NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA

(First Private Autonomous College in UttarPradesh)

Affiliated to

DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY LUCKNOW

Syllabus

For

M.Tech. (Biotechnology)
First Year

(Effective from the Session: 2020-21)

NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA

Study and Evaluation Scheme
M.TECH. BIO-TECHNOLOGY

(Effective from the session: 2020-21)

1st Year, 1st Semester

Sl. No.	Subject	Subject	Periods			Evaluation Schemes				End		Total	Credit
	Codes									Semester			
			L	T	P	CT	TA	TOTAL	PS	TE	PE		
1		Departmental course-I (*Applied Biochemistry & Molecular Biology*)	3	0	0	20	10	30		70		100	3
2		Departmental course-II (*Bioprocess Engineering & Technology*)	3	0	0	20	10	30		70		100	3
3		Research Methodology	3	0	0	20	10	30		70		100	3
5		Elective -I	3	0	0	20	10	30		70		100	3
6		Elective -II	3	0	0	20	10	30		70		100	3
7		Lab I (*Applied Biochemistry & Molecular Biology Lab*)	0	0	4				20		30	50	2
8		Lab II (*Bioprocess Engineering & Technology Lab*)	0	0	4				20		30	50	2
		TOTAL										**600**	**19**

L: Lecture T: Tutorial P: Practical/Project CT: Class Test TA: Teacher's Assessment, ESE: End Semester Examination

Departmental Elective-I

1.Immunology & Vaccine Technology
2.Quality Control in Biotechnology
3.Applied Clinical Research

Departmental Elective-II

1.Biological Treatment of Wastewater
2.Nano Biotechnology & Toxicology
3.Industrial Biotechnological Products

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1st Year, IInd Semester

Sl. No	Subject	Subject	Periods			Evaluation Schemes				End		Total	Credit
	Codes									Semester			
			L	T	P	CT	TA	TOTAL	PS	TE	PE		
1		Departmental course-I (*Bioinformatic*)	3	0	0	20	10	30		70		100	3
2		Departmental course-II (*Entrepreneurship, IPR Biosafety*)	3	0	0	20	10	30		70		100	3
3		Elective – III	3	0	0	20	10	30		70		100	3
4		Elective- IV	3	0	0	20	10	30		70		100	3
5		Elective- V	3	0	0	20	10	30		70		100	3
6		Lab- I (*Bioinformatics Lab*)	0	0	4				20		30	50	2
7		Lab- II (*Entrepreneurship, IPR & Biosafety*)	0	0	4				20		30	50	2
8		Seminar-I	0	0	2				20		30	50	1
		TOTAL										**650**	**20**
Frist Year Total Marks = 1250; Total Credit = 39													

L: Lecture T: Tutorial P: Practical/Project CT: Class Test TA: Teacher's Assessment, ESE: End Semester Examination

Departmental Elective-III

1.Genetic Engineering
2.Applied Food Biotechnology

3.Molecular Modelling & Industrial Application

Departmental Elective-IV

1.Bioreactor Analysis & Design

2.Enzyme Technology & Industrial Application

3.Applied Bioenergy

Departmental Elective-V

1.Tissue Culture Techniques

2.Diagnostic Techniques in Biotechnology

3. '3-D' Printing Technology

M.Tech.
Biotechnology
(First Semester)

	Applied Biochemistry & Molecular Biology	L: T: P
		3:0:0
Course objective:		
1	To understand the various concepts of molecular biology and biochemistry	
2	Determine the structure and function of biomolecules and evaluate the complexity of various biomolecules.	
3	Understand the principles of bioenergetics to learn the various pathways.	
4	Evaluate the concept of metabolisms of various types.	
5	Evaluate structure of genetic material and the central dogma of molecular biology.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus :		
Unit 1	**Structures and functions of Bio-molecules:**	**8 hr**
	Carbohydrates: classification, mono, di, oligo and polysaccharides. Lipids: fatty acids, simple, complex & derived lipids. Protein: Amino Acids Structure and function, Protein Structure Hierarchy. Nucleic acids: nucleosides, nucleotides, DNA & RNA.	
Unit 2	**Bioenergetics:**	**8 hr**
	Overview of principles of bioenergetics (free energy, enthalpy and entropy). Energy relationships between catabolic and anabolic pathways. Phosphoryl group transfers and ATP, Free-energy change for ATP hydrolysis.	
Unit 3	**Metabolism:**	**8 hr**
	Glycolysis, Gluconeogenesis, Respiration and Introduction to the Citric Acid Cycle, Electron Transport, Oxidative phosphorylation, Fatty Acid Catabolism: Fatty acid oxidation, Protein Metabolism: The Urea Cycle	
Unit 4	**Gene Structure and Function**	**10 hr**
	Gene structure, DNA & RNA as a genetic material, RNA World, packaging of DNA as chromosome, DNA replication- Prokaryotic and eukaryotic DNA replication, Mechanism ofreplication. Telomeres, telomerase and end replication. Role of telomerase in aging and cancer.	
Unit 5	**Central Dogma**	**10 hr**
	Transcription, genetic code, reverse transcription, mRNA processing. Translation, Gene regulation, operons: Lac operon, Trp operon, transposons.	
Course outcome		
CO1	After completion of the course, students will understand about the structure and function of biomolecules	
CO2	They will learn about principles of bioenergetics.	
CO3	They will understand the different types of metabolisms.	
CO4	Students will learn the overall gene structure and function.	
CO5	Students will be able to understand the molecular functioning of cells.	
Text books		
1	Biochemistry- L.Stryer , Third Edition	
2	Biochemistry- Voet & Voet.	
3	Principles of Biochemistry- A.Lehninger , CBS Publishers and Distributors , 1987.	
Reference Books		
1	Watson. J. D, Baker. T. A, Bell. S. P, Gann. A, Levine. M, Losick. R. Molecular Biology of Gene. 6th The Benjamin / Cummings Pub. Co. Inc, 2008.	

2	Darnell, Lodish and Baltimore. Molecular Cell Biology, Scientific American Publishing Inc, 2000.	
3	Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular biology of the Cell. 4th ed. Garland publishing Inc, 2002	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	BIOPROCESS ENGINEERING & TECHNOLOGY	L: T: P
		3:0:0
Course objective:		
1	To provide basic concepts of bioprocess engineering.	
2	To learn engineering principles that can be applied to processes involving cell or enzyme.	
3	To learn the basics of bioreactor design and operation control.	
4	To analyze variety of bioprocess techniques and also conduct related experiments.	
5	To understand various unit operations in bioprocess.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus :		
UNIT I	**Introduction to Bioprocess Technology**	**8 Hr.**
	Historical development of bioprocess technology, An overview of traditional and modern applications of biotechnological processes, General requirements of fermentation processes, Basic design and construction of fermenter and ancillaries, Main parameters for monitoring & control of fermentation processes, Different raw materials used in fermentation industry and their pretreatment, Medium for plant cell culture and animal cell culture, Medium design of commercial media for industrial fermentations-Plackett burman design, response surface methodology, simplex design.	
UNIT II	**Stoichiometry of Cell growth**	**8 Hr.**
	Stoichiometry of Cell growth and product formation, elemental balances, degrees of reduction of substrate and biomass, available electron balances, yield coefficients of biomass and product formation, maintenance coefficients Energetic analysis of microbial growth and product formation, oxygen consumption and heat evolution in aerobic cultures, thermodynamic efficiency of growth.	
UNIT III	**Mass Transfer in Bioreactors**	**8 Hr.**
	Mass transfer includes transport phenomena in bioprocesses, Factors affecting oxygen transfer rate in bioreactors, Techniques for measurement of volumetric oxygen transfer coefficient, Fluid rheology and factors affecting bioreactor processes, Flow Patterns in agitated tanks, Mechanism & Power requirements of mixing, Scale up of mixing systems.	
UNIT IV	**Metabolic Regulation**	**10 Hr.**
	Different regulatory mechanisms involved in controlling the catabolic and anabolic processes of microbes, Induction, nutritional repression, carbon catabolite repression, Crabtree effect, feedback inhibition and feedback repression, Concept of Overproduction of metabolites, Case studies on production of Lactic acid, Glutamic acid, Penicillin, Microbial Lipase and Protease, Recombinant Insulin, Interferons, Hepatitis Vaccines etc. Case studies should deal with strain improvement, medium designs, process optimization technology.	
UNIT V	**Bioprocess Unit Operations**	**10 Hr.**
	Unit Operation: Filtration, filter aids, filtration Equipment and filtration theory, Centrifugation process and its equipments, Cell disruption, Aqueous Two-Phase Liquid Extraction. Adsorption process and its operations, Chromatography: Theory and mechanism, Scaling-up chromatography.	

Course outcome:		
CO1	Describe the underlying principles of main bioprocess unit operations like fermentation, downstream processing.	
CO2	Demonstrate Stoichiometry of Cell growth and product formation.	
CO3	Design or Select appropriate bioreactor models based upon bioproducts and cell lines and other process criteria.	
CO4	Develop a basic understanding of regulatory mechanisms involved in controlling the catabolic and anabolic processes of microbes.	
CO5	Acquire a basic understanding of various unit operations in bioprocess engineering.	
Text books		
1	Principles of fermentation technology" by P F Stanbury and A Whitaker, Pergamon press.	
2	Bioprocess Technology - Kinetics & Reactors" by A Moser, Springer-Verlag.	
3	Biochemical Engineering and Biotechnology Handbook" by B. Atkinson & F. Mavituna, 2nd Ed. Stockton Press.	
4	Bioprocess Engineering Principles" by Pauline M. Doran, Academic Press.	
5	Biochemical Engineering- S. Aiba , A.E. Humphray, University of Tokyo Press.	
Reference Books		
1	Lee J.M, Biochemical Engineering 2nd ed, Prentice Hall, 2000.	
2	Principles of Cell Energetics": BIOTOL series, Butterworth - Heinemann.	
3	Biotechnology" Vol.4 Meaning Modelling and Control Ed. K.Schugerl, VCH (1991).	
4	Unit operations of Chemical Engineering" 5th ed. by W L McCabe, J C Smith and P. Harriot Mc Graw-Hill (1993).	
5	Diffusion" by E L Cussler, Cambridge University Press (1984).	
6	Bioprocess Engineering Principles" by Pauline M.Doran, Academic Press.	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	IMMUNOLOGY & VACCINE TECHNOLOGY	L: T: P
		3:0:0
Course objective:		
1	Learn the concept and components of the Immune system.	
2	Understand the kinetics and mechanisms of immune response.	
3	Evaluate the concept of vaccination and various types of vaccines.	
4	Understand the concept of various vaccine types viz. viral vaccines, bacterial vaccines and parasitic vaccines etc.	
5	Understand the vaccine industry and the safety and legal issues related to its production.	
Pre-requisites:		
	Students are expected to have knowledge of basic Cell and Molecular biology, knowledge of the various diseases and causative agents will be an edge.	
Course Contents / Syllabus :		
UNIT-I	**Fundamental of Immune System**	**8 hr**
	Fundamental concepts and anatomy of the immune system, Components of innate and acquired immunity, Humoral and Cell mediated immunity, Hematopoiesis, Antigens , immunogens, haptens, Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing.	
UNIT-II	**Immunological Processes**	**8 hr**
	Immunoglobulins-basic structure, classes and subclasses of immunoglobulins, antigenic determinants, Multigene organization of immunoglobulin genes, Immunological basis of self –non-self discrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity, Antigen processing and presentationendogenous antigens and exogenous antigens.	
UNIT-III	**Basic Introduction to Vaccines**	**8 hr**
	A short history of vaccination, Active and passive immunization, General immunization practices, Vaccination of immunocompromised hosts, Vaccination of human immunodeficiency virus infected persons, Vaccines, Live, killed, attenuated, subunit vaccines; Vaccine technology- Roleand properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines,reverse vaccinology; Peptide vaccines, conjugate vaccines.	
UNIT-IV	**Recent Advances in Vaccines**	**10 hr**
	Licensed vaccines, Viral Vaccine (Poliovirus vaccine-inactivated & Live, Rabies vaccines Hepatitis A & B vaccines), Bacterial Vaccine (Anthrax vaccines, Cholera vaccines, Diphtheria toxoid), Parasitic vaccine (Malaria Vaccine).	
UNIT-V	**Vaccine Industry (Production & Regulations)**	**10 hr**
	The vaccine industry, Vaccine manufacturing, Evolution of adjuvants across the centuries, Vaccine additives and manufacturing residuals, Regulation and testing of vaccines, Regulation of vaccines in developing countries, Vaccine safety and Legal issues.	
Course outcome		
CO 1	After completion of the course, students will understand the fundamentals of the immune system.	
CO 2	They will learn about immunological processes.	
CO 3	They will understand the different types of immunization and vaccines.	
CO 4	Students will learn the different types of advanced vaccines.	

CO 5	Students will be able to understand the vaccine industry and their production process.	
Text books		
1	Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002.	
2	Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002.	
3	Janeway et al., Immunobiology, 4th Edition, Current Biology publications., 1999. 4. Paul,	
4	Fundamental of Immunology, 4th edition, Lippencott Raven, 1999.	
Reference Books		
1	Stanley A. Plotkin & Walter Orenstein & Paul A. Offit, Vaccines, 6th Edition 2013 BMA Medical Book Awards Highly Commended in Public Health! Elsevier Publication.	
2	Roitt's Essential Immunology. 11th ed. P. Delves, et al., ed., Blackwell Publishing, 2006.	
3	Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular biology of the Cell. 4th ed. Garland publishing Inc, 2002	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	Quality Assurance and Quality Control	L: T: P
		3:0:0
Course objective:		
1	To learn the basics of GLP	
2	To learn the manufacturing process and its audit.	
3	To understand the clinical trial process	
4	To apply the statistical tools to the various QC events	
5	To understand the tools and softwares used in QC and QA.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus :		
UNIT I	**Concept of Quality control and quality assurance**	
	Concept and evolution of quality control and quality assurance. Total Quality Management, Philosophy of GMP and CGMP. Quality control laboratory responsibilities: GLP protocols on nonclinical testing control on animal house, data generation, integration and storage, standard test procedure, CPCSEA guidelines.	
UNIT II	**Documentation practices and root cause analysis**	
	Retention of sample records, Quality review and batch release document of finished products, Good documentation practices, route cause analysis, corrective action preventive action (CAPA), out of specifications (OOS) and out of trend (OOT)	
UNIT III	**Concept of Audits**	
	Annual product quality review and parametric release, Audits,Preparation of audit, Conducting audit, Audit Analysis, Audit Report and Audit follow up, quality audits of manufacturing processes and facilities, audits of quality control. Case Studies of Audit reports.	
UNIT IV	**Quality agreements and risk management**	
	Concepts and management of contract manufacturing guidelines,principles of quality risk management, ICH guidances for industry, BABE (bioavailability and bioequivalence) studies, post marketing surveillance, Pharmacovigilance,	
UNIT V	**Tools and softwares in QC and QA**	
	Statistical Tools for Quality Control and Precision, Tools of Problem Solving and Continuous Improvement. Softwares for inspection and quality testing and their applications. concept of automation of procedure through Digital, IoT and BOTS solutions. Systematic approach to scale-up and technology transfer in biotechnology quality systems: Applications and challenges.	
Course outcome		
CO1	Recognize the importance of quality control and assurance and understand the concept of GMP, CGMP anf GLP.	
CO2	Recognize the importance of good documentation practices and reframe the preventive actions.	
CO3	Analyse, develop, follow and audit the quality standards and guidelines, being followed in a biotechnology industry.	
CO4	Understand the contract guidelines to effectively manage the quality agreements.	
CO5	Apply statastical tools and modern softwares to evaluate and ensure quality control, assurance and precision.	

Text books		
1	Sharp J. Good Pharmaceutical Manufacturing Practice: Rationale and Compliance. CRC Press; 2005.	
2	Gad SC. Pharmaceutical Manufacturing Handbook: Production and Processes. John Wiley & Sons; 2008.	
3	Steinborn L. GMP/ISO Quality Audit Manual for Healthcare Manufacturers and Their Suppliers, Sixth Edition, (Volume 1 - With Checklists and Software Package). Taylor & Francis; 2003.	
4	Kolman J, Meng P, Scott G. Good Clinical Practice: Standard Operating Procedures for Clinical Researchers. Wiley; 1998.	
5	Waller P. An Introduction to Pharmacovigilance. John Wiley & Sons; 2011.	
Reference Books		
1	Niazi S. Handbook of Bioequivalence Testing. CRC Press; 2007.	
2	Chalmers AA. International Pharmaceutical Registration. Interpharm Press; 2000.	
3	Edwards AJ. ISO 14001 Environmental Certification Step- by-Steps: Revised Edition. Butterworth-Heinemann; 2003.	
4	Mantus D. FDA Regulatory Affairs: A Guide for Prescription Drugs, Medical Devices, and Biologics. Informa Healthcare USA; 2008.	
5	Chalmers AA. International Pharmaceutical Registration. Interpharm Press; 2000.	
6	Contract manufacturing arrangement for drugs, quality agreements: guidance for industry,November 2016 (www.fda.gov/media/86193/download)	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	APPLIED CLINICAL RESEARCH	L: T: P
		3:0:0
Course objective:		
1	To learn the basic of drug development process	
2	To learn the basic step involve in clinical trial of drug.	
3	To understand the ethics involved in clinical resrearch	
4	To understand the principles of controlled clinical trials	
5	To apply the statistical tool for data management.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus :		
UNIT I:	**Introduction to clinical research**	**8 Hr.**
	Basic pharmacology and drug development process, clinical researchdefinition, Basic terminology used in clinical research, preclinical studies, Introduction to pharmacoeconomics, Types of clinical trials, single blinding, double blinding, open access, randomized trials and their examples, interventional study, Good Clinical Practices, Types and Scope of Clinical Research.	
UNIT II:	**Clinical trials**	**8 Hr.**
	New drug discovery process- purpose, main steps involved in new drug discovery process, timelines of each steps, advantages and purposes of each steps, Pre clinical toxicology: General principles, Systemic toxicology (Single dose and repeat dose toxicity studies), Carcinogenicity, Mutagenicity, Teratogenicity, Reproductive toxicity, Local toxicity, Genotoxicity, animal toxicity requirements, Phase-I, II, III, IV trials: Introduction and designing, Various phases of clinical trials, Post Marketing surveillance, methods & Principles of sampling, Inclusion and exclusion criteria, Methods of allocation and randomization, Informed consent process in brief monitoring, treatment outcome, Termination of trial, Safety monitoring in clinical trials	
UNIT III:	**Ethics & Regulations in Clinical research**	**8 Hr.**
	Ethical Theories and Foundations, Ethics Review Committee and Informed Consent Process,Integrity & Misconduct in Clinical Research , unethical trials, thalidomide tragedy, Conflicts of Interest, Evolution and History of Regulations in Clinical Research, Study of various clinical trials (completed or ongoing) ,Patents US Regulatory Structure, Clinical Trial Application in India Import & Export of Drug in India , Investigational New Drug application (IND), New Drug Application (NDA), Abbreviated New Drug Application (ANDA), Post Drug Approval Activities, PMS, FDA Audits and Inspections EU Regulatory Affairs, EMEA Organization and Function, INDIAN Regulatory system, Schedule Y-Rules and Regulations.	
UNIT IV:	**Principles of controlled clinical trials**	**10 Hr.**
	Clinical trial design (observational and interventional) protocol, consent in clinical trials, placebo, bias and methods to prevent bias, monitoring. Multicentre clinical trials, Requirements, regulations and feasibility, Designing of Protocol, CRF, e-CRF, IB, ICF, SOP BA/BE Studies Report writing, Publication, Improving patient enrolment and retention in Clinical Trials. ADR monitoring,Pharmacovigilance Training in clinical research.	
UNIT V:	**Biostatistics and data management**	**10 Hr.**

	Preparation of a successful clinical study, Study management, Project management Documentation, Monitoring, Audits and Inspections. Budgeting in clinical research, Supplies and vendor management. Importance of statistics in clinical research Statistical considerations at the design, analysis and reporting stage. Data management, Data validation, SAE reconciliation, query management Software considerations. Clinical Trial studies: Cancers and Other Neoplasms , Behaviours and mental Disorders, Immune System studies, Urinary Tract, Sexual Organs and pregnancy condition.	
Course outcome		
CO1	Describe the process of drug development and principles of clinical pharmacology.	
CO2	Develop a clear understanding of why ethics are important in clinical research and be familiar with the regulatory practices in place to protect both the researcher and the subject	
CO3	Effectively manage the regulatory process from Innovation →Discovery → Approval→ Commercialization to bring the product to the market globally.	
CO4	Communicate ideas and data in writing, including of scientific concepts and research design of clinical trials	
CO5	Describe the various types of clinical studies and the methods used to choose the appropriate design, evaluation and interpretation of clinical trial results.	
Text books		
1	Basic and Clinical Pharmacology, Prentice hall, International, Katzung, B.G.	
2	Clinical Pharmacology, Scientific book agency, Laurence, DR and Bennet PN.	
3	Clinical pharmacokinetics, Pub. Springer Verlab, Dr. D.R Krishna, V. Klotz	
4	Remington Pharmaceutical Sciences, Lippincott, Williams and Wilkins	
5	Drug interaction, Kven Stockley. Hamsten	
Reference Books		
1	Clinical pharmacology and drug therapy Grahame smith and Aronson,	
2	Text Book of Therapeutics Drug and Disease Management Hardbound. Richard A Helms,	
3	Clinical Pharmacy and therapeutics Herfindal E T and Hirschman JL, Williams and Wilkins,	
4	Methodology of Clinical Drug Trials, 2nd Edition. Spriet A., Dupin-Spriet T., Simon P. Publisher: Karger.	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	BIOLOGICAL TREATMENT OF WASTE WATER	L: T: P
		3:0:0
Course objective:		
1	To learn about the mass balance involved in waste water treatment	
2	To understand the anarobic treatment process.	
3	To learn about the various chemical and physical processes involved in waste water treatment.	
4	To understand the basic of phosphorus and nitrogen removal	
5	To Learn about the recycling of waste	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus:		
UNIT I-	**ACTIVATED SLUDGE PROCESS-PROCESS ANALYSIS AND SELECTION**	**8 Hr.**
	Characteristics of Activated Sludge (aerobic and anaerobic); Analysis of Data–Mass Balance Analysis. Reactors used in waste water treatment- Up Flow Anaerobic Sludge Blanket (UASB), Two-stage, Aerobic UNI Tank System (TSU-System, Route Zone Treatment, Submerged Aerobic Fixed Film (SAFF) Reactor, and Fluidized Aerobic Bioreactor (FAB).	
UNIT II-	**AEROBIC FIXED-FILM & ANAEROBIC TREATMENT PROCESSES**	**8 Hr.**
	Biofilm process considerations; Trickling Filters and Biological Towers; Rotating Biological Contactors; Granular – Media Filters; Fluidized – Bed & Circulating Bed- Biofilm reactors. Hybrid Biofilm/suspended growth processes. Anaerobic Processes: Methanogenesis, process chemistry and microbiology; process kinetics and factors for the design of anaerobic digestors.	
UNIT III-	**ADVANCED WASTE WATER TREATMENT**	**8 Hr.**
	Technologies used in advanced treatment-Classification of technologies; Removal of Colloids and suspended particles-Depth Filtration, Surface Filtration, Membrane Filtration Absorption, Ion Exchange, Advanced oxidation process, Activated Carbon, Air Stripping, Heavy Metals Removal, Steam Stripping, Chemical Precipitation, and Electrolysis.	
UNIT IV-	**BIOLOGICAL PHOSPHORUS AND NITROGEN REMOVAL**	**10 Hr.**
	Nitrification & Denitrification Processes**:** Biochemistry and Physiology of Nitrifying Bacteria; Common process considerations; One sludge versus two sludge nitrification. Physiology of Denitrifying Bacteria; Tertiary Denitrification; One- sludge denitrification, Normal Phosphorus Uptake into Biomass; Mechanism for Biological Phosphorus Removal; Enhanced Biological Phosphorus Removal by Bacteria and Algae.	
UNIT V	**ENVIRONMENTAL CONCERNS & RECYCLING OF WASTES**	**10 Hr.**
	Environmental regulations and technology- Regulatory Concerns, Technology; Laws, regulations and permits, Air, Water, Solid Waste, Environmental Auditing, National Environmental Policy act, Occupational Safety and Health Act (OSHA), Storm Water Regulations; Technology (waste water); Recycling of Industrial wastes: paper, plastics, leather and chemicals.	
Course outcome		
CO1	After completing the course students will able to perform mass balance for the bioreactor	
CO2	After completing the course students will able to design an anaerobic system	

CO3	After completing the course students will able to categorize various chemical and physical processes involved in waste water treatment.	
CO4	After completing the course students will able to describe the basic of phosphorus and nitrogen removal	
CO5	After completing the course students will able to perform recycling of waste	
Text books		
1	Wastewater Engineering: Treatment Disposal Reuse by Metcalf & Eddy	
2	Environmental Biotechnology : Principles and Applications by Bruce E. Rittmann	
3	Waste water Engineering Treatment and Reuse: McGraw Hill, G. Tchobanoglous,FI Biston, 2002.	
4	Industrial Waste Water Managemnet Treatment and Disposal by Waste Water McGraw Hill III Edition 2008.	
5	Biological Wastewater Treatment", Second Edition, Marcel Dekker, Inc., New York,	
Reference Books		
1	Introduction to Waste Water Treatment- R. S. Ramalho, Academic Press.	
2	Environmental Biotechnology, B.C. Bhattacharya & Ritu Banerjee, Oxford Press, 2007.	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	NANO BIOTECHNOLOGY & TOXICOLOGY	L: T: P
		3:0:0
Course objective:		
1	To understand the fundamentals concepts of nanotechnology	
2	To learn about the different types of nanoparticles	
3	To understand the principle behind the different characterization techniques involved in nanotechnology	
4	To understand the applications of nanotechnology	
5	To learn the toxicology of nanomaterials	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biotech	
Course Contents / Syllabus :		
UNIT-I	**Introduction to Nanobiotechnology:**	**8hr.**
	Definition of Nanobiotechnology, History, Origin, Fundamental Concepts, Bottom-up versus Top-down approaches, Discussion on Nanofabrication, Current research, Tool and Techniques, Applications and Implications and Nanofabrication.	
UNIT-II	**Nanomaterials and Nanoparticles:**	**8hr.**
	Carbon nanotubes and related structures, Properties, Synthesis, Applications, Bucky balls, Nanoparticles types and their synthesis, Application of Gold, Silver and Zinc oxide nanoparticles, Interaction of nanoparticles with biomembrane and genes.	
UNIT-III	**Nanocharecterization Tool and Techniques:**	**8hr.**
	UV-visible spectrophotometry, Fourier transform infrared spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Scanning tunnelling microscopy (STM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), Zeta Potential size analyser etc.	
UNIT-IV	**Nanomedicine and Sensor Technology:**	**10 hr.**
	Drug delivery tools, Bioavailability, Nano imaging agents, Protein and peptide delivery (Cancer and Surgery) and Nano sensors technology with applications.	
UNIT-V	**Toxicology:**	**10 hr.**
	Definition of toxicology, History and origin of toxicology, Principles of Toxicology, Concept of Toxicology, Types of toxicology, Nanomaterial toxicity evaluation mechanism as in vitro, Nanomaterial toxicity evaluation mechanism as in vivo, Assessment of nanoparticles toxicity: A case study (Cytotoxicity, Genotoxicity, Hepatotoxicity, Neurotoxicity, Nephrotoxicity etc.)	
Course outcome		
CO1	After completing this course, the students will be able to learn the fundamentals concepts of nanotechnology	
CO2	After completing this course, the students will be able to ability for understanding and differentiate the various nano materials	
CO3	After completing this course, the students will be able to understand the principal behind the different characterization techniques involved in nanotechnology	
CO4	After completing this course, the students will be able to get insight the application of nanotechnology in drug delivery system	
CO5	After completing this course, the students will be able to evaluate the toxicology of nanomaterials	
Text books		
1	Nanomedicine: Biocompatibility- Robert A. Freitas; Landes Biosciences	

2	The Nanobiotechnology Hand Book- Yobing Xie, CRC Press.2012	
3	Nanobiotechnology: Christof M. Niemeyer, Chad A. Mirkin, John Wiley & Sons, 2004	
Reference Books		
1	Nancy A. Monteiro-Riviere, C. Lang Tran., 'Nanotoxicology: Characterization, Dosing and Health Effects',Informa Healthcare publishers, 2007.	
2	P. Houdy, M. Lahmani, F. Marano, 'Nanoethics and Nanotoxicology', Springer-Verlag Berlin Heidelberg 2011.	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	INDUSTRIAL BIOTECHNOLOGICAL PRODUCTS	L: T: P
		3:0:0
Course objective:		
1	To learn about the different media for the growth of microbes	
2	To understand the production process of Primary and Secondary metabolites	
3	To design and deliver useful modern biotechnology products to the Society.	
4	Understand the methods to obtain enzymes of industrial importance and in general about product development Research &Development	
5	To understand the manufacturing of various organic and alcoholic products	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, microbiology, cell biology and biochemistry	
Course Contents / Syllabus :		
Unit I	**Fundamentals of Fermentation**	**8 hr.**
	Different types of culture media; Substrates for industrial microbial processes; Industrially important micro-organisms: Isolation, screening, Selection of mutants; Process optimization techniques.	
Unit II	**Production of Metabolites**	**8 hr.**
	Process technology for the production of various Products: Primary metabolites: ethanol, citric acid, vineger and amino acid; Production of alcoholic beverages: wine and beer; Secondary metabolites: Antibiotics; Process technology for the production of microbial biomass.	
Unit III	**Bioproducts**	**8 hr.**
	Introduction and production of secondary metabolites with some case study. Production of bioplastics (PHB, PHA), bioinsecticides, bioherbicides, biopolymers, Biofertilizers and biological weapons with reference to anthrax,	
Unit-IV	**Production of industrially important enzymes**	**8 hr.**
	Production of industrially important enzymes: Solid state fermentation, submerged fermentation, Extraction, Purification and characterization of industrial enzymes: Proteases, Cellulase, Lipase, Amylase and Pectinase, industrial process using enzymes for production of drugs and fine chemicals, Enzyme based biosensors.	
Unit V	**Production of Fermented Food Products**	**8 hr.**
	Technological processes for industrial manufacture of selected foods of commercial importance from plants and animal sources. Process involved in preparation of Yoghurt, acidophilus milk, Koumis, kefir, cheese, bread, alcoholic beverage, vinegar and oriental fermented food. Food packaging, Equipment involved in the commercially important food processing methods.	
Course outcome		
CO1	Develop key practical skills in fermenting biotechnology and better understand operations and commercial opportunities in fermentation-based biotechnology	
CO2	Increase their understanding that 'industrial biotechnology' is based on using machines to control the growth of microorganisms	
CO3	Develop knowledge of a variety of fermentation strategies	
CO4	Analyse potential business opportunities in fermentation-based biotechnology	
CO5	Explore the biological and technological principles which govern actual and potential bio-business	
Text books		

1	Industrial Microbiology, Casida Jr. L. E. 1968) new Age International (P) Ltd. New Delhi.	
2	Presott & Dunn's Industrial Microbiology. Ed. E.G. Reed (1987). CBS Publishers, New Delhi.	
3	Biotechnology: A Text book of Induxctrial Microbiology 2nd Edition. Crueger, W. and Cruger, A. (2000) Panima Publishing Corporation, New Delhi.	
Reference Books		
1	Enzmes: Biochemistry, Biotechnology, Clinical Chemistry, Palmer, T. (2000) Horwood Publishing Colphon.	
2	Manual of Industrial Microbiology and Biotechnology 2nd Edition. Ed. Arnold L. Demain and Julian E. Davies (1999) ASM Press Washington D.C.	
3	Microbiology, Pelzar Jr. M.J.: Chan E.C.S. and Krieg, N. R. (1993) Tata Mc Graw Hill, New Delhi.	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	APPLIED BIOCHEMISTRY & MOLECULAR BIOLOGY LAB	L: T: P
		0:00:03
Course objective:		
1	To understand the various concepts of molecular biology and biochemistry	
2	Determine the structure and function of biomolecules and evaluate the complexity of various biomolecules.	
3	Understand the principles of bioenergetics to learn the various pathways.	
4	Evaluate the concept of metabolisms of various types.	
5	Evaluate structure of genetic material and the central dogma of molecular biology.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Suggested list of Experiment :		
Sr. No.	**Name of Experiment**	**CO**
1	Quantitative estimation of amino acids by ninhydrin reaction.	**1 2**
2	Quantitative estimation of proteins.	1 2
3	To separate lipids with the help of thin layer chromatography (TLC).	1 2
4	To verify the Lambert Beer's law with the help of UV absorption spectra of proteins.	1 2
5	Protein purification by ammonium sulfate precipitation.	1 2
6	Isolation of DNA and RNA from animal tissue and plant tissue.	1 2
7	Gel electrophoretic analysis of various DNA and their restriction digests	**1**
8	Transformation with plasmid and bacteriophage DNA	1 3
9	Restriction mapping of plasmid DNA	3
10	Blotting: northern blotting, southern blotting	**3**
11	PCR technique	3
Lab Course Outcome:		
CO 1	Students will be able to understand the various biomolecules.	
CO 2	Students will learn through demonstration the process of isolation and analysis of different biomolecules.	
CO 3	They will learn about the structure and function of DNA, RNA and Protein.	
CO 4	Students will learn advanced molecular methods.	

	Bioprocess Technology & Engineering Lab	L: T: P
		0:00:03
Course objective:		
1	To understand the various concepts of microbial culturing.	
2	To learn the activation energy, volumetric oxygen transfer coefficient etc.l	
3	To Understand the principles and various pathways of enzyme production.	
4	Evaluate the concept of separation and purification of microbial produce.	
5	To understand the process of fermentation.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Suggested list of Experiment :		
Sr. No.	**Name of Experiment**	
1	Determination of kinetic parameters for batch cultivation of yeast under shake flask conditions.	
2	Determination of volumetric oxygen transfer coefficient (KLa)	
3	Determination of activation energy (Ea) of microbial strains.	
4	Process optimization for enzyme production using specific experimental design.	
5	Preparation of immobilized enzymes & cells and evaluation of kinetic parameters.	
6	Computational Design of Fermentative Process.	
7	Fermenter designing and the study of various parts of fermenter and their function for microbial cell culture.	
8	Fermentative production of Penicillin by using Penicilium chrysogenum.	
9	Microbial production of enzymes Cellulase & Protease.	
10	Ethanol production from molasses or starchy raw material.	
11	Fermentative production of Wine from grapes.	
12	Separation and purification of microorganisms from yogurt and cheese.	
13	Fermentative production of alpha amylase under solid & submerged conditions	
14	Protein profiling of fermentation broth through dialysis procedure.	
15	To study the Scale-up and Sterilization in Bioreactors	
Lab Course Outcome:		
CO 1	Student will be able to understand the various concepts of microbial culturing.	
CO 2	Student will learn the activation energy, volumetric oxygen transfer coefficient etc.	
CO 3	Student will Understand the principles and various pathways of enzyme production.	
CO 4	Student will be able to evaluate the concept of separation and purification of microbial produce.	
CO 5	Student will be able to understand the process of fermentation.	

M.Tech.
Biotechnology
(Second Semester)

	BIOINFORMATICS	L: T: P
		3:0:0
Course objective:		
1	To learn the various online databases	
2	To learn the online tools for analysing various methods of sequence alignment	
3	To understand the phylogenetic analysis and related conclusions	
4	To understand the concepts of system biology.	
5	To understand the various methods of genome sequencing.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus		
UNIT I	Biological Databases	**8 Hr.**
	Introduction to Bioinformatics, Need for informatics tools and exercises, Bioinformatics resources: NCBI, EBI, ExPASy, RCSB. Significance of databases towards informatics projects. Primary and Secondary Databases. GenBank, DDBJ, EMBL, PIR, Uniprot-KB, SWISS-PROT, TrEMBL. Specialized databases: Pubmed, OMIM, Medical databases, KEGG, EST databases; Genome databases at NCBI, EBI, TIGR, SANGER. Overview of other popular tools for various bioinformatics exercises.	
UNIT II	Sequence Alignment	**8 Hr.**
	Introduction to sequence alignment, Optimal Alignment Methods, Substitution scores, substitution matrices, PAM, BLOSUM, Gap penalties, Statistical significance of Alignments, Pair wise sequence alignment algorithms, Practical Aspect of Multiple Sequence Alignment, Progressive and Iterative Alignment Methods, CLUSTALW, Database similarity searching, FASTA, BLAST, Low-Complexity Regions. PSIBLAST, PHI-BLAST.	
UNIT III	Phylogentic Analysis and Primer Design	**8 Hr.**
	Introduction to Phylogenetic analysis, Elements of phylogenetic Models, Phylogenetic Data Analysis, Phylogentic Tree -construction steps and Building Methods, Case studies realated to phylogentic analysis, Restriction mapping, Utilities, DNA strider, MacVector and OMIGA, gene construction KIT, Vector NTI, Web based tools (MAP, REBASE); Primer design – Primer design programs and software (PRIME3)	
UNIT IV	System Biology	**8 Hr.**
	Introduction to system biology, application realted to bioinformatics, introduction to different data types: PRIDE (Protein Identifications) databases, Post translational modification, P-P interaction, Rotameric Structures of Proteins (Conformational Flexibility), Canonical DNA Forms (DNA Sequence Effects).	
UNIT V	Genome Sequence Analysis	**8 Hr.**

	Genome sequencing technology and analysis methods, Bioinformatics tools and automation in Genome Sequencing, analysis of gene expreassion data, Utility of EST database in sequencing, Bioinformatics in detection of Polymorphisms, SNPs and their relevance, Bioinformatics tools in microarray data analysis. Usages of visualization software available in public domain like VMD, Rasmol, Pymol, SpdbViewer, Chime, Cn3D and GRASP.	
Course outcome		
CO1	The students shall get an adequate knowledge on the various online databases	
CO2	Students will be able to use the online tools for analysing various macromolecules of the cells	
CO3	The students shall Identify the role of phylogenetic analysis and related conclusions	
CO4	To learn the use of various tools for molecular analysis	
CO5	To understand the various methods for macromolecular sequencing	
Text books		
1	Bioinformatics (Sequence and Genome Analysis)- David W. Mount, Cold Spring Harbor Laboratory Press, 2001.	
2	Bioinformatics- Zoe Lacroix, Terence Critchlow, Morgan Kaufmann Publishersm, 2004.	
3	Bioinformatics – From Genomics to Drugs, Violume 1; Basic Technoliges, Thomas Lengauer, Wiley- VCH, 2001.	
4	Bioinformatics (Practical Approach): Sequence, Structure and Databanks – Des Higgins, OXFORD Univ. Press, 2003.	
5	Bioinformatics Computer Skills - Gibas & Jambeck, O' Reilly, 2001, I Ed.	
Reference Books		
1	Bioinformatics Computing- Bryan Berjeron, Prentice-Hall of India, Private Ltd., 2003.	
2	Computational Molecular Biology (An Algorithmic Approach)- Pavel A. Pevzner, PrenticeHall of India, Private Ltd., 2004.	
3	11. Introduction to bioinformatics- T K Attwood, D J Parry-Smith, Pearson Education, 2004.	
4	Sequence Analysis (In A Nutshell)- Scott Market & Darryl Leon, O' Reilly, Ist Edition, 2003.	
5	Scolnick. J.; Drug Discovery and Design, Academic Press, London,2001.	
6	N. R. Cohen, Editor, Guidebook on Molecular Modeling in Drug Design. Academic Press, San Diego, 1996.	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	ENTREPRENEURSHIP, IPR & BIOSAFETY	L: T: P
		3:0:0
Course objective:		
1	To learn the basics of accounting and finance in business	
2	To learn about the various policies of marketing	
3	To understand the use of IT in business development	
4	To learn about the IPR and its legal provisions.	
5	To learn about the various biosafety in various biological systems.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus		
Unit I	**Accounting and Finance:**	**8 Hr.**
	Taking decision on starting a venture; Assessment of feasibility of a new venture; Approach a bank for a loan; Sources of financial assistance; Making a business proposal/Plan for seeking loans from financial institution and Banks; Funds from bank for capital expenditure and for working; Statutory and legal requirements for starting a company/venture; Budget planning and cash flow management; Basics in accounting practices: concepts of balance sheet, P&L account, and double entry bookkeeping; Estimation of income, expenditure, profit, income tax etc.	
Unit II	**Marketing:**	**8 Hr.**
	Assessment of market demand for potential product(s) of interest; Market conditions, segments; Prediction of market changes; Identifying needs of customers including gaps in the market, packaging the product; Market linkages, branding issues; Developing distribution channels; Pricing/Policies/Competition; Promotion/Advertising; Services Marketing Negotiations/Strategy: With financiers, bankers etc.; With government/law enforcement authorities; With companies/Institutions for technology transfer; Dispute resolution skills; External environment/changes; Crisis/ Avoiding/Managing; Broader vision–Global thinking	
Unit III	**Information Technology:**	**8 Hr.**
	How to use IT for business administration; Use of IT in improving business performance; Available software for better financial management; E-business setup, management. Human Resource Development (HRD): Leadership skills; Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up.	
Unit IV	**IPR:**	**8 Hr.**
	Introduction to Intellectual Property, Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS, Filing of a patent application and Process of Technology Transfer	
Unit V	**Biosafety:**	

	An Introduction; Historical Backround; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Roles of Institutional Biosafety Committee, Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.	
Course outcome		
CO1	The students shall get an adequate knowledge on Accounting and Finance and will be able to do budget planning for any new venture	
CO2	Students will be able to Assessment of market demand for potential product(s) of interest and External environment/changes; Crisis/ Avoiding/Managing Broader vision–Global thinking	
CO3	The students shall Identify the role of Information Technology for business growth	
CO4	To disseminate knowledge on patents, patent regime in India and abroad and registration aspects and to make students aware about current trends in IPR and Govt. supports in promoting IPR	
CO5	The students shall Identify the role of regulatory committees in controlling the risk. Students should get enough information on ethical issues linked to research on animal models, transgenic, clinical trials.	
Text books		
1	Selected papers from scientific journals.	
2	Nithyananda, K V. (2019). Intellectual Property Rights: Protection and Management. India, IN: Cengage Learning India Private Limited.	
3	Neeraj, P., & Khusdeep, D. (2014). Intellectual Property Rights. India, IN: PHI learning Private Limited.	
4	V Sreekrishna, 2017. Bioethics and Biosafety in Biotechnology by New Age International publishers.	
E Reference resources		
	https://kclau.com/wealth-management/best-budgeting-tools-online-softwares/ https://www.ccl.org/articles/leading-effectively-articles/fundamental-4-core-leadership-skills-for-every-career-stage/ http://www.yourarticlelibrary.com/organization/8-types-of-organisational-structures-their-advantages-and-disadvantages/22143 https://opentextbc.ca/organizationalbehavioropenstax/chapter/reward-systems-in-organizations/#ch08rfin-9 https://online.hbs.edu/blog/post/accounting-skills-for-entrepreneurs https://www.investopedia.com/terms/f/feasibility-study.asp https://www.extension.iastate.edu/agdm/wholefarm/html/c5-92.html https://economictimes.indiatimes.com/wealth/tax/how-to-compute-your-total-taxable-income/articleshow/52956796.cms?from=mdr	
	•Subramanian, N., & Sundararaman, M. (2018). Intellectual Property Rights – An Overview. Retrieved from http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf	
	•World Intellectual Property Organization. (2004). WIPO Intellectual Property Handbook. (https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub	
	•_489.pdf)	
Journal Link:		

	https://www.springer.com/journal/10961	
	https://www.ip.mpg.de/en/publications/journals/iic-international-review-of-intellectual-property-and-competition-law.html	
	https://onlinelibrary.wiley.com/journal/15406261	

	Genetic Engineering	L: T: P
		3:0:0
Course objective:		
1	It is intended to impart basic undergraduate-level knowledge in the area of molecular biology and recombinant DNA technology.	
2	The student would be able to understand the working details of the cloning of a gene.	
3	They would also be able to assimilate recent research findings, advancement and development in the rDNA technology.	
4	The use of virtual lab and computational tools would enable them to perform in silico cloning of the selected DNA.	
5	To understand the DNA sequencing methods	
Pre-requisites:		
Students are expected to have knowledge of basic biology, cell biology and biochemistry		
Course Contents / Syllabus		
UNIT-I	**Molecular Tools**	**8 Hr.**
	DNA Structure and properties; Enzymes used in Genetic Engineering; Cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric tailing; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques, Hybridization techniques; Chromatin Immunoprecipitation; DNA-Protein Interactions-Electromobility shift assay; DNaseI footprinting; Methyl interference assay	
UNIT-II	**Vectors**	**8 Hr.**
	Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, Phagemids; Lambda vectors, Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors; Expression vectors; Inclusion bodies; Methodologies to reduce formation of inclusion bodies; Baculovirus and pichia vectors system, Plant based vectors, Ti and Ri as vectors, Yeast vectors, Shuttle vectors	
UNIT-III	**Techniques in Genetic Engineering**	**8 Hr.**
	Insertion of Foreign DNA into Host Cells; Transformation; Isolation of mRNA and total RNA; cDNA and genomic libraries and its construction; cDNA and genomic cloning; Expression cloning; Jumping and hopping libraries; Southwestern and Far-western cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression	
UNIT-IV	**PCR and its applications**	**8 Hr.**
	Primer design; Fidelity of thermostable enzymes; DNA polymerases; Concept of PCR, Types of PCR, Gene specific and degenerate primer design, linkers, adaptors, Fidelity of uDNA polymerase. Application of PCR. Chimeric protein engineering by PCR	
UNIT-V	**Sequencing Methods**	**8 Hr.**

	Sequencing methods; Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; RNA sequencing; Introduction of DNA into mammalian cells; Transfection techniques; Gene silencing techniques; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing; Gene Therapy; Suicide gene therapy; Gene replacement; cDNA and intragenic arrays; Differential gene expression and protein array, Genome editing-CRISPR and other genome editing tools.	
Course outcome		
CO 1	Understand the basic concept and procedure of gene cloning and the role of enzymes and vectors used for genetic manipulation and genetic engineering	
CO 2	Acquired theoretical knowledge of vectors, their different types and applications in genetic engineering.	
CO 3	Getting detailed knowledge of construction of gene libraries and their screening methods.	
CO 4	Have knowledge of PCR technique, their different types and applications.	
CO 5	Understand the basic concept of genetic engineering techniques for selection of recombinants.	
Text books		
1	Winnacker, Ernst L. (1987), From genes to clones: introduction to gene technology [Gene und Klone] (in German), Horst Ibelgaufts (trans.), Weinheim, New York: VCH, ISBN 0-89573-614-4.	
2	Genetic Engineering by Dr Smita Rastogi & Dr Neelak Pathak, Oxford University Press	
3	Genetic Engineering, Priciples & Practice by Sandhya Mitra, McGraw Hill Education.	
Reference Books		
1	Principles of Gene Manipulation and Genomics, Primrose & Twyman.	
2	Molecular Biology of the Cell. 4th edition. Alberts B, Johnson A, Lewis J, et al. New York: Garland Science; 2002.	
3	Modern Genetic Analysis. Griffiths AJF, Gelbart WM, Miller JH, et al. New York: W. H. Freeman; 1999.	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	APPLIED FOOD BIOTECHNOLOGY	L: T: P
		3:0:0
Course objective:		
1	To learn about the various microbiological examination of foods and food born diseases	
2	To learn about the development and production of novel products	
3	To understand GM foods and the legal issues associated with them.	
4	To learn about the industrial production of various food products	
5	To learn the methods of production of vitamins and enzymes.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus		
Unit I		**8 Hr.**
	Food Biotechnology: Introduction & Applications; Methods for the microbiological examination of water and foods; Control of Microbiological quality and safety; Food borne illnesses and diseases; Microbial cultures for food fermentation, their maintenance, strain development	
Unit II		**8 Hr.**
	Starter cultures–types, designing and development, micro encapsulation and packaging, scopes and challenge; Development and formulation of novel products such as probiotic foods. Nutrigenomics-concept, working, significance and relevance. Biosensors and novel tools and their application in food science & Technology	
Unit III		**8 Hr.**
	GM foods: Introduction and controversies related to GMOs. Ethical issues concerning GM foods; testing for GMOs; current guidelines for the production, release and movement of GMOs; labelling and traceability; trade related aspects; biosafety; risk assessment and risk management. Public perception of GM foods. IPR. GMO Act–2004. New products and processes in various food commodities including plant and animal products.	
Unit IV		**10 Hr.**
	Industrial production of organic acids (vinegar, lactic acid), alcoholic beverages (beer, wine, and distilled alcoholic beverages such as whiskey, rum, vodka), glycerol; Propagation of baker's yeasts; Fermented dairy products such as cheese, yoghurt, sweet curd, paneer, shreekhand, Fermented pickles.	
Unit V		**10 Hr.**
	Industrial production of important primary and secondary metabolites such as antibiotic, vitamins, biosurfantants, polysaccharides. Enzyme application in food industry.Advantages and constraints of immobilized enzymes and microbial cells. Types of enzyme reactors. Aerobic and anaerobic treatment of effluents from food processing industr	
Course outcome		
CO1	To identify microorganism responsible for food spoilage.	

CO2	Demonstrate knowledge methods of packing, and the application of biosensors in food industries	
CO3	To understand the ethical issues lined with GM food production	
CO4	Demonstrate the industrial production of various food products	
CO5	To explain the industrial application of various enzymes	
Text books		
1	Industrial Microbiology Prescott & Dunn, CBS Publishers	
2	Modern Food Microbiology by Jay JM, CBS Publishers	
3	Comprehensive Biotechnology by Murray & Mooyoung, Academic press	
4	Industrial Microbiology by Casida L.R., New Age International Pvt. Ltd.	
5	Food Microbiology; Frazier WC; 4th ed, Tata-McGrowhill Pub.	
Reference Books		
1	Microbiology by Pelczar, Chan, and Krieg, TMH	
2	Fermentation Biotechnology, Principles, Processed Products by Ward OP, Open	
3	University Press.	
4	Lee, B. H. Fundamentals of Food Biotechnology.VCH. 2006	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	MOLECULAR MODELING & INDUSTRIAL APPLICATION	L: T: P
		3:0:0
Course objective:		
1	To learn about he basics of molecular modelling	
2	To understand the usage of computer simulation	
3	To understand the basic of drug development.	
4	To learn about the herbal drug and its trade senario.	
5	To understand the method of vaccine production.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus		
Unit I		**8 Hr.**
	Molecular Modelling: Introduction; Useful Concepts in Molecular Modelling; The Molecular Modelling Literature; Molecular Modelling software: BIOSUITE; Force Fields	
Unit II		**8 Hr.**
	Energy Minimisation and Computer Simulation: Minimisation and Related Methods for Exploring the Energy Surface. Non-Derivative method, 1st and 2nd order minimisation methods. Results of a Simulation and Estimating Errors. GROMACS and CNS. Molecular Dynamics & Monte Carlo Simulation;	
Unit III		**8 Hr.**
	Drugs: An introduction, Overview of drug discovery process, Trends in drug discovery process. Rationale of Drug Discovery: Medical needs, Target identification, Target validation, Receptors and assay development.	
Unit IV		**8 Hr.**
	Herbal Drugs: Definition, Trade scenario, Phytochemical standardization and fingerprinting, Marker compounds, Polyherbal formulations. Drug Development and Pre-Clinical Studies: Drug receptor interactions; enzyme inhibition and inactivation, In-vitro and in-vivo pharmacodynamic models, Therapeutic index, Pharmacokinetics - Microbial and animal models, In-vitro and insilico toxicological models, Drug formulations.	
Unit V		**8 Hr.**
	Applications of microbes for designing vaccines: case study.	
Course outcome		
1	Students will learn about the basics of molecular modelling	
2	Students will understand the usage of computer simulation	
3	Students will understand the basic of drug development.	
4	Students will learn about the herbal drug and its trade scenario.	
5	Students will be able to understand the method of vaccine production.	
Text books		
1	A.R.Leach, Molecular Modelling Principles and Application, Longman, 2001.	

2	J.M.Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.	
3	Satya Prakash Gupta, QSAR and Molecular Modeling, Springer - Anamaya Publishers, 2008.	
4	Patwardhan B, Drug Discovery and Development-Traditional Medicine and Ethnopharmacology, New India Publishing (2007)	
5	Larsen PK, Leljifore T and Medsan U, Text Book of Drug Design and Discovery, CRC Press (2009)	
Reference Books		
1	Hillisch A and Hilgenfeld R, Modern Methods of Drug Discovery, Birkhauser (2003).	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	BIOREACTOR ANALYSIS AND DESIGN	L: T: P
		3:0:0
Course objective:		
1	To learn about the designing of bioreactor systems	
2	To learn about the control involved in bioreactor system	
3	To learn about the various types of bioreator processes	
4	To understand the reactor dynamics	
5	To learn the design aspect and safety issues.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus		
UNIT I	**Material balnace and design**	**8 Hr.**
	Introduction; General design information; Material and energy balance calculations; Process Flow sheeting, Selection of bioprocess equipment (upstream and downstream); Specifications of bioprocess equipment; Mechanical design of reactors, heat transfer and mass transfer equipment; Design considerations for maintaining sterility of process streams and process equipment; Piping and instrumentation; Materials of construction for bioprocess plants.	
UNIT II	**Control of bioreactor**	**8 Hr.**
	Basic aspects of bioreactor designing, Physical, chemical and biological sensors and control, Advanced control strategies viz. PID controllers, Fuzzy logic based controllers and Artificial Neural Network (ANN) based controllers, Basic concepts of computer modelling and optimization in bioprocess applications.	
UNIT III	**Ideal Bioreactor and its working**	**8 Hr.**
	Ideal bioreactors: Batch reactors, Fed-batch reactors, enzyme-catalyzed reaction in CSTRs, CSTR reactors with recycle and wall cell growth, the ideal plug-flow tubular reactor, Reactors with nonideal mixing: Mixing times in agitated tanks, residence time distribution, models for nonideal reactors, Mixing-bioreaction interactions.	
UNIT IV	**Types of Bioreactors**	**8 Hr.**
	Reactor dynamics and stability, Multiphase bioreactors: conversion of heterogeneous substrates, packed-bed reactors, bubble column bioreactors, fluidized bed bioreactors, trickle-bed reactors, airlift reactor, Immobilized Enzyme reactors, Photo bioreactors, Hollow fiber membrane bioreactors. Scale up and scale down issues: 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 coefficients.	
UNIT V	**Downstream Processing**	**8 Hr.**

	Facility design aspects; Utility supply aspects; Equipment cleaning aspects; Culture cell banks; cGMP guidelines; Validation; Safety. Process economics; Case studies, Scale up of downstream processes: Adsorption (LUB method); Chromatography (constant resolution etc.); Filtration (constant resistance etc.); Centrifugation (equivalent times etc.); Extractors (geometry based rules).	
Course outcome		
CO1	After completing the course students will able to design the bioreactor system	
CO2	After completing the course students will able to illustrate the control involved in bioreactor system	
CO3	After completing the course students will able to identify the various types of bioreactor processes	
CO4	After completing the course students will able to analyse the reactor dynamics	
CO5	After completing the course students will able to evaluate the design aspect and safety issues associated with reactor system.	
Text books		
1	Moser, Anton, Bioprocess Technology: Kinetics and Reactors, Springer Verlag, 1988.	
2	Bailey J.E. & Ollis, D.F. Biochemical Engineering Fundamentals, 2nd ed., McGraw Hill, 1986	
3	Lee, James M. Biochemical Engineering, PHI, USA.	
4	Atkinson, Handbook of Bioreactors, Blanch, H.W. Clark, D.S. Biochemical Engineering, Marcel Decker, 1999	
5	Biochemical Engineering fundamentals" 2nd ed. -J E Bailey and D F Ollis, McGraw-Hill (1986) Chapters 8,9&10.	
6	Biochemical Engineering" -S Aiba, A E Humphrey and N Millis , 1978, University of Tokyo Press.	
7	Biotechnology" Vols. 3 & 4 Eds., S Rehm and G Reed. VCH (1991).	
Reference Books		
1	Biochemical Engineering and Biotechnology Handbook" 2nd Ed., .Atkinson & F.Mavituna, Stockton Press (1991).	
2	Biorector Design & Product Yield" , BIOTOL series, Butterworth - Heinemann (1992).	
3	Principles of fermentation technology" - F Stanbury and A Whitaker, Pergamon press (1984)	
4	Unit operations of Chemical Engineering" 5th ed. by W L McCabe, J C Smith and P. Harriot Mc Graw-Hill (1993).	
5	Bioprocess Engineering Principles" by Pauline M.Doran, Academic Press.	
6	Feedback and Control systems- Schaum's outline series, McGraw-Hill Book Comp., 1967	
7	Unit Operations of Chemical Engineering- Mc Caba Smith, Harriott, Mc Graw – Hill Chemical Engg. Series., V Ed., 1985.	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	ENZYME TECHNOLOGY & INDUSTRIAL APPLICATION	L: T: P
		3:0:0
Course objective:		
1	To learn about the kinetics involved in ezymatic reactions.	
2	To learn about the various biochemical processes involved in the microbial growth	
3	To learn about the various processes in bioreactor	
4	To understand the various separation methods involved in bioprocess	
5	To analyze the different bioprocess steps in industrial production.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus		
UNIT I-	**ENZYME TECHNOLOGY**	**8 Hr.**
	Introductions: Enzymes- Michaelis-Menten kinetics. Kinetics and StatisticsInhibition- Effect of pH and temperature- Enzymology- Immobilized enzymes: Methods, Mass transfer considerations and Industrial enzymes.	
UNIT II-	**METABOLISM, STOICHIOMETRY AND MICROBIAL GROWTH KINETICS**	**8 Hr.**
	Introduction to metabolism- Nutrient transport- Glycolysis - TCA cycle and other pathways - Control of metabolism. Factors affecting microbial growth – Stoichiometry- mass balances and energy balances. Growth kinetics, Measurement of growth.	
UNIT III-	**BIOREACTORS, STERILIZATION, SENSORS AND INSTRUMENTATION**	**8 Hr.**
	Introduction to bioreactors - Batch and Fed-batch bioreactors, Continuous bioreactors, Immobilized cells, Bioreactor operation, Sterilization, Aeration, Sensors. Instrumentation, Culture - specific design aspects: plant/mammalian cell culture reactors.	
UNIT IV-	**PRIMARY & SECONDARY SEPARATION PROCESS**	**8 Hr.**
	Biomass removal - Biomass disruption – Membrane based techniques. Extraction -solvent, aqueous two phases, super critical, and Adsorption. Chromatography, Precipitation (Ammonium Sulfate, solvent), Electrophoresis (capillary), Crystallization, Drying and Freeze drying.	
UNIT V-	**INDUSTRIAL APPLICATION**	**8 Hr.**

	White Biotechnology: Few industrial process using enzymes for production of drugs and fine chemicals, Enzyme based biosensors, Enzyme in organic catalysis, Analytical applications,Applications in food industry,Pharmaceuticals,Biochemical applications: Role of soluble and immobilized enzymes in the synthesis and production of amino acids and chiral compounds; use of enzymes as detergents.Molecular Imprinting; Enzyme engineering: In vitro approaches to improve functional efficiency; Recombinant enzymes, Case study.	
Course outcome		
CO1	Describe the fundamentals of enzyme properties, nomenclatures, characteristics and mechanisms & plot graphs based on kinetics data.	
CO2	Demonstrate metabolism, stoichiometry and microbial growth kinetics.	
CO3	Perform bioreactor operations as applicable in bioprocess industries.	
CO4	Discuss various separation and purification process of fermentation products.	
CO5	Predict the current and future trends of applying enzyme technology for the commercialization purpose of biotechnological products.	
Text books		
1	Michael Shuler and FikretKargi. “Bioprocess Engineering: Basic Concepts”, 2nd Edition, Prentice Hall, and Englewood Cliffs, NJ, 2002.	
2	Pauline Doran. “Bioprocess engineering principles”, Academic Press, 1995.	
3	Colin Ratledge, Bjorn Kristiansen, “Basic Biotechnology”, 2nd Edition, Cambridge University Press, 2001.	
Reference Books		
1	Roger Harrison et al., “Bioseparation Science and Engineering”, Oxford University Press, 2003.	
2	Harrison R.G. Todd P., Rudge S.R. “Bioseparation Science and Engineering”, Oxford Press 2003.	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	APPLIED BIOENERGY	L: T: P
		3:0:0
Course objective:		
1	To understand the basics of bioenergy	
2	To learn the pricipals of biofule production	
3	To learn about the current application of bioenergy	
4	To understand the impact of energy on economy	
5	To understand production of biofuels in real life.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus		
Unit I		**8 Hr.**
	Introduction to applied bioenergy, Types of bioenergy, Energy scenario-role of energy in economic development and social transformation, Commercial and non-commercial forms of energy, Present and future global projections of energy consumptions.	
Unit II		**8 Hr.**
	Principles of biomass energy conversion processes, biological, chemical and thermo-chemical technologies for biomass conversion and their utilization covering: Biogas, Produces gas, Alcohol and Biodiesel, Second generation biofuel from high efficiency algal-derived biocrude, Biobased fats (Lipids) and oils from biomass for energy production, Biorefinery systems: An Overview. Microbial fuel cell and their application	
Unit III		**8 Hr.**
	Current bio-energy applications and conversion technologies, Advantages of applied bioenergy over other sources of energy, Advances in bio-energy research: An overview of technological developments, bioenergy value chain, Databases of bioenergy related enzymes, Sustainable farming of bioenergy crops.	
Unit IV		**8 Hr.**
	Impact of Energy on Economy, Development and Environment, Energy for Sustainable Development, Energy and Environmental policies, Need for use of new and renewable energy sources, Energy Policy Issues: Fossil Fuels, Renewable Energy, Power sector reforms, restructuring of energy supply sector, energy strategy for future, Status of Nuclear and Renewable Energy: Present Status and future promise.	
Unit V		**8 Hr.**
	Case stuy 1: Biodiesel from jatopra plant as transport fuel, A case study of UP State (India) 2. Generation of Bio-fuel by Using Waterweeds: A Case Study in Solapur City	
Course outcome		
CO1	Demonstrate different types of bioenergy's	
CO2	Demonstrate the production of various types of biofuel using different substrates	

CO3	To explain the advantages of applied bioenergy over other sources of energy and advances in bio-energy research	
CO4	To describe the Impact of Energy on Economy,	
CO5	To describe the application of of biofuel in real life	
Text books		
1	Anthony San Pietro (1980); Biochemical and Photosynthetic aspects of Energy Production, Academic Press, New York.	
2	Berman, ER Geothermal Energy, Noyes Data Corporation, New Jersey	
3	Parker, Colin & Roberts, (1985); Energy from Waste- An Evaluation of Conversion Technologies, Elsevier Applied Science London	
Reference Books		
1	Ralph E.H. Simsed. (2004); Bioenergy options for cleaner environment by World Renewable Energy Network.	
2	Ravindranath N.H. and Hall D.O. (1995); Biomass, Energy and Environment, A developing country perspective from India by, Oxford University Press,	
3	Brown Robert C. (2003); Biorenewable Resources: Engineering New Products from Agriculture, Iowa State University Press ,USA	
4	Boyle Godfrey ed. (1996): Renewable Energy: Power for a sustainable future, Oxford, OUP	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	CELL & TISSUE CULTURE TECHNIQUES	L: T: P
		3:0:0
Course objective:		
1	To learn the basics of animal cell culturing technique.	
2	To understand the various methods and advancements of culture techniques. .	
3	To analyse the applications of animal cell culturing.	
4	To learn the basics of plant cell and tissue culture technique. .	
5	To understand the various methods and advancements in plant cell and tissue culture. .	
Pre-requisites:		
	Students are expected to have knowledge of basic cell and molecular biology.	
Course Contents / Syllabus		
Unit 1	**Cell & Tissue Culture Tecchnology Basics**	**8 hr**
	Basic cell culture techniques, Types of cell culture media; Ingredients of media; Physiochemical properties; CO2 and bicarbonates; Buffering; Oxygen; Osmolarity; Temperature; Surface tension and foaming; Balance salt solutions; Antibiotics growth supplements;	
Unit 2	**Methods of Cell & Tissue Culture**	**8 hr**
	Different tissue culture techniques; Types of primary culture; Chicken embryo fibroblast culture; Chicken liver and kidney culture; Secondary culture; Trypsinization; Cell separation; Continuous cell lines; Suspension culture; Organ culture etc.; Behavior of cells in culture conditions: division, growth pattern, metabolism of estimation of cell number; Development of cell lines	
Unit 3	**Applications of Cell and Tissue Culture Technique**	**8 hr**
	Cell cloning and selection; Transfection and transformation of cells; Commercial scale production of animal cells, stem cells and their application; Application of animal cell culture for in vitro testing of drugs; Testing of toxicity of environmental pollutants in cell culture; Application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins, Green Meat, Organ Printing	
Unit 4	**Plant Cell & Tissue Culture Basics**	**10 hr**
	Fundamentals of plant tissue culture, plant regeneration: organogenesis. Somatic embryogenesis; somaclonal variation, its genetic basis and application in crop improvement. Cell/callus line selection for resistance to herbicide, stress and diseases.: Isolation, culture and plant regeneration, protoplast fusion, identification and characterization of somatic hybrids., Field techniques for propagation of regenerated plants.	
Unit 5	**Techniques of Plant Cell & Tissue Culture**	**10 hr**
	Explant selection, sterilization and inoculation; Various media preparations; MS, B5, SH PC L2; Callus and cell suspension culture; Induction and growth parameters; Chromosomal variability in callus culture. Plant regeneration from embryo, meristem and callus culture. Androgenesis: Anther and pollen culture.	
Course outcome:		
CO1	After completion of the course, students will learn the basics of animal cell culturing.	

CO2	They will understand about the various methods and protocols of cell culturing.	
CO3	They will analyse the different types of applications of animal cell culturing. .	
CO4	Students will learn the basics of plant tissue culture.	
CO5	Students will be able to understand the different methods of plant tissue culture and their applications.	
Text books		
1	B. Hafez and E.S.E Hafez, Reproduction in farm animals, 7th Edition, Wiley Blackwell, 2000	
2	G.E. Seidel, Jr. and S.M. Seidel, Training manual for embryo transfer in cattle (FAO Animal Production and Health Paper-77), 1st Edition, W.D. Hoard and sons FAO, 1991	
3	I. Gordon, Laboratory production of cattle embryos, 2nd edition, CAB International, 2003.	
Reference Books		
1	Louis-Marie Houdebine, Transgenic Animals: Generation and Use 5th Edition, CRC Press, 1997.	
2	Plant Tissue Culture: Theory and Practice, a Revised Edition by S.S. Bhojwani and M.K. Razda	
3	Plants from Test Tubes: An Introduction to Micropropagation by Lydiane Kyte	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	DIAGNOSTIC TECHNIQUES IN BIOTECHNOLOGY	L: T: P
		3:0:0
Course objective:		
1	To learn the basics of diagnostic techniques.	
2	To understand the different enzymes and related test methods.	
3	To learn the methods of immunodiagnostics.	
4	To understand the product development related to diagnostics.	
5	To learn the methods of DNA based diagnostics.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus		
Unit I		**8 hr**
	Volumetric analysis, Balancing & Weighing, Concept of solute & solvent, Units of measurement. Specimen Collection & Processing: Specimen collection (Blood, urine, spinal fluid, saliva synovial fluid, Amniotic fluid), Preservation, transportation	
Unit II		**8 hr**
	Clinical Enzymology: Principle of diagnostic enzymology, Digestive enzyme, Miscellaneous enzyme. General Function Tests: Liver function test, Cardiac Function Test, Renal Function Test, Thyroid Function test, Reproductive endocrime function test	
Unit III		**8 hr**
	Immunodiagnostics: Introduction, Antigen-Antibody Reactions, Conjugation Techniques, Antibody Production, Enzymes and Signal Amplification Systems, Separation and Solid-Phase Systems, Studies related to bacterial, viral and parasitic infections.	
Unit IV		**10 hr**
	Product Development: Immunoassay Classification and Commercial Technologies, Assay Development, Evaluation, and Validation, Reagent Formulations and Shelf Life Evaluation, Data Analysis, Documentation, Registration, and Diagnostics Start-Ups.	
Unit V		**10 hr**
	DNA based diagnostics: PCRRT-PCR, qPCR, Ht start PCR, Nested PCR), RFLP, SSCP, Microarrays, FISH, In-situ hybridization, Studies related to bacterial, viral and parasitic infections, Cell based diagnostics: Antibody markers, CD Markers, FACS, HLA typing, Bioassays, Viral DNA detection using Rapid kits and PCR	
Course outcome		
CO1	The students will learn the basics of diagnostic techniques.	
CO2	The students will understand the different enzymes and related test methods.	
CO3	The students will learn the methods of immunodiagnostics.	
CO4	The students will understand the product development related to diagnostics.	
CO5	The students will learn the methods of DNA based diagnostics.	
Text books		

1	Tietz Textbook of Clinical Chemistry, Carl A. Burtis, Edward R. Ashwood, Harcourt Brace & Company Aisa Pvt. Ltd.	
2	Commercial Biosensors: Graham Ramsay, John Wiley & Son, INC. (1998).	
3	Essentials of Diagnostic Microbiology, Lisa Anne Shimeld.	
Reference Books		
1	Diagnostic Microbiology, Balley & Scott's.	
2	Tietz Text book of Clinical Biochemistry, Burtis & Ashwood. 6. The Science of Laboratory Diagnosis, Crocker Burnett.	
Journal/Research Paper Link:		
	As suggested by concern subject faculty	

	3-D Printing Technology	L: T: P
Course objective:		**3:0:0**
1	Able to know the fundamentals of RP Systems & its evolution and the Process in RP and association of RP Systems with 3D modelling & Mesh	K1,K2
2	Able to know the RP Systems, Process, Materials & Classifications	K3, K4
3	Able to know and working with Mesh File & their formats like STL format, 3MF format, OBJ formats. Conversion to Mesh files, their properties, operations, storage, inspections & defects	K3, K4
4	Able to know the applications of RP Systems in various Fields	K3, K4
Pre-requisites:		
Basic understanding of Information Technology.		
Course Contents / Syllabus		
UNIT-I	**Introduction:**	**4 hours**
	Historical Developments, Fundamentals of RP Systems and its Classification on different basis, Rapid Prototyping Process Chains, 3D Modelling and Mesh Generation, Data Conversion and Transmission.	
UNIT-II	**RP Systems:**	**12 hours**
	Liquid Polymer Based Rapid Prototyping systems: SLA, Material Jetting, Solid Input Materials Based Rapid Prototyping Systems: Laminated Object Manufacturing (LOM) and Fused Deposition Modelling Systems, Power Based Rapid Prototyping Systems: Selective Laser Sintering, Multi-Jet Fusion, Binder Jetting Systems.	
UNIT-III	**RP Database & Design Optimization:**	**8 hours**
	Rapid Prototyping Data Formats, STL Format, STL file problems, STL file repair, DfAM, Topology Optimization, Gcode for RP Systems	
UNIT-IV	**RP Applications:**	**8 hours**
	Development of dies for Moulding, RP Applications in developing prototypes of products, application in medical fields, Development of bone replacements and tissues, etc., RP materials and their biological acceptability.	
Course outcome: After completion of this course students will be able to		
CO 1	Understand the fundamentals of RP Technologies and process involvement in them	K1,K2
CO 2	Understand the methodology to manufacture the products using RP technologies and study their applications, advantages and case studies	K3, K4
CO 3	Understand the Design aspects and their respective challenges along with the resolution for them	K3, K4, K5
CO 4	Understand the various applications of various RP Systems with case studies & Materials	K3,K4
Text books		
1	Rapid Prototyping: Principles an Applications: Chee Kai Chua, Kah Fai Leong, Chu Sing Lim	
2	Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing: Brent Stucker, David W. Rosen, Ian Gibson	
Reference Books		
1	Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling: Pham, Duc, Dimov, S.S.	

2	Rapid Prototyping and Manufacturing: Fundamentals of Stereo Lithography: P. Jacobs	
3	Rapid System Prototyping with FPGAs: Accelerating the Design Process: R.C. Cofer, Benjamin F. Harding	
4	Rapid Prototyping of Digital Systems: Hamblen, James O., Hall, Tyson S., Furman, Michael D.	

	BIOINFORMATICS LAB	L: T: P
		3:0:0
Course objective:		
1	To learn the various online datbases	
2	To learn the online tools for analyzing various macromolecules of the cells	
3	To understand the phylogenetic analysis and realted conclusions	
4	To learn the use of various tools for molecular analysis	
5	To understand the various methods for macromolecular sequencing	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus		
1	To perform pair wise local and global sequence alignment for any two proteins and DNA sequences.	
2	To perform multiple sequence alignment for any five sequences and predicts the Phylogenetic relationship among them.	
3	Phylogenetic Analysis using PHYLIP - Rooted trees and Unrooted trees	
4	To predict secondary structure for any given protein sequence using Chou-Fasman, GOR and Neural network algorithms.	
5	To visualize tertiary structure of any given protein sequence using Rasmol/PyMol/PMV.	
6	To visualize the genomic map of Human genome and find out the size, number of genes and number of proteins encoded on Chr-Y.	
7	Homology Modelling using Modeller	
8	To find out the RMSD value from any two-protein structure alignment.	
9	Construction of Cladogram	
10	Different interactions using CYTOSCAPE	
11	Primary Structure Analysis of a Protein Using ProtParam	
12	Finding the Active Site Pockets of a given Protein Molecule	
Course outcome		
CO1	The students will learn the various online databases	
CO2	Students will learn the online tools for analysing various macromolecules of the cells	
CO3	They will understand the phylogenetic analysis and related conclusions	
CO4	The students will learn the use of various tools for molecular analysis	
CO5	The students will understand the various methods for macromolecular sequencing	

	Entrepreneurship, IPR & Biosafety Lab	L: T: P
		3:0:0
Course objective:		
1	To make students aware of the process of patent registration.	
2	To learn to design Biosafety lab.	
3	To develop the entrepreneur and marketing skills.	
Pre-requisites:		
	Students are expected to have knowledge of basic biology, cell biology and biochemistry	
Course Contents / Syllabus		
1	Demonstration of Procedure for patent registration in India	
2	Writing a Patent Application	
3	Microbiological risk assessment	
4	Basic laboratories – Biosafety Levels 1 and 2 Basic laboratories – Biosafety Levels 1 and 2 Code of practice Laboratory design and facilities	
5	Laboratory equipment Health and medical surveillance	
6	Biosafety practices and procedures	
7	Development of project proposals - SWOT analysis	
8	SWOT analysis of selected enterprise	
9	Practical on developing distribution channels; Pricing/Policies/Competition; Promotion/Advertising through the use of social Media	
10	Preparation of Balance Sheet	
Course outcome		
CO1	Students will be able to understand the process of establishing Biosafety labs.	
CO2	Students will learn through demonstration the process Patent Registration.	
CO3	They will develop the skills of marketing and entrepreneur.	