HEALTH CARE POLICIES IN BIOTCHNOLOGY

PRE-REQUISITIES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of bioethics, quality assurance and governance.
- To develop advanced clinical trial management strategies including drug development and trial planning.
- To demonstrate project management in clinical trials.
- To apply consent and data protection methods.

UNIT – I : INTRODUCTION TO CLINICAL TRIALS	**(9 Periods)**
Fundamentals of clinical trials; Basic statistics for clinical trials; Clinical trials in practice; Reporting and reviewing clinical trials; Legislation and good clinical practice - overview of the European directives and legislation governing clinical trials in the 21stcentury; Principles of the International Committee on Harmonisation (ICH)-GCP.	
UNIT – II : REGULATIONS OF CLINICAL TRIALS	**(9 Periods)**
Drug development and trial planning - pre-study requirements for clinical trials; Regulatory approvals for clinical trials; Consort statement; Trial responsibilities and protocols - roles and responsibilities of investigators, sponsors and others; Requirements of clinical trials protocols; Clinical trials regulations in India- schedule Y- rules and regulations,Drugs and Cosmetics Act and Rules (DCA)	
UNIT – III : MANAGEMENT AND HEALTH CARE POLICIES	**(9 Periods)**
Clinical Trial Management System (CTMS), Software for CTMS study, SaaS. Legal issues in managing clinical data Health care informatics. Project management in clinical trials; Risk assessment; Research ethics and Bioethics - Principles of research ethics; Ethical issues in clinical trials; animal ethics; Use of humans in Scientific Experiments; Ethical committee system; Introduction to ethical codes and conduct; A case study on clinical trials of drugs in India with emphasis on ethical issues.	
UNIT – IV : INFORMED CONSENT	**(9 Periods)**
Consent and data protection- the principles of informed consent; Consent processes; Dataprotection; Legislation and its application; Data management – Introduction to trial masterfiles and essential documents; Data management.	
UNIT – V : QUALITY CONTROL AND GUIDELINES	**(9 Periods)**
Quality assurance and governance - quality control in clinical trials; Monitoring and audit; Inspections; Pharmacovigilance; Research governance; Trial closure and pitfalls-trial closure; Reporting and legal requirements;	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Matoren, Gary M.* ***"The Clinical Research Process In The Pharmaceutical Industry.*** *"Marcel Dekker, 1984.*
2. *Lawrence M.Friedman et al,* ***"Fundamentals of Clinical Trials",*** *Mosby,1996*
3. *Janet Woodcock, Frederick Ognibene, John Overbeke,* ***Assuring data quality and validity in clinical trials for regulatory decision making****, 2003.*

REFERENCE BOOKS:

1. *Lee, Chi-Jen et al, "****Clinical Trials or Drugs and Biopharmaceuticals****." CRC / Taylor & Francis,2011.*
2. *Curtis L Meinert et al,* ***"Clinical Trials - Design Conduct and Analysis"****, Oxford University Press 1986.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: apply ethical concepts and quality control measures in clinical trial projects
CO2: demonstrate project management in clinical trials.
CO3: develop clinical trials protocols, design consent and data protection.
CO4: operate consent and data protection methods.
CO5: Manage the trial coordination process.

COURSE ARTICULATION MATRIX:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	-	-	-	-	L	M	M	M	M	-	M	H	L
CO2	L	M	-	-	-	L	M	M	M	M	-	M	H	L
CO3	H	L	-	-	-	M	H	M	M	M	-	M	H	M
CO4	M	L	-	-	-	-	H	M	M	M	-	M	H	L
CO5	-	H	-	L	L	L	H	-	-	-	-	L	H	M
18BPE$34	M	-	-	L	L	H	M	M	L	M	-	M	H	L

L - Low, M-Moderate (Medium), H- High

18BPE$35	BIOTECHNOLOGICAL PRODUCTS AND ITS VALIDATION

PRE-REQUISITIES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Gain a thorough understanding of all aspects related to development, manufacturing and evaluation of bioproducts
- Acquire adequate understanding of process design of pharmaceuticals.
- Understand the principles of validation in biotech industry

UNIT – I: INTRODUCTION TO VALIDATION	**(9 periods)**
Guidelines to process validation; Introduction to calibration of instruments and its guidelines, Introduction to Qualification and Validation, Importance and scope of Validation, Types of Validation, and Validation master plan.	
UNIT – II : PROCESS VALIDATION OF PHARMACEUTICAL PRODUCTS	**(9 periods)**
Process Validation of different dosage forms - solid, semisolids and parenterals ;Qualification of equipment: DQ, IQ, OQ and PQ(Validation of critical equipment - mixer, compression machine, fluidized bed dryer (FBD), filling equipment, sterilization tunnel)	
UNIT – III : STERILE EQUIPMENT VALIDATION	**(9 periods)**
Sterile equipment train Validation, Validation of HVAC systems including clean room concepts, air handling equipment and water supply systems (purified, distilled and water for injection). Cleaning Validation.	
UNIT – IV : COMPUTER ENABLED SYSTEM VALIDATION	**(9 periods)**
Understanding of computer system validation (electronic records and digital signature21 CFR Part 11) concept of firmware, Commercial off the Shelf (COTS) and GAMP	
UNIT – V : CASE STUDY	**(9 periods)**
Analytical Test Methods for Biological and Biotechnological Products; Process Optimization and Characterization Studies for Purification of an E. coli -Expressed Protein Product – case study.	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Haider SI.* ***Pharmaceutical Master Validation Plan: The Ultimate Guide to FDA, GMP and GLP Compliance****. St. Lucie Press; 2002.*
2. *Wrigley GC.* ***Facility Validation: Theory, Practice, and Tools****. CRC Press; 2004.*
3. *Haider SI, Asif ES.* ***Cleaning Validation Manual: A Comprehensive Guide for the pharmaceutical and Biotechnology Industries.*** *CRC Press; 2010.*
4. *Segalstad SH.* ***International IT Regulations and Compliance: Quality Standards in the Pharmaceutical and Regulated Industries****.John Wiley & Sons; 2008.*

REFERENCE BOOKS:

1. *Ira R. Berry and Robert A. Nash,* ***Pharmaceutical process validation (Drugs and Pharmaceutical Series)****, Marcel Dekker Inc. New York.*
2. *Huber L.* ***Validation and Qualification in Analytical Laboratories****. Informa Healthcare; 2007*
3. *Agalloco JP, Carleton FJ.* ***Validation of Pharmaceutical Processes****. CRC Press; 2008.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Demonstrate the validation guidelines and procedures for bioproducts

CO2: Understand the validation involved in pharmaceutical industry

CO3: Exhibit the skill for validating the sterile equipment.

CO4: Analyze the computer enabled system validation for betterment of the biotech products Validation

CO5: Ability to identify the various strategies through case study.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	-	-	-	-	-	M	-	-	-	-	L	H	L
CO2	H	-	-	-	-	-	H	-	L	-	-	L	M	L
CO3	M	M	-	-	-	-	H	-	-	-	-	L	H	L
CO4	H	L	-	-	-	-	H	-	-	-	-	L	H	M
CO5	M	L	-	-	-	-	H	-	M	-	-	L	M	L
18BPE$35	M	H	-	-	-	-	H	-	L	-	-	L	H	L

L - Low, M - Moderate (Medium), H - High

18BPE$36	QUALITY ASSURANCE AND QUALITY CONTROL IN BIOTECHNOLOGY

PRE-REQUISITES: NIL

Category:PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To Understand the basic concepts of QA and QC
- To Analyse the quality control principles and guidelines in biotechnology industry
- To Gain knowledge about aseptic operation, containment levels, biosafety, GMP in biotechnology practices
- To Demonstrate quality control validation and documentation preparation
- To Understand quality control regulations

UNIT – I	BASIC CONCEPTS OF QC AND QA	(9 Periods)
Quality assurance and Quality control in industry – basic principles involved. Good ManufacturingPractices and Hazard Analysis Critical Control Points (HACCP) in foods, cosmetics andpharmaceuticals.		
UNIT – II	**BASIC QC OPERATIONS IN BIOTECHNOLOGY INDUSTRY**	**(9 Periods)**
Aseptic Operation and Containment. Biosafety in Industrial Biotechnology. Health hazards in biotechnology, Freeze-drying of biohazardous products, Industrial Safety and Hazard Management in Bio-Technology & related industry - live viruses, bacteria.		
UNIT – III	**QC AND QA IN FOOD AND BEVERAGE INDUSTRY**	**(9 Periods)**
Microbiological criteria of food products, beverages and water. Microbial quality assurance,monitoring of factory hygiene and sanitation, microbiological quality of ingredients, processing andfinished products with regard to specified standards. Quality assurance and validation principles andtheir applications in industries related to food and beverage. FDA rationale, Good Practices anddocumentation requirements.		
UNIT – IV	**QC AND QA IN PHARMACEUTICAL PRODUCTS**	**(9 Periods)**
International Biological standards, safety testing of pharmaceuticals, Quality control of antibiotics.Sterile Pharmaceutical Products: GMP aspects related to sterile products- General guidelines,personnel, building and premises, equipment, sanitation, processing, sterilization, Quality controland validation, Documentation.Introduction to Laboratory Safety, Safe laboratory practices, regulatory agencies, handling & storageof chemicals, reagents, microbial specimens and its preservation.		
UNIT – V	**DOCUMENTATION, ASSESSMENT AND EVALUATION OF QC / QA**	**(9 Periods)**
Document preparation for QC/QA norms of different sectors. Quality control in Microbiology.Laboratory assessment of aseptic condition, evaluation of possible channels of contamination,QC /QA norms for handling pathological samples.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *James P. Agalloco, Frederick J. Carleton, Validation of Pharmaceutical Processes, Third Edition, CRC press.*
2. *Kenneth E. Avis, Carmen M. Wagner, Vincent L. Wu, (1998), Biotechnology: QualityAssurance and Validationby CRC Press*.

3. *Quality assurance of pharmaceuticals (2006),A compendium of guidelines and related materials Volume 2, 2nd updated edition Good manufacturing practices and inspection.*
4. *Stephanie Clark, Stephanie Jung, BuddhiLamsal,* ***Food Processing: Principles and applications****, 2nd Edition, Wiley publishers*.

REFERENCE BOOKS:

1. *MA Potdar, NiraliPrakashan,Pharmaceutical Quality Assurance, 9th Edition,june 2020.*
2. *Ira R. Ferry & Robert Nash,Pharmaceutical Process Validation, Second Ed., MarcelDekker Inc1993.*
3. *Sidney H. Willig, Good Manufacturing Practices for Pharmaceuticals a plan for total quality control,Vol. 52, 3rd edition, Marcel Dekker Series.*
4. *Juran's Quality Control Handbook J.M. Jupron.4th Ed. 'Good design practices for GMP****Pharmaceutical facilities'****. Andrew A Signature, Marcel Dekker.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To demonstrate quality control principles in Biotechnology industry

CO2: To evaluate quality products and prepare documentation

CO3: To design industry specific quality assurance methods

CO4: To apply the knowledge gained on good manufacturing practices

CO5: To understand the regulations to be followed during the manufacturing of products

COURSE ARTICULATION MATRIX:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	-	-	-	-	L	M	M	M	M	-	M	H	L
CO2	L	M	-	-	-	L	M	M	M	M	-	M	H	L
CO3	H	L	-	-	-	M	H	M	M	M	-	M	H	M
CO4	M	L	-	-	-	-	H	M	M	M	-	M	H	L
CO5	L	-	-	-	-	-	M	L	L	L	-	-	H	L
18BPE$36	M	L	-	-	-	H	M	M	L	M	-	M	H	L

L - Low, M-Moderate (Medium), H- High

18BPE$37	ENTREPRENEURSHIP AND PATENT DESIGN

PRE-REQUISITES: NIL

Category:PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To enable the students to get familiarize with the different sources of entrepreneurial opportunities
- To train the students in developing entrepreneurial skills with an understanding of finance management, marketing strategies, ethical and legal issues related to various business affairs
- To provide knowledge on various aspects of Patents law and practices.

UNIT – I : INTRODUCTION TO ENTREPRENEURSHIP	**(9 Periods)**
Entrepreneurship Definition; Skills necessary for an Entrepreneur, Stages in entrepreneurship process, Role of entrepreneurship in economic development, Entrepreneurship- Innovation risk and failure.	
UNIT – II : BUSINESS MODELS AND FUNDING SOURCES	**(9 Periods)**
Business models- Vertical model, Platform business model, Service business model from bio based companies, Product model; Grants and Funding sources - Initial public offering, Government Grants, Informal funding, Pre seed and seed, Business angels, Venture capital, Incubators, Private investors, Creative financing, Corporate partners.	
UNIT – III : BUSINESS PLANNING AND DEVELOPMENT	**(9 Periods)**
Start-up Idea, Customers, Competitors, Resources, Technology, Planning, People, Writing business proposal, Checklist for business proposal writing; Location selection for business set up, Marketing Strategy, Financial management, Staff appointment and Management, Business Protection and Insurance- importance, Record Keeping and Accounting. Case studies on successful entrepreneurs- reason for success and failures.	
UNIT – IV : INTRODUCTION TO IPR AND PATENT	**(9 Periods)**
Introduction - Invention and Creativity - Intellectual Property (IP) - Importance - Protection of IPR. Patent- Historical development, Concepts, Novelty, Utility, Inventiveness/ Non-obviousness; Patentable subject matter, Patentability criteria, non-patentable inventions, Patent protection of pharmaceutical products and process, Software Patents, Patenting of Micro-organism.	
UNIT – V : PATENT LAW AND PRACTICES	**(9 Periods)**
Patent act and amendments, Rights of patentee, Procedure for granting a patent and obtaining patents, Grounds for opposition Working of Patents, Compulsory License Acquisition, Surrender, Revocation, Restoration, Transfer of patent rights; Patent infringement- types, determination of infringement, infringer, official machinery, controller, powers and functions, Defenses to infringement, Case Studies on - Patents (Basumati rice, Turmeric, Neem, etc.)	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Jogdand S.N, "**Entrepreneurship and Business of Biotechnology**", Himalaya Publishing Home, 2007.*
2. *Damian Hine, John Kapeleris and Edward Elgar, "**Innovation and Entrepreneurship in Biotechnology: An International Perspective, Concepts, Theories and Cases**", Edward Elgar Publishing Ltd, 2006.*
3. *N.S.Gopalakrishnan and T.G. Agitha, **Principles of Intellectual Property**, Eastern Book Company, Lucknow, 2nd edition, 2014.*

REFERENCE BOOKS:

1. *Oliver R, "**The coming biotech age: The business of biomaterials**", New York, McGraw Hill, 2000.*
2. *Cynthia Robbins-Roth, "**From Alchemy to IPO: The Business of Biotechnology**", Basic Books, 2001.*
3. *Subbaram N.R, **Handbook of Indian Patent Law and Practice**, S. Viswanathan Printers and Publishers Pvt. Ltd., 1998.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

- **CO1:** Develop an ability to communicate effectively, inculcate entrepreneurial skills leading to innovation and risk management.
- **CO2:** Demonstrate an ability to grab business opportunity and to gain support from various funding sources for the venture.
- **CO3:** Propose and develop appropriate business plan with a priority of business protection and analyse the reasons for success and failures of the real entrepreneurs to lead a profitable business.
- **CO4:** Classify the different forms of IPR and discriminate the patentable and non patentable inventions.
- **CO5:** Relate the patent law and application process and explore the patent infringement.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	-	-	-	H	L	-	L	-	H
CO2	-	-	-	-	-	-	-	-	H	-	H	-	-	H
CO3	-	-	M	-	-	-	-	-	-	H	H	-	-	H
CO4	-	-	-	-	-	-	-	H	-	-	-	-	-	H
CO5	-	-	-	-	-	-	-	H	-	-	-	-	-	H
18BPE$37	-	-	L	-	-	-	-	M	M	L	M	L	-	H

L - Low, M-Moderate (Medium), H- High

18BPE$38	INTELLECTUAL PROPERTY RIGHTS IN BIOTECHNOLOGY

PRE-REQUISITES: NIL

Category:PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To provide comprehensive knowledge to the students regarding the general principles of IPR, concept and theories, International regime relating to IPR.
* Students will learn the fundamentals and advanced strategies of IP. They will be given opportunity for understanding the same in MSME sector.
* They will be finally being provided with brief exposure about the valuation techniques and audits of IP.

UNIT – I	INTRODUCTION	(9 periods)
Introduction to IPR, Basic concepts and need for Intellectual Property - Patents, Copyrights, Geographical Indications, IPR in India and Abroad – Genesis and Development – the way from WTO to WIPO –TRIPS, Nature of Intellectual Property, Industrial Property, technological Research, Inventions and Innovations – Important examples of IPR.		
UNIT – II	**REGISTRATION OF IPR**	**(9 periods)**
Meaning and practical aspects of registration of CopyRights, Trademarks, Patents, Geographical Indications, Trade Secrets and Industrial Design registration in India and Abroad.		
UNIT – III	**AGREEMENTS AND LEGISLATIONS**	**(9 periods)**
International Treaties and Conventions on IPRs, TRIPS Agreement, PCT Agreement, Patent Act of India, Patent Amendment Act, Design Act, Trademark Act, Geographical Indication Act.		
UNIT – IV	**ENFORCEMENT OF IPR**	**(9 periods)**
Infringement of IPRs, Enforcement Measures, Emerging issues – Case Studies.		
UNIT – V	**IPR IN BIOTECHNOLOGY**	**(9 periods)**
Basic features of Indian Plant Varieties Protection & Farmer's Rights Act, UPOV, Invention/ Discovery, Patentable subject matter, Generics, Compulsory Licensing, Exclusive Marketing Rights (EMR), Bolar provision, Bayh-Dole act, Second medical use.		

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1 *V. Scople Vinod, **Managing Intellectual Property**, Prentice Hall of India pvt Ltd, 2012.*

2 *S. V. Satakar, "**Intellectual Property Rights and Copy Rights**, EssEss Publications, New Delhi, 2002*

REFERENCE BOOKS:

1 *Deborah E. Bouchoux, "**Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets**", Cengage Learning, Third Edition, 2012*
2 *PrabuddhaGanguli, "**Intellectual Property Rights: Unleashing the Knowledge Economy"**, McGraw Hill Education, 2011*
3 *Edited by Derek Bosworth and Elizabeth Webster, **The Management of Intellectual Property**, Edward Elgar Publishing Ltd., 2013.*

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO1: Identify different types of Intellectual Properties (IPs), the right of ownership, scope of protection as well as the ways to create and to extract value from IP.

CO2: To learn the procedure of obtaining Patents, Copyrights, Trade Marks & Industrial design.

CO3: To make the students to understand the statutory provisions of different forms of IPRs in simple forms.

CO4: Identify activities and constitute IP infringements and the remedies available to the IP owner and describe the precautious steps to be taken to prevent infringement of Proprietary rights in products and technology development

CO5: Explore the visionary aspects in the areas of Biotechnology

COURSE ARTICULATION MATRIX:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	-	-	-	-	-	L	-	-	-	-	-	L	L	M
CO2	-	-	-	-	-	-	L	-	-	-	-	-	L	M
CO3	-	-	-	-	-	-	M	-	-	-	-	L	L	M
CO4	-	-	-	-	-	L	-	-	-	-	-	-	L	M
CO5	-	-	-	-	-	-	-	-	-	-	M	L	L	M
18BPE$38	-	-	-	-	-	M	M	-	-	-	L	L	L	M

L – Low, M – Moderate (Medium), H – High

18BPE$39	BOISAFETY AND HAZARD MANAGEMENT

PRE-REQUISITES: NIL

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To enable the students to recognize the issues related to environment biosafety and regulatory framework of GMOs in India& at international level.
- To study about the types of hazards and techniques involved in hazard waste management.

UNIT – I : INTRODUCTION -BIOSAFETY	**(9 Periods)**
Introduction - Historical Background - Introduction to Biological Safety Cabinets - Primary Containment for Biohazards - Biosafety Levels - Biosafety Levels for handling Infectious agents and GMOs - Biosafety guidelines - Government of India - Definition of GMOs & LMOs - Environmental release of GMOs - Risk Analysis - Risk Assessment; Risk management and communication.	
UNIT – II : BIOSAFETY- REGULATORY FRAMEWORK FOR GMOS IN INDIA	**(9 Periods)**
Regulatory framework in India governing GMOs-Recombinant DNA Advisory Committee (RDAC) - Institutional Biosafety Committee (IBC) - Review Committee on Genetic Manipulation, Genetic Engineering Approval Committee (GEAC) - State Biosafety Coordination Committee (SBCC) - District Level Committee (DLC). Recombinant DNA Guidelines (2017) - Seed Policy (2002) The Food Safety and Standards Bill (2005) - Plant Quarantine Order (2003) - Regulation for Import of GM Products Under Foreign Trade Policy (2006-2007) - National Environment Policy (2006) - Rules for the manufacture, use/import/export and storage of hazardous microorganisms/genetically engineered organisms or cells (Ministry of Environment and Forests Notification, 1989), National biodiversity regulations.	
UNIT – III : BIOSAFETY-REGULATORY FRAMEWORK FOR GMOS AT INTERNATIONAL LEVEL	**(9 Periods)**
Convention of Biological Diversity (1992) – Cartagena Protocol on Biosafety – Objectives and salient features of Cartagena Protocol – Advanced Information Agreement (AIA) procedure – procedures for GMOs intended for direct use-risk assessment-risk management-handling, transport, packaging and identification of GMOs-Biosafety Clearing House-unintentional transboundary movement of GMOs-Benefits of becoming a party to the Cartagena Protocol status of implementation in India.	
UNIT – IV : PHYSICAL, CHEMICAL AND BIOLOGICAL HAZARDS	**(9 Periods)**
Noise compensation aspects- noise exposure regulation-properties of sound, occupational damage-risk factors-sound measuring instruments- octave band analyser, Recognition of chemical hazards-dust, fumes, mist, vapor, fog, gases, Types- Measurement Procedure- Instruments Procedure- Gas and Vapor monitors-dust sample collection devices- personal sampling; Classification of Biohazardous agents–examples-bacterial agents- rickettsial and chlamydial agents-viral agents, fungal, parasitic agents, infectious diseases-Biohazard control program-employee health program-laboratory safety program.	
UNIT – V : HAZARDOUS WASTE MANAGEMENT	**(9 Periods)**
Phytoremediation and Biomining; Biofertilizers and Biopesticides; Biofuel and Fundamentals of Composting process; Biosensors and its application in environmental issues. Production of bioelectricity from microbial fuel cell (MFC).Current status of biotechnology in environment protection and its future.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

*1. B.D. Singh, **"Biotechnology"**,1st Edition, Kalyani Publishers, 2003.*

*2. Krishnan N.V. **"Safety Management in Industry",** 1st Edition, Jaico Publishing House, Bombay, 1997.*

*3. Hyatt, N, **"Guidelines for process hazards analysis, hazards identification & risk analysis"**, DyademPress, 2004.*

REFERENCE BOOKS:

*1.Sasson A, **"Biotechnologies and Development",** UNESCO Publications, 2010.*

*2. Singh K, **"Intellectual Property rights on Biotechnology"**, BCIL, New Delhi, 2010.*

3. Regulatory Framework for GMOs in India, Ministry of Environment and Forest, Government of India, New Delhi, 2006.

4. Cartagena Protocol on Biosafety, Ministry of Environment and Forest, Government of India, New Delhi, 2006.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the basics and guidelines of biosafety.

CO2: Familiarize about the Indian standard of GMOs.

CO3: Familiarize about the International regulatory frameworks for GMOs.

CO4: Identify and analyze various types of hazards present in physical, chemical, and biological agents in a process.

CO5: Gain the knowledge about the hazardous waste management.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	-	L	-	-	-	-	-	-	-	-	L	L
CO2	-	-	-	-	-	H	-	L	-	-	-	-	L	L
CO3	-	-	-	-	-	H	-	L	-	-	-	-	L	L
CO4	-	L	L	-	-	-	-	-	-	-	-	-	M	M
CO5	-	L	-	-	L	-	-	-	-	-	L	-	M	M
18BPE$39	L	L	L	L	L	H	-	L	-	-	L	-	M	M

L - Low, M-Moderate (Medium), H – High

18BPE$40	CONSERVATION ECONOMICS

PRE-REQUISITES: NIL

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- Understand the relationship between economics and conservation
- Comprehend the concept of economics and trade
- Determine the value of impact manmade disasters

UNIT – I	INTRODUCTION	(9 periods)
Making Decisions, Interactions, Working of the Economy, Conservation in the Anthropocene, Human population growth and food requirements, Unsustainable development		
UNIT – II	**ENVIRONMENTAL IMPACT**	**(9 periods)**
Climate change, Plastics, Oil spills and mining, Push and pull factors :Localisation of species, Threats to species, Developmental Hazards and Ecotoxicology		
UNIT – III	**ECONOMICS**	**(9 periods)**
Need to understand controls, Thinking as an Economist, Interdependence and gains from trade, Demand and supply, Elasticity, Government policy, Surplus and market efficiency, Market Efficiency and Cost of Taxation, International Trade		
UNIT – IV	**TRADE**	**(9 periods)**
Externalities, Public goods and common resources, The design of the tax system, The Costs of Production, Competition, Monopoly, Markets for factors of production, Earnings and discrimination, Income inequality and poverty, Consumer choice, Asymmetric information, Politics and Behavioural Economics		
UNIT – V	**NATURAL RESOURCES AND DISASTER**	**(9 periods)**
Valuation of natural resource, Economics of Protected Areas, Economics of Environmental Disasters		

Contact Periods:

Lecture:45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS

1. *Charles Perrings, Ann Kinzig, "**Conservation: Economics, Science, and Policy**", Oxford University Press, 2021*
2. *Fred Van Dyke , Rachel L. Lamb, "**Conservation: BiologyFoundations, Concepts, Applications**", 3rd Edition,Springer Cham, 2020*
3. *Ghazala Shahabuddin and K Sivaramakrishnan, "**Nature Conservation in the New Economy: People, Wildlife and the Law in India**", Orient BlackSwan, 2019*

REFERENCES

1 *Clement A. Tisdell, "**Economics of Environmental Conservation, 2nd Edition**", Edward Elgar, 2005*

2 *K.N Ninan, "**The Economics of Biodiversity Conservation**", 1st Edition, Routledge, 2006*

COURSE OUTCOMES:

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

CO1 Exhibit Conceptual knowledge of the technology, economics and regulation related issues associated with conservation

CO2 Comprehend the impact of human activity on the environment

CO3 Explain the relationship between economic development and conservation outcomes

CO4 Understand laws and government policies governing trade

CO5 Evaluate value of natural resources

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	-	-	-	-	-	L	-	-	-	-	-	L	L	M
CO2	-	-	-	-	-	-	L	-	-	-	-	-	L	M
CO3	-	-	-	-	-	-	M	-	-	-	-	L	L	M
CO4	-	-	-	-	-	L	-	-	-	-	-	-	L	M
CO5	-	-	-	-	-	-	-	-	-	-	M	L	L	M
18BPE$40	-	-	-	-	-	L	M	-	-	-	L	L	L	M

L – Low, M – Moderate(Medium), H – High

18BPE$41	CHEMICAL PROCESS SAFETY

PRE-REQUISITES: NIL

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Become a skilled person in hazopard hazarel analysis and finding out the root cause of an accident.
- Gain knowledge in devising safety policy and procedures to be adopted to implement total safety in a plant

UNIT – I : INTRODUCTION TO SAFETY IN INDUSTRIES	**(9 periods)**
Need for safety in industries; Safety Programmes – components and realization; Potential hazards -extreme operating conditions, toxic chemicals; safe handling	
UNIT – II : IMPLEMENTATION OF SAFETY PROCEDURES	**(9 periods)**
Implementation of safety procedures – periodic inspection and replacement; Accidents – identification and prevention; promotion of industrial safety	
UNIT – III : RISK ANALYSIS	**(9 periods)**
Overall risk analysis--emergency planning-on site & off site emergency planning, risk management ISO 14000, EMS models case studies. Quantitative risk assessment - rapid and comprehensive risk analysis; Risk due to Radiation, explosion due to over pressure, jet fire-fire ball.	
UNIT – IV : HAZARD IDENTIFICATION ANALYSIS	**(9 periods)**
Hazard identification safety audits, checklist, what if analysis, vulnerability models event tree analysis fault tree analysis, Hazan past accident analysis Fixborough-Mexico-Madras-Vizag-Bopal analysis	
UNIT – V : HAZOP STUDIES	**(9 periods)**
Hazop-guide words, parameters, derivation-causes-consequences-recommendation-coarse Hazop study-case studies-pumping system-reactor-mass transfer system.	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Daniel A. Crowl, J.F. Louvar, Prantice Hall, NJ,'**Chemical Process Safety: Fundamentals with Applications**, 1990.*
2. *Fawatt, H.H. and Wood, W.S., "**Safety and Accident Prevention in Chemical Operation**", Wiley Interscience, 1965.*
3. *Marcel, V.C., **Major Chemical Hazard**- Ellis Harwood Ltd., Chi Chester, UK, 1987.*
4. *Hyatt, N., **Guidelines for process hazards analysis, hazards identification & risk analysis**, Dyadem Press, 2004.*

REFERENCE BOOKS:

1. *Handley, W., "**Industrial Safety Hand Book** ", 2nd Edn., McGraw-Hill Book Company, 1969.*
2. *Heinrich, H.W. Dan Peterson, P.E. and Rood, N., " **Industrial Accident Prevention**", McGrawHill Book Co., 1980.*
3. *Taylor, J.R., **Risk analysis for process plant, pipelines and transport**, Chapman and Hall, London, 1994.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Demonstrate the awareness of plant safety in selection and layout of chemical plants and the usage of safety codes.

CO2: Exhibit the skill in classifying chemical, fire, explosion hazards and to understand the occupational diseases

CO3: Analyze the bio medical and engineering response to health hazards and to implement the effective process control and instrumentation.

CO4: Analyze various safety protocols involved in industries

CO5: Study on different situation pertaining in environmental management in chemical process industries.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	H	-	-	-	-	-	M	-	-	-	-	L	H	L
CO2	M	-	-	-	-	-	M	-	L	-	-	L	M	L
CO3	M	H	-	-	-	-	H	-	-	-	-	L	H	L
CO4	M	L	L	-	-	-	M	-	-	-	-	L	M	M
CO5	M	L	-	-	-	-	H	-	L	-	-	L	M	M
CO6	-	H		L	L	L	H	-	-	-	-	L	H	M
18BPE$ 41	M	H	-	-	-	-	H	-	L	-	-	L	H	L

L - Low, M - Moderate (Medium), H - High

VERTICAL V

BIOSCIENCES

18BPE$42	HUMAN ANATOMY AND PHYSIOLOGY

PRE-REQUISITES: NIL

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the structure and functions of the various systems of human body
- To acquire knowledge on the importance of anatomical features and physiology of different human systems

UNIT – I :HUMAN ANATOMY	**(9 Periods)**
Basics of human anatomy, tissues of the human body- epithelial, connective, muscular and nervous tissues, their sub types and characteristics. Skeletal system- Structure, composition, classification of joint, anatomy of skeletal muscles.	
UNIT – II : CIRCULATORY SYSTEM	**(9 Periods)**
Circulatory system- Blood, lymph composition and function. Basic anatomy of the heart. Physiology of heart, blood vessels and circulation. Basic understanding of cardiac cycle, heart sounds and electrocardiogram. Blood pressure and its regulation. Brief outline of cardiovascular disorders like hypertension, hypotension, atherosclerosis, angina, myocardial infarction, congestive heart failure and cardiac arrhythmias.	
UNIT – III : DIGESTIVE AND ENDOCRINE SYSTEM	**(9 Periods)**
Digestive System- Anatomy of the gastro intestinal tract, functions of its different parts: liver, pancreas and gall bladder, various gastrointestinal secretions and their role in the absorption and digestion of food. Endocrine system- anatomy and functions of pituitary gland, adrenal gland, parathyroid gland, pancreas.	
UNIT – IV : RESPIRATORY, URINARY AND REPRODUCTIVE SYSTEM	**(9 Periods)**
Respiratory System- Anatomy of respiratory organs. Functions of respiration, mechanism and regulation of respiration, respiratory volumes and vital capacity. Urinary System- Various parts, structures and functions of the kidney and urinary tract. Reproductive system- testes and ovary, Anatomy and physiology of various parts of male and female reproductive systems.	
UNIT – V : NERVOUS SYSTEM	**(9 Periods)**
Central Nervous System- Functions of different parts of brain and spinal cord. Neuro-chemical transmission in central nervous system, reflex action, cranial nerves and their functions. Autonomic Nervous System- Physiology and functions of autonomic nervous system-mechanism of neuro humoral transmission in A.N.S.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Gerad. J. Tortora and Bryan H. Derrickson,* ***Principles of Anatomy and Physiology****, 16th edition, Wiley, 2020.*
2. *C.C.Chatterjee,* ***Human Physiology****, 13th edition, Vol I and II, CBS publishers and distributors, 2020.*

REFERENCE BOOKS:

1. *John. E. Hall, Guyton and Hall **Textbook of Medical Physiology**, 14th edition, Elseiver, 2020.*
2. *K. Sembulingam, PremaSembulingam, **Essentials of Medical Physiology**, 8th edition, JaypeeBrothers, New Delhi, 2019.*
3. *Marieb, Elaine N. and KatjaHoehn, **Human Anatomy & Physiology**, 11th edition, Pearson publishers, 2018.*
4. *Frederic H. Martini, Judi L. Nath, Edwin F. Bartholomew, **Fundamentals of Anatomy and Physiology**. Tenth Edition, Pearson Publishers, 2014.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Recognize the basic structural and functional elements of human body and human skeletal system.

CO2: Identify the anatomical and physiological characteristics of human circulatory system.

CO3: Differentiate the various structural and functional components of human digestive and endocrine system.

CO4: Report the anatomical features and physiology of human respiratory, urinary and reproductive system

CO5: Classify the structural framework and key functions of central nervous system.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	-	-	-	M	-	-	-	-	-	-	H	L
CO2	L	L	-	-	-	M	-	-	-	-	-	-	H	L
CO3	L	L	-	-	-	M	-	-	-	-	-	-	H	L
CO4	L	L	-	-	-	M	-	-	-	-	-	-	H	L
CO5	L	L	-	-	-	M	-	-	-	-	-	-	H	L
18BPE$42	L	L	-	-	-	M	-	-	-	-	-	-	H	L

L - Low, M-Moderate (Medium), H – High

18BPE$43	BIOETHICS

PRE-REQUISITES: NIL

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To enlighten the students about the ethical issues and responsibilities
- To discuss about the safety and risk assessment in various industrial process

UNIT – I :ENGINEERING ETHICS	**(9 Periods)**
Cardinal virtues and their development , concept of morality, ordinal virtues, Senses of "Engineering Ethics" – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg"s theory – Gilligan"s theory – Consensus and Controversy – Professions and Professionalism – Professional Ideals and Virtues – Uses of Ethical Theories.	
UNIT – II : ENGINEERING AS SOCIAL EXPERIMENTATION	**(9 Periods)**
Engineering as Experimentation – Engineers as responsible Experimenters – Research Ethics - Codes of Ethics – Industrial Standards - A Balanced Outlook on Law – The Challenger Case Study.	
UNIT – III : ENGINEER'S RESPONSIBILITY FOR SAFETY	**(9 Periods)**
Safety and Risk – Assessment of Safety and Risk – Risk Benefit Analysis – Reducing Risk – The Government Regulator's Approach to Risk - Chernobyl and Bhopal Case Studies.	
UNIT – IV : RESPONSIBILITIES AND RIGHTS	**(9 Periods)**
Collegiality and Loyalty – Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Intellectual Property Rights (IPR) - Discrimination.	
UNIT – V : GLOBAL ISSUES	**(9 Periods)**
Multinational Corporations – Business Ethics - Environmental Ethics – Computer Ethics - Role in Technological Development – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Honesty – Moral Leadership – Sample Code of Conduct.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Mike Martin and Roland Schinzinger, "**Ethics in Engineering**", McGraw Hill, New York, 2005.*
2. *Charles E Harris, Michael S Pritchard and Michael J Rabins, "**Engineering Ethics – Concepts and Cases**", Thompson Learning, 2000.*

REFERENCE BOOKS:

1. *Charles D Fleddermann, "**Engineering Ethics**", Prentice Hall, New Mexico, 1999.*
2. *John R Boatright, "**Ethics and the Conduct of Business**", Pearson Education, 2003.*
3. *Edmund G Seebauer and Robert L Barry, "**Fundamentals of Ethics for Scientists and Engineers**", Oxford University Press, 2001.*
4. *Prof. (Col) P S Bajaj and Dr. Raj Agrawal, "**Business Ethics – An Indian Perspective**", Biztantra, New Delhi, 2004.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

- **CO1:** Get familiarize with the basics of work ethics.
- **CO2:** Be aware of the engineer's social responsibility and standard industrial operating procedures.
- **CO3:** Acquire the responsibility of an engineer towards safety.
- **CO4:** Report the different ethical rights and responsibilities of an engineer.
- **CO5:** Explore the various global issues related to professional ethics.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	H	M	H	-	-	-	-	-	H
CO2	-	-	-	-	-	H	M	H	L	-	-	-	-	H
CO3	-	-	-	-	-	H	M	H	-	-	-	-	-	H
CO4	-	-	-	-	-	H	M	H	-	-	-	-	-	H
CO5	-	-	-	-	-	H	M	H	-	-	-	-	-	H
18BPE$43	-	-	-	-	-	H	M	H	L	-	-	-	-	H

L - Low, M-Moderate (Medium), H- High

18BPE$44	BIOMASS AND BIOENERGY

PRE-REQUISITES: NIL

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the importance of biomass as a resource.
- To familiarize with the various strategies in the production of biofuels.
- To evaluate various technologies on the basis of the substrates treated
- To enable them to design elements and conceptualize bioenergy plants

UNIT – I	BIOMASS: PROPERTIES AND TYPES	(9 periods)
Constituents of Biomass, Energy properties. Biomass typologies: Lignocellulosic, startchy, sugary, oilseeds,sewage sludge, manure. Biomass Conversion: Physical, Chemical, Biochemical process.		
UNIT – II	**MILESTONES IN BIOFUELS**	**(9 periods)**
First generation biofuels-bioethanol; Second generation biofuels-methane and hydrogen – production mechanisms by microbes; Third generation biofuels-biobutanol-biodesel from algae; Fourth generation biofuels- solarto fuel method to produce biofuels, Microbial fuel cell		
UNIT – III	**BIODIESEL AND BIOMETHANE**	**(9 periods)**
Sources and processing of biodiesel (fatty acid methyl ester); Sources and characteristics of lipids for use as biodiesel feedstock and conversion of feedstock into biodisel (transesterification); Biomethane or biogas-hydrolysis-anaerobic digestion-methanogenesis (acetoclastic, hydrogenotrophic) - rates of methane formation-one and two stage fermentation, Factors affecting gas production.		
UNIT – IV	**GASIFICATION & PYROLYSIS TECHNOLOGIES**	**(9 periods)**
Gasification processes and the main types of gasifier designs-production of electricity by combining a gasifier with a gas turbine or fuel cell; Combined-cycle electricity generation with gas and steam turbines and generation of heat and steam; Fast pyrolysis technology to produce liquid bio oil or pyrolysis oil (synthetic oil) from biomass-refined to produce a range of fuels- chemicals and fertilizer, Biochar		
UNIT – V	**CHEMICAL ENGINEERING TOOLS FOR ENERGY DESIGN PROCESSES**	**(9 periods)**
Reaction stoichiometry, reaction kinetics, reaction thermodynamics, reactors, process analysis and design		

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Samir K. Khanal,* ***"Bioenergy Production: Principles and Applications"****, Wiley-Blackwell Publishing, 1st edition, 2016.*
2. *David M. Mousdale,* ***"Biofuels: Biotechnology, Chemistry, and Sustainable Development"****, CRC Press Taylor and Francis group,1st edition, 2008*

REFERENCE BOOKS:

1. *Robert C. Brown,* ***"Biorenewable Resources: Engineering New Products from Agriculture"****, Wiley-Blackwell Publishing, 2nd edition, 2014.*
2. *Pogaku, Ravindra, Sarbatly, rosalamhj. (Eds.),* ***"Advances in Biofuels"****, Springer, 2013.*
3. *Martin Kaltschmitt and Hermann Hofbauer,* ***"Biomass Conversion and Biorefinery"****, Springer Publishing, 2008.*
4. *Gupta, Vijai Kumar; Tuohy, Maria G. (Eds.), "****Biofuel Technologies Recent Development",*** *Springer, 1st edition, 201*

Course outcomes:

Upon completion of the course, the students will be able to:

CO1: Understand the necessity of biomass to meet the growing energy demand.

CO2: Familiarize with the various sources of energy and classify it accordingly.

CO3: Gain knowledge on the chemical and biological reactions behind the production of biodiesel.

CO4: Illustrate the technologies of gasification and pyrolysis towards the production of various forms of fuels.

CO5: Understand the chemical reaction kinetics of biofuel production.

COURSE ARTICULATION MATRIX :

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	L	-	-	-	-	-	-	-	-	-	H	M
CO2	L	M	-	L	-	-	L	M	-	-	-	-	H	M
CO3	L	M	L	L	-	-	-	L	M	-	-	L	M	H
CO4	L	L	L	L	M	-	-	-	L	-	-	-	H	M
CO5	-	-	-	-	-	-	-	-	-	-	-	-	H	H
18BPE$44	L	M	L	L	M	-	L	M	M	-	-	L	H	M

L – Low, M – Moderate (Medium), H – High

18BPE$09	ENVIRONMENTAL BIOTECHNOLOGY

Category: PE

PRE-REQUISITES:

1. Microbiology
2. Environmental Sciences and Engineering

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To enable the students to get familiar with the diverse microorganism present in the environment and their various roles in environmental safety.
- To furnish knowledge about various pollutants present in the environment.

UNIT – I :FUNDAMENTALS OF SOIL MICROBIOLOGY	**(9 Periods)**
Microbial flora of soil, growth and ecological adaptations of soil microorganisms, interactions among soil microorganisms, biogeochemical role of soil microorganisms.	
UNIT – II : BIODEGRADATION OF XENOBIOTIC COMPOUNDS	**(9 Periods)**
Xenobiotics - persistence and biomagnification; Types of Recalcitrant xenobiotic compounds; Factors causing molecular recalcitrance; microbial pathways for biodegradation of petroleum hydrocarbons – aliphatic, aromatic, polycyclic and chlorinated hydrocarbons; biodegradation of pesticides and synthetic detergents.	
UNIT – III : WASTE WATER TREATMENT	**(9 Periods)**
Characteristics of Waste Waters - Physical, chemical and biological; Waste water treatment- Biological method- suspended growth and biofilm processes; design of activated sludge process; ponds and lagoons; trickling filters; anaerobic wastewater treatment; sludge digestion - design of anaerobic sludge digesters; nutrient removal – nitrogen and phosphorus.	
UNIT – IV : INDUSTRIAL WASTE WATER MANAGEMENT	**(9 Periods)**
Leather, pulp, pharmaceutical, dairy, textile and dye industries – production process, origin and characteristics of waste, waste minimization and treatment options; solid waste management; hazardous waste management.	
UNIT – V : DEVELOPMENTS PERTAINING TO ENVIRONMENTAL BIOTECHNOLOGY	**(9 Periods)**
Case studies: Bioleaching and Biomining; Biofertilizers and Biopesticides; Biofuel and Biogas; Bioremediation, Biosensors. Production of bioelectricity from microbial fuel cell (MFC).	

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Bruce E.R & Perry L.M, **"Environmental Biotech: Principle & Applications"**, McGraw Hill, 2012.*
2. *Mecalf& Eddy Inc, Tchobanoglous G, Burton F.L, Stensel H.D, **"Wastewater Engineering: Treatment Disposal Reuse"**, McGraw Hill, 4th edition, 2002.*
3. *Patwardhan, A.D, **"Industrial wastewater treatment"**, PHI learning private limited,2nd edition, 2017.*

REFERENCE BOOKS:

1. *Scragg A, **"Environmental Biotechnology"**, Oxford University press, 2nd edition., 2005.*
2. *Joanne M. W, Sherwood L, Woolverton C.J, **"Prescott's Microbiology"**, McGraw-Hill, 8th edition, 2011.*
3. *Parimal pal, **"Industrial water treatment process technology"**, Butterworth-Heinemann, 2017.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand various organism in soil and their roles in ecosystem management
CO2: Gain knowledge on various terms of pollutants and their accumulations
CO3: Review on xenobiotic compounds and their degradation pathway
CO4: Able to explain the characteristics and biological treatment of waste water
CO5: Analyze various industrial waste and their treatment process
CO6: Study on different applications of biotechnology for environmental problems

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	-	-	-	-	-	M	-	-	-	-	L	H	L
CO2	M	-	-	-	-	-	H	-	L	-	-	L	M	L
CO3	M	H	-	-	-	-	H	-	-	-	-	L	H	L
CO4	M	L	L	-	-	-	M	-	-	-	-	L	M	M
CO5	M	L	-	-	-	-	H	-	L	-	-	L	M	M
CO6	-	H		L	L	L	H	-	-	-	-	L	H	M
18BPE $09	M	H	-	-	-	-	H	-	L	-	-	L	H	L

L - Low, M-Moderate (Medium), H- High

18BPE$02	BIOPOLYMER TECHNOLOGY

PRE-REQUISITES: NIL

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the different types of biopolymers in biomedical applications, environmental protection, application of bio surfactants in food industry and to examine the different properties and market analysis through case studies

UNIT – I : INTRODUCTION	**(9 Periods)**
Biopolymers - definition, Plant and Animal biopolymers- polynucleotide, polyamides, polysaccharides, polyisoprene, lignin, polyphosphate and polyhydroxyalkanoates. Application and chemical synthesis of super absorbent polymers-Polyethylene glycol, Polypropylene glycol, Polytetramethylene glycol, Polyglycerine. Bioplastics and environment, Commercial bioplastics. Natural fibers like silk, wool, flax, jute, linen, cotton, bamboo. Biocomposite- properties and applications.	
UNIT – II : BIOPOLYMER TECHNOLOGY AND APPLICATIONS	**(9 Periods)**
Industrial biopolymers: Production of polyphenol resins by the enzyme soybean peroxidase; Novel synthesis of Artificial Biopolymers in Biomedical Applications- An Overview, Hydrogel as potential Nano scale drug delivery system , Low cost foods and drugs using immobilized enzymes on Biopolymers, Physiochemical characteristics of biopolymers. Biodegradable polymers for medical purposes, Biopolymers in controlled release systems. Synthetic polymericMembranes and their biological applications.	
UNIT – III : BIOSURFACTANTS	**(9 Periods)**
Biosurfactants: Source, characteristics and properties of Biosurfactants; Production of Biosurfactants via the fermentation and biotransformation routes; Production of Biosurfactants with immobilized cells; Integrated bioprocess for continuous production of Biosurfactants including downstream processing; Applications of Biosurfactants – Food Industry, Environmental Control.	
UNIT – IV : MATERIAL TESTING AND ANALYTICAL METHODS	**(9 Periods)**
An Overview of Available Testing Methods, Comparison of Test Systems for the Examination of the Fermentability of Biodegradable Materials, Evaluation of the properties of biopolymers to make good biomaterials; Tensile strength (both elasticity and breaking strength); Hydration, visco – elastic properties; viscosity. Criteria used in the evaluation of Biodegradable polymers – petridish screen – environmental chamber method – soil burial tests etc.	
UNIT – V : CASE STUDIES	**(9 Periods)**
Biopolymers: Synthesis from a simple biological monomer (i.e. Hyaluronate polymers); Dextran (used in chromatography columns); Rubberlike materials produced by bacteria and fungi – Polyhydroxybutyrate (PHB), Polycaprolactone (PCL), Xanthan gum; Production of a copolymer of PHB and PHV(Polyhydroxyvaleric acid), sold as Biopol by fermentation on *Alcaligeneseutrophus*; Biodegradable polymers.	

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Emo Chiellini , Helena Gil,* ***"Biorelated Polymers: Sustainable Polymer Science and Technology"****, Springer 2001.*
2. *Johnson .R.M, L.Y. Mwaikambo and N. Tucker,* ***"Biopolymers"****, Rapra Technology, 2003*

REFERENCE BOOKS:

1. *NaimKosaric (Ed).,* ***"Biosurfactants"****, Marcell Dekker Inc, 1993.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To employ the greener technologies to solve the environmental issues.

CO2: To familiar the different types of plant and animal derived biopolymers and their application as commercial bioplastics.

CO3: To illustrate the synthesis and application of biopolymers in nanoscale drug delivery systems, as biomimetic materials and waste water treatment methods.

CO4: To understand the properties of biosurfactants and their use in food industries.

CO5: To evaluate the tensile strength, hydration, viscoelastic properties using different Testing methods.

CO6: To analyze the different types of Biopolymers through case studies.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M	H	-	-	-	-	-	L	L	-	L	M	H
CO2	M	H	L	M	-	-	L	-	L	L	-	-	M	H
CO3	H	L	M	-	-	-	L	-	-	-	-	L	H	L
CO4	M	L	H	-	-	-	L	L	-	-	-	-	H	L
CO5	M	M	M	-	-	-	L	-	-	-	-	-	M	M
CO6	L	L	M	-	-	-	L	L	L	L	-	L	H	M
18BPE $02	M	L	M	L	-	-	-	-	L	L	-	L	M	H

-

L - Low, M-Moderate (Medium), H- High

18BPE$11	NANOBIOTECHNOLOGY

PRE-REQUISITES: NIL

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of nanotechnology, various form of nanomaterials, its properties and applications.
- To acquire knowledge about various methods of synthesis and characterization of nanoparticles.
- To understand the bionanomachinery in living cells for generating energy, motion, synthesizing biomolecules and to apply the knowledge to design bionanodevices.
- To understand and exploit the nanoparticles in biological applications.

UNIT – I : INTRODUCTION	**(9 Periods)**
Nano – definition; Fundamental science behind nanotechnology- electrons- atoms- ions- molecules- metals- biosystems; Nanobiotechnology –definition; Nanomaterials- types- Carbon nanomaterials (fullerene-grapheme- nanotubes; Characteristics and applications)- Quantum Dots and Wires; Metal nanoparticles - properties and applications.	
UNIT – II : METHODS OF NANOPARTICLES SYNTHESIS	**(9 Periods)**
Nanoparticles fabrication- Top-down & bottom-up approaches- Physical- chemical- biological methods; Use of bacteria- fungi- actinomycetes and plants for nanoparticle synthesis; Magnetotactic bacteria for natural synthesis of magnetic nanoparticles- mechanism of formation.	
UNIT – III : CHARACTERIZATION OF NANOPARTICLES	**(9 Periods)**
Characterization of nanoparticles – AFM- SEM- TEM- STM- XRD- EDAX- FTIR – principle and applications.	
UNIT – IV : NANOBIOMETRICS	**(9 Periods)**
Introduction- Lipids as nanobricks and mortor- Self assembled monolayers; Nanoscale motors; Ion channel as sensors; DNA based nano-cubes and nano-hinges; Protein based nanomotors- bacteriorhodopsin.	
UNIT – V : BIOMEDICAL APPLICATIONS OF NANOPARTICLES	**(9 Periods)**
Biocompatible In-organic devices (Implant coating- stems and seeds); Chips for molecular diagnostics –DNA microarrays- Protein microarrays- lab on a chip; Nanoparticles for drug delivery; Nanovectors for gene therapy; Nanobiosensors; In-vivo diagnostics in molecular imaging.	

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Kumar, N., Kumbhat, S., **"Essentials in Nanoscience and Nanotechnology"**, John Wiley & Sons, 2016.*
2. *Niemeyer, C.M., Mirkin,C.A., **"Nanobiotechnology: Concepts, Applications and Perspectives"**, Wiley-VCH, 2004.*
3. *Cao, G., **"Nanostructures and Nanomaterials-Synthesis, properties and applications"**, Imperial College Press, 2004.*
4. *de la Fuente, J.M., Grazu, V., **"Nanobiotechnology"**, In: Fronteries in Nanoscience (Vol.4), R.E. Palmer (Ed), Elsevier, 2012.*

REFERENCE BOOKS:

1. *Nicolini, C.,* ***"Nanobiotechnology and Nanobiosciences"****, Pan Stanford, 2008.*
2. *Yoseph, Bar-Cohen,* ***"Biomimetics : Biologically Inspired Technologies"****, CRC Press, 2006.*
3. *Roszek, B., de Jong, W.H., Geertsma, R.E.,* ***"Nanotechnology in medical applications: State-of-the-art in materials and devices"****, 2005.*
4. *Kirkland, A.I., Hutchison, J.L.,* ***"Nanocharacterization"****, RSC Publishing, 2007.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the different types of nanomaterials, its properties and applications.
CO2: Know about biological methods of nanoparticle synthesis
CO3: Characterize the synthesized nanoparticles using different analytical techniques
CO4: Understand the bionanomachinery in living cells to design bionanodevices.
CO5: Acquire knowledge about the biological applications of nanoparticles.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	-	-	-	L	-	-	-	-	-	M	H	M
CO2	M	H	M	-	-	-	L	L	-	-	-	-	H	M
CO3	M	M	-	H	M	-	-	-	-	L	-	-	M	H
CO4	M	L	M	-	-	-	-	-	-	-	-	-	M	H
CO5	M	-	-	-	-	M	-	-	-	-	-	L	M	H
18BPE $11	M	M	M	H	M	M	L	L	-	L	-	M	M	H

L - Low, M-Moderate (Medium), H- High

18BPE$45	BIOMASS CONVERSION AND BIOREFINERY

PRE-REQUISITES: NIL

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To understand the overview of world energy situation, and refinery and biorefinery concept.
- To familiarize techno-economic analysis of various biofuel conversion technologies and their environmental attributes.
- To acquire knowledge on converting waste to biofuels
- To give the concept of platform chemicals and their importance
- To able to design operations of an integrated biorefinery

UNIT – I	INTRODUCTION TO BIOMASS AND BIOREFINERY	9 Periods

World energy scenario and environmental issues, Biomass-Availability and abundance, photosynthesis, composition and energy potential, virgin biomass production and selection, waste biomass (municipal, industrial, agricultural and forestry) availability, abundance and potential, biomass as energy resources: dedicated energy crops, annual crops (maize, sorghum sugar beet, hemp), perennial herbaceous crops (sugarcane, switchgrass, miscanthus), short rotation woody crops (poplar, willow), oil crops and their biorefinery potential, microalgae as feedstock for biofuels and biochemical, enhancing biomass properties for biofuels, challenges in conversion, Biorefinery: Basic concept, types of biorefineries, biorefineryfeedstocks and properties, economics.

UNIT – II	PRETREATMENT METHODS	9 Periods

Biomass Pretreatment: Barriers in lignocellulosic biomass conversion, pretreatment technologies such as acid, alkali, autohydrolysis, hybrid methods, role of pretreatment in the biorefinery concept Physical and Thermal Conversion Processes: Types, fundamentals, equipments and applications; thermal conversion products, commercial success stories, Microbial Conversion Process: Types, fundamentals, equipments and applications, products, commercial success stories

UNIT – III	VALUE ADDED PRODUCTS PRODUCTION AND TECHNOLOGY	9 Periods

Biodiesel: Diesel from vegetable oils, microalgae and syngas; transesterification; FT process, catalysts; biodiesel purification, fuel properties, Biooil and Biochar: Factors affecting biooil, biochar production, fuel properties, biooilupgradation, Bioethanol and Biobutanol: Corn ethanol, lignocellulosic ethanol, microorganisms for fermentation, current industrial ethanol production technology, cellulases and their role in hydrolysis, concepts of SSF and CBP, advanced fermentation technologies, ABE fermentation pathway and kinetics, product recovery technologies.

UNIT – IV	TRANSFORMATION OF COMMODITY CHEMICALS	9 Periods

Hydrogen, Methane and Methanol: Biohydrogen generation, metabolic basics, feedstocks, dark fermentation by strict anaerobes, facultative anaerobes, thermophilic microorganisms, integration of biohydrogen with fuel cell; fundamentals of biogas technology, fermenter designs, biogas purification, methanol production and utilization,Organic Commodity Chemicals from Biomass: Biomass as feedstock for synthetic organic chemicals, lactic acid, polylactic acid, succinic acid, propionic acid, acetic acid, butyric acid, 1,3-propanediol, 2,3-butanedioil, PHA

UNIT – V	INTEGRATED BIOREFINERY	9 Periods
Integrated Biorefinery: Concept, corn/soybean/sugarcane biorefinery, lignocellulosicbiorefinery, aquaculture and algal biorefinery, waste biorefinery, hybrid chemical and biological conversion processes, techno- economic evaluation, life-cycle assessment.		
Contact Periods **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS

1 *Donald L. Klass,* ***Biomass for Renewable Energy, Fuels, and Chemicals****, Academic Press, Elsevier, 2006.*
2 *PrabirBasu,* ***Biomass Gasification, Pyrolysis and Torrefaction****, Academic Press, Elsevier, 2013.*

REFERENCES

1 *A.A. Vertes, N. Qureshi, H.P. Blaschek, H. Yukawa (Eds.),* ***Biomass to Biofuels : Strategies for Global Industries****, Wiley, 2010.*
2 *S. Yang, H.A. El-Enshasy, N. Thongchul (Eds.),* ***Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers****, Wiley, 2013.*
3 *Shang-Tian Yang (Ed.),* ***Bioprocessing for Value Added Products from Renewable Resources,*** *Elsevier, 2007.*

COURSE OUTCOMES:

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

CO1 : Understand the overview of world energy situation, and refinery and biorefinery concept.
CO2 : Familiarize techno-economic analysis of various biofuel conversion technologies and their environmental attributes.
CO3 : Acquire knowledge on converting waste to biofuels
CO4 : Give the concept of platform chemicals and their importance
CO5 : Able to design operations of an integrated biorefinery.

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	-	-	-	-	-	-	-	-	-	L	M
CO2	L	L	M	L	L	-	-	-	-	-	-	-	L	M
CO3	L	L	M	L	M	-	-	-	-	-	-	-	M	M
CO4	L	L	L	M	-	-	-	-	-	-	-	-	L	L
CO5	L	L	L	-	-	-	-	-	-	-	-	-	L	M
18BPE$45	M	L	M	L	L	-	-	-	-	-	-	-	M	M

L - Low, M - Moderate (Medium), H - High

18BPE$46	INTRODUCTION TO BIOSTATISTICS

PRE-REQUISITES: NIL **Category: PE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the role of biostatistics in public health or medical studies
- To use descriptive tools to summarize and display data from public health or medical studies.
- To understand the principles of various study designs, and explain their advantages and limitations.
- To identify appropriate tests to perform hypothesis testing, and interpret the outputs adequately.
- To differentiate between quantitative problems from public health or medical studies that can be addressed by statistical tools.

UNIT – I	**INTRODUCTION**	**(9 periods)**
Measure of location, properties of arithmetic mean, measure of spread, coefficient of variation, grouped data, graphic methods. Basics of Probability		
UNIT – II	**STATISTICAL ESTIMATION**	**(9 periods)**
Relationship between population and sample. Estimation of the Mean and variance of a distribution: point estimation, standard error of the mean, central limit theorem, interval estimation.		
UNIT – III	**TESTING OF HYPOTHESIS**	**(9 periods)**
One-sample inference: Introduction, general concepts, test for mean of a normal distribution – one sided, two sided alternatives, the power of a test, sample size determination. Two-sample inference: Paired t-test, comparison of means from two paired samples, t-test for two independent samples with equal variances, testing for equality of two variances, t-test for independent samples with unequal variances. Chi-square test for independence of attributes and goodness of fit		
UNIT – IV	**REGRESSION CORRELATION**	**(9 periods)**
General concepts, fitting regression lines- method of least squares, inferences about parameters, goodness of fit, simple correlation		
UNIT – V	**BIOSTATISTICS FOR BIOTECHNOLOGISTS**	**(9 periods)**
Statistical screening and optimization designs – FFD, PBD, CCD, BBD, Mixture Designs: D-Optimal, L-optimal and I-optimal designs, Artificial Neural Network for process modeling and statistical validation.		

Contact Periods:
Lecture:45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Bernard Rosner, "**Fundamental of Biostatistics**", Duxbury Thomson Learning, New York, 2006.*
2. *Richard I Levin and David. S. Rubin, **"Statistics for Management"**, Pearson Education, New Delhi, 2009.*

REFERENCE BOOKS:

1. *Ronald N Forthofer, EunSul Lee, **"Introduction to Biostatistics – A Guide to Design, Analysis and Discovery**", Academic Press, New York, 2006.*
2. *Glantz SA, "**Primer of Biostatistics**", McGraw Hill, New York, 1997.*
3. *Zar JH, "**Biostatistical Analysis**", Pearson Education, New Delhi, 2003.*
4. *Sundar Rao PSS, Richard J, "**An Introduction to Biostatistics. A model for students in health sciences**", Prentice Hall, New Delhi, 2006.*

COURSE OUTCOMES:

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

CO1: Understand the role of biostatistics in public health or medical studies

CO2: Use descriptive tools to summarize and display data from public health or medical studies

CO3: Understand the principles of various study designs, and explain their advantages and limitations

CO4: Identify appropriate tests to perform hypothesis testing, and interpret the outputs adequately

CO5: Differentiate between quantitative problems from public health or medical studies that can be addressed by statistical tools

COURSE ARTICULATION MATRIX :

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	H	L	-	-	L	-	-	-	-	-	L	-	H	L
CO2	L	M	H	-	M	L	-	L	M	M	L	M	L	M
CO3	L	M	H	L	M	L	M	L	M	M	L	M	H	L
CO4	L	M	-	L	M	L	M	M	M	M	L	M	H	L
CO5	L	M	H	L	M	L	M	L	M	M	L	M	H	L
18BPE$46	L	M	H	L	M	L	M	L	M	M	L	M	H	L

L – Low, M – Moderate (Medium), H – High