Title of the Course: Mass Transfer	L	T	P	Credit
Course Code: UBIO0501	3	1	-	4

Course Pre-Requisite:

Basic Concepts Of Fluid Mechanics, Heat Transfer And Bioprocess Calculation

Course Description:

The objective of this course is to provide biotechnology engineering students the basic principles of mass transfer

Course Objectives:

1. To Explain molecular diffusion and Fick's law
2. To identify role of convective and diffusive mass transfer in bioprocessing.
3. To analyze separation method like distillation, extraction, crystallization and drying.
4. To solve case studies on separation processes.

Course Learning Outcomes: At the end of the course the student will be able to:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Explain molecular diffusion and Fick's law	II	Understanding
CO2	Identify role of convective and diffusive mass transfer in bioprocessing	III	Applying
CO3	Analyze separation method like distillation, extraction, crystallization and drying	IV	Analyze
CO4	Solve case studies on separation processes	III	Applying

CO-PO Mapping:

CO\ PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO 1	PSO 2	PSO 3
CO1	3														
CO2	3														
CO3	3	2													
CO4	3	2											1	1	

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Unit 1: Diffusion Diffusion, Role of diffusion in mass transfer, molecular diffusion, Ficks law of diffusion, Diffusivity ,Molecular diffusion in gases, liquids and diffusion in solids, Mass transfer coefficient, Mechanism of mass transfer.	**8 Hrs.**
Unit 2: Role of diffusion in bioprocessing Film theory, Convective mass transfer. Oxygen uptake in cell culture, oxygen transfer in fermenter.	**4 Hrs.**
Unit 3: Distillation Vapour –liquid equilibrium, Raoult's law, Dalton's law, Relative volatility, Simple distillation, Flash distillation, Continuous rectification-binary systems, Analysis of fractionating column by McCabe- Thiele method, Reflux ratio, azeotropic and extractive distillation	**8 Hrs.**
Unit 4:Extraction Principles of extraction, difference between distillation and extraction, field of application of liquid extraction, distribution coefficient, selection of solvent for extraction, extraction equipments	**6 Hrs.**
Unit 5: Crystallization- Crystal Geometry, Nucleation, Crystal Growth, Crystallization theory, Crystallization practice, Crystallization equipment	**4 Hrs.**
Unit 6: Drying – Principles of drying, Phase equilibria, Cross circulation drying, Through circulation drying, Drying of suspended particles, Freeze drying, Drying equipments - dryers for solids and pastes, dryers for solution and slurries, Selection of drying equipment	**6 Hrs.**
Textbooks: 1. Robert E. Treybal,"Mass TransferOperations",Third Edition, McGrawHill, 1980. 2. McCabeandSmith,"UnitOperationofChemicalEngineering",5thEditionMcGrawHill, KogakushaLtd. 1998. 3. Bioprocess Engineering Principles by Pauline M.Doran – Academic Press.	
References: 1. C. JGeankolis, Transport Processes and unit operations, 3rd Edition, Prenticehall, India, 1993 2. Richardson &Coulson, "Chemical Engineering", Vol. 2, PergamonPress, 1970. 3. B.K Datta, Principles of mass transfer & separation process.	
Unit wise Measurable students Learning Outcomes: 1. Student should understand basic laws of mass transfer. 2. Students should understand role of diffusion in bioprocessing 3. Students should understand concept of distillation process and design of distillation column. 4. Students should understand Principles of extraction 5. Students should understand mechanism of crystallization 6. Students should understand Principles of drying	

Title of the Course: Biological Thermodynamics	L	T	P	Credit
Course Code: UBIO0502	3	-	-	3

Course Pre-Requisite:

Basics Of Unit And Conversions , Basics Of Thermodynamics At 10+2 Level

Course Description:

Thermodynamics helps biologists to evaluate which biochemical reaction is feasible. It can be used to state whether this reaction would occur or not, and if not then why not. For biotechnological aspect, this would help how to transform the biological process so that a non-spontaneous reaction becomes spontaneous. Thermodynamic principles are applied in Bioenergetics, what of metabolic activities, cellular respiration, growth and development processes, membrane transport systems, enzymatic reactions and much more.

Course Learning Objectives:

1. To explain the basic concepts of thermodynamics like heat, enthalpy, internal energy, work, energy and power
2. To utilize the basic concepts for deriving different laws
3. To examine different relationships between fundamental properties.
4. To evaluate energy requirements for different biochemical processes.

Course Outcomes:

At the end of the course the student will be able to:

CO	After the completion of the course the student should be able to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Explain the basic concepts of thermodynamics like heat, enthalpy, internal energy, work	II	Understand
CO2	Utilize the basic concepts for deriving different laws	III	Apply
CO3	Examine different relationships between fundamental properties.	IV	Analyze
CO4	Evaluate energy requirements for different biochemical processes.	V	Evaluate

CO-PO Mapping:

CO\PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2												2		
CO2	3	2											2		
CO3	3	2		3										1	
CO4	3	2		3									3	1	

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content

(normally last three modules) covered after MSE.	
Course Contents:	
Unit 1: Introduction and basic concepts Scope and limitations of thermodynamics, Force, pressure and energy, Equilibrium state and the phase rule, Temperature and Zeroth law of thermodynamics, Heat reservoirs and heat engines, reversible and irreversible processes.	6**Hrs.**
Unit 2: First Law of thermodynamics and P-V-T behavior: General Statements for first law of thermodynamics, Internal Energy, first law for non-flow process, Enthalpy, first law for flow process, Heat Capacity, Equation of state and concept of ideal gas, processes involving ideal gases- constant volume, constant pressure, constant temperature processes, adiabatic process, polytropic process	6**Hrs.**
Unit 3: Second Law of Thermodynamics: Limitations of first law of Thermodynamics- direction of change, General statements of the second law of thermodynamics, Entropy-concept, The CARNOT principle, Entropy –A state function, statistical explanation for entropy, Third law of thermodynamics	6**Hrs.**
Unit 4: Process thermodynamics and its application: Thermodynamic properties of pure fluids Classification of thermodynamic properties, Work function (Helmholtz Free Energy), Gibbs Free energy, Fundamental property relations, Maxwell's relations and its applications, Fugacity, standard state for fugacity, Fugacity coefficient , Effect of temp and pressure on fugacity.	6**Hrs.**
Unit 5: Gibbs free energy-theory Equilibrium, Reversible processes, Phase transitions, Chemical potential, Effect of solutes on boiling points and freezing points, Equilibrium constant, Effect of temperature on Keq , Chemical coupling, Redox reactions	6**Hrs.**
Unit 6: Gibbs free energy- application Applications of thermodynamics in metabolic reactions, Macromolecular interactions, Membrane transport, Molecular pharmacology, DNA, Enzyme-Substrate interactions, Substrate Cycling, Protein solubility, Protein stability, Protein dynamics	6**Hrs.**
Textbooks: Biological Thermodynamics – D.T. Haynie (Cambridge University Press) A textbook of Chemical Engineering Thermodynamics – K. V. Narayanan (Prentice Hall of India)	
Reference Books: Introduction to Chemical Engineering Thermodynamics – Smith, Van Ness, Abbott (TMH) Chemical, Biochemical and Engineering Thermodynamics – Stanley I. and Sandler (Wiley India Edition),Chemical engineering thermodynamics – Y.V.C. Rao (New Age international)	

Unit wise Measurable students Learning Outcomes:

Unit 1: Students should understand common basic concepts like Force, pressure and energy, Equilibrium state and the phase rule.

Unit 2: Students should understand procedure for how to apply first law for non-flow process, first law for flow process.

Unit 3: Students should understand, apply and solve the sums by applying The Carnot principle, Entropy –A state function, Mathematical statement of the second law of thermodynamics.

Unit 4: Students should able to classify different thermodynamic properties.

Unit 5: Students should apply the theoretical concept of Gibb's free energy for Equilibrium, Reversible processes, Phase transitions, Chemical potential, Effect of solutes on boiling points and freezing points, Equilibrium constant.

Unit 6: Students should understand application of Gibb's free energy Photosynthesis, Oxidative phosphorylation, Membrane transport, Enzyme-substrate interaction, Molecular pharmacology.

Title of the Course: Fermentation Technology	L	T	P	Credit
Course Code:UBIO0503	4	-	-	4

Course Pre-Requisite:

Microbiology, Biochemistry, Fluid Mechanics, Bioprocess Calculations, Heat Transfer

Course Description:

First section of this course explains the upstream processing part of a fermentation process. It covers isolation of producer strains, media requirements, media preparations and sterilization, inoculum development up and kinetics of biomass, substrate, product during the fermentation run. Second section explains the initial part of bioseparations where broth pre-treatment is used to remove the insoluble cells to process the liquid for purification of product.

Course Learning Objectives:

1. To recall the basics of microbiological concepts of selection, preservation of microorganisms and preparation and sterilization of media.
2. To explain the strategies of genetic improvement, media sterilization, inoculum development and broth pre-treatment.
3. To apply the techniques for genetic improvements, large scale media preparation, sterilization and removal of insoluble material from fermentation broth.
4. To examine the existing upstream fermentation process based on media preparation, sterilization, inoculation and broth pre-treatment.
5. To evaluate upstream process strategy with broth pre-treatment for a particular product.

Course Outcomes:

CO	After the completion of the course the student should be able to -	Bloom's Taxonomy	
		Level	Descriptor
CO1	Recall the basics of microbiological concepts of selection, preservation of microorganisms and preparation and sterilization of media.	I	Remember
CO2	Explain the strategies of genetic improvement, media sterilization and inoculum development and broth pre-treatment.	II	Understand
CO3	Apply the techniques for genetic improvements, large scale media preparation, sterilization and removal of insoluble material from fermentation broth	III	Apply
CO4	Examine the existing upstream fermentation process based on media preparation, sterilization, inoculation and broth pre-treatment.	IV	Analyze
CO5	Evaluate upstream process strategy with broth pre-treatment for a particular product.	V	Evaluate

CO-PO-PSOMapping:

CO/PO/PSO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	1													
CO2	3	2	2												
CO3	3	2	3	3	2								1		
CO4		2	2	3									1	3	1
CO5						1	1		1		2		1	3	1

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), one Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Isolation, preservation and improvement of industrial microorganism The isolation of industrially important microorganisms , The preservation of industrially important microorganisms, The improvement of industrial microorganisms, Systematic Improvement Programme	**7 Hrs.**
Unit 2:Media for industrial fermentations and sterilization Media – Types, Components and criteria of their choices (Energy sources, Carbon sources, Nitrogen sources, Buffers, Oxygen requirements, Antifoams), Media design and formulation, Medium optimization (one factor at a time method, statistical methods), Medium sterilization, The design and scale up of batch sterilization processes (Death kinetics, Del factor derivations), The design of continuous sterilization processes (Del factor and nutrient quality criterion), Filter sterilization (Design of depth filter for aseptic air inoculation)	**10 Hrs.**
Unit 3:Inocula development and fermentation kinetics The development of inocula for bacterial, streptomycete, yeast, fungal processes The aseptic inoculation of plant fermenters, Fermentation Kinetics - Microbial Growth Kinetics (Development of growth equation, Quantifying cell concentration, Growth patterns and Kinetics), Substrate consumption kinetics, Product formation kinetics	**7 Hrs.**
Unit 4:Broth Pretreatments for Product Recovery Classification of biotechnology products, Recovery in modern versus classical biotechnology, Characterization of fermentation broth / extract and product, Requirements and types of pretreatments (Coagulation, flocculation, filter aid usage, cell disruption for intracellular products)	**8 Hrs.**
Unit 5:Filtration Conventional filtration versus depth filtration, Basic theory of filtration, Types of filtration processes, Types of filtration equipments, Scale up	**8 Hrs.**
Unit 6:Centrifugation Theory of sedimentation, Equipments for sedimentation, Relative centrifugal field, Types of centrifugation, Types of centrifuges, Performance equation of centrifuges, Gyro and Sigma factor based scale up	**8 Hrs.**

Textbooks:

1. Principles of Fermentation Technology – Stanbury P.F., Whitaker A, Hall S. J. (Aditya Books)
2. Fermentation Microbiology and Biotechnology – El-Mansi E.M.T. ,Bryce C.F.A, Demain A.L., Allman A.R. (CRC Press)
3. Bioprocess Engineering: Basic Concepts – Shuler M.L., Kargi F. (Prentice Hall of India)
4. Bioprocess Engineering Principles – Doran Pauline M. (Elsevier Pub.)
5. Bioseparations - Belter P.A., Cussler E.L., Hu Wei-Shou (Wiley Publication)
6. Bioseparation - Shivshanker B. (Prentice Hall of India)

References:

1. Process Biotechnology fundamentals – Mokhopadhyay S. N. (Anshan Publishers)
2. Biochemical Engineering – Aiba S., HumphreyA.E. , Millis N. F. (Academic Press)
3. Introduction to Biochemical Engineering - Rao D.G. (Tata McGraw-Hill)
4. Fundamentals of Biochemical engineering -Rajiv Dutta (SpringerPub., Ann Books India)
5. Bioseparation Science and Engineering – Harrison R.G., Todd P., Rudge S.R., Petrides D.P. (Oxford University Press)
6. Product recovery in bioprocess technology – Biotol Series (Butterworth-Heinemann Ltd.)

Unit wise Measurable students Learning Outcomes:

1. At the end of the Unit Students will be able to –
2. Select different strategies of isolation, improvement and preservation of industriallyimportant microorganisms.
3. Design the media and perform sterilization on large scale.
4. Designinocula development strategies for different types of microorganisms.
5. Characterize and choose broth pretreatment strategy.
6. Design and perform scale up of filtration of broth.
7. Select and perform centrifugation of broth.

Title of the Course: Bioreaction Engineering	L	T	P	Credit
Course Code:UBIO0504	4	-	-	4

Course Pre-Requisite:
Fluid Mechanics, Mass And Energy Balances, Unit Operations

Course Description:
This course is designed to study enzyme and cell culture reaction kinetics in batch, fed batch and continuous modes of reactor operations including their non ideal behavior.

Course Objectives:

1. To explain the reaction yields and reaction rates
2. To develop enzyme and cell culture kinetics
3. To evaluate the performance of ideal batch, fed-batch and continuous modes of bioreactors
4. To analyze enzymes and cell culture reactions in different modes of bioreactors
5. To illustrate the concept of non-ideality and multiple reactor systems

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Explain the reaction yields and reaction rates	II	Understand
CO2	Develop enzyme and cell culture kinetics	III	Apply
CO3	Evaluate the performance of ideal batch, fed-batch and continuous modes of bioreactors	V	Evaluate
CO4	analyze enzymes and cell culture reactions in different modes of bioreactors	IV	Analyze
CO5	Illustrate the concept of non-ideality and multiple reactor systems	II	Understand

CO-PO Mapping:

CO\ PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3														
CO2	3	2	2			3						2		1	
CO3	3	3	2	3	2	2						2	2	3	
CO4	3	3	2	3		2			2			3	2	2	
CO5	2	2				1						1			

Assessments :Teacher Assessment:
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Unit 1:General Reaction kinetics for biological systems: Reaction thermodynamics, reaction yields, reaction rates, reaction Kinetics, Effect of temperature on reaction rates, calculation of reaction rates from experimental data- AREA method and Mid Point slope method, Zero order kinetics, First order kinetics, Problems based on it.	**8 Hrs**
Unit 2: Enzyme and Cell culture reaction kinetics for biological systems: Michaelis-Menten Kinetics, Kinetics of enzyme deactivation, Yields in cell culture, Cell growth kinetics, Cell growth kinetics with plasmid instability, production kinetics in cell culture, kinetics of substrate up take in cell culture in absence of product formation, kinetics of substrate up take in cell culture with product formation, Effect of Maintenance on Yields, Kinetics of cell death. Problems based on it.	**9 Hrs**
Unit 3: Ideal Batch operation of enzyme and cell culture bioreactors: Batch operation of mixed reactors: Mathematical expressions of enzyme reactions, Mathematical expressions of cell culture reactions for biomass formation, substrate consumption, product formation andtotal time for batch reaction cycle. Problems based on it.	**6 Hrs**
Unit 4: Ideal Fed Batch operation of enzyme and cell culture bioreactors: Batch operation of mixed reactors: Mathematical expressions of enzyme reactions, Mathematical expressions of cell culture reactions for biomass formation, substrate consumption, product formation and total time for batch reaction cycle. Problems based on it.	**6 Hrs**
Unit 5: Ideal Continuous operation of Steady state chemostat and Plug flow reactor: Mathematical expressions of enzyme reactions & cell culture reactions, chemostat for biomass formation, substrate consumption, product formation, chemostat cascade, chemostat with cell recycle, Continuous operation of enzyme and cell culture plug flow bioreactor, comparison between major modes of reactor operations- Problems based on it.	**10 Hrs**
Unit 6: Multiple Reaction-reactors Systems and Non - Ideality Continuous Stirred Tank reactors of Equal and unequal Size in series, Concept of Desired and Undesired product, Maximising Desired product in parallel reactions and reactor choice accordingly, Qualitative and quantitative discussions on series reactions. Concept of non-ideality, Reasons for Non Ideality, Residence Time Distribution Study- F, C and E curves	**9 Hrs**
Textbooks: 1. Chemical Reaction Engineering- Levenspile, O. (Wiley) 2. Bioprocess Engineering Principles – Doran Pauline M. (Elsevier Pub.) 3. Chemical Engineering Kinetics- Smith, J. ((McGraw Hill, New York) 4. Reaction Kinetics for Chemical Engineers- Walas, S.M. (McGraw Hill, New York). 5. Elements of Chemical Reaction Engineering- Scott. H. Fogler, (EES publication).	
References: 1. Biochemical Engineering Fundamentals- Bailey and Ollis, (McGraw Hill, New York) 2. Bioreaction Engineering-Schergeri, K. (John Wiley) 3. Bioprocess Engineering: Basic Concepts – Shuler M.L., Kargi F. (Prentice Hall of India) 4. Process Biotechnology Fundamentals, Mukhopadhaya, S.N. (Viva Books Pvt. Ltd.) 5. Biochemical Engineering- Blanch H.W. and Clark, D. S. (CRC Press)	
Unit wise Measurable students Learning Outcomes: 1. Apply reaction kinetics principles and analyze data.	

2. Do transient analysis of various enzyme and cell bioreactors using material balance
3. Describe multiple reactor systems
4. Differentiate reactions with respect to various types of reactors and design rate equations for reactions.
5. Select best reactor system for multiple reactions
6. Describe non-ideal behaviour of bioreactors and develop, analyze model for non-ideal behaviour of bioreactors

Title of the Course: Vaccine Technology	L	T	P	Credit
Course Code:UBIO0521	3	-	-	3

Course Pre-Requisite: Biochemistry,genetic engineering, molecular biology, immunology

Course Description: Course emphasizes on different vaccines

Course Objectives:

1. To Define the properties of different drugs.
2. To Interpret the drug formulation and administration.
3. To Identify the role of genes in degenerative disease and cancer.
4. To Examine the relative advantages and disadvantages of viral and non viral gene delivery strategies.

Course Learning Outcomes:

CO	After the completion of the course the student will beable to	Bloom's Cognitive	
		level	Descriptor
CO1	Define the properties of different drugs.	I	Remember
CO2	Interpret the drug formulation and administration.	II	Understand
CO3	Identify the role of genes in degenerative disease and cancer.	III	Apply
CO4	Examine the relative advantages and disadvantages of viral and non viral gene delivery strategies.	IV	Analyze

CO-PO Mapping:

CO\PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2										2	3		
CO2	2	2	3									2	3		3
CO3			2			2						2	2		
CO4			3			2						2	2		

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit: 1 Basic Concepts of Vaccination The history of vaccination, active and passive immunization, Microbial infections and mechanisms of disease induction, basic concepts of immunity and protection against infection	4Hrs.
Unit: 2 Conventional Vaccines: Classification, live attenuated vaccines, non- living vaccines; whole organism, subunit vaccines, diphtheria and tetanus toxoid, Acellularpertusis vaccine, polysaccharide vaccine	6 Hrs.
Unit 3: Modern Vaccine Technologies: Genetically improved live vaccines; genetically attenuated microorganisms, live vectors, genetically improved subunit vaccines; genetically detoxified proteins, proteins expressed in host cells, recombinant peptide vaccines, Antiidiotype antibody vaccines, synthetic peptide based vaccines, nucleic acid vaccines.	8Hrs.
Unit 4: Pharmaceutical Considerations: Production, formulation; additives, adjuvant and delivery systems, combination vaccines, characterization, storage.	6 Hrs.
Unit 5: Common Vaccines used in Modern Times epidemiology and etiology of microbial infections, Pneumonia and respiratory tract infection,sDiarrhoea, Neurological diseases Viral hepatitis and liver cancer Cervical cancer, Systemic infections, Domestic animal and wildlife vaccines	8 Hrs.
Unit 6: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.	4 Hrs.

References:

1. Pharmaceutical Biotechnology, 2nd Ed. By Crommelin D.J.A. &Sindelar R.D (Taylor &Francis)
2. Vaccines, 6th Edition - By Stanley A. Plotkin et al. Saunders, ISBN: 978-1-4557-0090-5 (http://www.sciencedirect.com/science/book/9781455700905) 3,
3. Health Topics – Vaccines. World Health Organization. Web access: http://www.who.int/topics/vaccines/en/ Vaccines and immunization.
4. US Center for Disease Control and Prevention (CDC) Web access: http://www.cdc.gov/vaccines/ Immunization against infectious disease (the Green Book).
5. Public Health England. Web access: https://www.gov.uk/government/collections/immunisation-againstinfectious-disease-the-green-book.

Unit wise Measurable students Learning Outcomes:

At the end of Unit Students will be able to –

1. Understand the scientific bases of immunity and protection ofinfections.
2. Understand the different types of vaccines and their applications.
3. Acquire an analytical and critical mind through a process ofquestioning and problem solving.

4. Acquire general understanding of risks/benefits of vaccines andabilities to make risk assessments for self and family members.
5. Acquire an awareness of the need for life-long vaccination in theprotection of society as a whole.

Title of the Course: Animal Biotechnology	L	T	P	Credit
Course Code:UBIO0522	3	-	-	3

Course Pre-Requisite: Microbiology, Cell Biology, Biochemistry

Course Description: The course contains central topics in Animal biotechnology .The focus is on IVF , Animal cell culture, Cell & Tissue Engineering. Furthermore, attempts to manipulate the animal cells are described.

Course Learning Objectives:

1. To recall type of animal cells and their basic characteristics.
2. To Summarize the types of media, their preparation, sterilization used for animal cell culture and tissue culture.
3. To plan a layout of a laboratory used for handling animal cell culture and tissue culture.
4. To examine the cell and tissue culture with various aspects in different applications.
5. To apply the knowledge of cell and tissue culturing in various applications.

Course Outcomes:

CO	After the completion of the course the student should beable to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Recall type of animal cells and their basic characteristics.	I	Remember
CO2	Summarize the types of media, their preparation, sterilization used for animal cell culture and tissue culture.	II	Understand
CO3	Plan a layout of a laboratory used for handling animal cell culture and tissue culture.	III	Apply
CO4	Examine the cell and tissue culture with various aspects in different applications.	IV	Analyze
CO5	Apply the knowledge of cell and tissue culturing in various applications.	V	Evaluate

CO-PO Mapping:

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Unit 1: Introduction to Animal Cell Structure and organization of animal cells of organ system, Cell signaling and energy metabolism, Structure and behaviour of cancer cells, Structure of clone cell involved in In-vitro fertilization and embryo transfer. Transgenic & Knockout animals.	**8 Hrs.**
Unit 2: Cell Culture Laboratory Design of cell culture laboratory, Equipments, Ultra-pure water, Reagents, Media types, Serum, Preparation of serum, Glasswares, Culture vessels, Sterilization. Bio-safety and Ethics for Laboratory.	**7 Hrs.**
Unit 3: Basic Techniques of animal cell culture: Isolation of tissues, enzymatic and non-enzymatic disaggregation, Primary culture-Lymphocytes, Liver, mesenchymal cells, Embryonic stem culture and its application. Need and advantages of cryopreservation. Organotypic Culture	**7 Hrs.**
Unit 4: Subculture and Propagation Separation of viable and , Terminology and commonly used cells nonviable cells contaminated cells lines. Subculture of monolayer cells and maintenance Subculture of cells growing in suspension and maintenance of subculture.	**7 Hrs.**
Unit 5: Characterization of cell culture Microscopic study and photography, Preparation of chromosomes for analysis, Fluorescence insitu, hybridization in the analysis of Genes and chromosomes. Isoenzyme analysisG-6-P LDH, Transformation, immortalization, Cytotoxicity testing	**7 Hrs.**
Unit 6: Cell and Tissue Engineering Review of Cell source, Cell and Media, Chondrocytes M5CS. Biomaterial scaffold and seeding. Bioreactors for animal cell culture and Cultivation, Monoclonal antibodies scale up in animal cell culture. Cell and tissue engineering.	**7 Hrs.**

Textbooks:

1. Animal Cell Culture by John R.W. (Masters Oxford University Press)
2. Introduction to Cell and Tissue Culture by Jennie P. Mather and Penelope E. Roberts (Plenum Press, New York and London)

References:

1. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988),(Academic press EACC Handbook).
2. Culture of animal cells; a manual of basic techniques, Freshney R. I. (1995) (John Wiley And Sons, USA)

Unit wise Measurable students Learning Outcomes:

After completing the course you will be able:

1. To define cells structure, physiology & terminology generally used in cell culture.
2. To prepare(setup) laboratory for cell culture, organ culture and embryonic c cell culture
3. To identify cell lines, collect the information of cell lines.
4. To illustrate types of cell cultures and their application.
5. To apply research skills to postgraduate research and industrial investigation

Title of the Course: Seminar	L	T	P	Credit
Course Code: UBIO0505	--	--	2	1

Course Pre-Requisite:

Technical Knowledge And Soft Skills.

Course Description:

The major objective of this course is to help students to develop their presentation skills and test the technical understanding learnt till third year while reading research articles.

Course Objectives:

1. To assess the process of reading research articles and presentation making.
2. To build technical understanding and presentation skills for professional life.
3. To develop lifelong learning skills such as time and stress management.

Course Learning Outcomes:

CO	After the completion of the course the student should beable to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Assess the process of reading research articles and presentation making.	III	Apply
CO2	Build technical understanding and presentation skills for professional life.	V	Evaluate
CO3	Develop lifelong learning skills such as time and stress management.	VI	Create

CO-PO Mapping:

CO/PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1					1					2			3		
CO2						2			3	3			2		
CO3										3		3			

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) having 100 % weitage.

Assessment	Marks
ISE	50

ISE is based on with rubrics such as supervisor meetings, research articles collection, analysis, presentation making, mock trials, final seminar delivery at audience

Title of the Course: Fermentation Technology (Lab)	L	T	P	Credit
Course Code:UBIO0531	-	-	4	2

Course Pre-Requisite:
Practical Handling Aspects Of Microbiology, Biochemistry And Mechanical Operations

Course Description:
Fermentation Technology laboratory course includes practical based onisolation of producer species, media preparations andanalysis, media optimizations, cell quantifications and fermentative production analysis in terms of biomass, substrate and product estimations for different bio-products.

Course Objectives:
1. To analyze the fermentation process starting from raw media pretreatments and analysis, media formulation, analysis of biomass, substrate and product and calculations of yield.

Course Learning Outcomes:

CO	After the completion of the course the student should beable to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Apply principles of isolation of producer species from different sources.	III	Apply
CO2	Analyze the fermentation process in terms of raw media pretreatments, media formulation, biomass, substrate and product.	IV	Analyze
CO3	Evaluate the fermentation process with respect to calculations of rates of growth, substrateconsumption, product formation, yield and yield coefficients.	V	Evaluate

CO-PO Mapping:

CO/PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1				2					3	3			3		1
CO2				3					3	3			3		1
CO3				3	1				3	3	3		3	1	1

Assessments :

Teacher Assessment:
One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE	50

ISE are based on Practical performance/ Quiz/ Mini-Project assignment/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on practical and oral examination

Course Contents:	
Experiment No. 1:Isolation Of Producers **Aim and Objectives:** To isolate enzyme producer from natural sources like soil or industrial wastes **Outcomes:** Students will learn to perform isolation of microorganism capable of producing the required enzyme from natural sources like soil or industrial wastes	**1 week**

Experiment No. 2:Pretreatment , preparation of fermentation media and estimation of carbohydrates and proteins from fermentation media **Aim and Objectives:** To pretreat the complex media sources and to estimate the carbohydrate and proteins in the media to help in the formulation **Outcomes:** Students will learn to formulate the media based on the estimations	**1 week**
Experiment No. 3:Study of growth kinetics of the organism **Aim and Objectives:** To calculate the specific growth rate of the microorganism under study in batch culture. **Outcomes:** Students will learn to calculate graphically the specific growth rate of the microorganism under study in batch culture	**1 week**
Experiment No. 4:Study of substrate utilization and product formation kinetics in fermentation **Aim and Objectives:** To calculate the specific substrate consumption and product formation rate of the microorganism under study in batch culture **Outcomes:** Students will learn to calculate the specific substrate consumption and product formation rate of the microorganism under study in batch culture	**1 week**
Experiment No. 5:Calculation of yield coefficients in fermentation **Aim and Objectives:** To calculate yield and yield coefficient in batch culture **Outcomes:** Students will learn to calculate yield coefficient in batch culture	**1 week**
Experiment No. 6:Production of alcoholic beverages/ organic acid/ antibiotics/ enzyme/ amino acid/ biosurfactant/ single cell proteins/ biofertilizers/ biopesticides etc. **Aim and Objectives:** To monitor and characterize the fermentation process at flask and fermenter level. **Outcomes:** Students will learn to monitor and characterize the fermentation process at flask and fermenter level.	**1 week**
Experiment No. 7:Study of fermenter, accessories and preparation of fermenter **Aim and Objectives:** To learn handling and use of batch scale fermenter **Outcomes:** Students will learn to learn handling and use of batch scale fermenter	**1 week**
Experiment No. 8:Study of Oxygen transfer efficiency in fermenter **Aim and Objectives:** To be able to calculate volumetric mass transfer coefficient in fermenter **Outcomes:** Students will learn to calculate volumetric mass transfer coefficient in fermenter	**1 week**

Textbooks:

1. Principles of Fermentation Technology – Stanbury P.F., Whitaker A, Hall S. J. (Aditya Books)
2. Fermentation Microbiology and Biotechnology – El-Mansi E.M.T. ,Bryce C.F.A, Demain A.L., Allman A.R. (CRC Press)
3. Bioprocess Engineering: Basic Concepts – Shuler M.L., Kargi F. (Prentice Hall of India)
4. Bioprocess Engineering Principles – Doran Pauline M. (Elsevier Pub.)

References:

1. Process Biotechnology fundamentals – Mokhopadhyay S. N. (Anshan Publishers)
2. Biochemical Engineering – Aiba S., HumphreyA.E. , Millis N. F. (Academic Press)
3. Introduction to Biochemical Engineering - Rao D.G. (Tata McGraw-Hill)
4. Fundamentals of Biochemical engineering -Rajiv Dutta (SpringerPub., Ann Books India)

Title of the Course: Bioreaction Engineering (Lab) Course Code:UBIO0532	L	T	P	Credit
	-	-	4	2

Course Pre-Requisite: Microbiology, Biochemistry and Fermentation Technology

Course Description:

This course includes practicals based on studies on bioreactions.

Course Objectives:

1. To interpret the order of reactions by experimental and graphical methods
2. To experiment with the enzyme catalyzed bioreactions

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Taxonomy	
		Level	Descriptor
CO1	interpret the order of reactions by experimental and graphical methods	II	Understand
CO2	To experiment with the enzyme catalyzed bioreactions	III	Apply

CO-PO Mapping:

CO\PO\PSO	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	2	2	3			1	3	2	3	3	1	2
CO2	3	3	3	3	2	3	2	2	1	3	2	3	3	3	2

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE	50

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1: Determination of First Order Reaction **Aim and Objectives:**To determine first order of reaction by experimental analysis **Outcomes**: Learners will able to find out order of reaction by experimental analysis	**2 Hrs.**
Experiment No. 2: Determination of Pseudo First Order Reaction **Aim and Objectives:**To determine pseudo first order of reaction by experimental analysis Outcomes: Learners will able to find out order of reaction by experimental analysis	**2 Hrs.**

Experiment No. 3: Determination of Second Order Reaction **Aim and Objectives:** To determine pseudo first order of reaction by experimental analysis **Outcomes:** Learners will able to find out order of reaction by experimental analysis	**2 Hrs.**
Experiment No. 4: Determination of Order of Reaction By Graphical Method **Aim and Objectives:** To study graphical method for determining order of reaction **Outcomes**: Learners will learn to determine the order of reaction by graphical method	**2 Hrs.**
Experiment No. 5: Standard Curve For Reducing Sugar Estimation **Aim and Objectives:** To get a standard curve for reducing sugar estimation by DNSA method **Outcomes:** Learners will learn to perform standard curve for reducing sugar estimation by DNSA method	**2 Hrs.**
Experiment No. 6:Enzyme Assay (any enzyme and substrate may be chosen e.g. alpha amylase and starch respectively) **Aim and Objectives**: To study assay of enzyme to know the activity of enzyme **Outcomes:** Learners will learn to calculate the activity of enzyme after performing assay	**2 Hrs.**
Experiment No. 7:Effect of Temperature and Ph on Enzyme Activity **Aim and Objectives:** To find optimum temperature of enzyme at fixed pH and fixed substrate concentration. To find optimum pH of enzyme at fixed temperature and fixed substrate concentration. **Outcomes:** Learners will learn to find temperature optimum of enzyme at fixed pH and fixed substrate concentration. Learners will learn to find pH optimum of enzyme at fixed temperature and fixed substrate concentration	**2 Hrs.**
Experiment No. 8:Effect of Substrate Concentration of Enzyme Activity **Aim and Objectives:** To perform enzyme reaction at varying concentration of substrate at fixed temperature and pH (preferably at optimum conditions) **Outcomes:** Learners will learn to plot M-M plot (on graph or MS excel)	**2 Hrs.**
Experiment No. 9: Free Versus Immobilized Enzymes **Aim and Objectives:** To compare performance of free vs immobilized enzyme and calculate enzyme activity recovery **Outcomes:** To compare performance of free vs immobilized enzyme and calculate enzyme activity recovery	**2 Hrs**.
Experiment No. 10:Deactivation Kinetics of Enzyme **Aim and Objectives:** To perform deactivation kinetics	**2 Hrs.**

Outcomes: Learners will learn effect of deactivation of enzymes	
Experiment No. 11:Immobilization of Cells Aim and Objectives: To immobilize cells by any immobilization method **Outcomes**: Learners will be able to immobilize cells	**2 Hrs.**

Textbooks:

1. Principles of Fermentation Technology – Stanbury P.F., Whitaker A, Hall S. J. (Aditya Books)
2. Fermentation Microbiology and Biotechnology – El-Mansi E.M.T. ,Bryce C.F.A, Demain A.L., Allman A.R. (CRC Press)
3. Bioprocess Engineering: Basic Concepts – Shuler M.L., Kargi F. (Prentice Hall of India)
4. Bioprocess Engineering Principles – Doran Pauline M. (Elsevier Pub.)

References:

1. Process Biotechnology fundamentals – Mokhopadhyay S. N. (Anshan Publishers)
2. Biochemical Engineering – Aiba S., HumphreyA.E. , Millis N. F. (Academic Press)
3. Introduction to Biochemical Engineering - Rao D.G. (Tata McGraw-Hill)
4. Fundamentals of Biochemical engineering -Rajiv Dutta (SpringerPub., Ann Books India)

Title of the Course: Basics of Cell Culture	L	T	P	Credit
Course Code:UBIO0561	2	-	-	Audit Course

Course Pre-Requisite:
Biochemistry, Cell biology, Microbiology

Course Description:
This course includes theoretical understanding of animal and plant cell and tissue culture.

Course Learning Objectives:
1. To explain media preparation and sterilization techniques in plant and animal tissue culturing.
2. To choose type of technique used in plant and animal tissue culturing.
3. To justify suitable technique of plant and animal tissue culture for various applications.

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Explain media preparation and sterilization techniques in plant and animal tissue culturing.	II	Understand
CO2	Choose type of technique used in plant and animal tissue culturing.	III	Apply
CO3	Justify suitable technique of plant and animal tissue culture for various applications.	V	Evaluate

CO-PO Mapping:

CO/PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2											1	
CO2	3	3	2											1	
CO3	3	3	2	1		2	2	2					1	1	

Assessments :

Teacher Assessment:
End Semester Examination (ESE) having 100% weightage

Assessment	Marks
ESE	100

ESE: Assessment is based on written examination

Course Contents:

Unit 1 Introduction to Plant tissue culture: Advantages and disadvantages**,** Application	**2 Hrs**
Unit 2 Plant tissue culture: Media preparation, sterilization	**2 Hrs**
Unit 3 Plant Tissue Culture: Isolation of explants, Callus Culture, shoot culture, root culture, Anther culture, pollen culture, leaf culture, flower culture, Artificial seed preparation	**8 Hrs**
Unit 4 Animal tissue culture: Advantages and disadvantages**,** application , primary treatment to cell material, primary cell lines, secondary cell lines, continuous cell lines	**4 Hrs**
Unit 5 Animal tissue culture: Media preparation, sterilization	**2 Hrs**
Unit 6 Animal tissue culture: **S**election and cloning of cell **, w**hole embrio culture, Organ culture, lymphocyte culture, viability count, characterization and preservation of cells	**6 Hrs**

Reference books:

1. Basic Principles of Cell Culture by R. Ian Freshney (John Wiley & Sons, Inc.)
2. Plant Tissue Culture: Theory and Practice by S.S. Bhojwani, M.K. Razdan (Elsevier)
3. Animal cell and tissue culture : Shivangi Mathur (Agrobios India)

Title of the Course: Bioprocess Equipment Design	L	T	P	Credit
Course Code: UBIO0601	4	-	-	4

Course Pre-Requisite: Equipments used in Bioprocess Industries

Course Description: This course is designed to satisfy the need of designing equipments like Reaction Vessels, Heat Exchangers and Dryers. Also students will learn basic about flow sheet preparation and development.

Course Learning Objectives:

1. To explain the codes and standards for the mechanical design of equipments
2. To develop process flow diagrams (PFDs) and piping and instrument diagrams (P&IDs)
3. To analyze design procedures for commonly used process equipment
4. To design different bioprocess equipments

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Explain the codes and standards for the mechanical design of equipments	II	Understand
CO2	Develop process flow diagrams (PFDs) and piping and instrument diagrams (P&IDs)	III	Apply
CO3	Analyze design procedures for commonly used process equipment	IV	Analyze
CO4	Design different bioprocess equipments	VI	Create

CO-PO Mapping:

CO\PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3		2	3			1	2							1
CO2	3	2	3	3	1						2		2	2	
CO3	2	3	3	3		1					2		2	2	3
CO4	2	3	3	3	1	1					3				3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Unit 1: Design preliminaries Design codes, Mechanical Properties of Materials, design pressure, design temperature, design stress and factor of safety, corrosion allowance, Weld joint efficiency factor, Design Loadings.	8Hrs.
Unit 2: Pressure vessels Classification of pressure vessels, Pressure Vessel Codes & Standards, selection of material, Design of Shell & its components, Thumb rules, process hazards and safety measures in equipment design.	8Hrs.
Unit 3: Flow sheet synthesis, development and drawing Process Information, Input/output structure, Functions diagrams, Operations diagram, process flow sheet, , Equipment symbols, equipment lettering , Instrument symbols and stream designation, piping and instrumentation (P&ID) , valves types.	8Hrs.
Unit 4: Heat exchanger Introduction, types of heat exchanger, Design of Shell & Tube Heat Exchanger, Material of Construction, , Shell, tube, tube sheet, baffles.	8 Hrs.
Unit 5: Reaction vessel- Introduction, material of construction, Classification of Reaction Vessels , Heating System: jackets and coils, types of agitators, Design of Agitator system components	10 Hrs.
Unit 6: Dryer Introduction, types, mechanical design of dryer	6 Hrs.
Textbooks: Joshi's Process Equipment Design, V.V.Mahajani & S.B.Umarji, fourth edition.(Macmillan publishers India Ltd) Introduction to Chemical Equipment Design-Mechanical Aspects, B.C.Bhattacharyya, (CBS, Publishers and Distributors)	
References: 1. Process Design of Equipment ,Dr. S.D. Dawande, 1st Edition,(Central Techno Publication) 2. Fundamentals of Equipment Design ,A. K. Koker,(Gulf Publication) 3. Process Heat Transfer, D.Q. Kern,(Tata McGraw Hill Company, New York). 4. Applied Process Design for Chemical and Petrochemical Plants ,E.E. Ludwig, Vol.I,II,III, , 3rd edition London, 1994(Gulf Publication) 5. Plant Design and Economics for Chemical Engineers M.S. Peters & K.D.Timmerhaus,", 5th edition, (McGraw Hill International Book Co) 6. "Chemical Engg." Vol. 2 & 6,Coulson J. M. and Richardson J. F (Pergaman Press)	
Unit wise Measurable students Learning Outcomes: 1. Students should understand preliminaries to start with the designing of equipments 2. Students should understand classification of pressure vessels and designing of the unfired vessels 3. Students should understand how to draw flow sheets , rules and regulation in flow sheeting 4. Students should understand types of heat exchangers and process and mechanical design of the heat exchanger 5. Students should understand types of reaction vessels and procedure to design the reaction vessel **6.** Students should understand types of dryers and process and mechanical design of the dryers.	

Title of the Course: Bioseparation Processes	L	T	P	Credit
Course Code:UBIO0602	3	1	-	4

Course Pre-Requisite:

Biochemistry, Fluid Mechanics, Mechanical Operations, Bioprocess Calculations, Heat and Mass Transfer, Biological Thermodynamics

Course Description:

Course emphasizes on different unit operations performed after insolubles removal for the bulk recovery and purification of bio-products.

Course Objectives:

1. To list down the range of bioproducts with respect to separation-based classification.
2. To explain the basic principles of different unit operations in bioseparations.
3. To apply principles and mathematical models for the process and equipment design.
4. To analyze the product and impurities for the selection and sequencing of unit operations for bioseparations.
5. To evaluate separation strategies based on product nature, yield, purification extent, costing and environmental impacts.

Course Learning Outcomes:

CO	After the completion of the course the student should beable to	Bloom's Taxonomy	
		Level	Descriptor
CO1	List down the range of bioproducts with respect to separation-based classification.	I	Remember
CO2	Explain the basic principles of different unit operations in bioseparations.	II	Understand
CO3	Apply principles and mathematical models for the process and equipment design.	III	Apply
CO4	Analyze the product and impurities for the selection and sequencing of unit operations for bioseparations.	IV	Analyze
CO5	Evaluate separation strategies based on product nature, yield, purification extent, costing and environmental impacts.	V	Evaluate

CO-PO Mapping:

CO/PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3														
CO2	3		2												
CO3	3	2	1	3											
CO4		3	3	2									2	3	
CO5		1	3	3		1	1				1	1		3	

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Unit 1:Extraction Partition coefficient basis of extraction, Type of extraction processes, Type of equipments, Scale up, Special extraction types (Aqueous two phase extraction, Supercritical fluid Extraction, Reverse Miceller Extraction)	**8 Hrs.**
Unit 2:Precipitation Chemistry of dissolution and precipitation, Difference between crystallization and precipitation, Types of precipitation (using salts, using organic solvents, using acid/alkali, using electrolytes, using non ionic polymers), Type of equipments, Scale up	**8 Hrs.**
Unit 3:Adsorption Chemistry of adsorption, Adsorbents, Batch adsorption, Adsorption isotherms (Linear, Freundlich, Langmuir), Continuous adsorption (Adsorption in CSTR, Adsorption in fixed beds) , Scale up	**8 Hrs.**
Unit 4:Membrane Separations Classification of membranes processes based on different driving forces (microfiltration, ultra filtration, diafiltration, nano filtration, reverse osmosis), Structure and preparation of membrane, Types of membrane modules, scale up	**10 Hrs.**
Unit 5:Chromatography Planar chromatography (paper and thin layer) , Column chromatography (Normal phase chromatography**,** Ion-exchange chromatography, Adsorptionchromatography, Reverse phase chromatography**,** Hydrophobic interaction chromatography, Affinity chromatography, Gel-filtration chromatography) Analytical chromatography (HPLC,GC,HPTLC) versus preparative chromatography	**10 Hrs.**
Unit 6:Finishing Finishing operations for API concentration (Buffer exchange, Crystallization, Drying, Lyophilization , Evaporation), Different Formulations of API , Stability studies	**4 Hrs.**

Textbooks:

1. Bioseparations - Belter P.A., Cussler E.L., Hu Wei-Shou (Wiley Publication)
2. Bioseparations - Shivshanker B. (Prentice Hall of India)

References:

1. Bioseparation Science and Engineering – Harrison R.G., Todd P., Rudge S.R., Petrides D.P. (Oxford University Press)
2. Product recovery in bioprocess technology – Biotol Series (Butterworth-Heinemann Ltd.)
3. Protein Purification: Principles and Practice - Scopes Robert K. (Springer – Verlag Pub.)
4. Separation processes in Biotechnology –Asenjo J.A. (Taylor and Francis Group)
5. Separation and Purification Techniques in Biotechnology – Dechow F.J. (Noyes Pub.)
6. Transport Processes and Separation Process Principles - Geankoplis Christie John (Prentice Hall of India)
7. Unit Operation of Chemical Engineering - McCabe W. L., Smith J., Harriot P.(McGraw- Hill Pub.)
8. Downstream Processing in Biotechnology – Anuj Kumar Rana (Global Vision Pub.)

Unit wise Measurable students Learning Outcomes:

At the end of Unit Students will be able to –

1. Analyze and design extractions for different biomolecules based on partition behavior.
2. Choose the and carry out precipitation method based on product characteristics.
3. Perform adsorption analysis in batch and continuous modes.
4. Perform membrane separations and troubleshooting for purifications.
5. Choose and perform various chromatographic operations.
6. Learn final polishing steps for purified biomolecule.

Title of the Course: Techniques in Biotechnology Course Code: UBIO0603	L	T	P	Credit
	4	-	-	4

Course Pre-Requisite:

Basic Knowledge Of Biological, Physical And Chemical Properties Of Small And Macromolecules, Basics Of Physics And Chemistry At 10+2 Level

Course Description:

This course contains the study of various analytical instruments in biotechnology with respect to working principles, instruments layouts, various parts and its functions.

Course Objectives:

1. To List the range of analytical instruments and recognize its end use application.
2. To Illustrate layouts of instruments
3. To select the analytical method based on the phenomena.
4. To analyze the data obtained from different instruments.
5. To Interpret the results of analysis

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Taxonomy	
		Level	Descriptor
CO1	List the range of analytical instruments and recognize its end use application.	I	Remember
CO2	Illustrate layouts of instruments	II	Understand
CO3	Select the analytical method based on the phenomena.	III	Apply
CO4	Analyze the data obtained from different instruments.	IV	Analyze
CO5	Interpret the results of analysis	V	Evaluate

CO-PO Mapping:

CO\PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1		2													
CO2	2	2											2		
CO3	2	2		3									3		
CO4	3	2		3	3								3	3	
CO5	3	2		3	3								3	3	

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Unit 1: Spectroscopic techniques Absorption spectrum, instrumentation for UV-Visible spectrophotometry, radiant energy sources, wavelength selectors, detection devices, amplification and read out, double beam operation, double wavelength spectrophotometer, applications of UV-Visible spectrophotometry, quality & quantitative analysis.Theory and applications of Infrared spectrophotometry, calculation of vibrational frequencies, modes of vibration, infrared spectra of common functional groups. Infrared Spectrophotometer: Mode of operation, sampling techniques, applications. Principles, components and applications of - Flame spectrophotometry, Fluorescence spectroscopy.	**10 Hrs.**
Unit 2: NMR And Mass Spectroscopic Techniques NMR: Theory and Principle of NMR - Multi nuclear NMR- Analysis of spectra and Interpretations - Case studies of drugs, peptides and proteins. NMR spectra Analysis Recent advances in protein NMR. Mass Spectrometer: Principles of modern ionization methods and mass analyzers (TOF), hybrid/tandem mass methods (MS-MS) and applications of MS in the analysis of drugs and macromolecules.	**10 Hrs.**
Unit 3: Microscopic Techniques Fluorescence microscopy, Phase contrast microscope, Electron microscope, Scanning electron microscopy, Transmission electron microscope. Application of microscope in analyzing biological samples.	**4 Hrs.**
Unit 4: Electrophoretic Techniques Electrophoresis; Principle, Design of horizontal and vertical gelelectrophoresisapparatus.SDS PAGE, Discontinuous (Disc) Gel Electrophoresis, High Voltage (HVE) Electrophoresis, Isoelectric focusing, 2D Gel Electrophoresis, Pulse-Field Gel Electrophoresis. Application of electrophoresis in analyzing macromolecules.	**10 Hrs.**
Unit 5: Chromatographic Techniques Plane Chromatography- Paper Chromatography, Thin Layer Chromatography. Column Chromatography- Adsorption Chromatography, Partition Chromatography, Liquid-Liquid Chromatography, Gas-Liquid Chromatography, Gel Permeation Chromatography, Ion Exchange Chromatography, Affinity Chromatography, High Performance Liquid Chromatography, GCMS, LCMS, HPTLC.	**10 Hrs.**
Unit 6: Certain physicochemical techniques useful in Biotechnology Geiger-Muller counter, scintillation counter, Enzyme-Linked Immunosorbent Assay (ELISA), Radio-Immunosorbent Assay (RIA), Flow cytometry	**4 Hrs.**
Textbooks: **1.** Bioanalytical Chemistry, A. Manz, N. Pamme and D. Iossifidis, (World Scientific Publishing Company) 2. Basic Methods in Microscopy, Protocols and concepts from cells: A Laboratory Manual, D. L. Spector & R. D. Goldman (Editors.), Cold Spring Harbor Laboratory Press, 2006 3. Live Cell Imaging: A Laboratory Manual R. D. Goldman, J. R. Swedlow and D. L.	

(Spector Cold Spring)
4. Harbor Laboratory Press; 2nd edition, 2009.
5. Biophysical Chemistry-Principles and Techniques, A. Upadhyay, K. Upadhyay, N. Nath. (Himalaya Publishing House)
6. Bioinstrumentation, J. Webster (John Wiley and Sons Inc.,).

References:

1. Skoog, D.A., Crouch, S.R., and Holler, F.J. "Principles of Instrumental Analysis", 6th edition, Brooks/Cole, USA, 2006.
2. Williams, D. and Fleming, I. "Spectroscopic Methods in Organic Chemistry", 6th edition, McGraw-Hill Higher Education, Maidenhead, UK, 2008.
3. Freifelder D., Physical Biochemistry, "Application to Biochemistry and Molecular Biology", 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.
4. Keith Wilson and John Walker, "Principles and Techniques of Practical Biochemistry", 5th Edition, Cambridge University Press, 2000.
5. Kwon, Young Min, Ricke, Steven C. (Eds), "High-Throughput Next Generation Sequencing Methods and Applications", Volume. 733, Humana Press, 2011.

Unit wise Measurable students Learning Outcomes:

1. To introduce the wide range of spectroscopic analytical instruments and its applications.
2. To explain NMR techniques, describe the types of equipments, discuss types of detection devices, and solve troubleshooting in Mass spectrophotometer.
3. To apply the basic principles, components and applications in microscopy.
4. To explain electrophoretic techniques, describe the types of equipments, discuss types of detection devices, and solve troubleshooting in electrophoresis.
5. To apply the basic principles, components and applications in chromatography.
6. To introduce the wide range of analytical instruments and its applications.

Title of the Course: Bioreactor Design and Controls	L	T	P	Credit
Course Code: UBIO0604	4	-	-	4

Course Pre-Requisite:
Fluid Mechanics , Mechanical Operations, Bioprocess Calculations, Heat and Mass Transfer, Biological Thermodynamics

Course Description:
Course describes the details of design, operation and control of bioreactors.

Course Objectives:
1. To list different types of reactors and their control requirements.
2. To explain the use of different reactors and their control systems.
3. To apply the principles to design the reactors and control system strategy.
4. To select the type of reactor and control system strategy.
5. To design and scale up the bioreactor.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Taxonomy	
		Level	Descriptor
CO1	List different types of reactors and their control requirements.	I	Remember
CO2	Explain the use of different reactors and their control systems.	II	Understand
CO3	Apply the principles to design the reactors and control system strategy.	III	Apply
CO4	Select the type of reactor and control system strategy.	IV	Analyze
CO5	Design and scale up the bioreactor.	VI	Evaluate

CO-PO Mapping:

CO/PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2														
CO2	3														
CO3	2	2	2	2										2	
CO4		3		2							1				
CO5		2	3	3							2		2	3	1

Assessments :

Teacher Assessment:
Two components of In Semester Evaluation (ISE), one Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Measurement of fermentation process variables	8Hrs.
Methods of measuring process variables (Temperature, Pressure, Weight, Microbial	

biomass, Flow rate, Dissolved oxygen, Inlet and Exit gas, pH, Rate of stirring)	
Unit 2:--- Control of fermentation processes – Fundamentals Requirement for control, Loop control, Sequence control Control systems – Components of basic control loop (Sensors, Controllers and Actuators) Basic fermentation control loops (Temp, pH, DO, Air flow rate, agitation, pressure and antifoam) Types of sensors, Types of controllers (Manual and automatic controllers), Type of control actions (ON-OFF, P, I, PI, PD, PID), Types of actuators	**10Hrs.**
Unit 3:--- Control of fermentation processes – Applications Case study - manual control of fermentation process Case study – automated control of fermentation process using logic gates Advanced fermentation control options – cascade feedback control, feed forward control, event tracking control	**6Hrs.**
Unit 4:--- Classification and selection of bioreactors Mass transfer characterization in bioreactors (Determination of KLa , Factors affecting KLa values) , The balance between oxygen supply and demand , Review of bioreaction kinetics and modes of fermentation operations – batch, fed batch, continuous , Classification of reactors based on agitation and aeration regime, Selection of reactors based on different criteria such as broth characteristics, producer entity type etc.	**10Hrs.**
Unit 5:--- Design and working aspects of Bioreactor Design, construction and working of Stirred tank reactor, Bubble column reactor, Air lift reactor, Packed bed reactor, Fluidized bed reactor, Disposable bioreactors, Reactor peripherals and accessories	**10Hrs.**
Unit 6:--- Scale up aspects of Bioreactor Scale up concerns of microbial, mammalian and plant cell processes Scale up criteria for bioreactors (Constant power per Unit volume, Constant KLa, Constant mixing quality, Constant impeller tip speed, Constant momentum factor, Constant mixing rate number, Similar drop size distribution), Selection of scale up criteria	**4 Hrs.**
Textbooks: 1. Principles of Fermentation Technology – Stanbury P.F., Whitaker A, Hall S. J. (Aditya Books) 2. Fermentation Microbiology and Biotechnology – El-Mansi E.M.T. ,Bryce C.F.A, Demain A.L., Allman A.R. (CRC Press) 3. Bioprocess Engineering: Basic Concepts – Shuler M.L., Kargi F. (Prentice Hall of India) 4. Bioprocess Engineering Principles – Doran Pauline M. (Elsevier Pub.)	
References: 1. Bioreactors in Biotechnology: A practical approach- Scragg A.H. (Ellis Horwood Pub.) 2. Process Biotechnology Fundamentals – Mokhopadhyay S. N. (Anshan Publishers) 3. Biochemical Engineering – Aiba S., HumphreyA.E. , Millis N. F. (Academic Press) 4. Introduction to Biochemical Engineering - Rao D.G. (Tata McGraw-Hill) 5. Fundamentals of Biochemical Engineering -Rajiv Dutta (SpringerPub., Ann Books India)	
Unit wise Measurable students Learning Outcomes: At the end of the Unit Students will be able to – 1. Explain the mechanism of process variable measurement. 2. Explain control loop strategy for different process variables. 3. Troubleshoot control system based on strategy used. 4. Classify bioreactors based on agitation aeration and characterize mass transfer condition in bioreactor. 5. Design and operate various types of bioreactors. 6. Calculate different scale up parameters for bioreactors.	

Title of the Course: Environmental Biotechnology (Open Elective – I) Course Code: UOEL0601	L	T	P	Credit
	3	-	-	3

Course Pre-Requisite: Environmental Sciences, Unit Operations

Course Description: This course contains the study of different microorganisms and techniques required for different waste treatments and its environmental impact assessment.

Course Objectives: After completing the course students are able to,

1. List the sources of environmental pollution and their causesDevelop engineering solutions to the social, economic and environmental problems.
2. To Utilize biological ways for management of agricultural soil , solid ,water and air pollution
3. To Develop bioremediation technological solutions for environmental issues
4. To Compare different biofuel technologies
5. To Evaluate environmental laws and policies for the global environmental problems.

Course Learning Outcomes:

CO	After the completion of the course the student should beable to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Listthe sources of environmental pollution and their causes	I	Remember
CO2	Utilize biological waysfor management of agricultural soil , solid ,water and air pollution	II	Understand
CO3	Develop bioremediation technological solutions for environmental issues	III	Apply
CO4	Compare different biofuel technologies	IV	Analyze
CO5	Evaluate environmental laws and policies for the global environmental problems.	V	Evaluate

CO-PO Mapping:

CO\PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1		2				3								
CO2	1	2	3			3	3								
CO3	2		3			3	3						3	3	2
CO4	2	2	3	2		3	3				2		3	3	2
CO5			3			3	3	3							3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Pollution and Waste Pollution – types, causes, effects and abatement Waste – sources of waste, different types of waste, chemical, physical and biochemical methods of waste minimization and recycling, Global atmosphere-green house gases, global warming, acid rain, ozone depletion and photochemical smog.	6 Hrs.
Unit 2:Management of Agricultural SoilsAnd Air Pollution Biofertilizer: introduction history, production of nitrogen fixing organisms *Rhizobium*, *Azotobacter*, Growth hormones (Gibberlic acid, Indole acetic acid) Bioinsecticides: Introduction, production of *Bacillus thuringenesis*, *Trichoderma* Bio-filters and Bio-scrubbers for decontamination of polluted air	6 Hrs.
Unit 3: Solid and Water Waste Management Sources, characteristic, waste reduction and material recovery, hazardous waste management, composting, Biogas production	6 Hrs.
Unit 4: Bioremediation – Fundamentals and Applications Definition, Types of bioremediation, *In-situ* and *Ex-situ* bioremediation techniques, Factors affecting bioremediation, Biodegradable plastics like PHA, Economics of pollution prevention, Process flow-sheet for pollution prevention, sustainable process design, life cycle analysis of plastics and paper.	8 Hrs.
Unit 5: Biofuels Energy crops, Plant derived fuels (Biodiesel), Bioethanol, Microbial Fuel Cell	5 Hrs.
Unit 6: Environmental Impact Analysis Basic concepts- biotic and abiotic environment, environmental acts and regulations, environment and public health, air quality standards.	5 Hrs.

Textbooks:

1. General Microbiology, H.G. Schlegel, 7thEd.(Cambridge University Press)
2. Manual on Solid Waste Management (CPHEEO, Govt. of India).
3. Microbial Ecology: Fundamentals and applications- Atlas Bartha, 4thEd.(Dorling Kinderley , India Pvt. Ltd).

References:

1] Manual of Industrial Microbiology and Biotechnology-Arnold Demain and Julian Davies, II Ed. (ASM Press Washington)
2] Wastewater Engineering treatment and reuse- Metcalf Eddy (Wiley Publications)
3] Introductory Practical Microbiology- JayababuMudili (Alpha Science International Limited).
4] Introduction to environmental engineering - P. AarneVeslind- Cenage learning
5] Environmental engineering - Joseph A. Salvato - wiley

Unit wise Measurable students Learning Outcomes:

At the end of the Unit Students will be able to -

1. identify type of pollutants
2. explain treatment technologies for management of soil and air pollution
3. learn solid and water waste management technologies
4. learn bioremediation fundamentals and its applications
5. learn the production technology for biofuels
6. understand environmental impact assessment

Title of the Course: Food Technology Course Code:UOEL0602	L	T	P	Credit
	4	-	-	4

Course Pre-Requisite: Biochemistry, Microbiology, Unit operation, Heat transfer, bioprocesses

Course Description: Course emphasizes on food analysis, processing, packaging and preservation.

Course Objectives:

1. To explain manufacturing of process food.
2. To identify the areas of concern in the processing of milk, meat, fish products, in relation to process control, undesirable microbes.
3. To Discuss energy engineering in food processing
4. To demonstrate food processing, preservation and packaging techniques.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Explain manufacturing of process food	II	Understanding
CO2	Identify the areas of concern in the processing of milk, meat, fish products, in relation to process control, undesirable microbes.	III	Apply
CO3	Discuss energy engineering in food processing	VI	Create
CO4	Demonstrate food processing, preservation and packaging techniques	II	Understanding

CO-PO Mapping:

CO	1	2	3	4	5	6	7	8	9	10	11	12
CO1	3											
CO2							2	1				
CO3	3	2										
CO4	3											
CO5	3	3										

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit: 1 Food Production Systems Factors influencing growth of crops - Environmental, Soil and Farming systems. Growth, yield and economic importance of major crops: Cereals - Maize, rice, sorghum, millet, etc; Legumes - soybean, cowpea, groundnuts etc; Root and Tubers -Cassava, Sweet potatoes, Yam, etc; Fruits and Vegetables - tomatoes, garden eggs, cabbage, etc. Animal production review in India - Poultry and Livestock.	**4 Hrs.**

Unit: 2 Food Microbiology and Fermentation Microbial isolation, preservation and management, Inoculum preparation. Starter cultures; Fermentation processes - Lactic acid fermentation (Yoghurt, sauerkraut, etc), Alcoholic fermentation (Ethanol, beer, wine, alcohol by-products), Acetic acid fermentation (Vinegar)	**8 Hrs.**
Unit 3: Food Packaging and preservation: Historical development of food packaging; Functions of packaging; Properties of packaging materials; Types of Packaging materials - Glass, metal cans, paper, plastics; Packaging requirements of foods; An integrated approach to the materials used for the packaging of food products, considering the physical, chemical and functional characteristics and their utility relative to the chemistry of the food system they are designed to enclose and preserve. New packaging technologies; statutory regulations affecting food packaging. Preservation - chilling, freezing, canning, smoking, curing, salting and drying	**8 Hrs.**
Unit 4:Energy engineering in food processing Generation of steam, Fuel utilization, Electric power Utilization, Process controls in Food processing, Systems for heating and cooling food products, thermal properties of foods, modes of heat transfer- freezing systems, Frozen food properties, freezing time, refrigeration system for food products	**8 Hrs.**
Unit 5: Milk, meat, fish & poultry Processing of **Milk** – Pasteurisation, homogenisation, sterilization, HTST and UHT processes; Processing and preservation of milk products **Meat**: commercially important meats;meat inspection and grading; animal welfare and safety in slaughter plant. Structure and composition of meat, carcass chilling, ageing; storage of fresh meat; Processing and preservation - artificial tenderizing, chilling, freezing, curing, smoking, ready-to-eat meats and meat products. **Marine and fresh water fish, shell fish** - composition and nutrition; commercially important fish and shell fish; spoilage factors, ship board operations, storage and transport fish meal and fish oils. **Types of poultry**: production, classification & designation, grading. Processing plant operations - slaughter, bleeding, scalding, defeathering, eviscerating, chilling, packaging; composition and nutrition, poultry meat products. **Eggs**- structure, composition, quality factors, storage.	**8 Hrs.**
Unit 6:Food Hygiene, Sanitation & Food Standards Scope and definition of hygiene; Prevention of microbial growth in foods; Prevention of contamination of foods, - Personal hygiene, waste disposal; Plant set-up and sanitation; cleaning and cleaning agents; Food hygiene legislation., . Introduction to Food Safety Management System (FSMS) and HACCP, Introduction to FSSAI standards. ISO 22000: Introduction, History, Benefits, Objectives, ISO 22000 family of standards series, ISO standard document, Role of BIS in ISO 22000	**4 Hrs.**

References:

1. Hamm, Wolf and Hamilton, R, J. "Edible Oil Processing", Blackwell / Ane Books, 2004.
2. Morris, Peter C and Bryce, J.H. "Cereal Biotechnology", CRC / Wood Head, 2000.
3. Arthey, David and Ashwat P.R. "Fruit Processing: Nutrition, Products, and Quality Management", 2nd Edition, Springer, 2005.
4. Eckles, C.H., W.B. Combs and H. Macy "Milk and Milk Products", 4th Edition, Tata McGraw-Hill, 1973.

5. Singh, I.S. "Post-Harvest Handling and Processing of Fruits and Vegetables" Westville Publishing, 2009.
6. Srivastava, A.P. et al., "Mechanisation of Vegetable Production and Post-Harvest Management". Westville Publishing, 2009.
Fortin, N.D. "Food Regulation : Law, Science, Policy, and Practice". John Wiley, 2009.
7. Lightbourne, Muriel "Food Security, Biological Diversity and Intellectual Property Rights" Ashgate, 2009.
8. Mehta, Rajesh and J. George "Food Safety Regulation Concerns and Trade : The Developing Country Perspective". Macmillan, 2005.
9. Robertson, G.L. "Food Packaging : Principles and Practice". 2nd Edition. Taylor &Francis, 2006.
10. Han, Jung H. "Innovations in Food Packaging". Elsevier, 2005.
11. Ahvenainen, Raija. "Novel Food Packaging Techniques". Wood Head Publishing,2003.
12. Mathlouthi, M. "Food packaging and Preservation". Aspen Publications, 1999.
13. Rao, M.A. et al., "Engineering Properties of Foods". 3rd Edition. CRC/Taylor& Fransis,2005.
14. Gopala Rao, Chandra "Essentials of Food Process Engineering". BS Publications,2006.
15. McCabe, W.L., J.C. Smith and P.Harriot "Unit Operations of Chemical Engineering",7thEdition, McGraw Hill, 2007.
16. Geankoplis, C.J. "Transport Processes and Separation process Principles", 4thEdition, PHI, 2006.
17. Subbulakshmi, G., and Shobha A. Udipi "Food Processing and Preservation".New Age Publications, 2006.

Unit wise Measurable students Learning Outcomes:
At the end of Unit Students will be able to –

1. Explain manufacturing of process food
2. Identify the areas of concern in the processing of milk, meat, fish products, in relation to process control, undesirable microbes.
3. Discuss energy engineering in food processing
4. Demonstrate food processing, preservation and packaging techniques

Title of the Course: Bioprocess Equipment Design (Lab) Course Code: UBIO0631	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite:
Equipments used in Bioprocess Industries

Course Description:
This course contains drawing of equipment symbols, instruments symbols, stream designations, P&IDs, different parts of equipments.

Course Objectives:'

1. To Show different equipment symbols, instruments symbols, stream designations.
2. To analyze parts of reactors and heat exchangers.
3. To develop standard P&IDs based on process requirements.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Show different equipment symbols, instruments symbols, stream designations	II	Understand
CO2	Analyze parts of reactors and heat exchangers	IV	Analyze
CO3	Develop standard P&IDs based on process requirements	VI	Create

CO-PO Mapping:

CO\PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3		2	3			1	2							1
CO2	3	2	3	3	1						2		2	2	
CO3	2	3	3	3		1					2		2	2	3
CO4	2	3	3	3	1	1					3				3

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE	50

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1: Equipment Symbols **Aim :** To Draw Equipment Symbols used in flow sheet synthesis **Objectives:** To understand various Equipment Symbols used in flow sheet synthesis **Outcomes:** Student will understand symbols used in flowsheet synthesis and demonstrate the same.	**2 Hrs.**
Experiment No. 2: Instrument Symbols and stream Designation **Aim:** To Draw Instrument Symbols and learn stream Designations used in flow sheet synthesis.	**2 Hrs.**

Objectives: To understand various Instrument Symbols and learn stream Designations used in flow sheet synthesis **Outcomes**: Student will understand Instrument Symbols and learn stream Designations used in flow sheet synthesis and demonstrate the same.	
Experiment No. 3: Piping and Instrumentation Diagram **Aim:** To Draw and understand the importance of Piping and Instrumentation Diagram used in flow sheet synthesis. **Objectives:** To understand various Piping and Instrumentation Diagram used in flow sheet synthesis **Outcomes:** Student will understand Piping and Instrumentation Diagram used in flowsheet synthesis and demonstrate the same.	**2 Hrs.**
Experiment No. 4: Types of Agitator **Aim:** To Draw and understand the importance of different types of agitators used in bioprocess industry. **Objectives:** To understand various types of agitators used in bioprocess industry. **Outcomes:** Student will understand types of agitators used in bioprocess industry.	**2 Hrs.**
Experiment No. 5: Components of Reaction Vessel **Aim:** To Draw and understand the importance of Components of Reaction Vessel **Objectives:** To understand various Components of Reaction Vessel **Outcomes:** Student will understand Components of Reaction Vessel.	**2 Hrs.**
Experiment No. 6:---Components of Shell and Tube Heat Exchanger **Aim:** To Draw and understand the importance of Components of Shell and Tube Heat Exchanger **Objectives:** To understand various Components of Shell and Tube Heat Exchanger **Outcomes:** Student will understandComponents of Shell and Tube Heat Exchanger	**2 Hrs.**
Experiment No. 7: Design of Reaction Vessel **Aim:** To Draw and understand the importance and calculations for design of Reaction Vessel **Objectives:** To understand various parts and their dimensions calculations of Reaction Vessel **Outcomes:** Student will understand how to design Reaction Vessel**.**	**2 Hrs.**
Experiment No. 8 : Design of Heat Exchanger **Aim:** To Draw and understand the importance and calculations for design of Heat Exchanger **Objectives:** To understand various parts and their dimensions calculations of Heat Exchanger **Outcomes:** Student will understand how to design Heat Exchanger	**2 Hrs.**

Textbooks:

1. Joshi's Process Equipment Design, V.V.Mahajani & S.B.Umarji, fourth edition. (Macmillan publishers India Ltd)
2. Introduction to Chemical Equipment Design-Mechanical Aspects, B.C.Bhattacharyya, CBS, Publishers and Distributors

References:

1. Process Design of Equipment ,Dr. S.D. Dawande, 1st Edition, (Central Techno Publication)
2. Fundamentals of Equipment Design ,A. K. Koker,(Gulf Publication)
3. Process Heat Transfer, D.Q. Kern,(Tata mcgraw Hill Company, New York).
4. Applied Process Design for Chemical and Petrochemical Plants ,E.E. Ludwig, Vol.I,II,III, , 3rd edition London, 1994(Gulf Publication)
5. Plant Design and Economics for Chemical Engineers M.S. Peters & K.D.Timmerhaus,", 5th edition, (mcgraw Hill International Book Co)

6. “Chemical Engg.” Vol. 2 & 6,Coulson J. M. And Richardson J. F (Pergaman Press)

Experiment wise Measurable students Learning Outcomes:

1. Students should understand symbols used in flowsheet synthesis and demonstrate the same.
2. Students should understand Instrument Symbols and learn stream Designations used in flow sheet synthesis and demonstrate the same.
3. Students should understand Piping and Instrumentation Diagram used in flowsheet synthesis and demonstrate the same.
4. Students should understand various types of agitators used in bioprocess industry
5. Students should understand Components of Reaction Vessel.
6. Students should understand how to design Heat Exchanger.

Title of the Course: Bioseparations Processes (Lab) Course Code:UBIO0632	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite:
Solution Preparations, Process Calculations.

Course Description:
Bioseparations laboratory course includes practical based on extraction, precipitation, adsorption, chromatography and membrane separations.

Course Objectives:
1. To analyze different unit operations involved in purification of bio-products.
2. To decide the choice of process steps in purification of bio-products.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Analyze different unit operations involved in purification of bio-products.	IV	Analyze
CO2	Decide the choice of process steps in purification of bio-products.	V	Evaluate

CO-PO Mapping:

CO/PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1		1		3					3	3			1	2	1
CO2		1		3					3	3			1	3	

Assessments :

Teacher Assessment:
One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE	50

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.
ESE: Assessment is based on practical and oral examination

Course Contents:	
Experiment No. 1: Single stage and multi stage extraction **Aim and Objectives:** To compare the performance of single stage versus multi-stage extraction process **Outcomes:** Students will be able to perform and comparesingle stage versus multi-stage extraction process	**6 Hrs.**
Experiment No. 2: Phyto-extraction using Soxhlet **Aim and Objectives:** To extract phyto-constituents by leaching process using Soxhlet apparatus and quantify the product **Outcomes:** Students will be able to extract phyto-constituents by leaching process using Soxhlet apparatus and quantify the product	**6 Hrs.**
Experiment No. 3: Aqueous two phase extraction **Aim and Objectives:** To select aqueous two phase extraction system and calculate partition coefficient **Outcomes:** Students will be able to select aqueous two phase extraction system and calculate partition coefficient	**2 Hrs.**
Experiment No. 4: Isoelectric point precipitation **Aim and Objectives:** To precipitate casein from milk using pI precipitation	**2 Hrs.**

Outcomes: Students will be able to precipitate casein from milk using pI precipitation	
Experiment No. 5: Salt precipitation / Organic solvent precipitation **Aim and Objectives:** To determine the best salt/organic solvent concentration to precipitate protein maximally **Outcomes:** Students will be able to determine the best salt/organic solvent concentration to precipitate protein maximally	**2 Hrs.**
Experiment No. 6: Study of adsorption isotherm **Aim and Objectives:** To determine the static binding capacity of the product on given adsorbent matrix **Outcomes:** Students will be able to determine the static binding capacity of the product on given adsorbent matrix	**6 Hrs.**
Experiment No. 7: Study of column adsorption (breakthrough curve) **Aim and Objectives:** To determine the dynamic binding capacity of the product on given adsorbent matrix **Outcomes:** Students will be able to determine the dynamic binding capacity of the product on given adsorbent matrix	**8 Hrs.**
Experiment No. 8: Ion exchange chromatography **Aim and Objectives:** To purify the protein of interest by ion exchange chromatography **Outcomes:** Students will be able to purify the protein of interest by ion exchange chromatography	**8 Hrs.**
Experiment No. 9: Gel filtration chromatography **Aim and Objectives:** To purify the protein of interest by gel filtration chromatography **Outcomes:** Students will be able to purify the protein of interest by gel filtration chromatography	**8 Hrs.**
Experiment No. 10: Affinity chromatography / Reverse phase chromatography **Aim and Objectives:** To purify the protein of interest by affinity/reverse phase chromatography **Outcomes:** Students will be able to purify the protein of interest by affinity/reverse phase chromatography	**8 Hrs.**
Experiment No. 11: Demonstration of membrane modules **Aim and Objectives:** To demonstrate membrane modules used in microfiltration and ultra filtration **Outcomes:** Students will be able to demonstrate membrane modules used in microfiltration and ultra filtration	**2 Hrs.**
Experiment No. 12: Case study of purification of product from fermentation broth **Aim and Objectives:** To purify the product using sequential unit operations in bioseparations **Outcomes:** Students will be able to purify the product using sequential unit operations in bioseparations	**1 week**
Textbooks: 1. Bioseparations - Belter P.A., Cussler E.L., Hu Wei-Shou (Wiley Publication) 2. Bioseparation - Shivshanker B. (Prentice Hall of India) 3. Bioseparation Science and Engineering – Harrison R.G., Todd P., Rudge S.R., Petrides D.P. (Oxford University Press) 4. Product recovery in bioprocess technology – Biotol Series (Butterworth-Heinemann Ltd.)	

References:

1. Protein Purification: Principles and Practice - Scopes Robert K. (Springer – Verlag Pub.)
2. Separation processes in Biotechnology –Asenjo J.A. (Taylor and Francis Group)
3. Separation and Purification Techniques in Biotechnology – Dechow F.J. (Noyes Pub.)
4. Transport Processes and Separation Process Principles - Geankoplis Christie John (Prentice Hall of India)
5. Unit Operation of Chemical Engineering - McCabe W. L., Smith J., Harriot P. (McGraw-Hill Pub.)

Downstream Processing in Biotechnology – Anuj Kumar Rana (Global Vision Pub.)

Title of the Course: Techniques in Biotechnology (Lab)	L	T	P	Credit
Course Code: UBIO0633	-	-	2	1

Course Pre-Requisite: Basic Knowledge Of Biological, Physical And Chemical Properties Of Small And Macromolecules, Basics Of Physics And Chemistry At 10+2 Level

Course Description:
This course contains the study of various analytical instruments in biotechnology with respect to working principles, instruments layouts, various parts and its functions.

Course Objectives:
1. To Define different parts, symbols of various instruments
2. To Explain working principle and application of instrument.
3. To Interpret the results of analysis.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Define different parts, symbols of various instruments.	I	Remember
CO2	Explain working principle and application of instrument.	II	Understand
CO3	Interpret the results of analysis.	V	Evaluate

CO-PO Mapping:

CO\PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2			2							2	2		
CO2	3	3			2							2	2		
CO3		3			2							2	2		

Assessments :

Teacher Assessment:
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE	50
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Experiment No. 1:Spectrophotomer- Absorption Mixture **Aim and Objectives:** Detections of components of mixtures using absorption mixture **Outcomes:** Students will be able to analysis λ_{max} of components present in the mixture and its concentration.	**4 Hrs.**
Experiment No. 2:Spectrophotomer- Kinetics Method **Aim and Objectives:** Determination of ALP using UV-Vis Spectrophotometer **Outcomes:** Students will be able to analysis the specific activity of enzyme by kinetics method.	**2 Hrs.**
Experiment No. 3:Phase Contrast Microscopy **Aim and Objectives:** Study of cell by Phase Contrast Microscopy	**2 Hrs.**

Outcomes: Students will be able to use Phase contrast microscope and study the epithelial cells.	
Experiment No. 4: SDS PAGE **Aim and Objectives:** Demonstration of SDS PAGE **Outcomes:** Students will be able to use SDS PAGE	**2 Hrs.**
Experiment No. 5: HPLC **Aim and Objectives:** Demonstration of HPLC **Outcomes:** Students will be able to use HPLC	**2 Hrs.**
Experiment No. 6: FTIR **Aim and Objectives:** Demonstration of FTIR **Outcomes:** Students will be able to use FTIR	**2 Hrs.**
Experiment No. 7: GCMS **Aim and Objectives:** Demonstration of GCMS **Outcomes:** Students will be able to use GCMS	**2 Hrs.**
Experiment No. 8: 2D Gel Electrophoresis **Aim and Objectives:** Demonstration of 2D Gel Electrophoresis **Outcomes:** Students will be able to use 2D Gel Electrophoresis	**2 Hrs.**
Experiment No. 9: HPTLC **Aim and Objectives:** Demonstration of HPTLC **Outcomes:** Students will be able to use 2D Gel Electrophoresis	**2 Hrs.**
Experiment No. 10: LCMS **Aim and Objectives:** Demonstration of LCMS **Outcomes:** Students will be able to use LCMS	**2 Hrs.**

Textbooks:

1. Bioanalytical Chemistry, A. Manz, N. Pamme and D. Iossifidis, (World ScientificPublishing Company)
2. Basic Methods in Microscopy, Protocols and concepts from cells: A LaboratoryManual, D. L. Spector & R. D. Goldman (Editors.), Cold Spring Harbor Laboratory Press, 2006
3. Live Cell Imaging: A Laboratory Manual R. D. Goldman, J. R. Swedlow and D. L. (Spector Cold Spring)
4. Harbor Laboratory Press; 2nd edition, 2009.
5. Biophysical Chemistry-Principles and Techniques, A. Upadhyay, K. Upadhyay, N. Nath. (Himalaya Publishing House)
6. Bioinstrumentation, J. Webster (John Wiley and Sons Inc.,).

References:

1. Skoog, D.A., Crouch, S.R., and Holler, F.J. “Principles of Instrumental Analysis”, 6th edition, Brooks/Cole, USA, 2006.
2. Williams, D. and Fleming, I. “Spectroscopic Methods in Organic Chemistry”, 6th edition, McGraw-Hill Higher Education, Maidenhead, UK, 2008.
3. Freifelder D., Physical Biochemistry, “Application to Biochemistry and Molecular Biology”, 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.
4. Keith Wilson and John Walker, “Principles and Techniques of Practical Biochemistry”, 5th Edition, Cambridge University Press, 2000.
5. Kwon, Young Min, Ricke, Steven C. (Eds), “High-Throughput Next Generation Sequencing Methods and Applications”, Volume. 733, Humana Press, 2011.

Title of the Course: Microbial Analysis	L	T	P	Credit
Course Code: UBIO0661	3	-	-	Audit Course

Course Pre-Requisite:
Biochemistry, Microbiology

Course Description:
This includes theoretical understanding of microbial analysis of domestic and industrial samples.

Course Learning Objectives:
1. To explain importance of microbes in environment.
2. To identify microorganisms in domestic and industrial samples
3. To apply various methods for effluent treatment.

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Taxonomy	
		Level	Descriptor
CO1	Explain importance of microbes in the environment	II	Understand
CO2	Identify microorganisms in domestic and industrial samples	IV	Analyze
CO3	Apply various methods for effluent treatment	III	Apply

CO-PO Mapping:

CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2				1									
CO2	2	2	2	3		2	3						3	1	
CO3	2	1	3	2		3	3						1	3	

Assessments :

Teacher Assessment:
One End Semester Examination (ESE) having 100% weightage

Assessment	Marks
ESE	100

ESE Assessment is based on written examination

Course Contents:

UNIT: 1 Role of microorganisms in waste treatment , Importance of *E coli* , Bacterial examination of water preliminary, confirmatory, and completed test, Biological and Chemical Oxygen Demand (BOD and COD)	**6 Hrs**
UNIT: 2 Special staining methods – Capsule and metachromatic granules and spore staining methods, Biochemical tests (Urease and TSI test **,** Catalase and Coagulase test Sugar fermentation test), TDT and TDP of food potent contaminant, SPC of water/food	**8 Hrs**
UNIT: 3 Physicochemical treatments (Screening, grit removal, oil and grease removal, primary sedimentation, precipitation)	**4 Hrs.**
UNIT: 4 Biological treatments Aerobic effluent treatment**,** Fundamentals and design of Suspended growth processes – Activated sludge process and its modification, Aerated lagoons, Attached growth processes – Trickling filters, Rotating	**6 Hrs**

biological contactors	
UNIT: 5 Anaerobic effluent treatment: Upflow Anaerobic Sludge blanket, Anaerobic digester Combined processes (Hybrid reactors)	**6 Hrs.**
UNIT: 6 Disinfection methods (Chlorination, UV treatment, ozone treatment) , Disposal standards and methods - Land filling, composting, Incineration	**6 Hrs**

Reference books:

1. Microbiological Examination Methods of Food and Water: A Laboratory Manual neusely da Silva et. al. CRC Press; 1 edition
2. Food Microbiology and Analytical Methods: New Technologies Mary Lou Tortorello, Steven M. Gendel CRC Press ISBN 9780824700874 1st Edition
3. Microbial analysis of water and waste water Maria Csuros Csaba Csuros

Unit wise Measurable students Learning Outcomes:

Students are able to do-

1. To learn the general history, physiology and anatomy of microorganisms.
2. To identify various types of microorganisms
3. To interpret the reasons of physicochemical treatments
4. To interpret the reasons of **aerobic effluent treatment**
5. To interpret the reasons of **Anaerobic effluent treatment**
6. To explain different disinfection method